

Sub-project ID-054

Program Based Research Grant (PBRG) Sub-project Completion Report

on

**Introduction of Profitable and
Agro-Ecologically Suitable Crop Varieties
and Development of Marketing Systems
for the Charlands of Northern Bangladesh**

Sub-project Duration

21 May 2018 to 15 February 2022

Coordinating Organization



On-Farm Research Division
Bangladesh Agricultural Research Institute
Gazipur-1701

Project Implementation Unit



National Agricultural Technology Program-Phase II Project
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

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Department of Crop Botany
Bangladesh Agricultural University
Mymensingh-2202

Project Implementation Unit



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Abbreviation and Acronyms

AEZ	Agro-ecological Zone
ARS	Agricultural Research Station
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
CP	Cropping Pattern
DAE	Department of Agricultural Extension
DAT	Days after Transplanting
FGD	Focal Group Discussion
FRG	Fertilizer Recommendation Guide
FY	Fiscal Year
GM	Gross Margin
GPS	Global Positioning System
GR	Gross Return
ha	Hectare
IDA	International Development Agency
IFAD	International Fund for Agricultural Development
IPM	Integrated Pest Management
LSP	Local Service Provider
MBCR	Marginal Benefit Cost Ratio
NATP	National Agricultural Technology Program
NGOs	Non-Government Organizations
OFRD	On-Farm Research Division
PCR	Project Compilation Report
PGR	Plant Growth Regulator
PIU	Project Implementation Unit
RCB	Randomized Complete Block Design
REY	Rice Equivalent Yield
TVC	Total Variable Cost
WB	World Bank

Table of Contents

Sl. No	Subject	Page No.
	Executive Summary	xiii
A	Sub Project Description	01
1	Title of the PBRG sub-project	01
2	Implementing organization (s)	01
3	Name and full address with phone, cell and email of Coordinator, Associate Coordinator and PI/Co-PI (s)	01
4	Sub-project budget	01
5	Duration of the sub-project	01
6	Background of the sub-project	02
7	Sub-project general objective	02
8	Sub-project specific objectives	02
9	Implementing locations	03
10	Methodology	03
11	Results and discussion	14
12	Research highlights	118
B	Implementation Status	123
1	Procurement	123
2	Establishment/renovation facilities	124
3	Training/Study tour//Workshop/Seminar	124
C	Financial and Physical progress	126
D	Achèvement of sub-project by objectives	128
E	Information/knowledge generated/policy generated	130
F	Material Development/Publication made	131
G	Description of generated technology/knowledge/policy	134
H	Technology/Knowledge generation/Policy Support	156
I	Information regarding Desk and Field monitoring	158
J	Sub-project Auditing	160
K	Lessons Learned	161
L	Challenges	161
M	Suggestions for Future Planning	162
N	References	163

List of Table

Sl. No.	Title	Page No.
01.	Table 9.1. General information of the selected charlands in three northern districts	03
02.	Table 10.1. List of different crops and varieties used under suitability study against local variety/practice in different char lands during 2018-19	05
03.	Table 10.2. List of the Crops and crop variety(ies) used in the pilot production in different char lands during 2019-20 and 2020-21	05
04.	Table 11.i.1. Average age and educational level of sample farmers in the three Char area of three Northern Districts	15
05.	Table 11.i.2. Average family size and effective family labour of Char farmers in the three Char area of three Northern Districts	15
06.	Table 11.i.3. Land ownership pattern of Char farmers in the three Char area of three Northern Districts	16
07.	Table 11.i.4. Irrigation status of the sample farmers in the three Char area of three Northern Districts	16
08.	Table 11.i.5. Major crops grown under Char farmers in the three Char area of three Northern Districts	16
09.	Table 11.i.6. Major cropping patterns practiced by the Char farmers in the three Char area of three Northern Districts	17
10.	Table 11.i.7. Sowing and harvesting time of major crops of Char farmers in the three Char area of three Northern Districts	18
11.	Table 11.i.8. Agronomic management practices of Char farmers in the three Char area of three Northern Districts	18
12.	Table 11.i.9a. Average per hectare input use of Char farmers in the char areas of Lalmonirhat	19
13.	Table 11.i. 9b. Average per hectare input use of different crops of Char farmers in the char areas of Kurigram	19
14.	Table 11.i.9c. Average per hectare input use of different crops of Char farmers in the char areas of Gaibandha	20
15.	Table 11.i.10a. Per hectare cost and return of different crops of char farmers in the char areas of Lalmonirhat (Tk ha ⁻¹)	20
16.	Table 11.i.10b. Per hectare cost and return of different crops of char in the char areas of Kurigram Tk ha ⁻¹)	21
17.	Table 11.i.10c. Per hectare cost and return of different crops of char farmers in the char areas of Gaibandha Tk ha ⁻¹)	21
18.	Table 11.i.11. Major marketing channel followed by the sampled farmers of Char farmers in the char areas of three Districts	22
19.	Table 11.i.12. Percent of sample farmer's received credit from different sources at char farmers in the char areas of three districts	22

Sl. No.	Title	Page No.
20.	Table 11.i.13. Per farm income of the sample farmers in the char areas of three districts Tk/farm/year	23
21.	Table 11.i.14. Per farm expenditure of sample farmers in char areas of three districts Tk/farm/year	23
22.	Table 11.i.15. Major climatic and biological vulnerability in the three char areas	24
23.	Table 11.i.16. Vulnerability in other matters in the three char areas	24
24.	Table 11.i.17. Problems faced by the farmers of char farmers in the three char areas	25
25.	Table 11.i.18. Probable solutions of the cited problems given by the farmers in the three char areas	26
26.	Table 11.ii.1. Sowing date, harvesting date, trial plot yield and adjusted yield of potato under OFRD, Rangpur and Gaibandha in 2018-19	29
27.	Table 11.ii.2. Cost and return of potato at different charland under OFRD, BARI, Rangpur and Gaibandha in 2018-19	29
28.	Table 11.ii.3. Sowing date, harvesting date, trial plot yield and adjusted yield of Sweet potato under OFRD, Rangpur and Gaibandha in 2018-19	30
29.	Table 11.ii.4. Cost and return of sweet potato at different charland under OFRD, BARI, Rangpur and Gaibandha in 2018-19	31
30.	Table 11.ii.5. Sowing date, harvesting date, trial plot yield and adjusted yield of Maize under OFRD, Rangpur and Gaibandha in 2018-19	32
31.	Table 11.ii.6. Economic performance of Maize at different charland under OFRD, BARI, Rangpur and Gaibandha in 2018-19	32
32.	Table 11.ii.7. Sowing date, harvesting date, trial plot yield and adjusted yield of Sweet gourd under OFRD, Rangpur and Gaibandha in 2018-19	33
33.	Table 11.ii.8. Cost and return of Sweet gourd at different charland under OFRD, BARI, Rangpur and Gaibandha in 2018-19	34
34.	Table 11.ii.9. Sowing date, harvesting date, trial plot yield and adjusted yield of Bitter gourd at Begumganj, Kurigram in 2018-19	35
35.	Table 11.ii.10. Cost and return of Bitter gourd at Begumganj, Kurigram in 2018-19	35
36.	Table 11.ii.11. Sowing date, harvesting date, trial plot yield and adjusted yield of lentil at Kurigram, Lalmonirhat and Gaibandha in 2018-19	36
37.	Table 11.ii.12. Cost and return of Lentil at different charland of Kurigram, Lalmonirhat and Gaibandha in 2018-19	37
38.	Table 11.ii.13. Sowing date, harvesting date, trial plot yield and adjusted yield of Onion at Kurigram, Lalmonirhat and Gaibandha in 2018-19	38
39.	Table 11.ii.14. Cost and return of Onion at different charland of Kurigram, Lalmonirhat and Gaibandha in 2018-19	38

Sl. No.	Title	Page No.
40.	Table 11.ii.15. Sowing date, harvesting date, trial plot yield and adjusted yield of Blackgram at Kurigram, Lalmonirhat and Gaibandha in 2018-19	39
41.	Table 11.ii.16. Cost and return of Blackgram at different charland of Kurigram, Lalmonirhat and Gaibandha in 2018-19	40
42.	Table 11.ii.17. Sowing date, harvesting date, trial plot yield and adjusted yield of chilli at Lalmonirhat and Gaibandha in 2018-19	41
43.	Table 11.ii.18. Cost and return of chilli at different charland of Lalmonirhat and Gaibandha in 2018-19	41
44.	Table 11.ii.19. Sowing date, harvesting date, trial plot yield and adjusted yield of Groundnut at Kurigram, Lalmonirhat and Gaibandha in 2018-19	42
45.	Table 11.ii.20. Cost and return of Groundnut at different charland of Kurigram, Lalmonirhat and Gaibandha in 2018-19	43
46.	Table 11.ii.21. Sowing date, harvesting date, trial plot yield and adjusted yield of Millet at Kurigram, Lalmonirhat and Gaibandha in 2018-19	44
47.	Table 11.ii.22. Cost and return ce of Millet at different charland of Kurigram, Lalmonirhat and Gaibandha in 2018-19	44
48.	Table 11.iii.1. Performance of Sweet gourd at Lalmonirhat during 2019-20 & 2020-21	46
49.	Table 11.iii.2. Performance of Bitter gourd at Kurigram during 2019-20 and 2020-21	47
50.	Table 11.iii.3. Performance of Groundnut at Kurigram and Lalmonirhat during 2019-20 & 2020-21	49
51.	Table 11.iii.4. Performance of onion at Kurigram and Gaibandha during 2019-20 & 2020-21	50
52.	Table 11.iii.5. Performance of chilli at charland Gaibandha and Lalmonirhat during 2019-20 & 2020-21	52
53.	Table 11.iii.6. Performance of Sweet potato at Gaibandha during 2019-20 & 2020-21	53
54.	Table 11.iii.7. Performance of Black gram at charland of Kurigram during 2019-20 & 2020-21	55
55.	Table 11.iii.8. Performance of foxtail millet at charland of Gaibandha during 2019-20 & 2020-21	56
56.	Table 11.iv.1. Marketing cost & margin of different marketing channel of sweet potato	67
57.	Table 11.iv.2. Marketing cost & margin of different marketing channel of foxtail millet	68
58.	Table 11.iv.3. Marketing cost and margins of different marketing channel for lentil	68

Sl. No.	Title	Page No.
59.	Table 11.iv.4. Marketing cost & margins of different marketing channel for groundnut	69
60.	Table 11.iv.5. Marketing cost & margins of different marketing channel for bitter gourd	69
61.	Table 11.iv.6. Marketing cost & margins of different marketing channel for sweet gourd	70
62.	Table 11.iv.7. Marketing cost & margins of different marketing channel for black gram	70
63.	Table 11.iv.8. Marketing cost & margins of different marketing channel for onion	71
64.	Table 11.v.1a.1: Final Germination Percentage (FGP, %), root length (mm) and shoot length (mm) of 30 maize Genotypes at three levels (0, 6 and 12% PEG) of water stress	74
65.	Table 11.v.1a.2: Germination Stress Tolerance Index (GSTI) of 30 maize Genotypes.	75
66.	Table 11.v.1a.3: Root Length Stress Index (RLSI) and Shoot Length Stress Index (SLSI) of 30 maize Genotypes. Values are treatment mean RLSI and SLSI of 6 and 12 % PEG treatments	76
67.	Table 11.v.1b.1: Effect of water stress on germination and growth parameters of chilli genotypes	77
68.	Table 11.v.1b.2: Germination and growth stress tolerance index of chilli genotypes against drought stress	77
69.	Table 11.v.1c.1: Final Germination Percentage (FGP, %), root length (mm) and shoot length (mm) of 45 Groundnut Genotypes at three levels (0%, 5% and 10 % PEG) of water stress	79
70.	Table 11.v.1c.2: Germination Stress Tolerance Index (GSTI) of 45 Groundnut Genotypes. Values are mean GSTI of 5% and 10 % PEG treatments	81
71.	Table 11.v.1c.3: Root Length Stress Index (RLSI) and Shoot Length Stress Index (SLSI) of 45 Groundnut Genotypes. Values are treatment mean RLSI and SLSI of 5% and 10% PEG treatments	82
72.	Table 11.v.1d.1: Final Germination Percentage (FGP, %), root length (mm) and shoot length (mm) of 13 Tomato genotypes at three levels (0%, 5% and 10 % PEG) of water stress	83
73.	Table 11.v.1d.2: Germination Stress Tolerance Index (GSTI) of 13 tomato Genotypes. Values are mean GSTI of 5% and 10 % PEG treatments	84
74.	Table 11.v.1d.3: Root Length Stress Index (RLSI) and Shoot Length Stress Index (SLSI) of tomato genotypes. Values are treatment mean RLSI and SLSI of 5 % and 10% PEG treatments	85
75.	Table 11.v.1e.1: Final germination percentage (FGP, %), root length (mm) and shoot length (mm) of 25 Foxtail millet genotypes at three levels (0%, 5% and 10 % PEG) of water stress	86

Sl. No.	Title	Page No.
76.	Table 11.v.1e.2: Germination Stress Tolerance Index (GSTI) of 25 Foxtail Millet genotypes. Values are mean GSTI of 5% and 10 % PEG treatments	87
77.	Table 11.v.1e.3: Root Length Stress Index (RLSI) and Shoot Length Stress Index (SLSI) of Foxtail millet Genotypes. Values are treatment mean RLSI and SLSI of 5 % and 10% PEG treatments	88
78.	Table 11.v.2a.1: Effect of PEG induced drought stress on morpho-physiological parameters of five maize genotypes at 0 & 10 % level of PEG under hydroponics	91
79.	Table 11.v.2b.1: Effect of PEG induced drought stress on root and shoot length (cm) of 16 groundnut genotypes at 0 & 10 % level of PEG under hydroponics	92
80.	Table 11.v.2b.2: Effect of PEG induced drought stress on root fresh and dry weight (g) of 16 groundnut genotypes at 0 & 10 % level of PEG under hydroponics	93
81.	Table 11.v.2b.3: Effect of PEG induced drought stress on shoot fresh and dry weight (g) of 16 groundnut genotypes at 0 & 10 % level of PEG under hydroponics	94
82.	Table 11.v.2b.4: Effect of PEG induced drought stress on SPAD value and relative water content (RWC) of 16 groundnut genotypes at 0 & 10% level of PEG under hydroponics	95
83.	Table 11.v.2d.1: Effect of PEG induced drought stress on morpho-physiological parameters of six foxtail millet genotypes at 0 & 10 % level of PEG under hydroponics	103
84.	Table 11.v.3a.1: Effect of drought stress on plant height and root length of five maize genotypes under pot culture	104
85.	Table 11.v.3a.2: Effect of drought stress on root and shoot fresh weight (g) of five maize genotypes under pot culture	105
86.	Table 11.v.3a.3: Effect of drought stress on the performance of five maize genotypes under pot culture	105
87.	Table 11.v.3b.1: Effect of drought stress on plant height and SPAD value of five chili genotypes under pot culture	106
88.	Table 11.v.3b.2: Effect of drought stress on root and shoot length (cm) value of five chili genotypes under pot culture	106
89.	Table 11.v.3b.3: Effect of drought stress on root and shoot fresh weight of five chili genotypes under pot culture	107
90.	Table 11.v.3b.4: Effect of drought stress on yield of five chilli genotypes under pot culture	107
91.	Table 11.v.3c.1: Effect of drought stress on plant height and root length of five groundnut genotypes under pot culture	108

Sl. No.	Title	Page No.
92.	Table 11.v.3c.2: Effect of drought stress on shoot fresh and dry weight of five groundnut genotypes under pot culture	108
93.	Table 11.v.3c.3: Effect of drought stress on no. of nodule per plant and N/peg of five groundnut genotypes under pot culture	109
94.	Table 11.v.3c.4: Effect of drought stress on yield of five groundnut genotypes under pot culture	109
95.	Table 11.v.4a.1: Morphological and yield attributes of selected three maize genotypes at charland condition under field performance	116
96.	Table 11.v.4b.1: Morphological and yield attributes of three selected chili genotypes at charland condition under field performance	117
97.	Table 11.v.4c.1: Morphological and yield attributes of three selected groundnut genotypes at charland condition under field performance	117
98.	Table B.1.1. Procurement status of Component-1 (OFRD, BARI)	123
99.	Table B.1.2. Procurement status of Component-2 (BAU)	124
100.	Table B.2. 2. Establishment/renovation facilities	124
101.	Table B.3.1. Training, Workshop, meeting under Coordination component	124
102.	Table B.3.2. Training, Workshop, Field day under Component-1 (OFRD, BARI)	125
103.	Table B.3.3. Training, Workshop, Networking meeting under Component-2 (BAU)	126
104.	Table C.1. Total fund received and expenditure (component-1, component-2 & co-ordination component)	126
105.	Table C.2. Fund received and expenditure under Co-ordination component	126
106.	Table C.3. Fund received and expenditure under Component-1 (OFRD, BARI)	127
107.	Table C.4. Fund received and expenditure under Component-2 (BAU)	127

List of Figure

Sl. No.	Title	Page No.
01.	Fig. 9.1: Selection of Char locations by sub-project personnel	03
02.	Fig.10.1: Photographs showing the performance of seed germination of maize at different levels of PEG induced drought stress (0, 6 and 12 % PEG)	07
03.	Fig.10.2: Photographs showing the performance of seed germination of chilies at different levels of PEG induced drought stress (0 and 5% PEG)	07
04.	Fig.10.3: Photographs showing the performance of seed germination of groundnut at different levels of PEG induced drought stress (0, 5 and 10 % PEG)	08
05.	Fig.10.4: Photographs showing the performance of seed germination of tomato at different levels of PEG induced drought stress (0, 5 and 10 % PEG)	08
06.	Fig.10.5: Photographs showing the performance of seed germination of foxtail millet at different levels of PEG induced drought stress (0, 5 and 10% PEG)	08
07.	Fig.10.6: Photographs showing the performance of maize at different levels of PEG induced drought stress (0 and 10 % PEG) under hydroponic conditions	09
08.	Fig.10.7: Photographs showing the performance of groundnut at different levels of PEG induced drought stress (0 and 10 % PEG) under hydroponic conditions	09
09.	Fig.10.8: Photographs showing the performance of foxtail millet at different levels of PEG induced drought stress (0 and 10 % PEG) under hydroponic conditions	10
10.	Fig.10.9: Photographs showing the performance of pot experiment of maize at different levels of drought stress (0, 50, 75 and 100% field capacity)	10
11.	Fig. 10.10: Photographs showing the performance of pot experiment of maize at different levels of drought stress (0, 50, 75 and 100% field capacity)	11
12.	Fig.10.11: Photographs showing the performance of pot experiment of groundnut at different levels of drought stress (0, 50, 75 and 100% field capacity)	11
13.	Fig.10.12: Photographs showing the performance of pot experiment of tomato at different levels of drought stress (control, moderate, severe drought)	12
14.	Fig.10.13: Photographs showing the field performance of maize at charland of Lalmonirhat	13
15.	Fig.10.14: Photographs showing the field performance of chili at charland of Lalmonirhat	13
16.	Fig.10.15: Photographs showing the field performance of groundnut at charland of Lalmonirhat	14
17.	Fig. 11.i.1: Baseline survey of farmers at different char locations by project personee l30	27
18.	Fig. 11.i.2: Farmers group meeting at different char locations	27
19.	Fig. 11.ii.1: Seed/vine of different crops distribution among the farmers at different char areas	28

Sl. No.	Title	Page No.
20.	Fig. 11.ii.2: Field view of Potato at different char locations	29
21.	Fig. 11.ii.3: Field view of sweet potato at different char locations	31
22.	Fig. 11.ii.4: Field view of Maize at different char locations	33
23.	Fig. 11.ii.5: Field view of Sweet gourd at different char locations	34
24.	Fig. 11.ii.6: Field view of Bitter gourd at Char Begumganj, Kurigram char locations	35
25.	Fig. 11.ii.7: Field view of Lentil at different char locations	37
26.	Fig. 11.ii.8: Field view of Onion at different char locations	38
27.	Fig. 11.ii.9: Field view of Blackgram at different char locations	40
28.	Fig. 11.ii.10: Field view of Chilli at different char locations	41
29.	Fig. 11.ii.11: Field view of Groundnut at different char locations	43
30.	Fig. 11.ii.12: Field view of Foxtail millet at char Gaibandha	44
31.	Fig. 11.iii.1: Pilot production of sweet gourd at Char Jagatber, Lalmonirhat	46
32.	Fig. 11.iii.2: Pilot production of Bittergourd at Char Begumganj, Kurigram	48
33.	Fig. 11.iii.3: Pilot production of groundnut at Char Begumganj, Kurigram	50
34.	Fig. 11.iii.4: Pilot production of onion at Char Begumganj, Kurigram and Char Saghata, Gaibandha	51
35.	Fig. 11.iii.5: Pilot production of Chilli at Char Jagatber, Lalmonirhat and Char Saghata, Gaibandha	53
36.	Fig. 11.iii.6: Pilot production of sweet potato at Char Char Saghata, Gaibandha	54
37.	Fig. 11.iii.7: Pilot production of blackgram at Char Begumganj, Kurigram	55
38.	Fig. 11.iii.8: Pilot production of Blackgram at Char Begumganj, Kurigram	56
39.	Fig. 11.iv.1: Crop product collection point establishment and container, tag, bag, packet etc. distribution for marketing system development at Char Begumganj, Kurigram, Jagatber, Lalmonirhat and Saghata, Gaibandha	72
40.	Fig. 11.iv.2: Sweet gourd harvesting, bringing to the collection point, transportation for marketing at Jagatber, Lalmonirhat	73
41.	Fig. 11.v.1a.1: Photographs show some good performing (first two columns) and some bad performing (last two columns) genotypes based on the performance of seed germination at different levels of water stress (0, 6 and 12 % PEG)	75
42.	Fig. 11.v.2c.1. Effects of PEG on shoot length of tomato genotype	96
43.	Fig. 11.v.2c.2. Effects of PEG on root length of tomato genotypes	97
44.	Fig. 11.v.2c.3. Effects of PEG on number of leaves per plant of four genotypes	98
45.	Fig. 11.v.2c.4. Effects of PEG on root fresh weight of tomato genotypes	99
46.	Fig. 11.v.2c.5. Effects of PEG on relative greenness (as SPAD) of tomato genotypes	100

Sl. No.	Title	Page No.
47.	Fig. 11.v.2c.6. Effects of PEG on proline content of leaf of tomato genotypes	101
48.	Fig. 11.v.3d.1. Leaf greenness (SPAD values) in five tomato cultivars under three drought levels	110
49.	Fig. 11.v.3d.2. Net photosynthesis (A) in five tomato cultivars under three drought levels	111
50.	Fig. 11.v.3d.3. Transpiration (E) rate in five tomato cultivars under three drought levels	112
51.	Fig. 11.v.3d.4. Stomatal conductance (gs) in five tomato cultivars under three drought levels	113
52.	Fig. 11.v.3d.5. Total chlorophyll (a+b) content in five tomato cultivars under three drought levels	114
53.	Fig. 11.v.3d.6. Fruit yield plant-1 in five tomato cultivars under three drought levels	115
54.	Fig. 11.v.3d.7: Combined effect of cultivars and three drought levels on tomato fruit	115
55.	Fig. B.3.1: Training and field day activities at different char locations	125
56.	Fig. B.3.2: Inception workshop	125
57.	Fig. B.3.3: Networking meeting	125
58.	Fig. F.1: Print and Electronic media coverage	132
59.	Fig. F.2: Print and Electronic media coverage	133

List of Flow Chart

Sl. No.	Title	Page No.
01.	Flow Chart 11.iv.1. Existing and improved marketing channel of sweet potato	59
02.	Flow Chart 11.iv.2. Existing and improved marketing channel of foxtail millet	60
03.	Flow Chart 11.iv.3. Existing and improved marketing channel of lentil	61
04.	Flow Chart 11.iv.4. Existing and improved marketing channel of groundnut	62
05.	Flow Chart 11.iv.5. Existing and improved marketing channel of bitter gourd	63
06.	Flow Chart 11.iv.6. Existing and improved marketing channel of sweet gourd	64
07.	Flow Chart 11.iv.7. Existing and improved marketing channel of black gram	65
08.	Flow Chart 11.iv.8. Existing and improved marketing channel of onion	66

Executive Summary

Charlands are highly dynamic and subject to erosion and accretion where no systemic crop cultivation is practiced due to unavailability of seeds of early & short duration drought tolerant crop varieties. In addition, the farmers are also getting less product price due to non-diversified and low-value crops production and improper marketing channel in the charland areas. Therefore, addressing the above situation, utilization of vast northern charland for increasing high-value crops production, income generation and livelihood improvement would be possible by identifying and adopting of agro-ecologically suitable crops and varieties, and also generating appropriate technologies/approaches including promotion of business, and these were the aspiration of the sub-project. Co-ordinated research activities were carried out during 2018-19 to 2020-21 under two components i.e., Component-1: OFRD, BARI, Rangpur & Gaibandha, and Component-2: Department of Crop Botany, Bangladesh Agricultural University (BAU), Mymensingh with the coordination of OFRD, BARI, Gazipur. Under component-1 (OFRD, BARI), the sub-project activities were implemented in the three char locations from northern districts i.e., Char Begumganj, Ulipur of Kurigram district; Char Jagatber of Lalmonirhat district and Char Saghata of Gaibandha district, where laboratory of Department of Crop Botany, BAU; ARS, Rangpur and Char Jagatber, Lalmonirhat were used under component-2 (BAU).

Under component-1, a baseline survey was undertaken at three char areas during July to September 2018 following random sampling to know the socio-economic status and to explore the existing agricultural practices for further improvement. It was revealed that majority of the sample farmers cultivated local variety of different crops with applying indiscriminate doses of fertilizer. In the three char areas, T. Aman rice, groundnut, chilli, grass pea, black gram, sweet potato, potato, sugarcane, and jute are the main cultivated crops. In the Kharif-II season, most of the lands are occupied with T. Aman rice as chance crop. The agricultural productivity in charland is less due to low fertility, riverbank erosion, poverty, poor irrigation facility, less intervention of modern agricultural technologies/varieties etc. Lack of knowledge about new and drought tolerant crop variety/technology was identified as the main problem of the farmer. The farmers are also getting less product price due to non-diversified and low-value crops, improper marketing channel, middleman, inefficient transportation system etc. Based on survey data, eleven types of crops (maize, foxtail millet, sweet gourd, bitter gourd, potato, sweet potato, blackgram, lentil, groundnut, chilli and onion) were selected, and trials were conducted during 2018-19 in the view to assess the suitability of BARI released high yielding crop varieties/technologies for the char lands. All improved varieties were compared with locally adapted cultivars/varieties involving a total of 90 farmers. Among the trial crops, all improved varieties/technologies performed better over the local varieties/practices except bitter gourd. Considering the crop performance, local market demand and farmers preferences, three to four improved varieties/technologies were selected for pilot production at each location. Groundnut (var. BARI Chinabadam-8), onion (var. BARI Piaj-1), black gram (var. BARI Mash-3) and bitter gourd (cv. Uche) with improved crop management practices were selected for Char Begumganj; sweet gourd (var. BARI Hybrid Mistikumra-1), groundnut (var. BARI Chinabadam-8) and chilli (var. BARI Morich-3) were selected for Char Jagatber; where sweet potato (var. BARI Misti Alu-8), chilli (var. BARI Morich-3) and foxtail millet (BARI Kaon-2) were selected for Char Saghata. During 2019-20 and 2020-21, the selected crops were piloted in farmers' group approach at Charland with the coverage of more than 2 hectares of each crop. The average yield in trial plots were increased by 28.37, 44.21, 68.75, 22.54, 24.35, 40.37, 58.82 and 49.67% in sweet gourd, bitter gourd, ground nut, onion, chilli, sweet potato, blackgram and foxtail millet, respectively compared to farmers existing practice. Besides of these, farmers' producer group formation, collection point improvement, Local Service Provider (LSP) development, quality improvement activities of the product, market information collection, marketing channel development etc. were continued for livelihood improvement of the char farmers.

Improved marketing channel includes farmers group or local service provider for getting higher price to the farmers. Out of some improved marketing channels, most effective marketing channel were Farmer-Local Service Provider-Aratters/commission agents-Retailer-Consumer for sweet potato, bitter gourd, sweet gourd and onion, Farmer-Local Service Provider- Processing Centre - Wholesaler-Retailer-Consumer for foxtail millet, lentil, ground nut and blackgram. Farmers can earn more profit by producing, storing, grading, and marketing their seeds. This sub-project helps farmers in this regard. So, some seed marketing channels were developed by LSP. The most effective seed marketing channel were Farmer-Local Service Provider- Grower for foxtail millet, Farmer-LSP-Retailer-Growers for lentil, ground nut and black gram and Farmer-LSP-Whole Saler-Retailer-Growers for onion.

Under component-2, the genotypes of five crops; chilli (9 genotypes); groundnut (45 genotypes); maize (30 genotypes), foxtail millet (25 genotypes); tomato (13 genotypes) were collected from BARI, BADC and other sources and these genotypes were subsequently evaluated through germination, hydroponics, pot and field trial. Seed quality assessment of different genotypes of different crops was done with different level of polyethylene glycol (PEG) induced drought stress. After that, selected genotypes of all crops were subsequently investigated in hydroponic culture with different level of PEG induced drought stress and pot culture based on morpho-physiological attributes. Based on previous seed quality, hydroponic culture and pot culture, potential genotypes of different crops were selected. Finally, three genotypes (selected from seed quality, hydroponic culture and pot culture) of groundnut, maize and chilli were put under field trial to evaluate their agro-physiological performance at charland of Lalmonirhat. From the germination, based on the different stress tolerance indices like GSTI, RSLI and SLSI six maize genotypes (Gold Star, BHM-13, Palaoan, 981, BHM-9 and Pioneer), five chilli genotypes (Local (Jhau), BARI Morich-3, BARI Morich-2, BARI Morich-1, BARI Morich-4), five tomato genotypes (BARI Tomato-2, BARI Tomato-15, BARI Tomato-16, BARI Tomato-18 and Binatomato-11), sixteen groundnut genotypes (BARI Chinabadam-9, ICGV-07214, ICGV-0504-7, ICGV-02125, ICGV-95070, ICGV-955090, Binachinabadam-4, BARI Chinabadam-8, ICGV-06279, Dhaka-1, ICGV-07245, ICGV-05158, BARI Chinabadam-6, Binachinabadam-8, BARI Chinabadam-10, ICGV-97232), six foxtail millet genotypes (BARI Kaon-1, BARI Kaon-2, BARI Kaon-3, Ulipur, Kaon BD 887, Kaon BD 876) performed better and selected for hydroponics and further investigations. From the hydroponics experiment, according to different morpho-physiological attributes, five maize (BHM-13, Pioneer, Palaoan, Bharati 981 and BHM-9), five groundnut genotypes (ICGV-0504-7, Binachinabadam-4, BARI Chinabadam-8, ICGV-07214 and Dhaka-1), five tomato genotypes (BARI Tomato-2, BARI Tomato-15, BARI Tomato-16, BARI Tomato-18 and Binatomato-11) and four foxtail millet (BARI Kaon-1, BARI Kaon-3, Local-Ulipur and Kaon BD-876) exhibited better performance and these genotypes were selected for pot trial and further investigations. From the pot experiment, on the basis of different morpho-physiological traits, three maize genotypes (BHM-9, Pioneer and Bharati 981), three chilli genotypes (Binamorich-1, BARI Morich-3, BARI Morich-4) and three groundnut genotypes (BARI Chinabadam-8, Binachinabadam-4 and Dhaka-1) showed better results and these genotypes were put under field trial in the charland of Lamonirhat. During field trial, based on yield and yield attributes Bharati 981 (maize genotype), BARI Morich-4 (chilli genotype) and BARI Chinabadam-8 (groundnut genotype) performed better at charland conditions and exhibited considerable amount of yield.

Finally, it can be concluded that identification and expansion of suitable high value crops in northern charland, and efficient marketing channel development created a positive impact on improving livelihood of resource poor char farmers during the sub-project duration.

Keywords: Char marketing system, high value crops, Agro-ecologically suitable crops, profitability, local service provider, northern charland.

PBRG Sub-project Completion Report (PCR)

A. Sub-project Description

1. Title of the PBRG sub-project

Introduction of Profitable and Agro-Ecologically Suitable Crop Varieties and Development of Marketing Systems for the Charlands of Northern Bangladesh

2. Implementing organization

On-Farm Research Division (OFRD), Bangladesh Agricultural Research Institute and Department of Crop Botany, Bangladesh Agricultural University

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

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4. Sub-project budget (Tk.)

4.1 Total (in Tk. as approved): 1,00,00,000.00

4.2 Latest Revised (if any): Tk. 1,00,00,000.00

5. Duration of the sub-project: 21 May 2018 to 15 February 2022

5.1 Start date (based on LoA signed): 21 May 2018

5.2 End date: 15 February 2022

6. Background of the sub-project

Charlands are highly dynamic as they disappear or reappear due to erosion or accretion. Since the chars are formed through the continual process of land erosion and deposition on the major rivers and coastal areas, the whole of the char land is unstable and prone to annual flooding. The soils are deficient of most of the plant nutrients, have very low organic matter contents and minimum moisture holding capacity, especially in the northern and middle region chars (SRDI, 2001). Flood is very common in every summer in most of the chars, though Lewis (2011) reported that the quality of flooded soils remained fertile due to huge sedimentation and carbon flux. Many other reports are also available that sporadically revealed the prevailing situations of the char lands in general (Ahmed et al., 2013; Karim, 2014; Rahman and Davis, 2005; Rogers et al., 2013). However, there exists hardly any comprehensive report that reflects the real agricultural problems in the char lands of different regions and captures the technological demand for mitigating the problems persist therein.

Bangladesh has acquired 5471 square kilometers of new land until 2010 since independence in riverine areas (Hasan et al., 2013). This has been a blessing for the small country where agricultural land is less than 14 decimals/capita (Ministry of Land, 2015) and it is shrinking every year at an alarming rate of 0.005 ha/capita/year since 1989 (Hossain and Bari, 1996). The total charland area in Rangpur, Kurigram, Gaibandha and Lalmonirhat districts are 77895 hectares and among them about 79% are cultivable (DAE, 2016), but unfortunately those are mostly underutilized or used for low-value crops production. In general, the agricultural productivity in charland is less due to low fertility, riverbank erosion, poverty, less intervention of modern agricultural technologies/varieties and also minimal services from government and NGOs. The farmers are also getting less product price due to non-diversified and low-value crops, improper marketing channel, middleman, inefficient transportation system etc. Therefore, addressing the above situation, utilization of vast northern charland for increased high-value crops production, income generation and livelihood improvement would be possible by generating and adopting appropriate technologies/approaches including promotion of business, and these were the aspiration of the sub-project.

7. Sub-project general objective(s)

Farmers livelihood improvement through introduce of high value crops and development of marketing system in northern charland.

8. Sub-project specific objectives

Component-1 (OFRD, BARI):

- i) To identify the suitable high value crops for different char ecosystems
- ii) To expand cultivation of selected crops through group approach with improved management system in northern charland
- iii) To develop marketing system for improving char farmers' livelihood in northern Bangladesh

Component-2 (BAU):

- i) To screening and evaluation of different high-value crops for charland ecosystem based on agro-physiological characteristics
- ii) To evaluate the agro-physiological performance of different high value crops under water stress condition in pot and hydroponic systems
- iii) To see the agro-economic performance of different high value crops under improved management in different char ecosystems

9. Implementing location(s)

Component-1 (OFRD, BARI):

The sub-project activities were conducted as a participatory approach in the farmer's field at three locations from three northern districts i.e. Char Begumganj, Ulipur of Kurigram district; Char Jagatber of Lalmonirhat district and Char Saghata of Gaibandha district. These locations were selected on the basis of season, stable and unstable char, communication, climatic, edaphic, social, vegetation and economic conditions of the regions so that the site be representative.

Table 9.1. General information of the selected charlands in three northern districts

Location	Area of the char (ha)	Land type	Soil type	AEZ	GPS
Char Begumganj, Ulipur, Kurigram	72	Unstable to stable Low land	Sandy to Sandy loam	AEZ-2 & 3	N 25045.465 E089041.528
Char Jagatber, Sadar, Lalmonirhat	152	Unstable to stable Low land	Sandy to Sandy loam	AEZ-2 & 3	N 25049.650 E089025.016
Char Saghata, Gaibandha	273	Unstable to stable, Medium low to low land	Sandy to Sandy loam	AEZ-3 & 7	N 25017.718 E089020.583



Char Begumganj, Kurigram



Char Jagatber, Lalmonirhat



Char Nalsia, Gaibandha

Fig. 9.1: Selection of Char locations by sub-project personnel

Component-2 (BAU):

Location 1: Plant physiology laboratory and growth chamber of the Dept. of Crop Botany, BAU, Mymensingh,

Location 2: Agricultural Research Station, OFRD, BARI, Alamnagar, Rangpur

Location 3: Char Jagatber, Lalmonirhat

10. Methodology

For the successful implementation of the char-based research and development program, the following methods were considered-

Identification of problems and prospects

It was done through detailed base line survey with total 300 farmers (100 farmers from each location) focused on geographical location, physical, biological, social and economic conditions, infra-structural condition, existing farming systems, resource situation, general problems etc.

Prioritization of problems and prospects

The prioritization of problems/prospects were done based on the stable and unstable charland, available resources, farmers' opinions, Soil and riverbank erosion, previous experiences, market orient activities etc.

Preparation of research and development program

Research and development programs were formulated against prioritized problems and prospects taking into consideration of available resources and previous experiences.

Discussion on the program (OFRD, BARI Component)

The programs were discussed at the site level and at the institutional level. At the site level discussion, Site Coordinator, Scientists, Scientific Assistants, and farmers were involved. At the institutional level, the research programs were discussed at the Research Team meeting headed by the concern divisional head, Project Coordinator, Principal Investigators, Co- Principal Investigators, Site Coordinators and Scientific Officers, other Subproject personnel and farmers.

Program execution

All the designed programs under BARI Component were executed at the farm level with the active participation of OFRD team and scientific personnel of Bangladesh Agricultural Research Institute (BARI).

Specific methodology of research activity

Component-1: OFRD, BARI

Activity-1 (OFRD, BARI): Baseline survey

The baseline survey was conducted at the sub-project area with the help of pretested questionnaire during 29 July-12 August 2018. Farm accounting data of 300 farm households were collected from char farms of Jagatber under Lalmonirhat Sadar Upazila of Lalmonirhat; Begumganj under Ulipur Upazila of Kurigram; and Chandanpat under Saghata Upazila of Gaibandha district containing 100 farmers from each char location for base line survey during July to September, 2018 under "Introduction of Profitable and Agro-Ecologically Suitable Crop Varieties and Development of Marketing Systems for the Charlands of Northern Bangladesh" sub-project. At first, a list of all farm households from the char areas was prepared and then 100 farm households from each were selected using random sampling technique method. After collection of the data, each interview schedule was verified for the sake of consistency and completeness. Editing was done before putting the data in the computer. Summarization, careful scrutiny and necessary summary tables have been made from the data. Tabular techniques have been used for analysis, interpretation and presentation of data to fulfill the objectives of the base line survey.

Activity-2 (OFRD, BARI): Feasibility of high-value crops production in northern charland of Bangladesh.

Initiatives were taken to produce high value crops in farmers' field to identify the suitable and profitable crops and varieties at charland. The programs were executed during 2018-19 in 03 rivers based charland area (stable and unstable) of 03 Northern districts, i.e. Char Dhorola river under Kurigram district (Char Begumganj); Char Tista river under Lalmonirhat district (Char Jagatber) and Char Bangali river under Gaibandha district (Char Saghata). A total of ten types of crops were tested at each char location, where each crop was replicated in 03 dispersed farmer's field including 02 varieties of each crop (one improved variety and one local variety/practice as check) maintaining RCB design. A total of 90 farmers (30 from each location) were involved in the program conducting research with 10 crops. For the successful crop production some critical inputs were supplemented in a participatory way, eg. Water reservoir, Portable shallow tube-well, Plastic pipe, Pheromone trap, Bio-pesticide, Mulching, Proper fertilizer, Quality seed/seedling, Digging and pit plantation etc.

Selection of the crops and crop varieties:

Eleven improved crop varieties (10 for each location) were selected for their suitability study against local variety/practice in the selected char lands in the northern districts during 1st year.

Table 10.1. List of different crops and varieties used under suitability study against local variety/ practice in different char lands during 2018-19

Crop group	Crop	Crop variety considered	
		Improved variety	Local
Cereal crops	Maize	BARI Hybrid Maize-9	Commercially grown hybrid
	Foxtail millet	BARI Kaon-2	Locally grown kaon
Vegetables	Sweet gourd	BARI Hybrid Mistikumra-1	Locally adapted Mistikumra
	Bitter gourd	Popular variety	Local cultivar Ucche
Tuber crops	Potato	BARI Alu-77	BARI Alu-25
	Sweet potato	BARI SP-8	Local variety
Pulse crops	Blackgram	BARI Mash-3	Local variety
	Lentil	BARI Moshur-8	Local variety
Oil Seed	Groundnut	BARI Chinabadam-8	Local variety (Dhaka-1)
Spices crops	Chilli	BARI Morich-2 & 3	Local variety
	Onion	BARI Piaj-1	Local variety

Follow-up evaluation

All the research activities were continuously monitored by the OFRD team. Cross evaluation of the executed programs was done by a group of officers of OFRD, Rangpur and Gaibandha including PI and Co-PI. Farmers under the research program were continuously suggested by the scientists and associated field staffs for better crop production and protection from insects and pests.

Activity-3 (OFRD, BARI): Pilot production program through group approach with selected variety of suitable crop(s) at charland

A common simple trial design was followed for all three locations and three crops for each location (one location covered four types of crops) covering more than 2 hectares for each crop and around 6 hectares' land area were taken under research activities in each location and 3 locations totally it covered more than 18 hectares during each year of 2019-20 and 2020-21.

Table 10.2. List of the Crops and crop variety(ies) used in the pilot production in different char lands during 2019-20 and 2020-21

Sl.No.	Crop	Crop variety used		
		Char Begumganj, Kurigram	Char Jagatber, Lalmonirhat	Char Saghata, Gaibandha
1.	Sweet gourd	-	BARI Hybrid Mistikumra-1	-
2.	Bitter gourd	Ucche (Local)	-	-
3.	Groundnut	BARI Chinabadam-8	BARI Chinabadam-8	-
4.	Onion	BARI Piaj-1	-	-
5.	Chilli	-	BARI Morich-3 & Local	BARI Morich-3 & Local
6.	Sweetpotato	-	-	BARI Mistialu-8
7.	Blackgram	BARI Mash-3	-	-
8.	Foxtail millet	-	-	BARI Kaon-2

Activity-4 (OFRD, BARI): Improvement of marketing system for high-value crops in northern charland of Bangladesh

Besides of pilot production of high value crops, activities were continued as follows for marketing system improvement to get higher market price by the farmer.

Year: 2nd & 3rd year: Marketing system were developed in participatory way with the collaboration of different stakeholders. Some major steps that were followed-

- Formation of Agro-Centre (Collection point),
- Formation of demand-based producer group
- Capacity building,
- Local Service Provider (LSP) development,
- Mini transporter improvement,
- Improvement of post-harvest processing,
- Technical backstopping,
- Development of storage opportunity,
- Facilitate for credit access,
- Linking with good seed source,
- Linking with agricultural product buyer,
- Strengthening linkage between farmers and marketing channels, etc.

Component-2: BAU

The genotypes of all crops, Chilli (9 genotypes); Groundnut (45 genotypes); Maize (30 genotypes), Foxtail millet (25 genotypes) and Tomato (13 genotypes) were collected from BARI, BADC and other sources. Seed quality assessment of different genotypes of different crops was done with different level of polyethylene glycol (PEG) induced for drought stress. After that, selected genotypes of all crops were subsequently investigated in hydroponic culture with different level of polyethylene glycol (PEG) induced drought stress and pot culture based on morpho-physiological attributes. Based on previous seed quality, hydroponic culture and pot culture, potential genotypes of different crops were selected. Finally, three genotypes (selected from seed quality, hydroponic culture and pot culture) of groundnut, maize and chilli were undergone for field trial to evaluate their agro-physiological performance at charland of Lalmonirhat. Overall, methodologies are briefly discussed below.

Experiment 1: Seed quality assessment of different genotypes of pre-selected crops through seed germination and seed health

Expt. 1a: Effect of drought stress on germination and early growth stage of maize

Thirty (30) maize genotypes were selected for seed quality assessment and these genotypes were assessed following CRD design with three replications using three treatments of PEG 6000 i.e. 0% (Control), 6%, and 12% at Plant physiology laboratory and growth chamber of the Dept. of Crop Botany, BAU (Fig. 10.1).





Fig.10.1: Photographs showing the performance of seed germination of maize at different levels of PEG induced drought stress (0, 6 and 12% PEG)

Expt. 1b: Effect of drought stress on germination and early growth stage of chilli

For seed quality assessment 9 chilli genotypes were selected and assessed by following CRD design with three replications using two treatments of PEG 6000 i.e. 0% (Control) and 5% at Plant physiology laboratory of the Dept. of Crop Botany, BAU (Fig. 10.2).



Fig.10.2: Photographs showing the performance of seed germination of chillies at different levels of PEG induced drought stress (0 and 5% PEG)

Expt. 1c: Effect of drought stress on germination and early growth stage of groundnut

For seed quality assessment 45 groundnut varieties/genotypes were taken and assessed by following CRD design with three replications using three treatments of PEG 6000 i.e. 0% (Control),5% and10% at Plant physiology laboratory and growth chamber of the Dept. of Crop Botany, BAU (Fig. 10.3).





Fig.10.3: Photographs showing the performance of seed germination of groundnut at different levels of PEG induced drought stress (0, 5 and 10 % PEG).

Expt. 1d: Effect of water stress on germination and early growth stage of tomato

Seed quality assessment of 13 tomato genotypes has been done following CRD design with three replications using three treatments of PEG 6000 i.e. 0% (Control), 5% and 10% at Plant physiology laboratory of the Dept. of Crop Botany, BAU (Fig. 10.4).



Fig.10.4: Photographs showing the performance of seed germination of tomato at different levels of PEG induced drought stress (0, 5 and 10 % PEG).

Expt. 1e: Effect of water stress on germination and early growth stage of foxtail millet

Seed quality assessment of 25 foxtail millet genotypes was done following CRD design with 3 replications using three treatments of PEG i.e. 0% (Control), 5% and 10% at Plant physiology laboratory and growth chamber of the Dept. of Crop Botany, BAU (Fig. 10.5).



Fig.10.5: Photographs showing the performance of seed germination of foxtail millet at different levels of PEG induced drought stress (0, 5 and 10 % PEG).

Experiment 2: Evaluation the performance of suitable genotypes of different crops based on initial growth under artificially induced drought stress condition in hydroponic system

Expt. 2a: Effect of drought stress on early growth stage of maize under hydroponic culture

Six maize genotypes from germination experiment (exp. 1a) have been done in hydroponic culture following CRD design with three replications using two treatments of PEG 6000 i.e. 0% (Control) and 10% at Plant physiology laboratory of the Dept. of Crop Botany, BAU. Seven days old seedlings were transplanted in Gazi tank containing 32L water (Fig. 10.6). Nutrients were added according to Hoagland's solution composition along with treatment. According to their growth 21 days old seedlings have been finalized for data collection.



Fig.10.6: Photographs showing the performance of maize at different levels of PEG induced drought stress (0 and 10 % PEG) under hydroponic conditions

Expt. 2b: Effect of drought stress on early growth stage of groundnut under hydroponic culture

Sixteen groundnut genotypes from germination experiment (exp. 1c) has been done in hydroponic culture following CRD design with three replications using two treatments of PEG 6000 i.e. 0% (Control) and 10% at Plant physiology laboratory of the Dept. of Crop Botany, BAU. Seven days old seedlings were transplanted in Gazi tank containing 32L water (Fig. 10.7). Nutrients were added according to Hoagland's solution composition along with treatment. According to their growth 28 days old seedlings have been finalized for data collection.



Fig.10.7: Photographs showing the performance of groundnut at different levels of PEG induced drought stress (0 and 10 % PEG) under hydroponic conditions

Expt. 2c: Effect of drought stress on early growth stage of tomato under hydroponic culture

Six tomato genotypes from germination (exp. 1d) have been done in hydroponic culture following CRD design with three replications using two treatments of PEG 6000 i.e. 0% (Control) and 10% at Plant physiology laboratory of the Dept. of Crop Botany, BAU. Seven days old seedlings were transplanted in Gazi tank containing 32L water. Nutrients were added according to Hoagland's solution composition along with treatment. According to their growth 28 days old seedlings have been finalized for data collection.

Expt. 2d: Effect of drought stress on early growth stage of foxtail millet under hydroponic culture

Six foxtail millet genotypes from germination (exp. 1e) has been done in hydroponic culture following CRD design with three replications using two treatments of PEG 6000 i.e. 0% (Control) and 10% at Plant physiology laboratory of the Dept. of Crop Botany, BAU. Seven days old seedlings were transplanted in pot containing 4L water (Fig. 10.8). Nutrients were added according to Hoagland's solution composition along with treatment. According to their growth 28 days old seedlings have been finalized for data collection.

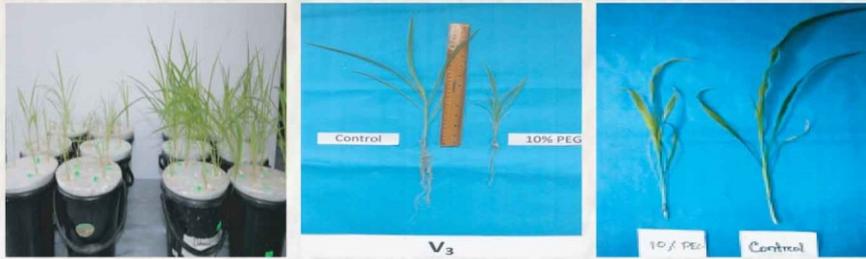


Fig.10.8: Photographs showing the performance of foxtail millet at different levels of PEG induced drought stress (0 and 10 % PEG) under hydroponic conditions

Experiment 3: Agronomic and physio-chemical responses of selected high-value crops genotypes at vegetative and reproductive stages under drought stress condition in pot

Expt. 3a: Effect of drought stress on vegetative and reproductive stages of maize under pot culture

From the experiment of hydroponic culture five (5) maize genotypes were selected for pot culture. These genotypes were undergone pot trial following CRD design with three replications using four treatments of drought i.e., 100% Field Capacity (FC), 75% FC, 50% FC and 0% FC at OFRD, BARI, Rangpur (Fig. 10.9).

Expt. 3b: Effect of drought stress on vegetative and reproductive stages of chilli under pot culture

Five (5) chilli genotypes were selected for pot culture. These genotypes were undergone pot trial following CRD design with three replications using four treatments of drought i.e., 100% Field Capacity (FC), 75% FC, 50% FC and 0% FC at OFRD, BARI, Rangpur (Fig. 10.10).



Fig.10.9: Photographs showing the performance of pot experiment of maize at different levels of drought stress (0, 50, 75 and 100% field capacity).



Fig. 10.10: Photographs showing the performance of pot experiment of maize at different levels of drought stress (0, 50, 75 and 100% field capacity).

Expt. 3c: Effect of drought stress on vegetative and reproductive stages of groundnut under pot culture

From the experiment of hydroponic culture five (5) groundnut genotypes were selected for pot culture. These genotypes were undergone pot trial following CRD design with three replications using four treatments of drought i.e. 100% Field Capacity (FC), 75% FC, 50% FC and 0% FC at OFRD, BARI, Rangpur (Fig. 10.11).



Fig.10.11: Photographs showing the performance of pot experiment of groundnut at different levels of drought stress (0, 50, 75 and 100% field capacity).

Expt. 3d: Effect of drought stress on vegetative and reproductive stages of tomato under pot culture
From the experiment of hydroponic culture five (5) tomato genotypes were selected for pot culture. These genotypes were undergone pot trial following CRD design with three replications using three treatments of drought i.e. Control, moderate and severe drought at BAU, Mymensingh (Fig. 10.12).



Fig.10.12: Photographs showing the performance of pot experiment of tomato at different levels of drought stress (control, moderate, severe drought).

Expt. 4: Agronomic and physio-chemical responses of primarily selected different high-value crops at charlands

Expt. 4a: Agronomic and physio-chemical responses of primarily selected maize genotypes at charlands

From the previous experiment of pot culture, three (3) genotypes of maize were selected for field trail in natural charland conditions where the crop faced natural drought stress (Fig. 13). Different morpho-physiological aspects were addressed for selection of potential maize genotype for charland ecosystem.

Expt. 4b: Agronomic and physio-chemical responses of primarily selected chilli genotypes at charlands

From the previous experiment of pot culture, three (3) genotypes of chilli were selected for field trail in natural charland conditions where the crop faced natural drought stress (Fig. 14). Different morpho-physiological aspects were addressed for selection of potential chilli genotype for charland ecosystem



Fig.10.13: Photographs showing the performance of pot experiment of tomato at different levels of drought stress (control, moderate, severe drought).



Fig.10.14: Photographs showing the field performance of chilli at charland of Lalmonirhat

Expt. 4c: Agronomic and physio-chemical responses of primarily selected groundnut genotypes at charlands

From the previous experiment of pot culture, three (3) genotypes (Dhaka-1, BARI Chinabadam-8, Binachinabadam-4) of groundnut were selected for field trail in natural charland conditions where the crop faced natural drought stress (Fig. 10.15). Different morpho-physiological aspects were addressed for selection of potential groundnut genotype for charland ecosystem.



Fig.10.15: Photographs showing the field performance of groundnut at charland of Lalmonirhat

11. Results and discussion

Component-1: OFRD, BARI

11.i. Activity 1 (OFRD, BARI): Baseline survey

Baseline survey was conducted on 29 July to 12 August 2018. There is a variation among the farmers age, but a little variation observed in the average age of households of the char areas in the three Upazilas. In case of farming, age and literacy have important impact on decision making processes. The younger farmers are more technically efficient than the older farmers and a younger farmer can easily adopt new technology and thereby increase his efficiency (Coelli and Battese (1995). The average ages of char farm household of Jagatber under Lalmonirhat Sadar, Begumganj under Ulipur, Kurigram and Chandanpat under Saghata, Gaibandha are 42, 46, and 47 years, respectively.

Level of education of the sample farmers have been divided into four groups, illiterate, primary level, secondary level and above secondary level. In the three char areas, among above four levels, highest percentage of the farmers was in illiterate level whereas lowest in above secondary level (Table 11.i.1) due to lack of education facility.

Table 11.i.1. Average age and educational level of sample farmers in the three char area of three northern districts

Upazila	Farmer's age (year)	Educational level (%)				
		Illiterate	Primary Level	Secondary Level	Above Secondary Level	Total literate
Char Jagatber, Lalmonirhat	42	45	32	18	5	55
Char Begumganj, Kurigram	46	54	36	7	3	46
Char Chandanpat, Gaibandha	47	42	41	13	4	58
Average	45	47	36	13	4	53

A. Family Composition and effective family labour

Out of sample farmers of 3 char areas, family size was slightly higher in Saghata, Gaibandha compared to other two char areas (Table 11.i.2). Contrary, effective family member was higher in Lalmonirhat Sadar, Lalmonirhat followed by Ulipur, Kurigram and Saghata, Gaibandha, respectively.

Table 11.i.2. Average family size and effective family labour of char farmers in the three char area of three northern districts

Upazila	Family size (no.)			Effective family labour (%)		
	Male	Female	Total	Male	Female	Total
Char Jagatber	3	3	6	26	21	48
Char Begumganj	4	2	6	23	17	40
Char Chandanpat	4	3	7	20	19	39
Average	4	3	6	24	18	43

B. Land ownership pattern of different farm categories

In the three char areas, three types of land holding systems were observed. These were (i) rented in and rented out land holding system, (ii) leased in and leased out land holding system, and (iii) mortgage in and mortgage out land holding system. In the 1st system, land holder provides one third of their produces to the owner of the land. In the 2nd system, land holder cultivates a land providing a certain amount of money (non-returnable) to the owner of the land. In the 3rd system, land holder cultivates a land providing a certain amount of money (returnable) to the owner of the land. The formula for computing farm size is own cultivated land + rented in land + leased in land + mortgage in land - rented out land - leased out land - mortgage in land + homestead land + orchard + pond + fallow land. Average own cultivated land of char farm at Jagatber of Lalmonirhat sadar, Begumganj of Ulipur and Chandamhat of Saghata were 0.51 ha, 0.62 ha and 0.43 ha, respectively whereas total cultivated land of the char farm were 0.94 ha, 1.18 ha and 0.86 ha, respectively (Table 11.i.3).

Table 11.i.3. Land ownership pattern of char farmers in the three char area of three northern districts

Upazila	Own cultivated land (ha)	Rented/Lease /Mortgage in land (ha)	Rented/Lease /Mortgage out land (ha)	Homestead Area (ha)	Fallow land (ha)	Farm size (ha)
Char Jagatber	0.51	0.51	0.08	0.07	0.10	0.94
Char Begumganj	0.62	0.68	0.12	0.082	0.13	1.18
Char Chandanpat	0.43	0.49	0.06	0.07	0.15	0.86
Average	0.52	0.56	0.09	0.07	0.13	0.99

Farm size = Own land+all in land-all out land

C. Irrigation status of the sample farmers

Irrigation status of the sample farmers in the char areas of the three different upazila of the three districts have been shown in the Table 4. The land under T. Aman, grass pea, blackgram and jute are non-irrigated. Again, the land of boro rice, groundnut, chilli, sugarcane, potato, sweet potato, and onion are irrigated land. In most of the char areas the percentages of - irrigated land are higher compared to non-irrigated land (Table 11.i.4).

Table 11.i.4. Irrigation status of the sample farmers in the three char area of three northern districts

Upazila	Area coverage (%)		
	Irrigated	Non-irrigated	Total
Char Jagatber	64	36	100
Char Begumganj	68	32	100
Char Chandanpat	72	28	100
All	68	32	100

D. Cropped area of major crops of the sample farmers

Percentage of cropped area under major crops of the sample farmers have been shown in the table 11.i.5. Among the cropped areas, the cropped area of T. Aman was the highest in Jagatber and Chandanpat unions whereas it was 2nd position in Begumganj. Again, lot of minor crops (Sweet gourd, Wheat, Maize, Millet, China, Onion, Garlic, Bitter gourd, Pointed gourd, Ridge gourd, Radish, Eggplant, etc) have been producing in the three char areas and individually their cropped area not more than 3%.

Table 11.i.5. Major crops grown under char farmers in the three char area of three northern districts

Upazila	Cropped land(%)											
	T. Aman Rice	Boro Rice	Ground nut	Chilli	Jute	Grass pea	Potato	Suger cane	Sweet Potato	Mash	Other*	Total (%)
Char Jagatber	24	6	12	6	21	-	8	-	-	-	23	100
Char Begumganj	19	8	11	-	24	8	-	-	-	8	22	100
Char Chandanpat	25	8	-	0	18	-	-	15	12	-	22	100

*Sweet gourd, Wheat, Maize, Millet, China, Onion, Garlic, bitter gourd, Pointed gourd, Ridge gourd, Radish, Eggplant, etc.

E. Major cropping patterns of three char areas

Cropping patterns differs on lands (types of land), farms (marginal, small, medium and large) and AEZ due to climate, soil and farmers' attention of crop production. Four to five types of major cropping patterns exist in the char areas. Among the major cropping patterns, Groundnut- Fallow-T. Aman/Fallow was in Char Jagatber, Grass pea-Jute-T. Aman/Fallow was in Char Begumganj and Sugarcane-Sugarcane-Sugarcane was in Char Chandanpat were dominant (Table 11.i.6).

Table 11.i.6. Major cropping patterns practiced by the char farmers in the three char area of three northern districts

Upazila	Cropping patterns	Percent of farmers
Char Jagatber, Lalmonirhatsadar, Lalmonirhat	Potato - Jute - T. Aman/Fallow	12
	Groundnut- Fallow -T. Aman/Fallow	20
	Boro rice -Fallow - T. Aman/Fallow	15
	Chilli- Jute- T. Aman/Fallow	18
	Groundnut - Jute -T. Aman/Fallow	8
	Other*	27
Char Begumganj, Ulipur, Kurigram	Grass pea - Jute- T. Aman/Fallow	24
	Blackgram - Boro rice -T. Aman/Fallow	23
	Ground nut - Jute -T. Aman/Fallow	15
	Grass pea - Sesbania -T. Aman/Fallow	10
	Other*	28
Char Chandanpat, Saghata, Gaibandha	Boro rice - Fallow- T. Aman/Fallow	18
	Sugarcane - Sugarcane - Sugarcane	24
	Sweet potato -Jute- T. Aman/Fallow	16
	Sweet potato - Fallow -T. Aman/Fallow	10
	Other*	32

Other* → Sweet gourd, Wheat, Maize, Millet, China, Onion, Garlic, Bitter gourd, Pointed gourd, Ridge gourd, Radish, Eggplant, etc

F. Sowing and harvesting the major crops

Sowing/planting and harvesting time differs in the char lands compared to plain lands. Sowing/planting and harvesting time of the 3 char areas are shown in the Table 11.i.7. Most of the char land occupy with jute in Kharif-I season, so T. Aman planting is comparatively late (1st to 3rd week August). Actually T. Aman is a chance crop in char areas due flood. When flood comes late (August/September), then there is no chance to grow T. Aman. Instead of T. Aman, then the farmers go the Rabi crops.

Table 11.i.7. Sowing and harvesting time of major crops of char farmers in the three char area of three northern districts

Crops	Sowing/planting period	Harvesting period
T. Aman rice	3 rd week of July to 2 nd week of September	4 th week of Nov. to 3 rd week of December
Boro rice	1 st to 3 rd week of February	3 rd week of May to 3 rd week of June
Jute	2 nd week of April to 1 st week of May	August
Groundnut	2 nd to 4 th week of November	3 rd to 4 th week of April
Blackgram	Last week of Oct. to 1 st week of November	1 st to 2 nd week of February
Grass pea	1 st to 3 rd week of November	1 st to 2 nd week of April
Sugarcane	2 nd to 3 rd week of November	2 nd to 3 rd week of December
Potato	November	2 nd week of February to 1 st week of March
Sweet Potato	November	March-April
Chilli	November	February - May

G. Agronomic management practices of different field crops

The agronomic management includes variety selection, seed rate, seeding age, water management, application of pesticide and irrigation. Cultivated crops of char farmers of three Northern char areas were T. Aman, boro, jute, potato, ground nut, chilli, grasspea, grass pea, blackgram, sweet potato and sugarcane. Agronomic managements of the cultivated crops have been shown in the Table 11.i.8.

Table 11.i.8. Agronomic management practices of char farmers in the three char area of three northern districts

Factors	T. Aman	Boro	Jute	Ground nut	Chilli
Variety	Gutisarna, Gangia BRRI dhan 28, 51	BRRI dhan 28, Hybrid	Indian Tosha	Local/BARI Chinabadam-8	Local
Seed rate (kg ha ⁻¹)	45	50	1	55	0.50
Seeding age	30-35 day	45-50	-	-	-
Weeding (no.)	30-35 1-2 2-3	1-2	2-3	2-3	4-5
Irrigation (no.)	-	30-35	1-2	3-4	5-10
Pesticide application (no.)	1-2	1-2	-	1-2	-5-8

Cont.

Factors	Grass Pea	Potato	Sugar Cane	Sweet Potato	Mash
Variety	Local, BARI Khesari-1	Local, BARI Alu-25	Local	Local	Local, BARI Mash-1
Seed rate (kg ha ⁻¹)	45	2000			40
Weeding (no.)	-	1	1	1	-
Irrigation (no.)	-	2-4	2-3	1-2	-

H. Per hectare input used by the sample farmers

Labour, Seed, Urea, TSP, MP, DAP, Cowdung, Pesticide, Irrigation are the main inputs for crop production. In the char areas of three upazila of northern districts, T. Aman rice, boro rice, jute, potato, ground nut, chilli, grass pea, blackgram, sweet potato and sugarcane are the main cultivated crops. In the three areas, the highest input cost was for sugarcane cultivation followed by potato, sweet potato, chilli, boro rice, ground nut, jute, blackgram and grass pea (Table 11.i.9a, 11.i.9b, 11.i.9c).

Table 11.i.9a. Average per hectare input use of char farmers in the char areas of Lalmonirhat

Name of crops	Input use (no. or kg ha ⁻¹)								Cost (Tk ha ⁻¹)			
	Labor (Male+Female)	Seed	Urea	TSP	MP	DAP	Gypsum	Cow dung	Pesticide	Irrigation	Tillage	Total input cost
T. Aman	79	70	115	-	-	-	-	-	-	-	3458	31913
Boro	99	60	196	115	85	-	62	-	780	-14650	10374	66300
Jute	127	8	125	-	-	96	-	-	620	-	6910	51643
Groundnut	92	122	56	35	22	28	-	-	1010	2560	6910	53265
Chilli	150	3	90	66	45	30	44	1232	5565	-4360	6910	76844
Potato	93	2140	105	110	96	-	62	1390	4575	4250	10374	105260

Table 11.i.9b. Average per hectare input use of different crops of char farmers in the char areas of Kurigram

Name of crops	Input use (no. or kg ha ⁻¹)								Cost (Tk ha ⁻¹)			
	Labor (Male+Female)	Seed	Urea	TSP	MP	DAP	Gypsum	Cow dung	Pesticide	Irrigation	Tillage	Total input cost
T. Aman	75	60	95	-	-	-	-	-	-	-	6910	33425
Boro	88	55	120	95	62	-	65	-	860	14969	10374	61052
Jute	121	8.4	120	-	-	70	-	-	750	-	6910	43220
Groundnut	89	120	45	85	65	-	25	-	1025	5424	6910	56355
Grasspea	26	38	-	-	-	-	-	-	-	-	-	12550
Mash	32	35	-	-	-	-	-	-	-	-	3455	15330

Table 11.i.9c. Average per hectare input use of different crops of char farmers in the char areas of Gaibandha

Name of crops	Input use (no. or kg ha ⁻¹)								Cost (Tk ha ⁻¹)			
	Labor (Male+Female)	Seed	Urea	TSP	MP	DAP	Gypsum	Cow dung	Pesticide	Irrigation	Tillage	Total input cost
T. Aman	91	56	82	-	-	-	-	-	1105	-	4446	36485
Boro rice	126	61	123	106	96	-	52	-	1540	7440	8892	59559
Sugarcane	176	40000*	234	167	126	92	45	1698	3580	3464	8892	46894
Sweet Potato	95	90000**	85	45	41	-	35	-	1250	2880	8892	110581
Jute	118	8.12	108	54	-	58	-	-	1020	-	4446	67709

*Number of stick of sugercane and **Number of vine of sweet potato

I. Per hectare cost and return of different crops

Total cost, gross return, gross margin and BCR have been shown in the table 11.i.10a, 11.i.10b and 11.i.10c. In the three char areas of three Northern district, out of the major ten crops (T. Aman rice, boro rice, jute, potato, ground nut, chilli, grass pea, blackgram, sweet potato and sugarcane), gross margin was the highest in chilli cultivation followed by sweet potato, ground nut, jute, blackgram, grass pea, sugarcane, T. Aman and potato. On the other hand, benefit cost ratio (BCR) was the highest in grasspea production followed by sweet potato, chilli, ground nut, blackgram, jute, T. Aman, sugarcane and potato. Gross margin as well as benefit cost ratio showed negative for Boro rice production in char Jagatber and char Begumganj, except char Chandanpat.

Table 11.i.10a. Per hectare cost and return of different crops of char farmers in the char areas of Lalmonirhat (Tk ha⁻¹)

Items	T. Aman	Boro	Jute	Groundnut	Chilli	Potato
Labour	23700	29700	38100	27600	45000	27900
Ploughing	3458	10374	6910	6910	6910	10374
Seed	2800	2400	1200	12200	6000	47080
Manure	0	0	0	0	3696	4170
Fertilizer	1955	8396	4813	2985	5313	6911
Pesticides	0	780	620	1010	5565	4575
Irrigation	0	14650	0	2560	4360	4250
Land cost	7485	14969	7485	14969	14969	14969
Interest on oper. capital	421	974	658	703	1046	1389
Total var. cost	31913	66300	51643	53265	76844	105260
Total cost	39819	82243	59786	68937	92859	121618
Yield (t ha ⁻¹)	2967	4734	2112	1473	5455	17456
By product	7500	3500	7500	0	0	0
Gross return	54972	79244	77420	88380	163650	130920
Gross margin	15153	-2999	17634	19443	70791	9302
BCR	1.38	0.96	1.29	1.28	1.76	1.07

Table 11.i.10b. Per hectare cost and return of different crops of char in the char areas of Kurigram (Tk ha⁻¹)

Items	T. Aman	Boro	Jute	Groundnut	Grass pea	Blackgram
Labour	22500	26400	36300	26700	7800	7500
Ploughing	6910	10374	6910	6910	0	3455
Seed	2400	2200	1260	12000	4750	4375
Manure	0	0	0	0	-	-
Fertilizer	1615	6249	4000	4295	-	-
Pesticides	0	860	750	1025	-	-
Irrigation	0	14969	0	5425	-	-
Land cost	3750	7500	3750	3750	3750	3750
Interest on oper. capital	441	805	649	743	132	230
Total var. cost	33425	61052	49220	56355	12550	15330
Total cost	37616	69357	53619	60848	16432	19310
Yield (t ha ⁻¹)	2192	4356	2068	1568	1025	1188
By product	5475	2737	7500	0	0	0
Gross return	40547	68077	79880	94080	41000	47520
Gross margin	2931	-1280	26261	33232	24568	28210
BCR	1.09	0.98	1.49	1.54	2.49	1.46

Table 11.i.10c. Per hectare cost and return of different crops of char farmers in the char areas of Gaibandha (Tk ha⁻¹)

Items	T. Aman	Boro	Jute	Sugar cane	Sweet potato
Labour	27300	28500	35400	52800	28500
Ploughing	4446	8892	4446	8892	8892
Seed	2240	2440	1218	20000	22500
Manure	0	0	0	8490	0
Fertilizer	1394	6997	4810	13355	3687
Pesticides	1105	1540	1020	3580	1250
Irrigation	0	7440	0	3464	2880
Land cost	3750	3750	3750	7500	3750
Interest on oper. capital	529	787	619	2919	939
Total var. cost	36485	59559	46894	110581	67709
Total cost	40764	60346	51263	121000	72398
Yield (t ha ⁻¹)	2676	4196	2105	41324	13414
By product	5510	2350	7500	0	0
Gross return	48326	65290	81175	134303	134140
Gross margin	7562	4944	29912	13303	61742
BCR	1.19	1.08	1.59	1.11	1.85

J. Markets and trades

All agricultural commodities are traded at village, union and upazila level markets called hats. These typically open twice per week and are officially overseen by government. Faria, Bepari traders mostly operate village and union level hats. In addition to traders of agricultural inputs and equipment, livestock feed, fish and other commodities mostly operate in upazila level.

Upazila level rice, pulse, oilseed, etc traders are linked with larger traders both within the district, as well as in distant trading centers. Most commodities produced in the char zone are traded in the upazila and union hats located in adjacent parts of the river basin zone (there are no upazila centres located on the chars).

K. Major marketing channel

Major marketing channel followed by the sampled farmers of the three char areas of Northern districts have been shown in Table 11.i.11. In case of rice, jute, blackgram, grasspea and sugarcane, most of the farmers used 1st and 2nd channel. Again, in case of potato, sweet potato, chilli and ground nut most of the sample farmers used 3rd channel and 4th channel.

Table 11.i.11. Major marketing channel followed by the sampled farmers of char farmers in the char areas of three districts

Channel	Marketing channel
Channel 1	Farmers- Faria - Bepari -Aratdar/Mill- Retailer -Consumer
Channel 1	Farmers- Bepari -Aratdar/Mill - Wholesaler - Retailer -Consumer
Channel 1	Farmers- Bepari - Wholesaler - Retailer -Consumer
Channel 1	Farmers- Retailer -Consumer

L. Credit

The farmers of Bangladesh have not always solvency to purchase inputs for crop cultivation. So, sometimes they receive credit from local somity, NGO (Asha, BRAC etc), bank (Krishi Bank, Gramen Bank, etc), money lenders and others (relatives, friends, etc) for household service, small business, livestock and crop cultivation. Percent of sample farmer's received credit from above mentioned different sources shown in the table 11.i.12.

Table 11.i.12. Percent of sample farmer's received credit from different sources at char farmers in the char areas of three districts

Upazila	Percent credit receiver sample farmers
Lalmonirhat Sadar, Lalmonirhat	28
Ulipur, Kurigram	35
Saghata, Gaibandha	27

M. Per farm income of the sample farmers

Average per farm income (Tk.) of the sample farmers in the year 2018 have been shown in the table 11.i.13. The items of income were categorized by crop, livestock, fishing, business, services, labour and others. Income from crop sector was higher compared to income from livestock sector. Contrary, income from service, business and fishing was very low than crop, livestock and labour due to a smaller number of farmer involve on it. Again, income from labour was higher due to most of the farmer sell their labour in the kharif-II season when only T. Aman crop remain in the field.

Table 11.i.13. Per farm income of the sample farmers in the char areas of three districts

Item	Upazila		
	Lalmonirhat sadar, Lalmonirhat	Ulipur, Kurigram	Saghata, Gaibandha
Crop	66410	58908	64303
Livestock	15652	13129	12386
Fishing	532	1509	1388
Business	1680	1182	1045
Services	1273	1042	1012
Labour	22136	32340	26822
Other	1426	1682	1283
Total	109109	109792	108239

N. Per farm expenditure of the sample farmers

Payment of cash for goods or services against available funds in settlement of an obligation as evidenced by receipt, voucher or other such document is called expenditure. Mainly food, cloth, housing, education, medicine, purchase of agriculture inputs, social expenditure, payment of loan, etc are the expenditure of farm household. Average per farm expenditure of the sample farmers have been shown in the table 11.i.14. Expenditure for food was higher compared to other expenditures in the char areas.

Table 11.i.14. Per farm expenditure of sample farmers in char areas of three districts

Item	Upazila		
	Lalmonirhat Sadar, Lalmonirhat	Ulipur, Kurigram	Saghata, Gaibandha
Food	84672	81144	80448
Cloth	5050	4156	5498
Housing	5882	6471	5588
Education	1413	1655	1293
Medicine	503	366	476
Purchase Agricultural Inputs	5620	6182	5339
Social Expenditure	677	594	418
Deposit	2085	3893	2681
Payment of Loan	1435	1579	1364
Other	1370	1208	1230
Total	108707	107248	104335

O. Constraints (Weakness)

A warming climate will contribute to slowing the reduction in poverty. While the lives of everyone in the char area will be altered by climate change, the impacts of progressive global warming will fall hardest on the resource poor farmer. Low crop yields and associated income loss from agriculture will continue the trend toward migration from char to rural/urban. Crop of char has become regularly vulnerable to the hazards of climate change-flood, flash flood,

rain and heat stress, and Biological factors -weed, disease & insect and irrigation. In addition, financial crunch, quality degradation of soil, inputs unavailability, farm machinery unavailability and non available of manpower have largely contributed to significant decline in crop productivity. Small and marginal farmers that constitute majority of farm population are constrained by poor financial resources and cannot, therefore, afford high management costs of high input technology. Flash flood or stagnation of water for a long duration is a severe problem in the three char areas of three Northern districts. Severity and its frequency of climatic, biological and other matters have been shown in table 11.i.15.

Table 11.i.15. Major climatic and biological vulnerability in the three char areas

Constraints	Sub-items	Severity/ Frequency	Char of Lalmonirhat Sadar	Char of Ulipur Upazila	Char of Saghata Upazila
Climatic	Flood	Severity	++	++	++
		Frequency	**	**	**
	Flash Flood	Severity	+++	+++	+++
		Frequency	**	**	**
	Rain	Severity	++	++	++
		Frequency	**	**	**
	Heat Stress	Severity	++	++	+++
		Frequency	**	**	**
Biological	Weed	Severity	++	++	++
		Frequency	**	**	**
	Disease and insect	Severity	+	+	+
		Frequency	*	*	*
	Irrigation	Severity	+++	+++	+++
		Frequency	**	**	**

Severity= +: Mild, ++: Moderate, +++: Severe; Frequency= *: Infrequent, **: Sometimes, ***: Every Year

Table 11.i.16. Vulnerability in other matters in the three char areas

Constraints	Severity/ Frequency	Char of Lalmonirhat Sadar	Char of Ulipur Upazila	Char of Saghata Upazila
Financial crunch	Severity	+++	+++	+++
	Frequency	***	***	***
Quality degradation of soil	Severity	++	++	++
	Frequency	**	*	*
Inputs non- availability	Frequency	**	**	**
	Frequency	*	*	*
Farm machinery non-availability	Severity	++	++	++
	Frequency	**	**	**
Non -availability of manpower	Severity	+++	+++	+++
	Frequency	**	**	**

P. Problem faced by the farmers

There are many problems for crop production in the char area. Out of the problems, 11 problems have been described in the tables 11.i.17. Farmers were asked about the problems and they answered more than 7 problems. These problems summarized and showed in the table 11.i.17. Lack of knowledge about new crop variety/technology was the main problem of the farmer in the char areas of the three Upazilas.

In the char farmers of Lalmonirhat Sadar, the 2nd important problem was low price of output followed by low yield of crops, lack of cash money for buying inputs, less number of buyers in the market, high price of labour, lack of credit facility, lack of irrigation facility, lack of quality seeds and infestation of insect/pests. In the char farmers of Ulipur, Kurigram, the 2nd important problem was low yield of harvested crops followed by low price of output, lack of cash money for buying inputs, less number of buyers in the market, high price of labour, lack of credit facility, lack of storage facility, Lack of irrigation facility and infestation of insect/pests. In the char farmers of Saghata, Gaibandha, the 2nd important problem was low prices of output followed by high price of labour, low yield of crops, lack of cash money for buying inputs, lack of credit facility, lack of quality seeds, lack of irrigation facility, infestation of insect/pests and lack of storage facility.

Table 11.i.17. Problems faced by the farmers of char farmers in the three char areas

Problems	Farmers responded (%) under different Upazila		
	Lalmonirhat Sadar, Lalmonirhat	Ulipur, Kurigram	Saghata, Gaibandha
Lack of knowledge about new crop variety/technology	93	95	92
Low yield of crops	84	85	76
Low prices of output	92	84	80
Less Number of buyers in the market	76	78	72
Lack of cash money for buying inputs	82	84	74
Lack of irrigation facility	60	48	56
Lack of quality seeds	56	52	56
High Price of labour	76	72	80
Infestation of insect/pests	44	38	54
Lack of credit facility	65	68	66
Lack of storage facility	56	52	46

Q. Probable solutions of the cited problems

Farmers were asked about the solutions of the cited problems. In the char farmers of Lalmonirhat Sadar told mamey solutions of their problems. Their 1st solution were training and field day on new crop variety and its production technology followed by provide easy credit facility, increase irrigation facility through Govt. initiation (Subsidy for DTO and STO), development of communication from char areas mkt to big wholesale market, introduce harvester and seeder, timely farm input supply, need vehicles development for easy transportation of product, infrastructure development in char areas market and increase IPM technology for pest control. In the char farmers of Ulipur, Kurigram, the major solutions were training and field day on new crop variety and its production technology, provide easy credit facility, increase irrigation facility through Govt. initiation (Subsidy for DTO and STO), development of communication from char areas mkt to big wholesale market, introduce harvester and seeder, infrastructure development in char areas market, need vehicles development for easy transportation of product and increase IPM technology for pest control.

In the char farmers of Saghata, Gaibandha, the solutions of the 1st problem was Training and field day on new crop variety and its production technology followed by provide easy credit facility, timely farm input supply, increase irrigation facility through Govt. initiation (Subsidy for DTO and STO), development of communication from char areas mkt to big wholesale market, introduce harvester and seeder, infrastructure development in char areas market, need vehicles development for easy transportation of product, improve storage facility for seed preservation and increase IPM technology for pest control.

Table 11.i.18. Probable solutions of the cited problems given by the farmers in the three char areas

Solutions	Farmers responded (%) under different Upazila		
	Lalmonirhat Sadar, Lalmonirhat	Ulipur, Kurigram	Saghata, Gaibandha
Training and field day on new crop variety and its production technology	84	88	76
Provide easy credit facility	82	86	88
Timely farm input supply	64	60	72
Development of Communication from char areas mkt to big wholesale mkt	56	68	54
Infrastructure development in char areas mkt	46	50	52
Need vehicles development for easy transportation of product	56	52	46
Improve storage facility for seed preservation	36	44	40
Introduce harvester and seeder	58	62	54
Increase irrigation facility through Govt. initiation (Subsidy for DTO and STO)	70	76	78
Increase IPM technology for pest control	36	40	28

Recommendations

1. Yield of major crops are low in the char areas. It is necessary to extend newly released varieties and technologies through BARI, BINA, BRRI, BJRI, DAE, BADC, NGOs, etc.
2. Training on crop production is very important for technology transfer. So, more training (farmers and sub assistant agriculture officers) should provide (especially insect and pest) on crop production in the district.
3. Timely seed, fertilizer, etc. supply is very much needed to the farmers. BADC and seed companies can play a big role in this respect
4. Most of the farmers are small and marginal, and always suffering for cash money. So, more credit facility should be provided to the farmers through easy conditions.
5. Irrigation facility in the char areas is insufficient. So Govt. can take an initiative to supply irrigation water through BADC and NGO in subsidized price
6. Char market information, infrastructure and transportation is not sufficient. So, Govt. should take initiative to make necessary road, infrastructure and transportation, and create market information facility through LGED, DAM and DAE.
7. In the marketing channel of char Bangladesh, many intermediaries involed in the input and output marketing channel. So, Govt should take initiatives to develop local service provider by establishing collection point in each char areas for getting higher product and lower input price of the char farmers.

8. Lack of storage facility of crop or seed is a big problem of char farmers. In the rainy season, frequently flood damage their housing infrastructure. Therefore, Govt. should create seed storage facility in the safe place near to char areas.
9. IPM, ICM and IFM technology should be extending in the char areas through DAE, BARI, BRRI, etc.



Char Begumganj, Kurigram

Char Jagatber, Lalmonirhat

Char Nalsia, Gaibandha

Fig. 11.i.1: Baseline survey of farmers at different char locations by project personnel



Char Begumganj, Kurigram

Char Nalsia, Gaibandha

Fig. 11.i.2: Farmers group meeting at different char locations

11.ii. Activity 2 (OFRD, BARI): Feasibility of high-value crops production in northern charland of Bangladesh

Seed/Seedling/vine distribution

Ten improved crop varieties were selected, and their seed/seedling/vine were distributed for their suitability study in the selected char lands in the northern districts.



Char Begumganj, Kurigram

Char Jagatber, Lalmonirhat

Char Begumganj, Kurigram

Fig. 11.ii.1: Seed/vine of different crops distribution among the farmers at different char areas

Crop-wise findings are given below -

A. Potato

A total of 9 trials of potato where 3 in Saghata, Gaibandha; 3 in Begumganj, Kurigram and 3 in Jagatber, Lalmonirhat were conducted at different charlands. Treatments were, T1=BARI Alu-77 (Late Blight resistant potato variety) and BARI Alu-25 (Control) Unit plot size was 10 decimals for each treatment. RCBD (Dispersed) replication were followed in conducting the experiment.

Total 2000 kg seed potato of both the varieties were equally distributed among the 9 trial farmers at charland areas of Gaibandha, Rangpur and Lalmonirhat. Plantings started on 18 November 2018 and completed on 26 November 2018. Standard fertilizer packages were applied in the trial plots (FRG 2018) and intercultural management practices were followed as when necessary. A safety pesticide free production package was followed in cultivating BARI Alu-77 in charland. During the crop growth period, protective measures were taken to control Late Blight for BARI Alu-25. But for BARI Alu-77, no chemicals were needed to control the Late Blight of potato. Harvesting of 9 trials started on 15 February 2019 and completed on 4 March 2019.

The potato varieties emerged more than 98% and exhibited with vigorous growth at farmer's field in charland condition. Crops in the vegetative stage had an extra ordinary look than other potato varieties grown in the charland. Farmers were instructed to spray fungicides (5-6 times in 7-10 days intervals depends on severity of Late Blight infection) when Late Blight of potato appears in their field. The infection of Late Blight appeared tuber bulking stage and continued up to tuber maturity stage. The LB infection was ranged from 15- 25 % in BARI Alu-25 and no Late blight symptoms was shown in BARI Alu-77.

Among all the charlands of the 3 districts (Gaibandha, Kurigram and Lalmonirhat), the highest tuber yield was obtained from BARI Alu-77 compared to BARI Alu-25. In the treatment plots (T1), the yield of BARI Alu-77 was ranged from 20.77 to 24.44 t ha⁻¹ and in the control plots (T2), the tuber yield of BARI Alu-25 was ranged from 17.36 to 21.59 t ha⁻¹. The average highest tuber yield (22.36 t ha⁻¹) was obtained from of BARI Alu-77 which was 15.61% higher compared to BARI-Alu-25 (19.34 t ha⁻¹).

The cost and return analysis (Table 11.ii.2) showed that the highest gross margin was obtained from BARI Alu-77; Tk. 94,998 ha⁻¹ in the Charlands of Lalmonirhat followed by Tk. 76,227 ha⁻¹ in the charlands of Gaibandha. The lowest gross margin was accounted from Kurigram sites from BARI Alu-25 (Tk. 66,428 ha⁻¹) due to poor tuber yield. The average highest gross margin was accounted from BARI Alu-77 (Tk. 77,289 ha⁻¹) which was Tk. 47,026 higher than control (BARI Alu-25).

Table 11.ii.1. Sowing date, harvesting date, trial plot yield and adjusted yield of potato under OFRD, Rangpur and Gaibandha in 2018-19

Location	Sowing date	Harvesting date	Trial Plot yield (kg plot ⁻¹)		t-value	Adjusted yield (t ha ⁻¹)		t-value
			T ₁	T ₂		T ₁	T ₂	
Gaibandha	18-19 Nov. 2018	15-18 Feb. 2019	886.00	772.00	5.93 *	21.88	19.07	5.92 *
Kurigram	24-26 Nov. 2018	22 Feb. 2019	841.00	703.00	25.29 **	20.77	17.36	25.15 **
Lalmonirhat	22-25 Nov. 2018	28 Feb.-4 Mar.2019	989.51	873.99	2.65	24.44	21.59	2.64
Mean	-	-	905.50	783.00	-	22.36	19.34	-

Table 11.ii.2. Per hectare cost and return of potato at different charland under OFRD, BARI, Rangpur and Gaibandha in 2018-19

Variety	Location	Gross return		TVC		Gross Margin	
		T ₁ (BARI Alu-77)	T ₂ (Control)	T ₁ (BARI Alu-77)	T ₂ (Control)	T ₁ (BARI Alu-77)	T ₂ (Control)
Potato	Gaibandha	218800	190600	142573	142573	76227	48027
	Kurigram	207612	173592	146970	146970	60642	26622
	Lalmonirhat	244448	215878	149450	149450	94998	66428
Mean	-	223620	193357	146331	146331	77289	47026

Market price (Tk. kg-1): Potato = 10.

Farmer's opinion

- ★ Major amount of the tuber produced in the charland was sold as fresh just after harvest. Farmers in the charland in most of the Upazilla's do not enjoy the facilities of cold storage due to either unavailability or lack of good communication in the nearer place. Establishment of cold storage in the nearer places may encourage them to preserve tuber for next year cultivation.
- ★ Farmers under the program were interested in cultivating of the newly released potato variety (BARI Alu-77) due to zero/minimum Late Blight disease as well as reduction of production cost from fungicide with higher tuber yield potentials.



Char Begumganj, Kurigram



Char Jagatber, Lalmonirhat



Char Nalsia, Gaibandha

Fig. 11.ii.2: Field view of Potato at different char locations

B. Sweet potato

A total of 9 trials on sweet potato of which, 3 in Saghata, Gaibandha; 3 in Begumganj, Kurigram and 3 in Jagatber, Lalmonirhat were conducted. Treatments were, T1=BARI Mistialu-8 (Vitamin-A enriched sweet potato variety) and T2=Local variety (Control). Unit plot size was 10 decimals for each treatment. RCBD (Dispersed) replication were followed in conducting the experiment. Total 50,000 potato vines of both the varieties were equally distributed among the 9 trial farmers of Gaibandha, Rangpur and Lalmonirhat. Plantings started on 25 October 2018 and completed on 5 November 2018. Standard fertilizer packages were followed in the trial plots and intercultural management practices were followed as when necessary. Harvesting of 9 trials started on 7 February 2019 and completed on 3 April 2019. The sweet potato variety, BARI Mistialu-8 exhibited with vigorous growth at farmer's field in charland condition compared to their local sweet potato variety.

Sweet potato variety BARI Mistialu-8 performed better than locally adapted sweetpotato in all three locations. In the treatment plots (T1), the root yield of BARI Mistialu-8 was ranged from 21.38 to 36.35 t ha⁻¹ where the highest root yield was recorded from Saghata, Gaibandha followed by Jagatber, Lalmonirhat site. In the control plots, the root yield of locally adapted sweet potato variety was ranged from 16.33 to 23.26 t ha⁻¹. BARI Mistialu-8 (29.75 t ha⁻¹) produced the average 48.45% higher yield than locally adapted sweet potato (20.04 t ha⁻¹).

The cost and return analysis (Table 11.ii.4) showed that the highest gross margin was obtained from BARI Mistialu-8; Tk. 317953 ha⁻¹ in the Charlands of Gaibandha followed by Tk. 214129 ha⁻¹ in the charlands of Lalmonirhat. The lowest gross margin was accounted from Kurigram sites from locally adapted sweet potato (Tk. 45606 ha⁻¹) due to poor root yield. The average highest gross margin was accounted from BARI SP-8 (Tk. 171,929 ha⁻¹) which was Tk. 72,140 higher than locally adapted sweet potato.

Table 11.ii.3. Sowing date, harvesting date, trial plot yield and adjusted yield of Sweet potato under OFRD, Rangpur and Gaibandha in 2018-19

Location	Sowing date	Harvesting date	Trial Plot yield (kg plot ⁻¹)		t-value	Adjusted yield (t ha ⁻¹)		t-value
			T ₁	T ₂		T ₁	T ₂	
Gaibandha	25-29 oct. 2018	7-13 Feb. 2019	1471.67	941.67	8.83 *	36.35	23.26	8.81 *
Kurigram	31 oct. 2018	6 Mar. 2019	865.60	661.07	11.13 **	21.38	16.33	11.19 **
Lalmonirhat	1-5 Nov. 2018	28 Mr. 3 Apr. 2019	1276.67	831.67	11.28 **	31.53	20.54	11.27 **
Mean	-	-	1204.65	811.47	-	29.75	20.04	-

T1 (BARI Mistialu-8); T2 (Control)

* and ** significant differences on the same location between T1 and T2 at 5% and 1%, respectively, according to the t-test.

Table 11.ii.4. Per hectare cost and return of Sweet potato at different charland under OFRD, BARI, Rangpur and Gaibandha in 2018-19

Variety	Location	Gross return		TVC		Gross Margin	
		T ₁ (BARI Mistialu-8)	T ₂ (Control)	T ₁ (BARI Mistialu-8)	T ₂ (Control)	T ₁ (BARI Mistialu-8)	T ₂ (Control)
Sweet potato	Gaibandha	436202	232592	118249	118249	317953	114343
	Kurigram	213803	163283	117677	117677	96126	45606
	Lalmonirhat	331806	205421	117677	117677	214129	87744
Mean	-	277879	205739	105950	105950	171929	99789

Market price (Tk. kg-1): Sweet potato = 9-10.

Farmer's opinion

- Farmers in the charland of Gaibandha started early harvesting as they got higher market price than other two locations. Specially in the charland of Gaibandha; farmers are more interested in BARI Mistialu-8 cultivation as because of they have got extra income (Taka 2/kg more in BARI Mistialu-8) compared to local sweet potato cultivars.
- Farmers in the charland of Gaibandha are now more interested in BARI Mistialu-8, reason being its higher root yield, nutritive value and its importance to the human health and other uses.
- New income generation activities created by sweet potato vine multiplication in the home stead area of the char lands and farmers can earn Tk. 4500-5000 From 5 decimal of land by selling their vines of BARI Mistialu-8 which ultimately encourages sweet potato cultivation.
- Orange-flesh in the roots attracted the young boys and girls as raw consumption in the Charland area as raw consumption.
- Green leaves of the sweet potato vines are suitable to consume as leafy vegetable.
- Farmers of charland area are now using chopped dried green sweet potato vines as cattle food.



Char Begumganj, Kurigram



Char Jagatber, Lalmonirhat



Char Nalsia, Gaibandha

Fig. 11.ii.3: Field view of sweet potato at different char locations

C. Maize

A total of 9 trials on maize of which, 3 were conducted in the charlands of Saghata, Gaibandha; 3 were in the charlands of Begumganj, Kurigram and 3 were in the charlands of Jagatber, Lalmonirhat. Treatments were, T₁=BHM-9 and T₂=Locally available commercial variety (Control). Unit plot size was 10 decimals for each treatment. RCBD (Dispersed) replication were followed in conducting the experiment. Total 40 kg hybrid maize seeds of both the varieties (BHM-9 and commercial hybrid variety) were equally distributed among the 9 trial farmers in the charland areas of Gaibandha, Rangpur and Lalmonirhat. Seedings started

on 24 October 2018 and completed on 21 December 2018. Standard fertilizer packages were followed in the trial plots and intercultural management practices were followed as when necessary. Harvesting of 9 trials started on 17 March 2019 and completed on 20 May 2019. The BHM-9 variety, exhibited with vigorous growth at farmer's field in charland condition compared to their local commercial maize variety.

Maize variety BHM-9 performed little bit better than commercial hybrid maize variety in all three locations. In the treatment plots (T1), the grain yield of BHM-9 was ranged from 9.19 to 9.39 t ha⁻¹ where the highest grain yield was recorded from Saghata, Gaibandha followed by Jagatber, Lalmonirhat site. In the control plots, the grain yield of locally popular commercial hybrid variety was ranged from 8.66 to 9.73 t ha⁻¹. The average higher maize grain yield was obtained from of BHM-9 (9.28 t ha⁻¹) compared to commercial hybrid maize variety (9.11 t ha⁻¹).

The cost and return analysis (Table 11.ii.6) showed that the highest gross margin was obtained from commercial hybrid maize variety; Tk. 56479 ha⁻¹ followed by BHM-9; Tk. 50,026 ha⁻¹ in the Charlands of Lalmonirha. The lowest gross margin was accounted from Gaibandha sites from locally adapted commercial hybrid maize variety (Tk. 41611 ha⁻¹) due to lower grain yield. The average highest gross margin was accounted from BHM-9 (Tk. 48,908 ha⁻¹) which was Tk. 2291 higher than locally available commercial maize variety.

Table 11.ii.5. Sowing date, harvesting date, trial plot yield and adjusted yield of Maize under OFRD, Rangpur and Gaibandha in 2018-19

Location	Sowing date	Harvesting date	Trial Plot yield (kg)		t-value	Adjusted grain yield (t ha ⁻¹)		t-value
			T ₁	T ₂		T ₁	T ₂	
Gaibandha	24 Oct. 2018	17 Mar. 2019	380.00	362.00	11.78 **	9.39	8.94	11.94 **
Kurigram	21 Dec. 2018	20-May-19	371.90	350.67	1.99	9.19	8.66	1.99
Lalmonirhat	26 Nov-7 Dec. 2018	1-11 Apr. 2019	375.00	394.00	4.75 *	9.26	9.73	4.70 *
Mean	-	-	375.63	368.89	-	9.28	9.11	-

T₁ (BHM-9); T₂ (Control)

* and ** significant differences on the same location between T₁ and T₂ at 5% and 1%, respectively, according to the t-test.

Table 11.ii.6. Per hectare economic performance of Maize at different charland under OFRD, BARI, Rangpur and Gaibandha in 2018-19

Variety	Location	Gross return		TVC		Gross Margin	
		T ₁ (BARI HYM 9)	T ₂ (Commercial Hybrid)	T ₁ (BARI HYM 9)	T ₂ (Commercial Hybrid)	T ₁ (BARI HYM 9)	T ₂ (Commercial Hybrid)
Maize	Gaibandha	129058	122944	81333	81333	47725	41611
	Kurigram	126307	119095	77333	77333	48974	41762
	Lalmonirhat	127359	133812	77333	77333	50026	56479
Mean	-	127575	125284	78666	78666	48908	46617

Market price (Tk. kg⁻¹): Maize grain = 13.75.

Farmer's opinion

- ★ Farmers in the charland of Gaibandha, Kurigram and Lalmonirhat prefer commercial hybrid maize variety because seed is readily available in the local market.
- ★ BHM-9 produced almost similar yield but its seed is not available in the local market.
- ★ BARI should take necessary steps to produce more seed for its dissemination and popularize.



Fig. 11.ii.4: Field view of Maize at different char locations

D. Sweet gourd

A total of 6 trials on sweet gourd of which, 3 were conducted in the charlands of Saghata, Gaibandha and 3 were in the charlands of Jagatber, Lalmonirhat. Treatments were, T_1 = BARI Hybrid Mistikumra-1 and T_2 = locally available variety (Control). Unit plot size was 10 decimals for each treatment. RCBD (Dispersed) replication were followed in conducting the experiment. Sweet gourd seeds of both the varieties (BARI Hybrid Mistikumra-1 and locally adapted variety) were equally distributed among the 6 trial farmers in the charland areas of Gaibandha and Lalmonirhat. Plantings started on 24 October 2018 and completed on 22 November 2018. Standard fertilizer packages were followed in the trial plots and intercultural management practices were followed as when necessary. Harvesting of 6 trials started on 13 February 2019 and completed on 20 February 2019.

Sweet gourd variety BARI Hybrid Mistikumra-1 performed little bit better than locally grown/adapted sweet gourd variety in two locations. In the treatment plots (T_1), the fruit yield of BARI Hybrid Mistikumra-1 were ranged from 16.88 to 31.70 t ha⁻¹ where the highest fruit yield was recorded in Jagatber, Lalmonirhat site and the lowest was in Saghata, Gaibandha site. In the control plots (T_2), the fruit yield of locally adapted sweet gourd variety was ranged from 11.36 to 28.41 t ha⁻¹. The average higher fruit yield was obtained from of BARI Hybrid Mistikumra-1 (24.29 t ha⁻¹) which was 23.0% higher than locally adapted sweet gourd variety (19.89 t ha⁻¹).

Table 11.ii.7. Sowing date, harvesting date, trial plot yield and adjusted yield of Sweet gourd under OFRD, Rangpur and Gaibandha in 2018-19

Location	Sowing date	Harvesting date	Trial Plot yield (kg)		t-value	Adjusted grain yield (t ha ⁻¹)		t-value
			T ₁	T ₂		T ₁	T ₂	
Gaibandha	24 Oct. 2018	13 Feb. 2019	683	460	7.02 *	16.88	11.36	7.02 *
Lalmonirhat	18-22 Nov. 2018	15-20 Feb. 2019	1283	1150	4.00	31.70	28.41	4.00
Mean	-	-	983	805	-	24.29	19.89	-

T₁ (BARI Hybrid Mistikumra-1); T₂ (Control)

* and ** significant differences on the same location between T₁ and T₂ at 5% and 1%, respectively, according to the t-test.

The cost and return analysis (Table 11.ii.8) showed that the highest gross margin was obtained from BARI Hybrid Mistikumra-1; Tk. 282833 ha⁻¹ followed by locally adapted mistikumra; Tk. 249,900 ha⁻¹ in the Charlands of Lalmonirhat. The lowest gross margin was accounted from Gaibandha sites from locally adapted sweet gourd variety (Tk. 63535 ha⁻¹) due to lower fruit yield. The average highest gross margin was accounted from BARI Hybrid Mistikumra-1 (Tk. 200,784 ha⁻¹) which was Tk. 44,066 higher than locally adapted sweet gourd cultivar.

Table 11.ii.8. Per hectare cost and return of Sweet gourd at different charland under OFRD, BARI, Rangpur and Gaibandha in 2018-19

Variety	Location	Gross return		TVC		Gross Margin	
		T ₁ (BARI Hybrid Mistikumra-1)	T ₂ (Local)	T ₁ (BARI Hybrid Mistikumra-1)	T ₂ (Local)	T ₁ (BARI Hybrid Mistikumra-1)	T ₂ (Local)
Sweet gourd	Gaibandha	168800	113600	50065	50065	118735	63535
	Lalmonirhat	316983	284050	34150	34150	282833	249900
Mean	-	242892	198825	42108	42108	200784	156718

Market price (Tk. kg⁻¹): Sweet gourd = 10.

Farmer's choice

- ★ Farmers in the charland of Gaibandha and Lalmonirhat like, BARI Hybrid Mistikumra-1 because of its higher fruit yield, uniform fruit size and heavy bearing.
- ★ Farmers demand for availability of BARI released Hybrid Mistikumra seeds in the local market.



Char Begumganj, Kurigram



Char Jagatber, Lalmonirhat



Char Nalsia, Gaibandha

Fig. 11.ii.5: Field view of Sweet gourd at different char locations

E. Bitter gourd

Three large plot trials of bitter gourd were conducted in the charland of Begumganj, Kurigram. Locally adapted Ucche Korla was used as treatment. For cultivating Ucche korla in the charland a special method a new approach (Digging pit and re-filling with sand) was followed to cultivate Ucche Korla in the char land condition. This technique includes digging very narrow pit (2-3 feet deep) with a special type of digging tool where soil moisture is readily available. After then collected soils of the open pit were mixed properly through breaking the soil crust and refilled the pit again. 2-3 seeds of Ucche korla were deeply placed in the refilled pit. Unit plot size was 100 decimals for each treatment. RCBD (Dispersed) replication was followed in conducting the experiment.

Seeds of Ucche Korla cultivar was distributed among the 3 trial farmers in the charland areas of Begumganj, Ulipur, Kurigram. Plantings started on 20 September 2018 and completed on 4 October 2018. No standard fertilizer packages were followed in the trial plots and intercultural

management practices were followed as when necessary. Harvesting of 3 trials started on 25 January 2019 and completed on 17 May 2019.

Ucche Korola was grown-up nicely in the sandy soils of the char lands. The fruit yield of Ucche Korola was ranged from 3.5 to 4.5 t ha⁻¹ with an average of 4.0 t ha⁻¹. The cost and return analysis (Table 11.ii.10) showed that the gross margin was for Ucche Korola variety; 200757 Tk. ha⁻¹.

Table 11.ii.9. Sowing date, harvesting date, trial plot yield and adjusted yield of Bitter gourd at Begumganj, Kurigram in 2018-19

Location	Sowing date	Harvesting date	Trial Plot yield (kg)		t-value	Adjusted grain yield (t ha ⁻¹)		t-value
			T ₁	T ₂		T ₁	T ₂	
Kurigram	20 Sep.-4 Oct. 2018	25 Jan-17 May 2019	165	118	4.54 *	4.07	2.91	4.54 *

T₁ (Ucche korola); T₂ (Control)

* and ** significant differences on the same location between T1 and T2 at 5% and 1%, respectively, according to the t-test.

Table 11.ii.10. Per hectare cost and return of Bittergourd at Begumganj, Kurigram in 2018-19

Variety	Location	Gross return		TVC		Gross Margin	
		T ₁ (Ucche korola with improve management)	T ₂ (Local with farmer management)	T ₁ (Ucche korola with improve management)	T ₂ (Local with farmer management)	T ₁ (Ucche korola with improve management)	T ₂ (Local with farmer management)
Bitter gourd	Kurigram	293181	208891	92424	85200	200757	123691

Market price (Tk. kg⁻¹): Sweet gourd = 72.

Farmer's opinion

- Farmers liked the technique of Ucche Korla cultivation in the charland of Kurigram.
- As the crop are being cultivated in the interior char land of Kurigram, they did not get the expected market price due to lack of communication system and market facilities.
- During carrying the fruits in the long-distance market some fruits appeared bruising injury which deteriorate the market price also.
- They demanded to improve their carrying system.



Fig. 11.ii.6: Field view of Bitter gourd at Char Begumganj, Kurigram char locations

F. Lentil

A total of 9 trials of lentil where, 3 were conducted in the charlands of Saghata, Gaibandha and 3 were in the charlands of Jagatber, Lalmonirhat and 3 were in Begumganj, Kurigram. Treatments were, T_1 = BARI Moshur-8 and T_2 = locally adapted lentil variety (Control). Unit plot size was 10 decimals for each treatment. RCBD (Dispersed) replication were followed in conducting the experiment.

Sowing of lentil were started on 28 October 2018 and completed on 5 November 2018. Standard fertilizer packages were followed in the trial plots and intercultural management practices were followed as when necessary. Harvesting of 9 trials started on 13 February 2019 and completed on 6 March 2019. The BARI Moshur-8 variety exhibited with vigorous growth at farmer's field in charland condition compared to their locally adapted lentil variety.

BARI Moshur-8 performed petite bit better than locally grown/adapted lentil variety in all locations. In the treatment plots (T_1), the seed yield of BARI Moshur-8 were ranged from 1.13 to 1.38 t ha⁻¹ where the highest yield was recorded from Jagatber, Lalmonirhat site followed by Begumganj, Kurigram site. In the control plots (T_2), the yield of locally adapted lentil variety was ranged from 0.68 to 1.32 t ha⁻¹. The average higher lentil yield was obtained from of BARI Moshur-8 (1.28 t ha⁻¹) which produced 31.95% more yield than locally adapted lentil variety (0.97 t ha⁻¹).

Table 11.ii.11. Sowing date, harvesting date, trial plot yield and adjusted yield of lentil at Kurigram, Lalmonirhat and Gaibandha in 2018-19

Location	Sowing date	Harvesting date	Trial Plot yield (kg)		t-value	Adjusted grain yield (t ha ⁻¹)		t-value
			T ₁	T ₂		T ₁	T ₂	
Gaibandha	5 Nov. 2018	28 Feb. 2019	46	27	11.00 **	1.13	0.68	10.54 **
Kurigram	3 Nov. 2018	13 Feb. 2019	54	37	13.94 **	1.34	0.90	13.94 **
Lalmonirhat	28 oct-12 Nov. 2018	2-6 Mar. 2019	56	54	2.43	1.38	1.32	2.43
Mean	-	-	52	39	-	1.28	0.97	-

T₁ (BARI Masur-8); T₂ (Control)

* and ** significant differences on the same location between T₁ and T₂ at 5% and 1%, respectively, according to the t-test.

The cost and return analysis (Table 11.ii.12) showed that the highest gross return and gross margin was obtained from BARI Moshur-8 variety; Tk. 62,107 ha⁻¹ and Tk. 36527 ha⁻¹, respectively in the Charlands of Lalmonirhat. The lowest gross return and margin was accounted from Gaibandha sites from locally adapted lentil variety Tk. 26,010 ha⁻¹ and Tk. 5,760 ha⁻¹, respectively due to lower yield. The average highest gross return and margin was accounted from BARI Moshur-8; Tk. 57758 ha⁻¹ & Tk. 32,425 ha⁻¹, respectively than locally adapted lentil variety.

Table 11.ii.12. Per hectare cost and return of Lentil at different charland of Kurigram, Lalmonirhat and Gaibandha in 2018-19

Variety	Location	Gross return		TVC		Gross Margin	
		T ₁ (BARI Moshur-8)	T ₂ (Local)	T ₁ (BARI Moshur-8)	T ₂ (Local)	T ₁ (BARI Moshur-8)	T ₂ (Local)
Lentil	Gaibandha	50850	30600	24840	24840	26010	5760
	Kurigram	60317	40607	25580	25580	34737	15027
	Lalmonirhat	62107	59558	25580	25580	36527	33978
Mean	-	57758	43588	25333	25333	32425	18255

Market price (Tk. kg⁻¹): Lentil = 45.

Farmer's opinion

The lentil growing farmers in the char areas likes the lentil variety BARI Moshur-8 due to its higher yield potential.



Char Begumganj, Kurigram



Char Jagatber, Lalmonirhat



Char Nalsia, Gaibandha

Fig. 11.ii.7: Field view of Lentil at different char locations

G. Onion

A total of 9 trials of onion where, 3 were conducted in the charlands of Saghata, Gaibandha and 3 were in the charlands of Jagatber, Lalmonirhat and 3 were in Begumganj, Kurigram. Treatments were, T₁ = BARI Piaj-1 and T₂ = locally adapted variety (Control). Unit plot size was 10 decimals for each treatment. RCBD (Dispersed) replication were followed in conducting the experiment.

Sowing of onion were started on 10 December 2018 and completed on 8 January 2019. Standard fertilizer packages were followed in the trial plots and intercultural management practices were followed as when necessary. Harvesting of 9 trials started on 8 April 2019 and completed on 25 April 2019.

Onion variety BARI Piaj-1 performed better than locally grown/adapted onion variety in all locations. In the treatment plots (T₁), the bulb yield of BARI Piaj-1 were ranged from 3.60 to 8.56 t ha⁻¹ where the highest yield was recorded from Gaibandha site followed by Kurigram site. In the control plots (T₂), the bulb yield of locally adapted onion variety was ranged from 3.38 to 7.40 t ha⁻¹. BARI Piaj-1 (6.87 t ha⁻¹) produced the average 15.07% higher bulb yield than locally adapted onion variety (5.97 t ha⁻¹).

Table 11.ii.13. Sowing date, harvesting date, trial plot yield and adjusted yield of Onion at Kurigram, Lalmonirhat and Gaibandha in 2018-19

Location	Sowing date	Harvesting date	Trial Plot yield (kg)		t-value	Adjusted grain yield (t ha ⁻¹)		t-value
			T ₁	T ₂		T ₁	T ₂	
Gaibandha	8 Jan. 2018	25 Apr. 2019	347	288	4.01	8.56	7.12	4.01
Kurigram	23 Dec. 2018	8 Apr. 2019	342	300	4.73 *	8.46	7.40	4.73 *
Lalmonirhat	10-17 Dec. 2018	8-12 Apr. 2019	146	137	2.98	3.60	3.38	2.98
Mean	-	-	278	242	-	6.87	5.97	-

T₁ (BARI Pijaj-1); T₂ (Control)

* and ** significant differences on the same location between T₁ and T₂ at 5% and 1%, respectively, according to the t-test.

The cost and return analysis (Table 11.ii.14) showed that the highest gross return and gross margin was obtained from onion variety BARI Pijaj-1 variety; Tk. 145,520 ha⁻¹ and Tk. 64,780 ha⁻¹, respectively in the Charlands of Gaibandha. The lowest gross return and margin was accounted from Lalmonirhat sites from locally adapted onion variety Tk. 57,519 ha⁻¹ with negative gross margin Tk. (-22693) ha⁻¹, respectively due to lower yield. The average highest gross return and margin was accounted from BARI Pijaj-1; Tk. 116,832 ha⁻¹ & Tk. 33,989 ha⁻¹, respectively.

Table 11.ii.14. Per hectare cost and return of Onion at different charland of Kurigram, Lalmonirhat and Gaibandha in 2018-19

Variety	Location	Gross return		TVC		Gross Margin	
		T ₁ (BARI Pijaj-1)	T ₂ (Local)	T ₁ (BARI Pijaj-1)	T ₂ (Local)	T ₁ (BARI Pijaj-1)	T ₂ (Local)
Onion	Gaibandha	145520	121040	80740	80740	64780	40300
	Kurigram	143774	125858	83895	83895	59879	41963
	Lalmonirhat	61202	57519	83895	83895	-22693	-26376
Mean	-	116832	101472	82843	82843	33989	18629

Market price (Tk. kg⁻¹): Onion = 17.

Farmer's opinion

- Onion variety BARI Pijaj-1 variety exhibited with vigorous growth at farmer's field in charland condition compared to their locally adapted one.
- They demand for the availability of the onion variety BARI Pijaj-1 seed.



Char Jagatber, Lalmonirhat



Char Nalsia, Gaibandha

Fig. 11.ii.8: Field view of Onion at different char locations

H. Blackgram

A total of 9 trials of balackgram where, 3 were conducted in the charlands of Saghata, Gaibandha and 3 were in the charlands of Jagatber, Lalmonirhat and 3 were in Begumganj, Kurigram. Treatments were, T₁ = BARI Mash-3 and locally available variety (Control). Unit plot size was 10 decimals for each treatment. RCBD (Dispersed) replication were followed in conducting the experiment.

Sowing of blackgram were started on 8 September 2018 and completed on 5 October 2018. Standard fertilizer packages (FRG'2018) were followed in the trial plots and intercultural management practices were followed as when necessary. Harvesting of 9 trials started on 20 November 2018 and completed on 6 February 2019.

Blackgram variety BARI Mash-3 performed better than locally grown/adapted blackgram in all locations. In the treatment plots (T₁), the yield of BARI Mash-3 was ranged from 1.12 to 1.68 t ha⁻¹ where higher yield was recorded from Kurigram site followed by Lalmonirhat site. In the control plots, the yield of locally adapted mash variety was ranged from 0.99 to 1.32 t ha⁻¹. The average highest blackgram yield was obtained from of BARI Mash-3 (1.38 t ha⁻¹) and the lowest from adapted Mash variety (1.11 t ha⁻¹).

Table 11.ii.15. Sowing date, harvesting date, trial plot yield and adjusted yield of Blackgram at Kurigram, Lalmonirhat and Gaibandha in 2018-19

Location	Sowing date	Harvesting date	Trial Plot yield (kg)		t-value	Adjusted grain yield (t ha ⁻¹)		t-value
			T ₁	T ₂		T ₁	T ₂	
Gaibandha	8 Sep. 2018	20 Nov. 2018	45	40	8.00 *	1.12	0.99	8.00 *
Kurigram	5 Oct. 2018	1 Dec. 2018	68	53	44 *	1.68	1.32	62.3 *
Lalmonirhat	26 Sep. - 3 Oct. 2018	28 Jan.-6 Feb. 2019	54	42	5.28 *	1.33	1.03	5.28 *
Mean	-	-	56	45	-	1.38	1.11	-

T₁ (BARI Mash-3); T₂ (Control)

* and ** significant differences on the same location between T₁ and T₂ at 5% and 1%, respectively, according to the t-test.

The cost and return analysis (Table 11.ii.16) showed that the highest gross return and gross margin was obtained from BARI Mash-3 variety; Tk. 75,630 ha⁻¹ and Tk. 50,355 ha⁻¹, respectively in the Charlands of Kurigram. The lowest gross return and margin was accounted from Gaibandha sites from locally adapted blackgram variety Tk. 44,550 ha⁻¹ with gross margin Tk. (19,275) ha⁻¹, respectively due to lower yield. The average highest gross return and margin was accounted from BARI Mash-3; Tk. 62,012 ha⁻¹ & Tk. 36,737 ha⁻¹, respectively than locally adapted blackgram variety.

Table 11.ii.16. Per hectare cost and return of Blackgram at different charland of Kurigram, Lalmonirhat and Gaibandha in 2018-19

Variety	Location	Gross return		TVC		Gross Margin	
		T ₁ (BARI Mash-3)	T ₂ (Local)	T ₁ (BARI Mash-3)	T ₂ (Local)	T ₁ (BARI Mash-3)	T ₂ (Local)
Blackgram	Gaibandha	50400	44550	25275	25275	25125	19275
	Kurigram	75630	59443	25275	25275	50355	34168
	Lalmonirhat	60006	46205	25275	25275	34731	20930
Mean	-	62012	50066	25275	25275	36737	24791

Market price (Tk. kg⁻¹): blackgram = 45.

Farmer's opinion

- ★ Farmers in the char area choose BARI Mash-3 variety due to its vigorous growth and higher yield than their locally adapted blackgram variety.



Char Begumganj, Kurigram

Char Jagatber, Lalmonirhat

Char Nalsia, Gaibandha

Fig. 11.ii.9: Field view of Blackgram at different char locations

I. Chilli

A total of 6 trials of chilli where, 3 were conducted in the charlands of Saghata, Gaibandha and 3 were in the charlands of Jagatber, Lalmonirhat. Treatments were, T₁ = BARI Morich-3 and locally adapted chilli variety (Control). Unit plot size was 10 decimals for each treatment. RCBD (Dispersed) replication were followed in conducting the experiment. Sowing of chilli were started on 28 September 2018 and completed on 2 November 2018. Standard fertilizer packages (FRG 2018) were followed in the trial plots and intercultural management practices were followed as when necessary. Harvesting of 6 trials started on 2 March 2019 and completed on 18 March 2019. The BARI Morich-3 variety exhibited with vigorous growth at farmer's field in charland condition compared to their locally adapted chilli variety.

Chilli variety BARI Morich-3 performed better than locally grown/adapted Chilli in all locations. In the treatment plots (T₁), the fruit yield of BARI Morich-3 was ranged from 8.46 to 8.60 t ha⁻¹ with an average of 8.53 t ha⁻¹ where the highest yield was recorded from Lalmonirhat site. In the control plots (T₂), the yield of locally adapted chilli variety was ranged from 8.66 to 7.57 t ha⁻¹. The average higher chilli yield was obtained from of BARI Morich-3 (8.53 t ha⁻¹) compared to locally adapted Chilli (8.11 t ha⁻¹).

Table 11.ii.17. Sowing date, harvesting date, trial plot yield and adjusted yield of Chilli at Lalmonirhat and Gaibandha in 2018-19

Location	Sowing date	Harvesting date	Trial Plot yield (kg)		t-value	Adjusted grain yield (t ha ⁻¹)		t-value
			T ₁	T ₂		T ₁	T ₂	
Gaibandha	2 Nov. 2018	18 Mar-10 Apr. 2019	342	351	4.11	8.46	8.66	4.11
Lalmonirhat	28-30 Sep. 2018	2-18 Mar. 2019	348	306	31.03 **	8.60	7.57	31.03 **
Mean	-	-	345	329	-	8.53	8.11	-

T₁ (BARI Morich-3); T₂ (Control)

* and ** significant differences on the same location between T₁ and T₂ at 5% and 1%, respectively, according to the t-test.

The cost and return analysis (Table 11.ii.18) showed that the highest gross return and gross margin was obtained from local chilli variety; Tk. 86,600 ha⁻¹ and Tk. 16280 ha⁻¹, respectively in the Charlands of Gaibandha. The lowest gross return and margin was accounted from Lalmonirhat sites from locally chilli variety, Tk. 75668 ha⁻¹ with gross margin Tk. 4318 ha⁻¹, respectively due to lower yield. The average highest gross return and margin was accounted from BARI Morich-3; Tk. 85,301 ha⁻¹ & Tk. 14,466 ha⁻¹, respectively.

Table 11.ii.18. Per hectare cost and return of Chilli at different charland of Lalmonirhat and Gaibandha in 2018-19

Variety	Location	Gross return		TVC		Gross Margin	
		T ₁ (BARI Morich-3)	T ₂ (Local)	T ₁ (BARI Morich-3)	T ₂ (Local)	T ₁ (BARI Morich-3)	T ₂ (Local)
Chilli	Gaibandha	84600	86600	70320	70320	14280	16280
	Lalmonirhat	86001	75668	71350	71350	14651	4318
Mean	-	85301	81134	70835	70835	14466	10299

Market price (Tk. kg⁻¹): Chilli = 10.

Farmer's opinion

Farmers in the char area choose to prefer local chilli variety than BARI Morich-3 variety due to its higher yield, less insect infestation and greater adaptability in the char areas.



Char Begumganj, Kurigram

Char Jagatber, Lalmonirhat

Char Nalsia, Gaibandha

Fig. 11.ii.10: Field view of Chilli at different char locations

J. Groundnut

A total of 9 trials of groundnut where, 3 were conducted in the charlands of Saghata, Gaibandha and 3 were in the charlands of Jagatber, Lalmonirhat and 3 were in the charlands of Begumganj, Kurigram. Treatments were, T₁ = BARI Chinabadam-8 and T₂ = Dhaka-1 (Control). Unit plot size was 10 decimals for each treatment. RCBD (Dispersed) replication were followed in conducting the experiment.

Sowing of groundnut were started on 28 September 2018 and completed on 17 October 2018. Standard fertilizer packages were followed in the trial plots and intercultural management practices were followed as when necessary. Harvesting of 9 trials started on 2 March 2019 and completed on 18 March 2019. The BARI Chinabadam-8 variety exhibited with vigorous growth at farmer's field in charland condition compared to their locally adapted groundnut (Dhaka-1) variety.

Groundnut variety BARI Chinabadam-8 performed better than locally grown (Dhaka-1) variety in all locations. In the treatment plots (T₁), the nut yield of BARI Chinabadam-8 were ranged from 2.10 to 3.05 t ha⁻¹ with an average of 2.48t ha⁻¹ where the highest yield was recorded from Gaibandha site. In the control plots (T₂), the yield of locally adapted Chinabadam variety were ranged from 1.79 to 2.80 t ha⁻¹ where the highest groundnut yield was recorded from Gaibandha site. The average highest groundnut yield was obtained from of BARI Chinabadam-8 (2.48 t ha⁻¹) which was 13.24% higher than locally adapted groundnut variety (2.19 t ha⁻¹).

Table 11.ii.19. Sowing date, harvesting date, trial plot yield and adjusted yield of Groundnut at Kurigram, Lalmonirhat and Gaibandha in 2018-19

Location	Sowing date	Harvesting date	Trial Plot yield (kg)		t-value	Adjusted grain yield (t ha ⁻¹)		t-value
			T ₁	T ₂		T ₁	T ₂	
Gaibandha	17 Oct. 2018	10-17 Mar. 2019	123	113	5.0 *	3.05	2.80	5.0 *
Kurigram	5-6 Oct. 2018	2-5 Mar. 2019	93	73	3.61	2.29	1.79	3.61
Lalmonirhat	28 Sep.-3 Oct. 2018	27-30 Jan. 2019	85	80	2.45	2.10	1.98	2.45
Mean	-	-	100	89	-	2.48	2.19	-

T₁ (BARI Chinabadam-8); T₂ (Control)

* and ** significant differences on the same location between T₁ and T₂ at 5% and 1%, respectively, according to the t-test.

The cost and return analysis (Table 11.ii.20) showed that the highest gross return and gross margin was obtained from BARI Chinabadam-8 variety; Tk. 144875 ha⁻¹ and Tk. 99855 ha⁻¹, respectively in the Charlands of Gaibandha. The lowest gross return and margin was accounted from Kurigram sites from locally adapted local groundnut variety, Tk. 85256 ha⁻¹ with gross margin Tk. 15691 ha⁻¹, respectively due to lower yield. The average highest gross return and margin was accounted from BARI Chinabadam-8; Tk. 117837 ha⁻¹ & Tk. 56453 ha⁻¹, respectively.

Table 11.ii.20. Per hectare cost and return of Groundnut at different charland of Kurigram, Lalmonirhat and Gaibandha in 2018-19

Variety	Location	Gross return		TVC		Gross Margin	
		T ₁ (BARI Chinabadam-8)	T ₂ (Local)	T ₁ (BARI Chinabadam-8)	T ₂ (Local)	T ₁ (BARI Chinabadam-8)	T ₂ (Local)
Groundnut	Gaibandha	144,875	133000	45020	45020	99,855	87980
	Kurigram	108878	85256	69565	69565	39313	15691
	Lalmonirhat	99758	93899	69565	69565	30193	24334
Mean	-	117837	104052	61383	61383	56453	42668

Market price (Tk. kg⁻¹): Groundnut = 47.50.

Farmer's opinion

- ★ Farmers of charland of Gaibandha are more interested in groundnut variety BARI Chinabadam-8 cultivation for its higher yield and higher return.



Char Begumganj, Kurigram

Char Jagatber, Lalmonirhat

Char Nalsia, Gaibandha

Fig. 11.ii.11: Field view of Groundnut at different char locations

K. Foxtail millet

A total of 9 trials on foxtail millet where, 3 were conducted in the charlands of Saghata, Gaibandha and 3 were in the charlands of Jagatber, Lalmonirhat and 3 were in the charlands of Begumganj, Kurigram. Treatments were, T₁ = BARI Kaon-2 and T₂ = locally available variety (Control). Unit plot size was 10 decimals for each treatment. RCBD (Dispersed) replication were followed in conducting the experiment. Sowing of kaon were started on 27 January to 8 February 2019. Standard fertilizer packages were followed in the trial plots and intercultural management practices were followed as when necessary. Harvesting of 9 trials started on 27 May 2019 and completed on 24 June 2019. The BARI Kaon-2 variety exhibited with vigorous growth at farmer's field in charland condition compared to their locally adapted kaon variety.

Foxtail millet variety BARI Kaon-2 performed better than locally grown/adapted variety in all locations. In the treatment plots (T₁), the yield of BARI Kaon-2 were ranged from 1.69 to 2.83 t ha⁻¹ with an average of 2.32 t ha⁻¹ where the highest yield was recorded from Gaibandha site (2.83 t ha⁻¹). In the control plots (T₂), the yield of locally adapted kaon variety was ranged from 1.35 to 1.85 t ha⁻¹. The average highest foxtail millet yield was obtained from of BARI Kaon-2 (2.32 t ha⁻¹) which was 50.64% higher than locally adapted one (1.54 t ha⁻¹).

Table 11.ii.21. Sowing date, harvesting date, trial plot yield and adjusted yield of Millet at Kurigram, Lalmonirhat and Gaibandha in 2018-19

Location	Sowing date	Harvesting date	Trial Plot yield (kg)		t-value	Adjusted grain yield (t ha ⁻¹)		t-value
			T ₁	T ₂		T ₁	T ₂	
Gaibandha	27 Jan. 2019	27-30 May 2019	115	55	51.9 **	2.83	1.35	51.9 **
Kurigram	21 Feb. 2019	20-24 June 2019	99	75	24.0 **	2.45	1.85	24.0 **
Lalmonirhat	5-8 Feb. 2019	8-10 June 2019	68	58	16.0 **	1.69	1.42	16.0 **
Mean	-	-	94	62	-	2.32	1.54	-

T₁ (BARI Kaon-2); T₂ (Control)

* and ** significant differences on the same location between T₁ and T₂ at 5% and 1%, respectively, according to the t-test.

The cost and return analysis (Table 11.ii.22) showed that the highest gross return and gross margin was obtained from BARI Kaon-2 variety; Tk. 56600 ha⁻¹ and Tk. 33400 ha⁻¹, respectively in the Charlands of Gaibandha. The lowest gross return and margin was accounted from Lalmonirhat sites from locally adapted local variety, Tk. 14244 ha⁻¹ with gross margin Tk. 224 ha⁻¹, respectively due to lower yield. The average highest gross return and margin was accounted from BARI Kaon-2; Tk. 38757 ha⁻¹ & Tk 18015 ha⁻¹, respectively.

Table 11.ii.22. Per hectare cost and return ce of Millet at different charland of Kurigram, Lalmonirhat and Gaibandha in 2018-19

Variety	Location	Gross return		TVC		Gross Margin	
		T ₁ (BARI Kaon-2)	T ₂ (Local)	T ₁ (BARI Kaon-2)	T ₂ (Local)	T ₁ (BARI Kaon-2)	T ₂ (Local)
Millet	Gaibandha	56600	27000	23200	23200	33400	3800
	Kurigram	42793	32419	25007	25007	17786	7412
	Lalmonirhat	16878	14244	14020	14020	2858	224
Mean	-	38757	24554	20742	20742	18015	3812

Market price (Tk. kg⁻¹): Foxtail millet = 10-20.

Farmer's opinion

Farmers of charland of Gaibandha are more interested in foxtail millet variety BARI Kaon-2 cultivation for its higher yield and higher return.



Fig. 11.ii.12: Field view of Foxtail millet at char Gaibandha

11.iii. Activity 3 (OFRD, BARI): Pilot production program through group approach with selected variety of suitable crop(s) at charland

The pilot production program has been executed in 2019-20 and 2020-21 based on the previous year adaptive trial results of FY 2018-19, farmers' choices and local market demands of the crops in the char lands of Kurigram, Lalmonirhat and Gaibandha districts.

During 2019-20 and 2020-21, total eight (8) types of crops were found profitable and agro-ecologically suitable, and the crops variety were BARI Chinabadam-8, BARI Hybrid Mistikumra-1, BARI Morich-3 & local Morich cultivar, Uchhe (local), BARI Piaj-1, BARI Mistialu-8, BARI Mash-3 and BARI Kaon-2.

Out of these 8 crops, 3 crops (BARI Chinabadam-8, BARI Hybrid Mistikumra-1 and BARI Morich-3 & local Morich cultivar) for Char Jagatber, Lalmonirhat; 4 crops (BARI Chinabadam-8, Uchhe, BARI Piaj-1 and BARI Mash-3) for Char Begumganj, Kurigram and 3 crops (BARI Kaon-2, BARI BARI Morich-3 & local Morich cultivar and BARI Mistialu-8) for char lands of Saghata, Gaibandha were found suitable and profitable.

Under the pilot production program, total 8.54 ha (2110 decimal) and 7.46 ha (1842 decimal) of char land in Jagatber of Lalmonirhat, 10.47 ha (2585 decimal) and 9.43 ha (2330 decimal) in Char Begumganj of Kurigram and 6.86 ha (1695 decimal) and 9.01 ha (2225 decimal) in char lands of Saghata of Gaibandha were successfully brought under cultivation during 2019-20 and 2020-21, respectively (Table 11.iii.1-8).

Individual crop-wise information is given below-

A. Sweet gourd

The trial results with BARI Hybrid Mistikumra-1 in char Jagatber of Lalmonirhat district is presented in Table 11.iii.1. Total 15 farmers in each year were involved with the area coverage of 924 and 750 decimal in 2019-20 and 2020-21, respectively. The range of seed sowing date was 17-30 October in both the years. Harvesting of Sweet gourd started on 08 December and continued up to 28 February. Sex Pheromone trap and Attack and kill were set up in the trial plots to control fruit fly infestation in the small size sweet gourds. From the trial plots of 02 years, a total of 234591 kg sweet gourd was produced from total land of 1674 decimal. From the two years average results, it was found that the yield of farmers practiced variety was ranged from 25.40 to 25.50 t ha⁻¹ whereas, in the trial plot yield of BARI Hybrid Mistikumra-1 was ranged from 33.15 to 39.40 t ha⁻¹ with an average value of 32.67 t ha⁻¹. The cost and return analysis (Table 11.iii.1) showed that the average gross return and gross margin was Tk. 490000 and Tk. 411775 ha⁻¹.

Table 11.iii.1. Performance of sweet gourd at Lalmonirhat during 2019-20 & 2020-21

Variety	Location	Year	No. of farmers	Proposed area (dec.)	Actual area covered (dec.)	Sowing date	Harvesting date	Trial plot production (kg)	Seed preserved (kg)
BARI Hybrid Mistikumra-1	Char Jagatber, Lalmonirhat	2019-20	15	495	924	20-30 Oct, 2019	08 Dec., 2019-28 Feb., 2020	134298	-
		2020-21	15	495	750	17-25 Oct, 2020	10 Dec., 2020-25 Feb., 2021	100293	-
		Total	30	990	1674	17-30 Oct.	08 Dec.-28 Feb.	234591	-

Table 11.iii.1 Continue.

Variety	Location	Year	Farmers variety & yield (t ha ⁻¹)	Trial plot yield (t ha ⁻¹)			Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross Margin (Tk. ha ⁻¹)
				Min	Max	Av.			
BARI Hybrid Mistikumra-1	Char Jagatber, Lalmonirhat	2019-20	25.40	32.80	38.70	32.30	484500	78150	406350
		2020-21	25.50	33.50	40.10	33.03	495500	78300	417350
		Average	25.45	33.15	39.40	32.67	490000	78225	411775

Market price (Tk/kg): 15

Pest incidence: There was no remarkable disease found during the growing period. Fruit fly infestation was very little and controlled by using sex pheromone trap and Attack and kill.

Farmer's opinion

Farmers preferred BARI Hybrid Mistikumra-1 variety due to its uniform shape and size, higher yield than local variety, profuse bearing and good market demand.



Fig. 11.iii.1: Pilot production of sweet gourd at Char Jagatber, Lalmonirhat.

B. Bitter gourd

Bitter gourd (Ucche) trial was conducted at char Begumganj of Kurigram district and the results are presented in Table 11.iii.2. A total of 15 farmers in each year were involved with the area coverage of 990 and 800 decimal in 2019-20 and 2020-21, respectively. The range of seed

sowing date was 05-18 October in both the years. Harvesting of Sweet gourd started on 03 February and continued up to 28 May. Sex Pheromone trap and Attack and kill were set up in the trial plots to control fruit fly infestation. Plant nutrient enriched PGR was sprayed 2-3 times for better plant growth. From the two years trial, a total of 29782 kg bitter gourd was produced from total land of 1790 decimal. From the two years average results, it was found that the yield of farmers practiced plot was 2.85 t ha⁻¹ whereas, in the trial plot yield of Ucce was ranged from 3.35 to 4.75 t ha⁻¹ with an average value of 4.11 t ha⁻¹. The cost and return analysis showed that the average gross return and gross margin was Tk. 225775 and Tk. 169088 ha⁻¹ (Table 11.iii.2).

Table 11.iii.2. Performance of Bitter gourd at Kurigram during 2019-20 and 2020-21

Variety	Location	Year	No. of farmers	Proposed area (dec.)	Actual area covered (dec.)	Sowing date	Harvesting date	Trial plot production (kg)	Seed preserved (kg)
Ucce korola	Char Begumganj Kurigram	2019	15	495	990	07-18 Oct.	03 Feb.-22	16633	60
		-20				2019	May, 2020		
		2020	15	495	800	05-15 Oct.	12 Feb.-28	13149	50
		-21				2020	May, 2021		
		Total	30	990	1790	05-18 Oct.	03 Feb.-28 May	29782	110

Table 11.iii.2 Continue.

Variety	Location	Year	Farmers variety & yield (t ha ⁻¹)	Trial plot yield (t ha ⁻¹)			Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross Margin (Tk. ha ⁻¹)
				Min	Max	Av.			
Ucce korola	Char Begumganj Kurigram	2019	2.85	3.34	4.72	4.15	228250	56625	171625
		-20							
		2020	2.84	3.35	4.77	4.06	223300	56750	166550
		Average	2.85	3.35	4.75	4.11	225775	56688	169088

Pest incidence: There was no remarkable disease found during the growing period. Fruit fly infestation was very little and controlled by using sex pheromone trap and Attack and kill.

Farmer's opinion

Farmers opined that PGR spray help to increase crop duration as well as fruit yield. Early high market price of bitter gourd and very low input production system encouraged farmers for bitter gourd production in next year.



Fig. 11.iii.2: Pilot production of Bittergourd at Char Begumganj, Kurigram.

C. Ground nut

The trial of ground nut was conducted at char Begumganj of Kurigram and Char Jagatber of Lalmonirhat district and results are presented in Table 11.iii.3. A total of 15 farmers in each year were involved with the area coverage of 510 and 515 decimal at Begumganj and 594 and 525 decimal at Jagatber in 2019-20 and 2020-21, respectively. The range of seed sowing date was 15-25 October at char Begumganj and 28 January-11 February at char Jagatber in both the years. Harvesting of ground nut was started on 15-20 March at char Begumganj and 05-14 June at char Jagatber. From the two years trial of two locations, a total of 19239 kg ground nut was produced from total land of 2144 decimal. From the two years average results, it was found that the yield of farmers practiced plot was 1.28 t ha^{-1} whereas, in the trial plot yield of ground nut was ranged from 1.91 to 2.41 t ha^{-1} with an average value of 2.16 t ha^{-1} . The cost and return analysis (Table 11.iii.3) showed that the average gross return and gross margin was Tk. 177700 and Tk. 106825 ha^{-1} .

Table 11.iii.3. Performance of groundnut at Kurigram and Lalmonirhat during 2019-20 & 2020-21

Variety	Location	Year	No. of farmers	Proposed area (dec.)	Actual area covered (dec.)	Sowing date	Harvesting date	Trial plot production (kg)	Seed preserved (kg)
BARI Chinabadam-8	Char Begumganj, Kurigram	2019	15	495	510	19-24	15-18 Mar.,	4893	350
		-20				Oct, 2019	2020		
	Char Jagatber, Lalmonirhat	2020	15	495	515	15-25	15-20 Mar.,	4660	250
		-21				Oct, 2020	2021		
	Char Jagatber, Lalmonirhat	2019	15	495	594	28 Jan-11	09-14 Jun,	5074	890
		-20				Feb, 2020	2020		
Char Jagatber, Lalmonirhat	2020	15	495	525	29 Jan.-05	05-10 Jun,	4612	400	
	-21				Feb 2021	2021			
		Total	60	1980	2144	15-25 Oct. & 28 Jan.-11 Feb	15-20 March & 05-14 Jun	19239	1890

Table 11.iii.3 Continue.

Variety	Location	Year	Farmers variety & yield (t ha ⁻¹)	Trial plot yield (t ha ⁻¹)			Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross Margin (Tk. ha ⁻¹)
				Min	Max	Av.			
BARI China badam-9	Char Begumganj, Kurigram	2019-20	1.32	1.93	2.45	2.19	189600	70850	118750
		2020-21	1.33	1.97	2.50	2.24	178800	70900	107900
	Char Jagatber, Lalmonirhat	2019-20	1.20	1.85	2.25	2.05	168800	70850	97950
		2020-21	1.25	1.89	2.45	2.17	173600	70900	102700
		Average	1.28	1.91	2.41	2.16	177700	70875	106825

Market price (Tk/kg): 80

Pest incidence: There was no remarkable insect and disease found during the growing period. However, two times fungicide were sprayed to protect from Tikka disease.

Farmer's opinion

Farmers opined that the market price was moderate due to sell as feed purpose. If it could be planted in kharif-2 season would be helpful to get higher market price by selling quality seed.



Fig. 11.iii.3: Pilot production of groundnut at Char Begumganj, Kurigram.

D. Onion

The trial of onion was conducted at char Begumganj of Kurigram and Char Saghata of Gaibandha district and the trial results are presented in Table 11.iii.4. A total of 15 farmers in each year were involved with the area coverage of 590 and 530 decimal at Begumganj in 2019-20 and 2020-21, respectively and 500 decimal at Saghata in 2020-21. The range of seed sowing date was 15 November to 18 December at char Begumganj and 25 November to 15 December at char Saghata in both the years. Harvesting of onion was started on 15 March-08 April at char Begumganj and 25 March-10 April at char Saghata. From the two years trial of two locations, a total of 72290 kg onion was produced from total land of 1620 decimal. From the two years average results, it was found that the yield in farmers practiced plot was 9.14 t ha⁻¹ whereas, in the trial plot yield of onion was ranged from 10.08 to 12.32 t ha⁻¹ with an average value of 11.20 t ha⁻¹. The cost and return analysis (Table-7) showed that the average gross return and gross margin was Tk. 336050 and Tk. 249830 ha⁻¹.

Table 11.iii.4. Performance of onion at Kurigram and Gaibandha during 2019-20 & 2020-21

Variety	Location	Year	No. of farmers	Proposed area (dec.)	Actual area covered (dec.)	Sowing date	Harvesting date	Trial plot production (kg)	Seed preserved (kg)
BARI Pijaj-1	Char Begumganj, Kurigram	2019-20	15	495	590	20-Nov-18 Dec. 2019	26 Mar.-05 Apr., 2020	25917	160
	Char Begumganj, Kurigram	2020-21	15	495	530	15-Nov-16 Dec. 2020	15 Mar.-08 Apr., 2021	23447	100
	Char Saghata, Gaibandha	2020-21	15	495	500	25-Nov-15 Dec. 2020	25 Mar.-10 Apr., 2021	22926	80
	Total		45	1485	1620	16-Nov-18 Dec.	15 Mar.-10 Apr.	72290	340

Table 11.iii.4 Continue.

Variety	Location	Year	Farmers variety & yield (t ha ⁻¹)	Trial plot yield (t ha ⁻¹)			Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
				Min	Max	Av.			
BARI Pijaj-1	Char Begumganj, Kurigram	2019-20	8.40	9.20	11.75	10.48	314250	85985	228265
	Char Begumganj, Kurigram	2020-21	8.90	10.50	12.89	11.70	350850	86775	264075
	Char Saghata, Gaibandha	2020-21	10.11	10.54	12.33	11.44	343050	85900	257150
	Average		9.14	10.08	12.32	11.20	336050	86220	249830

Market price (Tk/kg): 30

Pest incidence: Tip burn disease was slightly hampered the onion production.

Farmer's opinion

Farmers opined that the market price and demand was very high in last year as well as this year.



Fig. 11.iii.4: Pilot production of onion at Char Begumganj, Kurigram and Char Saghata, Gaibandha.

E. Chilli

The trial of chilli was conducted at char Saghata of Gaibandha and Char Jagatber of Lalmonirhat district and the trial results are presented in Table 11.iii.5. A total of 15 farmers in each year were involved with the area coverage of 525 and 545 decimal at Saghata and 592 and 567 decimal at Jagatber in 2019-20 and 2020-21, respectively. Seed sowing dates were 10-22 October at char Saghata and 15-30 October at char Jagatber in both the years. Harvesting of chilli was started on 25 November and continued up to 28 March at char Saghata and started on 18 November and continued up to 20 March at char Jagatber. From the two years trial of

the two locations, a total of 78623 kg chilli was produced from total land of 2229 decimal. From the two years average results, it was found that the yield in farmers practiced plot was 7.35 t ha⁻¹ whereas, in the trial plot yield of chilli was ranged from 8.54 to 9.75 t ha⁻¹ with an average value of 9.14 t ha⁻¹. The cost and return analysis (Table 11.iii.5) showed that the average gross return and gross margin was Tk. 365600 and Tk. 293500 ha⁻¹.

Table 11.iii.5. Performance of chilli at charland Gaibandha and Lalmonirhat during 2019-20 & 2020-21

Variety	Location	Year	No. of farmers	Proposed area (dec.)	Actual area covered (dec.)	Sowing date	Harvesting date	Trial plot production (kg)	Seed preserved (kg)
BARI Morich-3 & Local	Char Chinirpotol, Saghata, Gaibandha	2019-20	15	495	525	10-20 Oct., 2019	25 Nov.-20 Mar., 2020	18236	25
		2020-21	15	495	545	15-22 Oct., 2020	29 Nov.-28 Mar., 2021	20233	30
	Char Jagatber, Lalmonirhat	2019-20	15	495	592	15-20 Oct., 2019	21 Nov.-14 Mar., 2020	21858	35
		2020-21	15	495	567	25-30 Oct., 2020	18 Nov.-20 Mar., 2021	18296	30
	Total		60	1980	2229	10-30 Oct.	18 Nov.-28 Mar.	78623	120

Table 11.iii.5 Continue.

Variety	Location	Year	Farmers variety & yield (t ha ⁻¹)	Trial plot yield (t ha ⁻¹)			Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
				Min	Max	Av.			
BARI Morich-3 & Local	Char Chinirpotol, Saghata, Gaibandha	2019-20	7.17	8.52	9.67	9.10	363800	72250	291550
		2020-21	7.28	8.56	9.77	9.17	366600	72400	294200
	Char Jagatber, Lalmonirhat	2019-20	7.57	8.48	9.87	9.18	367000	71350	295650
		2020-21	7.37	8.58	9.67	9.13	365000	72400	292600
	Average		7.35	8.54	9.75	9.14	365600	72100	293500

Market price (Tk/kg): 40

Pest incidence: Mite and thrips infestation was slightly hampared the chilli production at initial stage but finally controlled successfully by spraying miticide and insecticide.

Farmer's opinion

Farmers opined that both the varieties is suitable but local variety is relatively better due to more peppery.



Fig. 11.iii.5: Pilot production of Chilli at Char Jagatber, Lalmonirhat and Char Saghata, Gaibandha.

F. Sweet potato

The trial of sweet potato was conducted at char Saghata of Gaibandha district and the trial results are presented in Table 11.iii.6. A total of 15 farmers in each year were involved with the area coverage of 550 and 565 decimal at Saghata in 2019-20 and 2020-21, respectively. The vine plantation dates lied between 25 February to 31 March in both the years. Harvesting of sweet potato was started on 25 February and continued up to 31 March at char Saghata. From the two years trial, a total of 142837 kg sweet potato was produced from total land of 1115 decimal. From the two years average results, it was found that the yield in farmers practiced plot was 22.54 t ha⁻¹ whereas, in the trial plot yield of sweet potato was ranged from 28.00 to 35.28 t ha⁻¹ with an average value of 31.64 t ha⁻¹. The cost and return analysis (Table 11.iii.6) showed that the average gross return and gross margin was Tk. 474600 and Tk. 352120 ha⁻¹.

Table 11.iii.6. Performance of Sweet potato at Gaibandha during 2019-20 & 2020-21

Variety	Location	Year	No. of farmers	Proposed area (dec.)	Actual area covered (dec.)	Sowing date	Harvesting date	Trial plot production (kg)	Seed preserved (kg)
BARI Mistialu-8	Char Chandanpat, Saghata, Gaibandha	2019	15	495	550	15-30 Oct. 2019	25 Feb-31 Mar. 2020	70142	40
		-20	15	495	565	25-30 Oct. 2020	10 Mar-31 Mar. 2021	72695	40
		Total	30	990	1115	15-30 Oct.	25 Feb-31 Mar.	142837	80

Table 11.iii.6 Continue.

Variety	Location	Year	Farmers variety & yield (t ha ⁻¹)	Trial plot yield (t ha ⁻¹)			Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross Margin (Tk. ha ⁻¹)
				Min	Max	Av.			
BARI Mistialu-8	Char Chandanpat, Saghata, Gaibandha	2019-20	23.40	27.33	35.67	31.50	472500	122440	350060
		2020-21	21.67	28.67	34.89	31.78	476700	122520	354180
		Average	22.54	28.00	35.28	31.64	474600	122480	352120

Market price (Tk/kg): 15

Pest incidence: There was no remarkable disease and insect found during the growing period.

Farmer's opinion

Farmers opined that sweet potato variety BARI Misti Alu-8 is high yielding as well as tasty. The challenge is vine preservation for the next season.



Fig. 11.iii.6: Pilot production of sweet potato at Char Char Saghata, Gaibandha.

G. Blackgram

The trial of blackgram was conducted at char Begumganj of Kurigram district and the trial results are presented in Table 11.iii.7. A total of 15 farmers in each year were involved with the area coverage of 495 and 485 decimal at char Begumganj in 2019-20 and 2020-21, respectively. The seed sowing dates lied between 02-15 October in both the years. Harvesting of sweet potato was started on 11 January and continued up to 20 January at char Begumganj. From the two years trial, a total of 5355 kg blackgram was produced from total land of 980 decimal. From the two years average results, it was found that the yield in farmers practiced plot was 0.85 t ha⁻¹ whereas, in the trial plot yield of blackgram was ranged from 1.31 to 1.39 t ha⁻¹ with an average value of 1.35 t ha⁻¹. The cost and return analysis (Table 11.iii.7) showed that the average gross return and gross margin was Tk. 80850 and Tk. 55807 ha⁻¹.

Table 11.iii.7. Performance of blackgram at charland of Kurigram during 2019-20 & 2020-21

Variety	Location	Year	No. of farmers	Proposed area (dec.)	Actual area covered (dec.)	Sowing date	Harvesting date	Trial plot production (kg)	Seed preserved (kg)
BARI Mash-3	Char Begumganj Kurigram	2019	15	495	495	02-08 Oct., 2019	11-17 Jan., 2020	2705	150
		-20							
		2020	15	495	485	10-15 Oct., 2020	15-20 Jan., 2021	2650	100
		-21							
		Total	30	990	980	02-15 Oct.	11-20 Jan.	5355	250

Table 11.iii.7 Continue.

Variety	Location	Year	Farmers variety & yield (t ha ⁻¹)	Trial plot yield (t ha ⁻¹)			Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
				Min	Max	Av.			
BARI Mash-3	Char Begumganj, Kurigram	2019-20	0.85	1.31	1.38	1.35	81000	24987	56013
		2020-21	0.84	1.30	1.39	1.35	80700	25100	55600
		Average	0.85	1.31	1.39	1.35	80850	25043	55807

Market price (Tk/kg): 60

Pest incidence: There was partially infestation of powdery mildew disease and partially controlled by fungicide spraying.

Farmer's opinion

Farmers opined that blackgram variety BARI Mash-3 is relatively high yielding and its production cost is very low.



Fig. 11.iii.7: Pilot production of blackgram at Char Begumganj, Kurigram.

H. Foxtail millet

The trial of foxtail millet was conducted at char Saghata of Gaibandha district and the trial results are presented in Table 11.iii.8. A total of 15 farmers in each year were involved with the area coverage of 620 and 615 decimal at char Saghata in 2019-20 and 2020-21, respectively. The seed sowing dates lied between 02-25 January in both the years. Harvesting of foxtail millet was started on 15 April and continued up to 30 April at char Saghata. From the two years trial, a total of 11312 kg foxtail millet was produced from total land of 990 decimal. From the two years average results, it was found that the yield in farmers practiced plot was 1.51 t ha⁻¹ whereas, in the trial plot yield of foxtail millet was ranged from 1.98 to 2.55 t ha⁻¹ with an average value of 2.26 t ha⁻¹. The cost and return analysis (Table 11.iii.8) showed that the average gross return and gross margin was Tk. 56563 and Tk. 32188 ha⁻¹.

Table 11.iii.8. Performance of foxtail millet at charland of Gaibandha during 2019-20 & 2020-21

Variety	Location	Year	No. of farmers	Proposed area (dec.)	Actual area covered (dec.)	Sowing date	Harvesting date	Trial plot production (kg)	Seed preserved (kg)
BARI Kaon-2	Char Saghata, Gaibandha	2019	15	495	620	05-25 Jan.,	20-30 April,	5623	40
		-20				2020	2020		
		2020	15	495	615	02-20 Jan.,	15-25 April,	5689	50
		-21				2021	2021		
		Total	30	990	1235	02-25 Jan.	15-30 April	11312	90

Table 11.iii.8 Continue.

Variety	Location	Year	Farmers variety & yield (t ha ⁻¹)	Trial plot yield (t ha ⁻¹)			Gross return (Tk. ha ⁻¹)	TVC (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)
				Min	Max	Av.			
BARI Kaon-2	Char Nolsia, Saghata, Gaibandha	2019-20	1.52	1.95	2.54	2.24	56000	24300	31700
		2020-21	1.5	2.01	2.56	2.28	57125	24450	32675
		Average	1.51	1.98	2.55	2.26	56563	24375	32188

Market price (Tk/kg): 25

Pest incidence: There was no remarkable insect or disease was found in the foxtail field.

Farmer's opinion

Farmers opined that foxtail millet variety BARI Kaon-2 is relatively high yielding and its production cost is very low. The demand as well as area of foxtail millet is increasing day by day.



Fig. 11.iii.8: Pilot production of Blackgram at Char Begumganj, Kurigram.

11.iv. Activity 4 (OFRD, BARI): Improvement of marketing system for high-value crops in northern charland of Bangladesh

Methods

Crops/varieties including improved production technologies performed well in first year and selected for Pilot production programs in 2nd year. Development of marketing channel of the selected crops (sweet gourd, groundnut, onion, blackgram, bitter gourd, sweet potato, chilli, foxtail millet, etc.) reduces the marketing costs of a product due to connected to producers to buyers.

The study was conducted in three districts namely Kurigram, Lalmonirhat and Gaibandha of Rangpur Division, Bangladesh. A total of 155 respondents, 80 were the farmers of pilot production program from which 60 came from Kurigram and Lalmonirhat, and 20 from Gaibandha. From the remaining 75 respondent 10 were faria, 10 were Bepari, 10 were wholesaler, 10 were retailer, 10 were arothders (Commission Agents), 10 were members of the local service providers, 5 were processors and remaining 10 were Consumers. Data were collected through survey method using a pre- designed and pre-tested questionnaire during 2020-2021. The collected data were then edited, summarized, tabulated, and analysed to achieve the objectives of the study. From the data existing and improved marketing channels developed. Tabular analysis also used for marketing cost and margin. The following supports, services and inputs were provided for the developing of marketing channels.

- Formation of Agro-Centre
- Formation of demand based producer group
- Capacity building
- Local Service Provider (LSP) development
- Mini transporter improvement
- Improvement of post-harvest processing
- Technical backstopping,
- Development of storage opportunity,
- Linking with good seed source,
- Linking with agricultural product buyer,
- Strengthening linkage between farmers and marketing channels, etc.

Existing and Improved Flow Charts of Marketing Channels

Existing and improved flow charts of marketing channels of sweet potato, foxtail millet, lentil, ground nut, bitter gourd, sweet gourd, blackgram and onion have been shown in the flow chart 1,2,3,4,5,6,7 and 8. Existing marketing channels of farm product consists of farmer, faria, bepari, whole saler, retailer, sometimes arothder or commission agents, processing centre, etc. Again, Improved marketing channels of farm product consists of farmer, local service provider (LSP), whole saler, retailer, sometimes arothder or commission agents, processing centre, etc. It is the way farm products get to the end-user, the consumer.

The faria are the middlemen who purchase comparatively small quantities of farm product directly from the farmers either at the farmyards or in the primary markets. They are mostly seasonal traders. Some may have other occupation such as operating small sized farm. Generally the bepari purchase farm product either from the farmers or from the faria and sell to the arothders or commission agents. Commission agents, also known as aratdars, have a fixed establishment in the market and operate as middlemen between any two traders. The millers purchase farm product from the Bepari or farmers groups or traders at the mill gates through their purchased centers or commission agents in different parts of the country. The wholesaler, also known as the distributor, acquires product from a arothd or commission agents or mills or processing centers and then sells them to retailers. Retailer purchases products from the wholesaler and sells it further in small

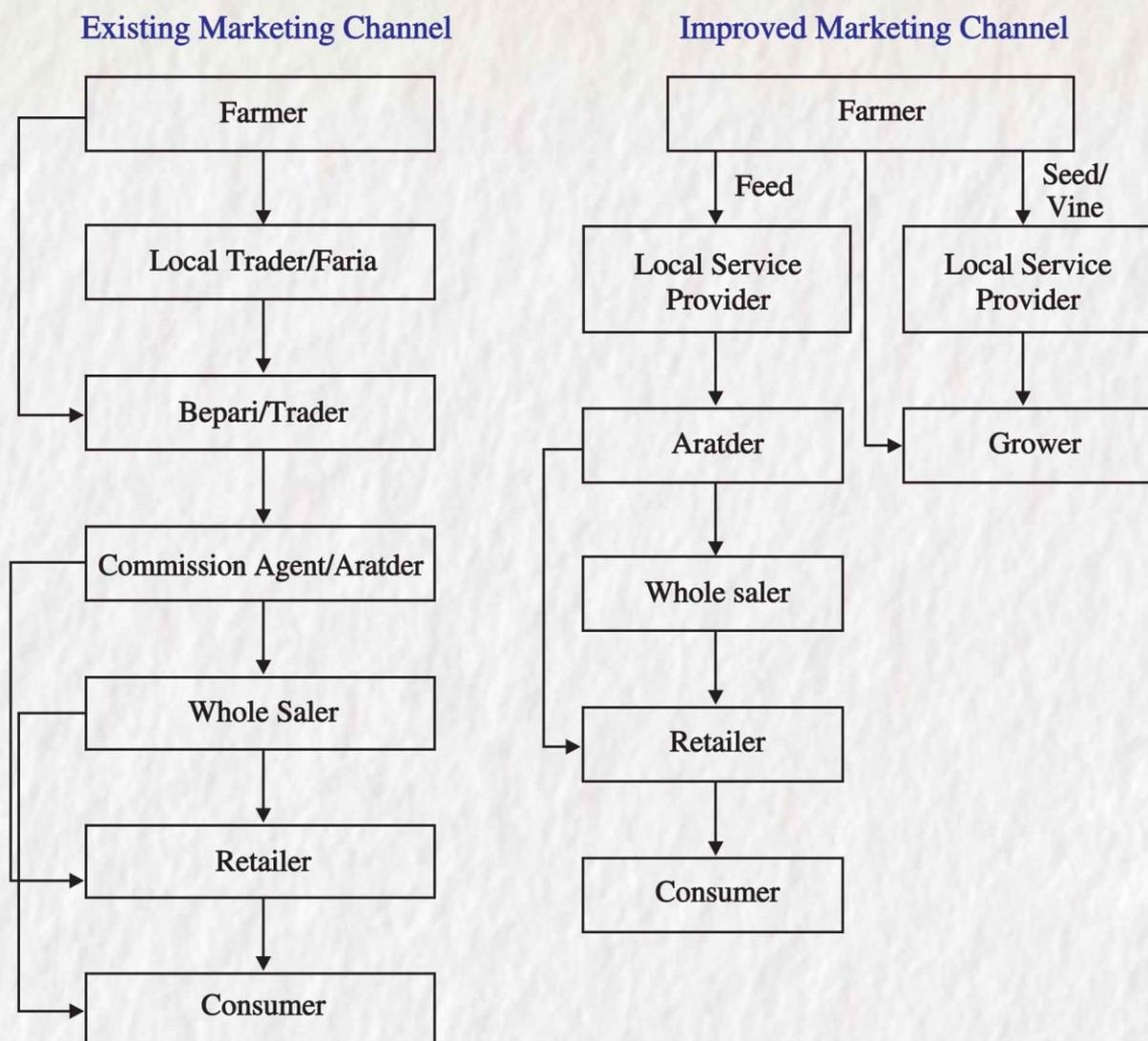
quantities to the end customer. Farmers group can play a very important role for enhancing crop production and marketing. Local service provider (farmers group) consists of some farmers formed a group and the group should be producing the same crops. By selling collectively their products or crops, the local service provider (LSP) increases their bargaining power, compared to individual selling. Farmers can take advantage of the presence of several buyers to auction their own commodity, awarding it to the highest bidder and thereby maximizing their gain. Collection point can help provide a direct link between farm groups and aratders or processing centers or mills.

Three or four existing marketing channels were observed in each of sweet potato, foxtail millet, lentil, groundnut, bitter gourd, sweet gourd, blackgram and onion. Most effective existing marketing channel were-

- Farmer-Bepari-Arothder -Retailer-Consumer for sweet potato.
- Farmer-Faria-Bepari-Processing Centre-Wholesaler-Retailer-Consumer for foxtail millet and lentil.
- Farmer-Bepari-Processing Centre-Whole Saler-Retilar-consumer for ground nut.
- Farmer-Faria-Bepari-Commission Agent-Retilar-consumer for bitter gourd, sweet gourd and onion.
- Farmer-Faria-Bepari-Processing Mill-Whole Saler-Retailer-Consumer for blackgram.

Again, improved marketing channel includes farmers group or local service provider for getting higher price to the farmers. Out of some improved marketing channels, most effective marketing channel were Farmer-Local Service Provider-Aratders/commission agents-Retailer-Consumer for sweet potato, bitter gourd, sweet gourd and onion, Farmer-Local Service Provider- Processing Centre -Wholesaler-Retailer-Consumer for foxtail millet, lentil, ground nut and blackgram. Farmers can earn more profit by producing, storing, grading, and marketing their seeds. This project helps farmers in this regard. So, some seed marketing channels were developed by LSP. The most effective seed marketing channel were Farmer-Local Service Provider- Grower for foxtail millet, Farmer-LSP-Retailer-Growers for lentil, ground nut and blackgram and Farmer-LSP-Whole Saler-Retailer-Growers for onion.

Flow Chart 11.iv.1. Existing and improved marketing channel of sweet potato



Existing Marketing Channel

Channel-1: Farmer → Faria → Bepari → Aratder → Wholesaler → Retailer → Consumer ----- 19%

Channel-2: Farmer → Bepari → Aratder → Wholesaler → Retailer → Consumer ----- 13%

Channel-3: Farmer → Bepari → Aratder → Retailer → Consumer ----- 64%

Channel-4: Farmer → Bepari → Aratder → Consumer ----- 5%

Improved Marketing Channel

For Sweet Potato

Channel-5: Farmer → LSP → Wholesaler → Retailer → Consumer ----- 25%

Channel-6: Farmer → LSP → Aratder → Retailer → Consumer ---- 68%

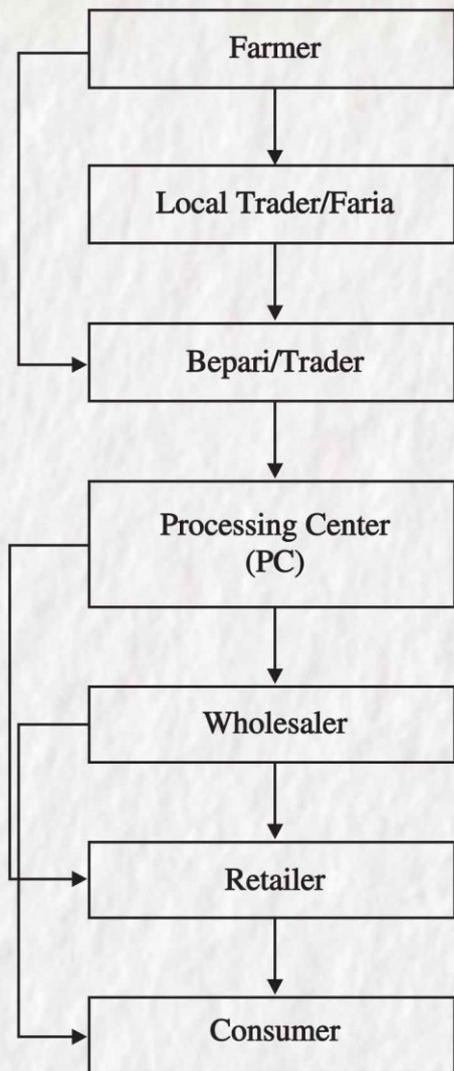
Channel-7: Farmer → LSP → Retailer → Consumer ----- 7%

For Vine/Seed

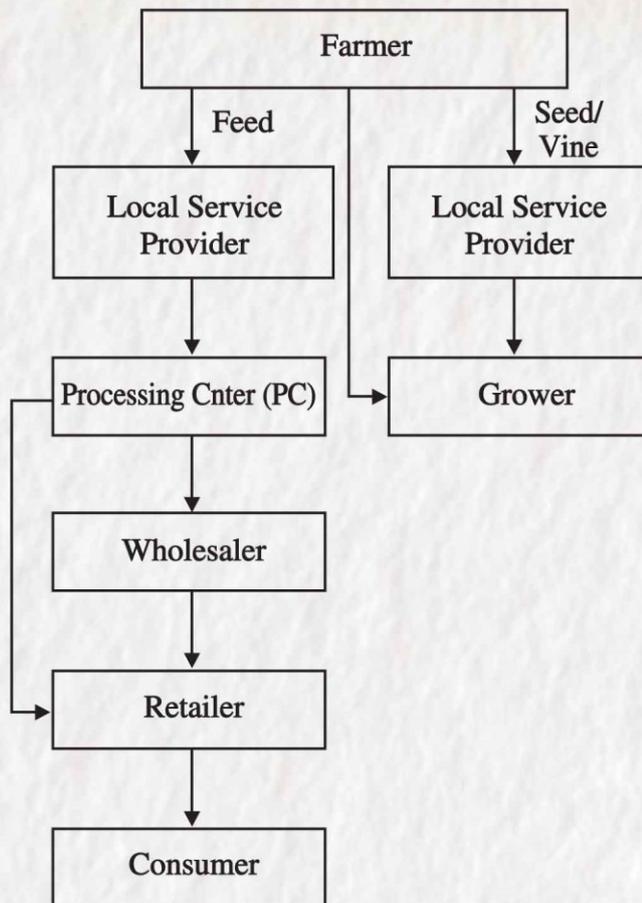
Channel-8: Farmer → LSP → Grower ----- 12%

Flow Chart 11.iv.2. Existing and improved marketing channel of foxtail millet

Existing Marketing Channel



Improved Marketing Channel



Existing Marketing Channel

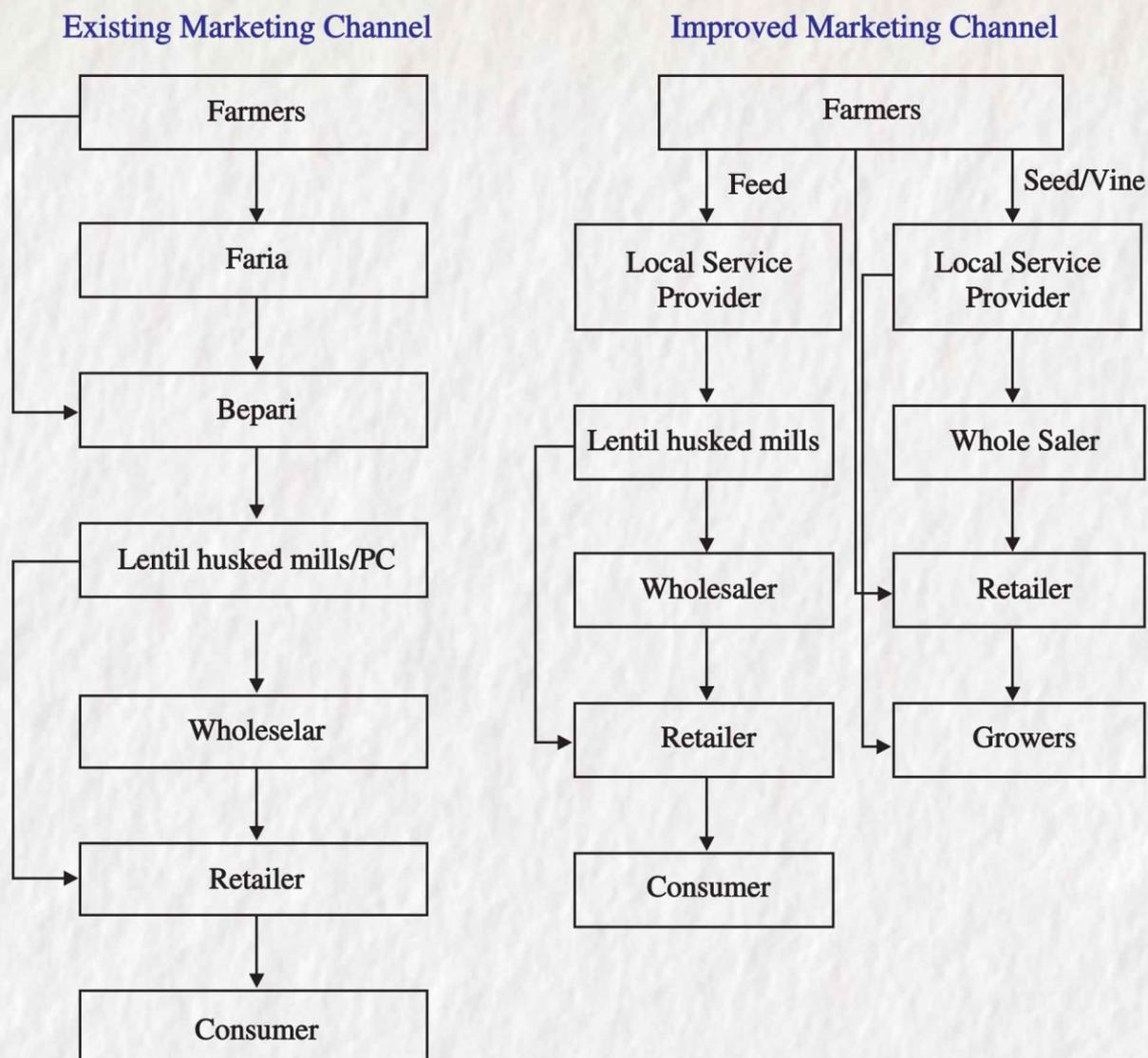
- Channel-1: Farmer → Faria → Bepari → Processing centre → Wholesaler → Retailer → Consumer ----- 52%
- Channel-2: Farmer → Bepari → Processing centre → Wholesaler → Retailer → Consumer ----- 26%
- Channel-3: Farmer → Bepari → Processing centre → Retailer → Consumer ----- 19%
- Channel-4: Farmer → Bepari → Processing centre → Wholesaler → Consumer ----- 3%

Improved Marketing Channel

For Feed

- Channel-5: Farmer → LSP → Processing centre → Wholesaler → Retailer → Consumer ----- 65%
- Channel-6: Farmer → LSP → Processing centre → Wholesaler → Consumer ----- 12%
- Channel-7: Farmer → LSP → Processing center → Retailer → Consumer → Retailer → Consumer ---- 23%
- Channel-8: Farmer → LSP → Grower ----- 10%

Flow Chart 11.iv.3. Existing and improved marketing channel of lentil



Existing marketing Channel

Process Lentil

- Channel-1: Farmer → Faria → Bepari → Processing centre → Wholesaler → Retailer → Consumer ----- 55%
- Channel-2: Farmer → Bepari → Processing centre → Wholesaler → Retailer → Consumer ---- 27%
- Channel-3: Farmer → Bepari → Processing centre → Retailer → Consumer ---- 11%
- Channel-4: Farmer → Bepari → Processing centre → Wholesaler → Consumer ---- 7%

Improved Marketing Channel

For Feed

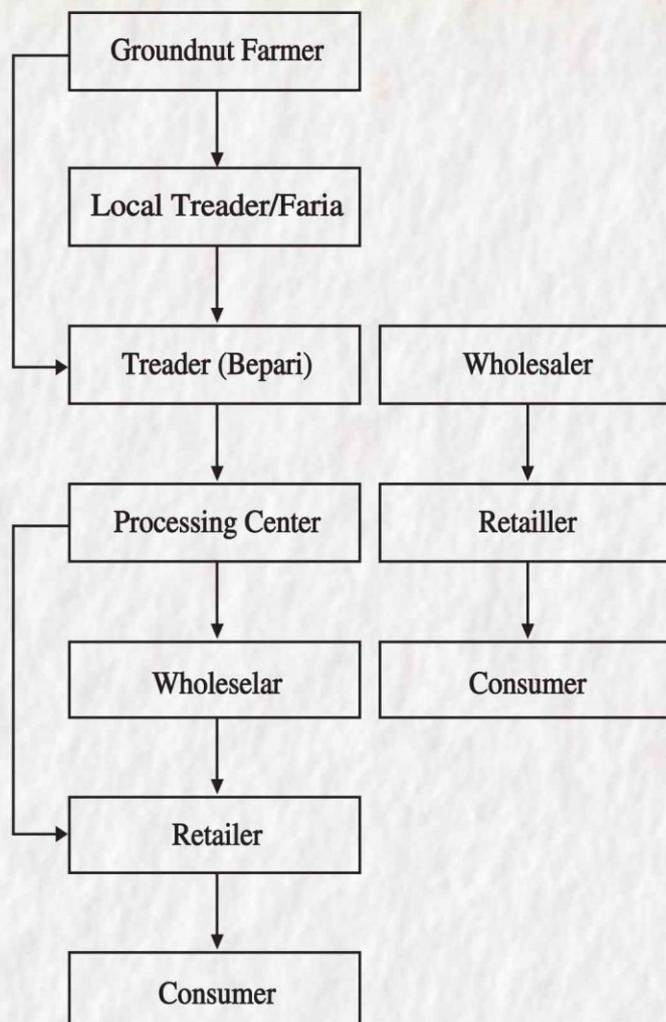
- Channel-5: Farmer → LSP → Processing centre → Wholesaler → Retailer → Consumer ---- 15%

Seed

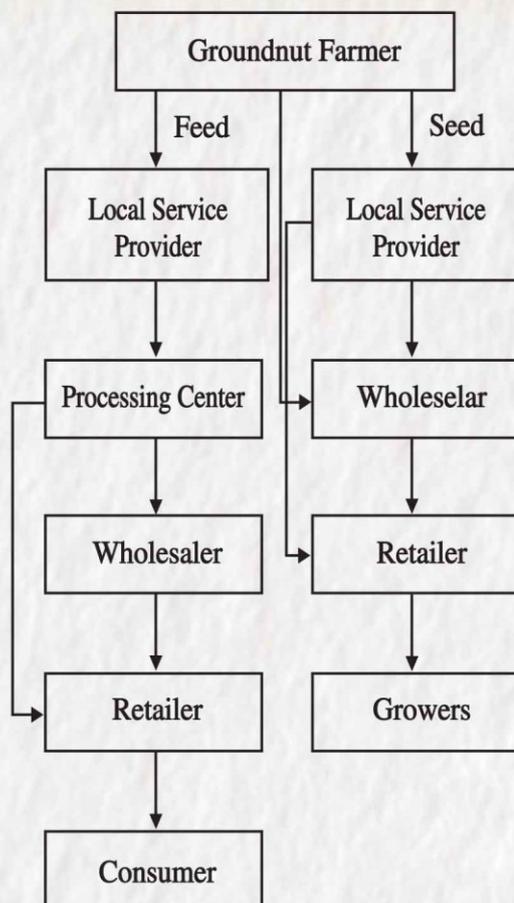
- Channel-6: Farmer → LSP → Wholesaler → Retailer → Growers ---- 32%
- Channel-7: Farmer → LSP → Retailer → Growers ---- 48%
- Channel-8: Farmer → LSP → Growers ---- 20%

Flow Chart 11.iv.4. Existing and improved marketing channel of Groundnut

Existing Marketing Channel



Improved Marketing Channel



Existing marketing Channel

Process Groundnut

Channel-1: Farmer → Faria → Bepari → Processing centre → Wholesaler → Retailer → Consumer ----- 25%

Channel-2: Farmer → Bepari → Processing centre → Wholesaler → Retailer → Consumer ----- 65%

Un Process Groundnut

Channel-3: Farmer → Faria → Bepari → Wholesaler → Retailer → Consumer ----- 7%

Improved Marketing Channel

For Feed

Channel-4: Farmer → Bepari → Wholesaler → Consumer ----- 7%

Channel-5: Farmer → LSP → Processing centre → Wholesaler → Retailer → Consumer ----- 15%

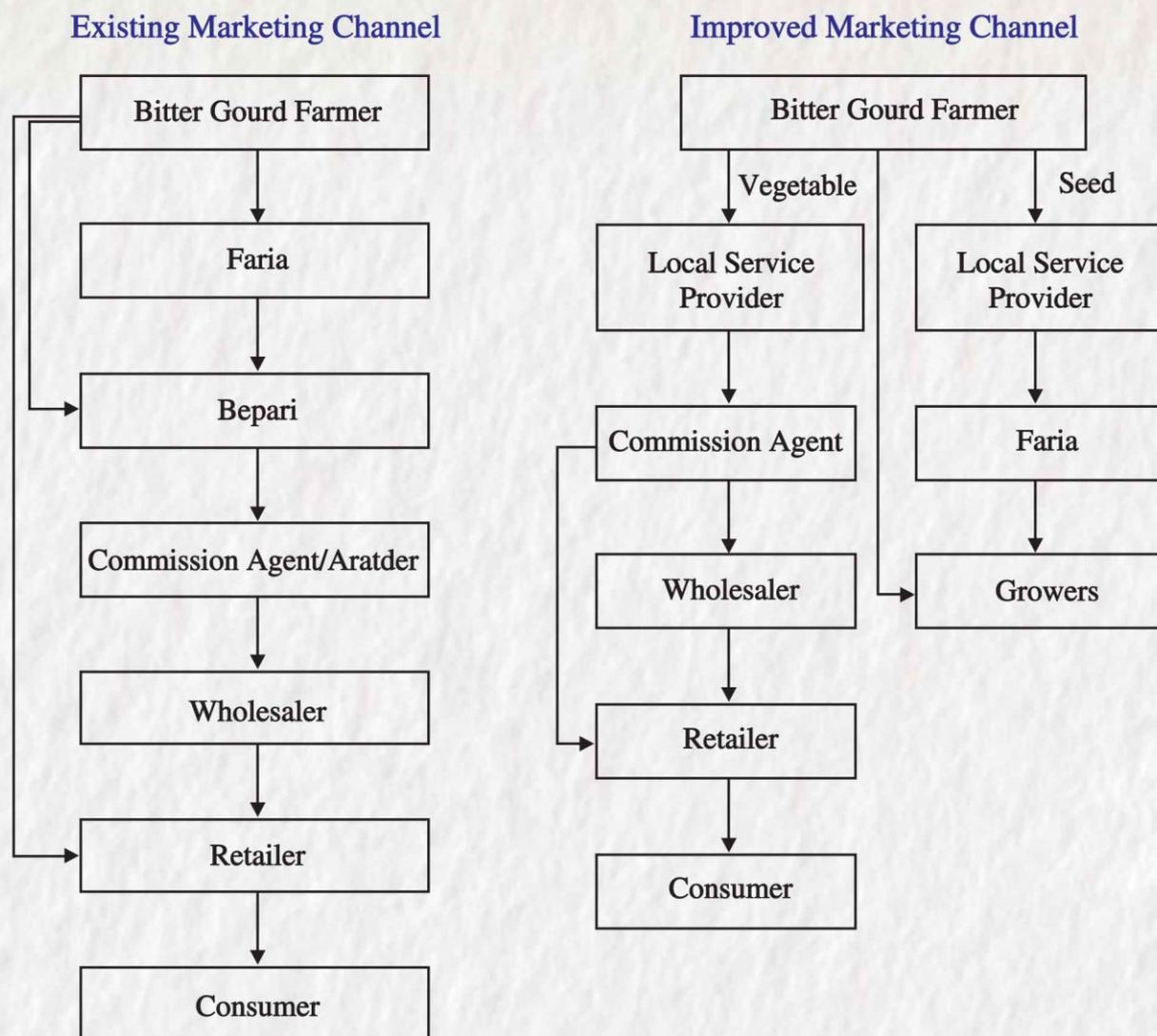
Seed

Channel-6: Farmer → LSP → Wholesaler → Retailer → Growers ----- 35%

Channel-7: Farmer → LSP → Retailer → Growers ----- 55%

Channel-8: Farmer → LSP → Growers ----- 10%

Flow Chart 11.iv.5. Existing and improved marketing channel of Bitter gourd



Existing Marketing Channel

Channel-1: Farmer → Bepari → Commission agent → Wholesaler → Retailer → Consumer ----- 8%

Channel-2: Farmer → Faria → Bepari → Commission agent → Retailer → Consumer ----- 61%

Channel-3: Farmer → Bepari → Commission agent → Retailer → Consumer ----- 23%

Channel-4: Farmer → Retailer → Consumer ----- 8%

Improved Marketing Channel

Channel for Fresh Vegetable

Channel-5: Farmer → LSP → Commission agent → Wholesaler → Retailer → Consumer ----- 15%

Channel-6: Farmer → LSP → Commission agent → Retailer → Consumer ----- 85%

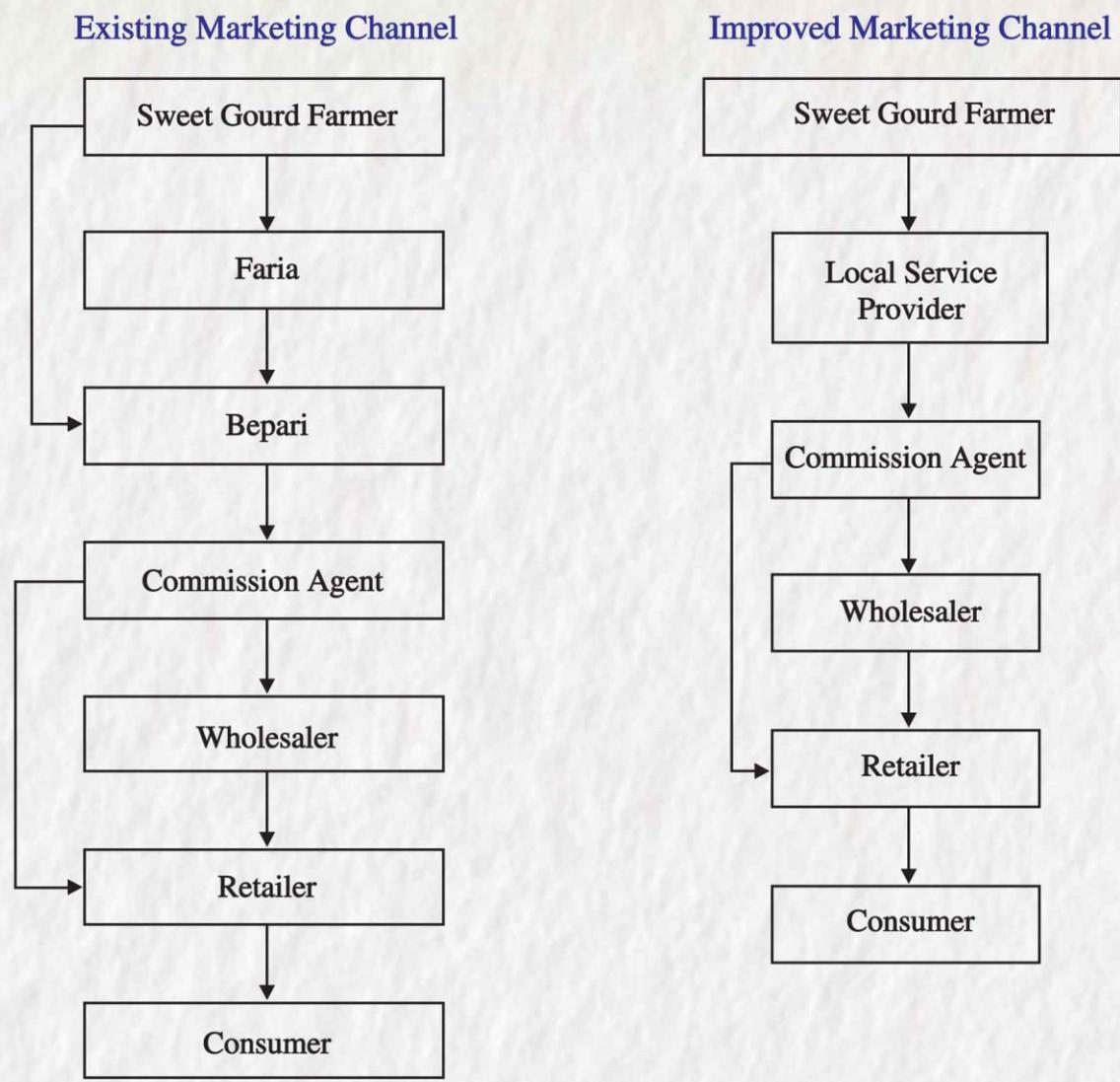
Channel for Seed

Channel-7: Farmer → LSP → Retailer → Grower ----- 51%

Channel-8: Farmer → LSP → Growers ----- 35%

Channel-9: Farmer → Growers ----- 14%

Flow Chart 11.iv.6. Existing and improved marketing channel of Sweet gourd



Existing Marketing Channel

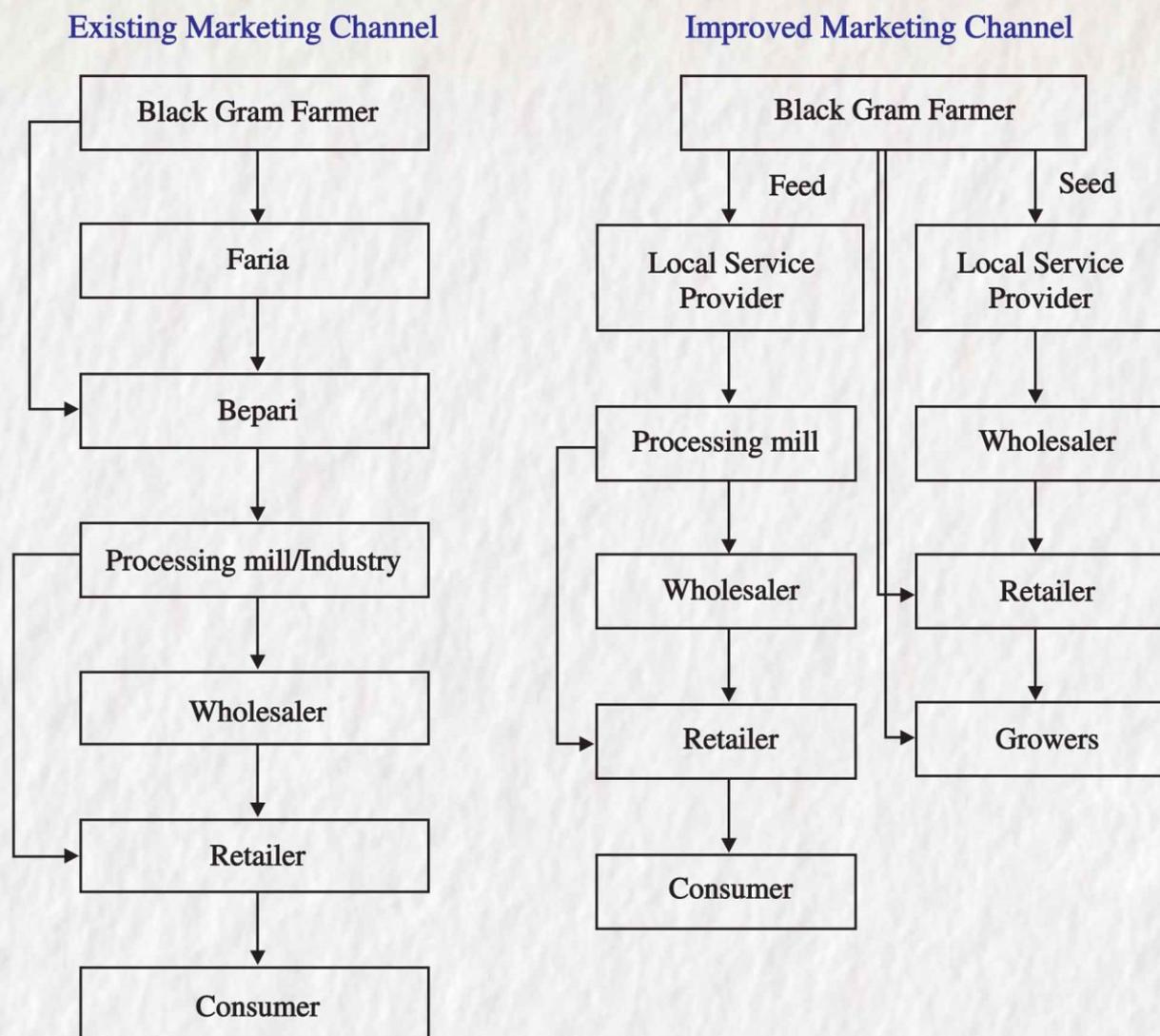
- Channel-1: Farmer → Bepari → Commission agent → Wholesaler → Retailer → Consumer ----- 12%
- Channel-2: Farmer → Faria → Bepari → Commission agent → Wholesaler → Retailer → Consumer ----- 26%
- Channel-3: Farmer → Faria → Bepari → Commission agent → Retailer → Consumer ----- 57%
- Channel-4: Farmer → Retailer → Consumer ----- 5%

Improved Marketing Channel

Channel for Fresh Vegetable

- Channel-5: Farmer → LSP → Commission agent → Wholesaler → Retailer → Consumer ----- 24%
- Channel-6: Farmer → LSP → Commission agent → Retailer → Consumer ----- 76%

Flow Chart 11.iv.7. Existing and improved marketing channel of Blackgram



Existing Marketing Channel

Channel-1: Farmer → Faria → Bepari → Processing mill → Wholesaler → Retailer → Consumer ----- 61%

Channel-2: Farmer → Bepari → Processing mill → Wholesaler → Retailer → Consumer ----- 29%

Channel-3: Farmer → Bepari → Processing mill → Retailer → Consumer ----- 10%

Improved Marketing Channel

Improved (Feed)

Channel-4: Farmer → LSP → Processing mill → Wholesaler → Retailer → Consumer ----- 84%

Channel-5: Farmer → LSP → Processing mill → Retailer → Consumer ----- 16%

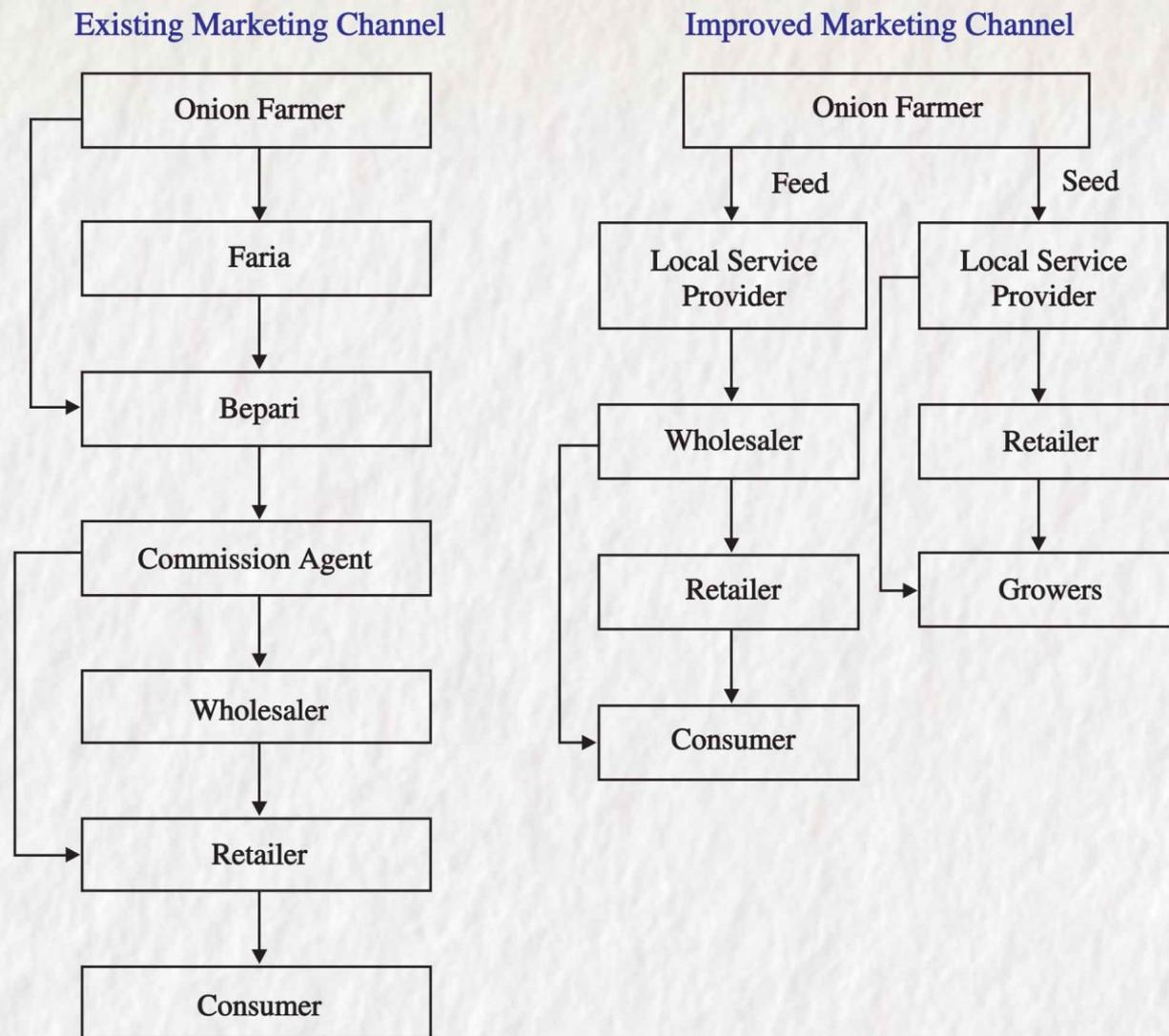
Improved (Seed)

Channel-6: Farmer → LSP → Wholesaler → Retailer → Growers ----- 71%

Channel-7: Farmer → Retailer → Growers ----- 17%

Channel-8: Farmer → Growers ----- 12%

Flow Chart 11.iv.8. Existing and improved marketing channel of Onion



Existing Marketing Channel

- Channel-1: Farmer → Faria → Bepari → Commission agent → Retailer → Consumer ----- 75%
- Channel-2: Farmer → Bepari → Commission agent → Wholesaler → Retailer → Consumer ----- 10%
- Channel-3: Farmer → Bepari → Commission agent → Retailer → Consumer ----- 15%

Improved Marketing Channel

Improved (Feed)

- Channel-4: Farmer → LSP → Commission agent → Wholesaler → Retailer → Consumer ----- 14%
- Channel-5: Farmer → LSP → Commission agent → Retailer → Consumer ----- 86%

Improved (Seed)

- Channel-6: Farmer → LSP → Retailer → Growers ----- 59%
- Channel-7: Farmer → LSP → Growers ----- 34%

Marketing cost and margin

A marketing margin is the percentage of the final weighted average selling price taken by each stage of the marketing chain. The margin must cover the costs involved in transferring produce from one stage to the next and provide a reasonable return to those doing the marketing. Generally, marketing margin is the difference between consumer's price and farmer's price. Marketing costs or expenses include expenses incurred to change the title of goods, promotion of goods, inventory costs, distribution of goods etc. There were many marketing channels involved in farm product (Blackgram, Ground nut, Foxtail millet, Sweet gourd, Sweet potato, Bitter gourd, chilli and Onion) marketing. Mainly, most efficient marketing channel indicates lesser number of middlemen, the lowest marketing margin and also the lowest marketing cost. Marketing cost and margins of different marketing channel for sweet potato, foxtail millet, lentil, ground nut, bitter gourd, sweet gourd, blackgram, and onion have been shown in the Table-11.iv.1-8. In the existing marketing channel of sweet potato, channel-4 (Farmer-Bepari-Aratder/commission agent-consumer) was efficient (rank 1) whereas in the improved marketing channel, channel-7 (Famer-local service provider-Retailer-Consumer) was efficient (rank-1). In the existing marketing channel, Farmer-Bepari-Processing center-whole saler-Consumer was the efficient channel for lentil and foxtail millet marketing. Again, in the improved marketing channel Farmer-Local service provider-commission agent-retailer-Consumer was the efficient marketing channel (rank 1) for sweet gourd, bitter gourd and onion.

Table 11.iv.1. Marketing cost & margin of different marketing channel of sweet potato

Particulars	Existing marketing channel (Feed)				Improved marketing channel (Feed)		
	Channel-1	Channel-2	Channel-3	Channel-4	Channel-5	Channel-6	Channel-7
Farmers' price (Tk/qt)	1520	1525	1525	1525	1650	1650	1650
Consumer price (Tk/qt)	3250	3240	3010	2905	2860	2780	2110
Marketing margins (Tk/qt)	1730	1715	1485	1380	1210	1130	460
Rank	7	6	5	4	3	2	1
Marketing cost (MC)	1730	1715	1485	1380	1210	1130	460
Net Margins	650	625	575	500	530	420	140
Rank	6	5	4	3	4	2	1

Channel-1: Farmer → Faria → Bepari → Aratder → Wholesaler → Retailer → Consumer

Channel-2: Farmer → Bepari → Aratder → Wholesaler → Retailer → Consumer

Channel-3: Farmer → Bepari → Aratder → Retailer → Consumer

Channel-4: Farmer → Bepari → Aratder → Consumer

Channel-5: Farmer → Local Service Provider → Wholesaler → Retailer → Consumer

Channel-6: Farmer → Local Service Provider → Aratder → Retailer → Consumer

Channel-7: Farmer → Local Service Provider → Retailer → Consumer

Table 11.iv.2. Marketing cost & margin of different marketing channel of foxtail millet

Particulars	Existing marketing channel				Improved marketing channel			
	Feed				Feed			Seed
	Channel-1	Channel-2	Channel-3	Channel-4	Channel-5	Channel-6	Channel-7	Channel-8
Farmers' price (Tk/qt)	4125	4175	4175	4175	4475	4475	4475	4875
Consumer price (Tk/qt)	9875	9825	9750	9710	9875	9925	8900	8700
Marketing margins (Tk/qt)	5750	5650	5575	5535	5400	5450	4425	3825
Rank	4	3	2	1	2	3	1	-
Marketing cost (Tk/qt)	2725	2720	2680	2610	2535	2625	2450	1200
Net marketing margins (Tk/qt)	3025	2930	2895	2925	2865	2825	1975	2625
Rank	7	6	4	5	3	2	1	-

Channel-1: Farmer → Faria → Bepari → Processing centre → Wholesaler → Retailer → Consumer-----52%;

Channel-2: Farmer → Bepari → Processing centre → Wholesaler → Retailer consumer-----26%;

Channel-3: Farmer → Bepari Processing centre → Retailer → Consumer-----19%;

Channel-4: Farmer → Bepari → Processing centre → Wholesaler → Consumer-----3%;

Channel-5: Farmer → Local service provider → Processing centre → Wholesaler → Retailer → Consumer ----- 65;

Channel-6: Farmer → Local service provider → Processing centre → Wholesaler → Consumer ----- 12;

Channel-7: Farmer → Local service provider → Processing center → Retailer → Consumer → Retailer → Consumer ---- 23;

Channel-8: Farmer → Local service provider → Grower

Table 11.iv.3. Marketing cost and margins of different marketing channel for lentil

Particulars	Existing marketing channel				Improved marketing channel			
	Feed				Feed	Seed		
	Channel-1	Channel-2	Channel-3	Channel-4	Channel-5	Channel-6	Channel-7	Channel-8
Farmers' price (Tk/qt)	5560	5540	5540	5540	5630	8110	8110	8110
Consumer price (Tk/qt)	8190	8150	8140	8105	8090	9870	9650	9550
Marketing margins (Tk/qt)	2630	2610	2600	2565	2460	1760	1540	1440
Rank	4	3	2	1	0	3	2	1
Marketing cost (Tk/qt)	1350	1310	1240	1220	1225	950	920	850
Net marketing margins (Tk/qt)	1280	1300	1360	1345	1235	810	620	590
Rank	6	7	8	5	4	3	2	1

Channel-1: Farmer → Faria → Bepari → Processing centre → Wholesaler → Retailer → Consumer ----- 55%;

Channel-2: Farmer → Bepari → Processing centre → Wholesaler → Retailer → Consumer ----- 27%;

Channel-3: Farmer → Bepari → Processing centre → Retailer → Consumer ----- 11%;

Channel-4: Farmer → Bepari → Processing centre → Wholesaler → Consumer ----- 7%;

Channel-5: Farmer → LSP → Processing centre → Wholesaler → Retailer → Consumer ----- 15%;

Channel-6: Farmer → LSP → Wholesaler → Retailer → Growers ----- 32%;

Channel-7: Farmer → LSP → Retailer → Growers ----- 48%;

Channel-8: Farmer → LSP → Growers ----- 20%

Table 11.iv.4. Marketing cost & margins of different marketing channel for groundnut

Particulars	Existing marketing channel				Improved marketing channel			
	Feed				Feed	Seed		
	Channel-1	Channel-2	Channel-3	Channel-4	Channel-5	Channel-6	Channel-7	Channel-8
Farmers' price (Tk/qt)	4625	4690	4575	4595	4750	9750	9750	9750
Consumer price (Tk/qt)	9875	9825	6910	6875	9725	14400	13625	13475
Marketing margins (Tk/qt)	5250	5135	2335	2280	4975	4650	3875	3725
Rank	2	1	2	1	-	3	2	1
Marketing cost (Tk/qt)	2390	2325	950	975	2225	3200	2850	2750
Net marketing margins (Tk/qt)	2860	2810	1385	1305	2750	1450	1025	975
Rank	8	7	5	4	6	3	2	1

Channel-1: Farmer → Faria → Bepari → Processing centre → Wholesaler → Retilar → Consumer ---- 25%;

Channel-2: Farmer → Bepari → Processing centre → Wholesaler → Retilar → Consumer ---- 65%;

Channel-3: Farmer → Faria → Bepari → Wholesaler → Retilar → Consumer ---- 7%;

Channel-4: Farmer → Bepari → Wholesaler → Retilar → Consumer ---- 3%;

Channel-5: Farmer → LSP → Processing centre → Wholesaler → Retilar → Consumer ---- 10%;

Channel-6: Farmer → LSP → Wholesaler → Retailer → Growers ---- 35%

Channel-7: Farmer → LSP → Retailer → Growers ---- 55%;

Channel-8: Farmer → LSP → Growers ---- 10%

Table 11.iv.5. Marketing cost & margins of different marketing channel for bitter gourd

Particulars	Existing marketing channel				Improved marketing channel				
	Feed				Feed		Seed		
	Channel-1	Channel-2	Channel-3	Channel-4	Channel-5	Channel-6	Channel-7	Channel-8	Channel-9
Farmers' price (Tk/qt)	3450	3410	3440	3450	3490	3490	13150	13150	13150
Consumer price (Tk/qt)	6144	6240	6045	5542	6010	5990	17440	17102	16220
Marketing margins (Tk/qt)	2694	2830	2605	2092	2520	2500	4290	3952	3070
Rank	4	3	2	1	2	1	3	2	1
Marketing cost (Tk/qt)	1230	1310	1150	740	1125	1280	1320	1350	1260
Net marketing margins (Tk/qt)	1464	1520	1455	1352	1395	1220	2970	2602	1810
Rank	5	6	4	2	3	1	3	2	1

Channel-1: Farmer → Bepari → Commission agent → Wholesaler → Retailer → Consumer ----- 8%;

Channel-2: Farmer → Faria → Bepari → Commission agent → Retailer → Consumer ----- 61%;

Channel-3: Farmer → Bepari → Commission agent → Retailer → Consumer ----- 23%;

Channel-4: Farmer → Retailer → Consumer ----- 71%;

Channel-5: Farmer → LSP → Commission agent → Wholesaler → Retailer → Consumer ----- 15%;

Channel-6: Farmer → LSP → Commission agent → Retailer → Consumer ----- 85%;

Channel-7: Farmer → LSP → Retailer → Grower ----- 51%;

Channel-8: Farmer → LSP → Growers ----- 35%;

Channel-9: Farmer → Growers ----- 14%

Table 11.iv.6. Marketing cost & margins of different marketing channel for sweet gourd

Particulars	Existing marketing channel (Feed)				Improved marketing channel (Feed)	
	Channel-1	Channel-2	Channel-3	Channel-4	Channel-5	Channel-6
Farmers' price (Tk/qt)	1820	1890	1890	1760	1890	1896
Consumer price (Tk/qt)	3450	3550	3510	2730	3470	3450
Marketing margins (Tk/qt)	1630	1660	1620	970	1580	1554
Rank	3	4	2	1	2	1
Marketing cost (Tk/qt)	880	850	820	440	860	840
Marketing margins (Tk/qt)	750	810	800	530	720	714
Rank	4	6	5	1	3	2

Channel-1: Farmer → Bepari → Commission agent → Wholesaler → Retailer → Consumer ----- 12%

Channel-2: Farmer → Faria → Bepari → Commission agent → Wholesaler → Retailer → Consumer ----- 26%

Channel-3: Farmer → Bepari → Faria → Bepari Commission agent → Retailer → Consumer ----- 57%

Channel-4: Farmer → Retailer → Consumer ----- 5%

Channel-5: Farmer → LSP → Commission agent → Wholesaler → Retailer → Consumer ----- 24%

Channel-6: Farmer → LSP → Commission agent → Retailer → Consumer ----- 76%

Table 11.iv.7. Marketing cost & margins of different marketing channel for blackgram

Particulars	Existing marketing channel			Improved marketing channel				
	Channel-1	Channel-2	Channel-3	Channel-4	Channel-5	Channel-6	Channel-7	Channel-8
Farmers' price (Tk/qt)	7380	7290	7290	7450	7450	8450	8340	8310
Consumer price (Tk/qt)	11250	11160	11060	11020	10960	11150	11030	10850
Marketing margins (Tk/qt)	3870	3870	3770	3570	3510	2700	2690	2540
Rank	2	2	1	2	1	3	2	1
Marketing cost (Tk/qt)	2750	2780	2710	2640	2650	1320	1280	1160
Net marketing margins (Tk/qt)	1120	1090	1060	930	860	1380	1410	1380
Rank	5	4	3	2	1	3	2	1

Channel-1: Farmer → Faria → Bepari → Processing mill → Wholesaler → Retailer → Consumer ----- 61%

Channel-2: Farmer → Bepari → Processing mill → Wholesaler → Retailer → Consumer ----- 29%

Channel-3: Farmer → Bepari → Processing mill → Retailer → Consumer ----- 10%

Channel-4: Farmer → LSP → Processing mill → Wholesaler → Retailer → Consumer ----- 84%

Channel-5: Farmer → LSP → Processing mill → Retailer → Consumer ----- 16%

Channel-6: Farmer → LSP → Wholesaler → Retailer → Growers ----- 71%

Channel-7: Farmer → Retailer → Growers ----- 17%

Channel-8: Farmer → Growers ----- 12%

Table 11.iv.8. Marketing cost & margins of different marketing channel for onion

Particulars	Existing marketing channel			Improved marketing channel			
	Feed			Feed		Seed	
	Channel-1	Channel-2	Channel-3	Channel-4	Channel-5	Channel-6	Channel-7
Farmers' price (Tk/qt)	3150	3140	3140	3250	3250	275000	275000
Consumer price (Tk/qt)	4860	4810	4750	4750	4710	284500	284200
Marketing margins (Tk/qt)	1710	1670	1610	1500	1460	9500	9200
Rank	3	2	1	2	1	2	1
Marketing cost (MC)	980	970	960	860	850	2552	2450
Net Margins	730	700	650	640	610	6948	6750
Rank	5	4	3	2	1	2	1

Channel-1: Farmer → Faria → Bepari → Commission agent → Retailer → Consumer.....75%

Channel-2: Farmer → Bepari → Commission agent → Wholesaler → Retailer → Consumer.....10%

Channel-3: Farmer → Bepari → Commission agent → Retailer → Consumer.....15%

Channel-4: Farmer → LSP → Commission agent → Wholesaler → Retailer Consumer.....14%

Channel-5: Farmer → LSP → Commission agent → Retailer → Consumer.....86%

Channel-6: Farmer → LSP → Retailer → Growers.....59%

Channel-7: Farmer → LSP → Growers.....34%



Fig. 11.iv.1: Crop product collection point establishment and container, tag, bag, packet etc. distribution for marketing system development at Char Begumganj, Kurigram, Jagatber, Lalmonirhat and Saghata, Gaibandha.



Fig. 11.iv.2: Sweet gourd harvesting, bringing to the collection point, transportation for marketing at Jagatber, Lalmonirhat.

Component-2: BAU

11.v.1 (Experiment 1): Seed quality assessment of different genotypes of pre-selected crops through seed germination and seed health

11.v.1a (Expt.1a): Effect of drought stress on germination and early growth stage of maize

Among the 30 Genotypes, FGP levels were higher in 981, KMH 25K15, Gold Star, Kaveri 218, Star Beej 7 star at different PEG concentrations (Fig. 11.v.1a.1, Table 11.v.1a.1). On the other hand, very low levels of FGP were observed in the cultivars BM6, BM7, BHM7, BHM3, BARI Misti Bhutta and Mohor at 6 and 12% Polyethylene Glycol (PEG) treatments (Fig. 11.v.1a.1, Table 11.v.1a.1). The highest FGP at 12% PEG concentration was found in Gold Star, Star Beej 7star and Essence Platinum whereas the lowest FGP was recorded in BM6 followed by Mohor cultivar.

Table 11.v.1a.1: Final Germination Percentage (FGP, %), root length (mm) and shoot length (mm) of 30 maize Genotypes at three levels (0, 6 and 12 % PEG) of water stress

Genotypes	% Germination			Root length (mm)			Shoot length (mm)		
	0	6	12	0	6	12	0	6	12
Laxmi 949	90	57	17	123.0	35.7	6.0	6.7	0.0	0.0
Bisco 740	93	73	23	251.7	100.7	21.5	9.3	2.0	0.0
Kaveri 218	100	77	67	241.7	88.0	38.3	35.0	9.3	6.3
Pioneer	97	87	67	131.0	71.3	37.3	21.0	2.7	3.3
KMH 25K15	100	87	77	248.3	114.7	42.3	46.3	1.0	1.5
Bharati 40	97	80	50	139.0	91.0	15.3	9.0	6.0	1.3
981	100	97	73	291.7	191.0	41.3	51.0	17.0	3.3
Bharati 888	90	53	57	149.7	70.0	29.3	4.7	1.3	0.3
Paloan	90	87	73	143.0	111.0	66.7	14.7	2.0	1.7
Gold Star	100	93	83	218.3	83.0	64.7	33.7	3.3	0.5
Dekalb Elit	100	100	73	230.0	158.3	49.0	13.7	19.7	2.0
Dekalb 900M	97	80	67	226.7	91.7	41.0	27.3	7.7	2.0
Bisco 51	100	93	77	232.0	101.7	64.7	7.0	2.3	2.3
BHM-13	87	87	80	213.0	122.3	89.7	46.0	20.3	11.7
Probhat	83	80	67	195.0	83.7	37.0	12.3	5.0	2.0
Seed Tech Bisco Prince	100	90	70	336.7	110.0	39.3	23.0	3.3	0.7
Star Beej 7star	100	90	83	326.7	138.0	62.0	30.3	10.3	2.3
Star Beej Kohinoor	80	70	43	127.3	79.7	21.0	10.7	0.3	0.0
Essence Platinum	100	97	83	366.7	192.3	76.3	101.7	31.3	13.3
Unigreen UB100	93	83	47	211.0	104.7	29.3	28.3	8.0	3.0
Unigreen NK41	97	100	77	185.0	127.7	64.3	43.7	22.0	5.7
BARI Misti Bhutta	27	43	7	35.0	22.0	3.0	4.3	3.3	0.0
BHM3	63	43	3	71.7	25.7	1.0	15.7	3.0	0.0
BHM5	90	73	13	144.3	51.7	2.0	33.0	9.0	0.0
BHM6	73	70	37	117.7	64.7	17.3	26.0	3.0	1.3
BHM7	93	33	10	240.7	20.0	4.0	45.3	0.0	0.0
BHM-9	97	70	17	128.3	50.7	5.7	25.3	3.7	0.7
BM6	30	23	0	6.7	8.0	0.0	3.3	1.0	0.0
BM7	77	57	27	143.3	28.7	7.3	25.0	0.3	0.0
Mohor	0	3	0	0.0	1.0	0.0	0.0	0.0	0.0

The better FGP performing cultivars also showed higher root and shoot length at different PEG concentrations (Table 11.v.1.1). Essence Platinum and BHM-13 cultivars had the highest root length at 6 and 12 % PEG treatments, respectively. The lowest root length was recorded in Mohor at both PEG treatments. The maximum shoot length was observed in Essence Platinum followed by BHM-13 whereas the minimum shoot length were found in Mohor and BHM7 at both PEG concentrations (Table 11.v.1.1).

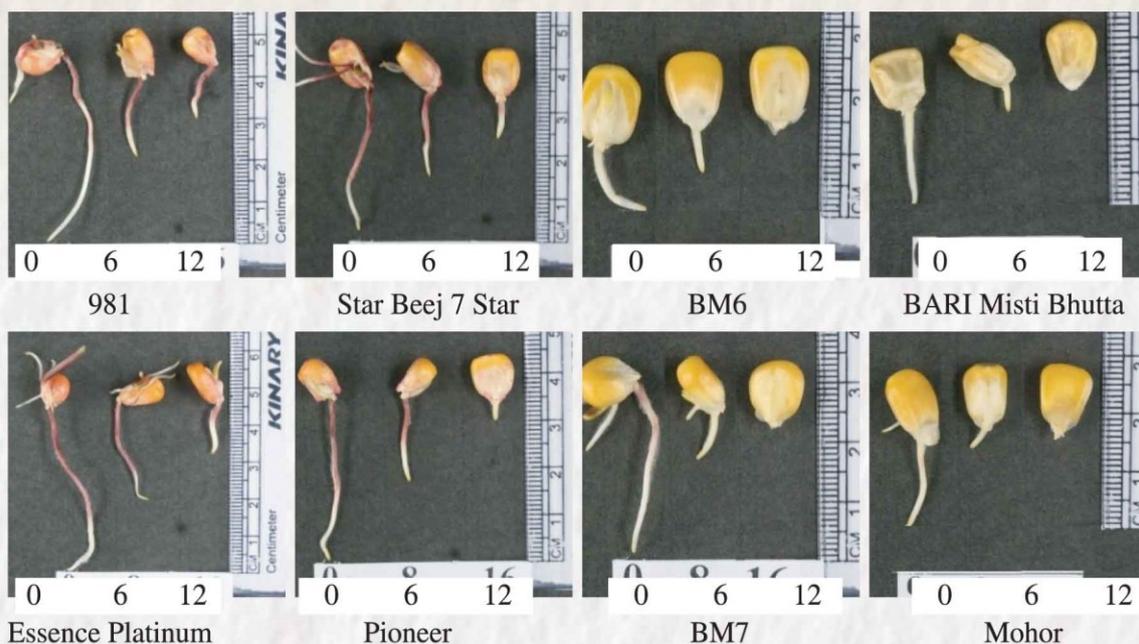


Fig. 11.v.1a.1: Photographs show some good performing (first two columns) and some bad performing (last two columns) genotypes based on the performance of seed germination at different levels of water stress (0, 6 and 12 % PEG).

Genotypes had different responses in Germination Stress Tolerance Index (GSTI) at different levels of water stress (Table 11.v.1a.2). The mean GSTI values of two PEG treatments (6 and 12 % PEG) of all genotypes are shown in Table 11.v.1.2 and this GSTI ranking was used for the screening of maize genotypes for drought tolerance. The GSTI of all genotypes ranged from 0 to 84% with a significant variation among them (Table 11.v.1a.2).

Table 11.v.1a.2: Germination Stress Tolerance Index (GSTI) of 30 maize Genotypes. Values are mean GSTI of 6 and 12 % PEG treatments

Genotypes	Treat. Means	Genotypes	Treat. means
981	83.52 a	BHM6	45.13 defghi
BHM-13	74.202 ab	Kaveri 218	43.24 defghij
Essence Platinum	66.04 abc	Shuvra	42.82 efghijk
Pioneer	65.93 abc	BARI Misti Bhutta	36.56 fghijkl
Dekalb Elit	65.84 abc	BHM5	31.00 ghijklm
Unigreen NK41	63.30 abcd	Bisco 740	30.55 hijklm
BISCO 51	62.21 bcde	BHM-9	26.64 ijklm
Star beej 7star	62.00 bcde	Bornali	25.45 ijklm
Paloan	61.61 bcde	Laxmi 949	25.45 ijklm
Bharati 40	60.24 bcde	Khoi Bhutta	24.94 ijklm
Probhat	59.32 bcde	BM6	24.08 jklm
Seed Tech Bisco Prince	59.23 bcde	BM7	22.94 klm
Gold Star	58.96 bcde	BHM3	20.90 lm
Dekalb 900M	56.41 bcdef	BHM7	10.90 mn
KMH 25K15	52.30 cdef	Mohor	0.00 n
Level of sig.	***		***

In a column, figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.
 *** = Significant at 0.1% level of probability.

The RLSI values ranged from 0 to 68% while the SLSI values of all Genotypes ranged from 0 to 58% (Table 11.v.1a.3). The genotypes 981 had the highest and Mohor had the lowest RLSI and SLSI values, respectively (Table 11.v.1a.3). The RLSI and SLSI values of 6 and 12 % PEG are shown in Table 11.v.1a.3.

Table 11.v.1a.3: Root Length Stress Index (RLSI) and Shoot Length Stress Index (SLSI) of 30 maize Genotypes. Values are treatment mean RLSI and SLSI of 6 and 12 % PEG treatments

Genotypes	RLSI (%)		SLSI (%)	
	Means	Genotypes	Means	Genotypes
981	67.7 a	981	58.06 a	
BHM-13	66.9 ab	BHM-13	38.6 ab	
Unigreen NK41	55.8 abc	Unigreen NK41	37.3 abc	
Bisco 51	51.8 abcd	Paloan	30.1 abcd	
Pioneer	50.0 abcde	Essence Platinum	29.2 abcd	
Gold Star	49.8 abcde	Star Beej 7star	28.7 abcd	
Dekalb Elit	46.5 abcdef	Dekalb Elit	27.2 abcd	
Star Beej 7star	46.4 abcdef	Probhat	25.5 abcd	
Probhat	44.0 abcdefgh	Unigreen UB100	19.2 abcd	
Bharati 40	44.0 abcdefgh	Pioneer	18.1 bcd	
Kaveri 218	42.3 abcdefgh	KMH 25K15	16.9 bcd	
Paloan	41.7 abcdefgh	Seed Tech Bisco Prince	16.7 bcd	
Dekalb 900M	40.5 bcdefgh	BHM-9	16.3 bcd	
BHM6	37.4 cdefghi	Bharati 40	13.9 bcd	
KMH 25K15	37.1 cdefghi	Kaveri 218	12.6 bcd	
BARI Misti Bhutta	36.6 cdefghi	Bisco 51	12.4 bcd	
Essence Platinum	35.9 cdefghi	Dekalb 900M	12.3 bcd	
Khoi Bhutta	35.5 cdefghi	BHM5	10.8 bcd	
Seed Tech BiscoPrince	35.3 cdefghi	BHM6	9.7 bcd	
Shuvra	32.1 cdefghi	Gold Star	9.5 bcd	
Bisco740	29.4 cdefghi	Bharati 888	2.3 bcd	
Bornali	25.1 defghij	Shuvra	1.9 cd	
BHM5	23.2 efghij	Bisco740	0.9 d	
BHM-9	22.4 fghij	Bornali	0.5 d	
Laxmi 949	21.8 fghij	BM7	0.0 d	
BM6	17.7 ghij	Star Beej Kohinoor	0.0 d	
BHM7	17.5 ghij	BARI Misti Bhutta	0.0 d	
BM7	17.2 hij	BHM7	0.0 d	
BHM3	12.4 ij	Laxmi 949	0.0 d	
Mohor	0.0 j	Mohor	0.0 d	
Level of sig.	***	***	***	

In a column, figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.
 *** = Significant at 0.1% level of probability

Based on the above discussed parameters, it was found Gold Star, BHM-13, Paloan, 981, BHM-9 and Pioneer performed better and selected for hydroponics and further investigations.

11.v.1b (Expt. 1b): Effect of drought stress on germination and early growth stage of chilli

Among the 9 Genotypes, FGP levels were higher in BARI Morich-1 followed by BARI Morich-2 and local (Jhau) at 5% PEG levels (Table 11.v.1b.1). On the other hand, very low levels of FGP were observed in the cultivars local (Shampur), local (Kurigram) and BARI Morich-4 at 5% Polyethylene Glycol (PEG) treatments (Table 4). The lowest FGP at 5% PEG concentration was found in local (Ulipur).

The better FGP performing cultivars also showed higher root and shoot length at different PEG level concentrations (Table 11.v.1b.2). Local (Jhau) cultivars had the highest root length at 5% PEG treatments. The lowest root length was recorded in local (Ulipur) at 5% PEG treatments. The maximum shoot length was observed in BARI Morich-4 whereas the minimum shoot length were found in BARI Morich-2 followed by local (Shampur) at 5% PEG concentrations (Table 11.v.1b.2).

Genotypes had different responses in Germination Stress Tolerance Index (GSTI) at 5% levels of water stress (Table 11.v.1b.2). The mean GSTI, RLSI and SLSI values of 5% PEG treatments of all genotypes are shown in Table 11.v.1b.2 and this GSTI, RSLI and SLSI ranking was used for the screening of chilli genotypes for drought tolerance. Local (Jhau), BARI Morich-3, BARI Morich-2, Binamorich-1, BARI Morich-4 genotypes were selected based on GSTI, RSLI and SLSI.

Table 11.v.1b.1: Effect of water stress on germination and growth parameters of chilli genotypes

Genotypes	% Germination		Root length (mm)		Shoot length (mm)	
	Control	5% PEG	Control	5% PEG	Control	5% PEG
Local (Jhau)	90.0	80.0	4.27	3.47	1.17	0.83
Local (Shampur)	63.3	53.3	3.07	2.27	0.85	0.54
BARI Morich-3	86.7	60.0	2.33	1.23	1.46	0.93
Local (Kurigram)	66.7	50.0	1.80	1.23	1.08	0.76
BARI Morich-2	83.3	80.0	2.37	1.93	1.73	0.53
Local (Ulipur)	60.0	36.7	1.30	0.72	0.93	0.43
BARI Morich-1	90.0	80.0	2.07	1.67	1.93	1.02
BINA Morich-1	86.7	73.3	2.69	1.20	1.45	0.98
BARI Morich-4	86.7	56.7	2.37	1.83	1.85	1.69

Table 11.v.1b.2: Germination and growth stress tolerance index of chilli genotypes against drought stress

Genotypes	GSTI	RLSI (%)	SLSI (%)
Local (Jhau)	76.5 a	86.3 ab	71.313b
Local (Shampur)	64.6 bc	69.0 bc	30.653e
BARI Morich-3	73.3 a	80.5 ab	63.939bcd
Local (Kurigram)	53.1 d	54.6 c	51.614d
BARI Morich-2	72.7 a	81.4 ab	63.702bcd
Local (Ulipur)	57.2 cd	77.739ab	52.726cd
BARI Morich-1	71.9 ab	84.768ab	67.913bc
BINA Morich-1	73.0 a	90.417a	91.488a
BARI Morich-4	73.8 a	53.103c	27.157e
Level of Sig.	***	***	***

In a column, figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.
*** = Significant at 0.1% level of probability.

11.v.1c (Expt. 1c): Effect of drought stress on germination and early growth stage of groundnut

Germination percentage, root and shoot length

In the life cycle of plant germination is one of the most critical periods. The effect of increasing concentration of PEG during seed germination and the response of genotypes to the increasing concentrations was measured to determine the tolerance of groundnut genotypes under water deficit conditions. Table 11.v.1c.1 showed that the germination percentage was reduced with the increase of PEG concentration. The highest germination was found in the control condition and the minimum was at 10% PEG (Table 11.v.1c.1). However, there are many genotypes which showed 100% germination even in the high PEG concentration such as ICGV-1224-G75, BARI Chinabadam-9, ICGV-00338, ICGV-02125 and BARI Chinabadam- 10 while the lowest germination value was shown in ICGV-07217 at 10% PEG followed by K-2 and ICGV-06279 (60%). In the case of root length and shoot length, similar results were found in different genotypes. At 10% PEG concentration, the highest root length was observed in ICGV-07214 (5.8 mm) followed by BARI Chinabadam-8 (5.62) while some genotypes were found without any root length at the same PEG concentration (Table 11.v.1c.1).

Similarly, the shoot length was found higher in the minimum stress condition whereas it was decreasing with increasing PEG concentration. At 10% PEG concentration, the highest shoot length was found in ICGV-02125 while some genotypes were found with no shoot at all such as BARI Chinabadam-6, BARI Chinabadam-8, ICGV-06279, SDG-568, ICGV-95469, ICGV-95063, K-2, SDG-532-01, ICGV-02096, ICGV-95460, ICGV-0504-7, ICGV-0207, BARI Chinabadam-10, ICGV-00338, ICGV-07220 and ICGV-05096.

Table 11.v.1c.1: Final Germination Percentage (FGP, %), root length (mm) and shoot length (mm) of 45 Groundnut Genotypes at three levels (0%, 5% and 10 % PEG) of water stress

Genotypes	FGP (%)			Root length (mm)			Shoot length (mm)		
	0%	5%	10%	0%	5%	10%	0%	5%	10%
ICGV-1224-G75	100.00	100	100	6.4	3.76	2.37	8.067	5.23	3.43
BARI Chinabadam-9	96.67	100	100	9.21	5.81	5.27	7.1	6.27	4.13
ICGV-07214	100.00	96.67	93.33	10.69	7.46	5.8	8.1	7.51	4.05
ICGV-05096	96.67	96.67	96.67	7.25	4.17	2.12	7.21	4.33	0
ICGV-07220	100.00	93.33	90	5.73	2.62	0	9.45	0	0
ICGV-00338	100.00	100	100	6.8	3.90	2.24	9.4	4.38	0
BARI Chinabadam-10	100.00	100	100	10.42	7.23	5.48	7.07	5.58	0
ICGV-02125	100.00	96.67	100	8.64	6.2	4.45	11.74	9.86	6.16
ICGV-06423	90.00	93.33	90.67	8.18	4.46	3.82	7.47	5.11	3.11
ICGV-07220	100.00	96.67	86.67	6.83	3.84	2.96	9.92	3.99	3.07
ICGV-0207	96.67	90	86.67	9.06	4.42	2.23	6.42	3.53	0
ICGV-0504-7	100.00	96.67	90	9.16	6.22	2.97	7.35	5.76	0
ICGV-00338	100.00	90	73.33	8.88	5.22	2.26	11.31	8.43	2.52
ICGV-95460	100.00	100	93.33	9.1	5.2	3.2	6.41	3.51	0
ICGV-95070	100.00	96.67	90	9.87	6.8	2.93	8.00	6.62	3.85
ICGV-0140	100	93.33	90	6.87	3.63	2.18	8.71	5.91	1.7
DF 090038-2	100	86.67	80	7.93	4.87	2.87	5.95	2.52	2.42
ICGV-02096	100	86.67	73.33	9.07	5.28	3.54	8.91	5.41	0
ICGV-96175	96.67	96.67	83.33	6.08	3.16	2.31	5.13	2.47	1.61
SDG-532-01	100	93.33	80	7.28	4.18	3.13	4.61	3	0
NCGV-01704	93.3	86.67	83.33	8.03	4.81	2.59	6.25	3.81	1.64
DF-090035	93.3	86.67	80	7.89	4.19	2.60	6.85	4.59	2.52
TG-24	100	80	70	8.07	4.64	3.1	8.71	5.43	2.78
ICGV-93280	83.3	96.67	76.67	7.93	4.27	2.81	6.3	3.86	1.34
ICGV-955090	90	100	73.33	4.96	2.91	2.1	6.03	4.41	2.55
SDG-543-2	100	86.67	70	7.25	4.04	2.19	7.6	5.47	1.05
K-2	83.3	80	60	3.73	1.9	0.76	3.6	0.52	0
ICGV-95063	100	90	73.33	6.05	0	0	6.01	0	0
ICGV-95469	100	100	80	7.5	1.01	0	7.4	1.01	0
ICGV-97232	100	100	90	9.83	5.95	4.71	7.62	6.57	5.35
Binachinabadam-4	100	90	100	9.72	6.22	4.62	6.07	5.31	3.55
ICGV-07217	100	86.67	50	7.4	3.5	2.4	4.93	2.21	0.69
NCGV-14303	96.67	80	100	6.51	2.82	2.61	7.35	3.42	1.26
ICGV-06285	93.33	86.67	83.33	8.17	4.31	2.82	6.01	2.21	0.68
SDG-568	100	93.33	83.33	6.5	3.52	2.96	6.12	2.42	0
BARI Chinabadam-8	96.67	100	86.67	10.57	7.53	5.62	9	7.1	0
ICGV-06279	90	73.33	60	6.23	3.23	0.5	4.52	1.2	0
ICGV-02038	90	86.67	76.67	8.02	3.12	1.07	8.63	1.1	0.36
ICGV-06237	96.67	90	76.67	6.26	3.24	1.73	6.85	4.27	1.63
DHAKA -1	90	93.33	90	10.03	6.13	3.7	8.24	5.65	3.1
BARI Chinabadam-4	86.67	83.33	76.67	6.73	3.45	1.23	4.29	2.84	1.33
Binachinabadam-8	90	93.33	80	8.74	6.02	4.89	6.08	4.95	2.73
ICGV-07245	96.67	96.67	93.33	7.93	5.03	2.84	7.04	4.5	2.80
ICGV-05158	100	96.67	93.33	6.75	4.3	1.4	8.7	5.05	3.39
BARI Chinabadam-6	66.67	76.67	63.33	4.86	2.75	2.00	5.81	0	0

Stress tolerance indices (STI)

The germination stress tolerance index (GSTI) showed a similar decrease pattern with increase PEG concentration (Table 7). At 10% PEG concentration the highest GSTI was observed in ICGV-97232 (67.033) followed by BARI Chinabadam-8 (62.943) and the lowest was found in TG-24 (35.130) followed by BARI Chinabadam-4 (38.850). In case of RLSI, it was found decreased with the increase of drought stress level. At 10% PEG concentration the highest RLSI was observed in BARI Chinabadam-9 (57.205) and the lowest was found in ICGV-02038 (13.295; Table 8). In case of SLSI the genotypes showed gradual decrease with the increase of PEG concentration (Table 8). At 10% PEG concentration, the highest SLSI value was recorded in ICGV-1224-G75 (70.166) and the lowest SLSI was in ICGV-97232, Binabadam-4, ICGV-07217, NCGV-14303, ICGV-06285, SDG-568, BARI Chinabadam-8, ICGV-06279, ICGV-02038, ICGV-06237, Dhaka-1, BARI Chinabadam-4, Binabadam -8, ICGV-07245, ICGV-05158 and BARI Chinabadam-6.

Table 11.v.1c.2: Germination Stress Tolerance Index (GSTI) of 45 Groundnut Genotypes. Values are mean GSTI of 5% and 10 % PEG treatments:

Genotypes	GSTI	
	5% PEG	10% PEG
ICGV-1224-G75	61.267 ghijkl	46.987 ijklmn
BARI Chinabadam-9	70.970 bcde	53.730 efgh
ICGV-07214	73.927 abc	59.647 bcde
ICGV-05096	61.000 hijkl	54.213 efg
ICGV-07220	59.133 jkl	49.207 ghijk
ICGV-00338	62.550 ghijkl	49.763 fghijk
BARI Chinabadam-10	75.610 abc	61.450 abcd
ICGV-02125	68.210 def	56.077 def
ICGV-06423	65.747 efghi	47.260 ijklm
ICGV-07220	64.460 fghij	45.773 ijklmn
ICGV-0207	60.483 ijkl	46.023 ijklmn
ICGV-0504-7	70.590 cde	57.710 cde
ICGV-00338	63.570 fghijkl	47.440 hijkl
ICGV-95460	64.463 fghij	54.163 efg
ICGV-95070	68.173 def	57.727 cde
ICGV-0140	72.670 abcd	50.403 fghij
DF 090038-2	59.830 jkl	46.813 ijklmn
ICGV-02096	58.877 kl	46.270 ijklmn
ICGV-96175	62.033 ghijkl	49.263 ghijk
SDG-532-01	62.597 ghijkl	44.057 jklmno
NCGV-01704	63.797fghijkl	50.927 fghi
DF-090035	65.820 efghi	40.900 mnop
TG-24	46.550 m	35.130 p
ICGV-93280	58.510 l	45.877 ijklmn
ICGV-955090	66.207 efgh	46.253 ijklmn
SDG-543-2	59.167 jkl	46.897 ijklmn
K-2	63.510 fghijkl	40.820 nop
ICGV-95063	59.543 jkl	46.653 ijklmn
ICGV-95469	61.490 ghijkl	44.470 jklmno
ICGV-97232	77.177 a	67.033 a
Binachinabadam-4	75.493 abc	58.093 cde
ICGV-07217	66.640 efg	41.500 lmnop
NCGV-14303	62.673 ghijkl	49.870 fghijk
ICGV-06285	58.667 kl	45.853 ijklmn
SDG-568	61.560 ghijkl	49.570 ghijk
BARI Chinabadam-8	76.123 ab	62.943 abc
ICGV-06279	64.067 fghijk	46.283 ijklmn
ICGV-02038	64.017 fghijk	50.910 fghi
ICGV-06237	60.563 ijkl	45.070 ijklmno
DHAKA -1	77.257 a	61.867 abcd
BARI Chinabadam-4	61.923 ghijkl	38.850 op
Binachinabadam-8	74.073 abc	64.653 ab
ICGV-07245	59.167 jkl	43.527 klmno
ICGV-05158	74.237abc	58.780 bcde
BARI Chinabadam-6	63.133 fghijkl	47.703 hijkl
Level of sig.	***	***

In a column, figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.
 *** = Significant at 0.1% level of probability.

Table 11.v.1c.3: Root Length Stress Index (RLSI) and Shoot Length Stress Index (SLSI) of 45 Groundnut Genotypes. Values are treatment mean RLSI and SLSI of 5% and 10 % PEG treatments

Genotypes	RLSI (%)		SLSI (%)	
	5%	10%	5%	10%
ICGV-1224-G75	58.708 hij	37.090NO	64.877 kl	70.166 a
BARI Chinabadam-9	63.071 ef	57.205 A	88.273 b	58.397 b
ICGV-07214	69.785 bc	54.256 C	92.729 a	58.204 b
ICGV-05096	57.545 jkl	29.254 UV	60.089 n	52.515 c
ICGV-07220	45.765 t	0.0000 b	0.0000 z	50.008 d
ICGV-00338	57.415 jkl	32.945 S	46.561 r	48.105 e
BARI Chinabadam-10	69.419 bcd	52.624 DE	78.941 f	44.853 f
ICGV-02125	71.758 a	51.544 E	83.983 d	42.551 g
ICGV-06423	54.523 mno	46.739 G	68.485 i	42.263 g
ICGV-07220	56.262 klm	43.319 I	40.188 u	41.699 gh
ICGV-0207	48.768 s	24.641 X	54.983 p	40.617 hi
ICGV-0504-7	67.843 d	32.412 ST	78.452 f	39.725 ij
ICGV-00338	58.821 hij	25.488 X	74.506 g	38.932 j
ICGV-95460	57.152 jkl	35.172 QR	54.730 pq	37.605 k
ICGV-95070	68.872 cd	29.675 UV	82.674 de	36.739 k
ICGV-0140	52.839 opq	31.732 T	67.827 i	31.917 l
DF 090038-2	61.439 fg	36.208 OPQ	42.297 t	31.299 l
ICGV-02096	58.177 ijk	39.030 LM	60.718 n	31.082 l
ICGV-96175	51.974 pqr	37.993 MN	48.052 r	30.982 l
SDG-532-01	57.392 jkl	43.022 I	65.032 kl	23.795 n
NCGV-01704	59.900 ghi	32.254 ST	60.874 mn	22.252 o
DF-090035	53.098 opq	33.013 S	67.056 ij	21.217 o
TG-24	57.484 jkl	38.426 M	62.304 m	19.510 p
ICGV-93280	53.846 nop	35.435 QR	61.270 mn	17.188 q
ICGV-955090	58.736 hij	42.339 IJ	73.099 gh	13.996 r
SDG-543-2	55.678 lmn	30.253 U	71.974 h	13.815 r
K-2	50.877 r	20.360 Y	14.351 x	11.314 s
ICGV-95063	0.0000 x	0.0000 b	0.0000 z	4.1314 t
ICGV-95469	13.424 w	0.0000 b	13.649 xy	0.0000 u
ICGV-97232	60.507 gh	47.965 F	86.176 c	0.0000 u
Binachinabadam-4	64.014 e	47.548 FG	87.492 bc	0.0000 u
ICGV-07217	47.297 st	32.430 ST	44.895 s	0.0000 u
NCGV-14303	43.326 u	40.102 KL	46.531 r	0.0000 u
ICGV-06285	52.776 opqr	34.530 R	36.827 v	0.0000 u
SDG-568	54.164 no	45.545 H	39.543 u	0.0000 u
BARI Chinabadam-8	71.249 ab	53.158 CD	78.891 f	0.0000 u
ICGV-06279	51.836 qr	8.0246 a	26.544 w	0.0000 u
ICGV-02038	38.887 v	13.295 Z	12.742 y	0.0000 u
ICGV-06237	51.757 qr	27.635 W	62.386 m	0.0000u
DHAKA -1	61.105 g	36.873 NOP	68.501 i	0.0000 u
BARI Chinabadam-4	51.238 qr	35.752 PQ	66.279 jk	0.0000 u
Binachinabadam -8	68.905 cd	55.933 B	81.365 e	0.0000 u
ICGV-07245	63.449 e	35.758 PQ	63.924 l	0.0000 u
ICGV-05158	63.703 e	20.742 Y	58.087 o	0.0000 u
BARI Chinabadam-6	56.584 kl	41.221 JK	0.0000 z	0.0000 u
Level of sig.	***	***	***	***

In a column, figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.

*** = Significant at 0.1% level of probability.

Based on the above discussed parameters, it was found BARI Chinabadam-9, ICGV-07214, ICGV-0504-7, ICGV-02125, ICGV-95070, ICGV-955090, Binachinabadam-4, BARI Chinabadam-8, ICGV-06279, DHAKA -1, ICGV-07245, ICGV-05158, BARI Chinabadam-6, Binachinabadam-8, BARI Chinabadam-10, ICGV-97232 performed better and these 16 genotypes was selected for hydroponics and further investigations.

11.v.1d (Expt. 1d): Effect of water stress on germination and early growth stage of tomato

Germination percentage, root and shoot length

The effect of increasing concentration of PEG during seed germination and the response of genotypes to the increasing concentrations was measured to determine the tolerance of tomato genotypes under water deficit conditions. Table 11.v.1d.1 showed that the germination percentage of tomato seeds was reduced with the increase of PEG concentration. The highest germination was found in the control condition and the minimum was at 10% PEG (Table 11.v.1d.1). However, at 10% PEG concentration the highest germination percentage was found in BARI Tomato-3 (93.33%) followed by BARI Tomato-2 (90%) while the lowest germination was found in BARI Tomato-8 (63.33%) followed by BARI Tomato 14 and Binatomato-11 (66.67%). In the case of root length and shoot length, similar results were found in different genotypes. At 10 % PEG concentration, the highest root length was observed in BARI Tomato-3 (6.10mm) followed by BARI Tomato-16 (5.93mm) while the lowest length was observed in BARI Tomato-11 (2.04mm). Similarly, the shoot length was found higher in the minimum stress condition whereas it was decreasing with increasing PEG concentration. At 10% PEG concentration, the highest shoot length was found in BARI Tomato-15 (4.21mm) while the lowest was found in Binatomato-11 (1.92mm).

Table 11.v.1d.1: Final Germination Percentage (FGP, %), root length (mm) and shoot length (mm) of 13 Tomato genotypes at three levels (0%, 5% and 10 % PEG) of water stress

Genotypes	FGP (%)			Root length (mm)			Shoot length (mm)		
	0%	5%	10%	0%	5%	10%	0%	5%	10%
BARI Tomato-2	100.00	100.00	90.00	8.27	7.17	5.18	5.90	4.89	4.15
BARI Tomato-3	98.33	91.67	93.33	9.11	7.52	6.10	6.24	5.40	3.79
BARI Tomato-8	90.00	85.00	63.33	7.41	5.10	3.74	5.30	3.52	2.43
BARI Tomato-11	100.00	63.33	85.00	4.17	3.2	2.04	4.12	3.14	2.63
BARI Tomato-14	68.33	76.67	66.67	7.50	5.40	4.42	4.12	3.23	2.46
BARI Tomato-15	93.33	90.00	86.67	7.58	6.66	5.35	5.31	4.32	4.21
BARI Tomato-16	96.67	93.33	81.67	9.38	7.58	5.93	5.42	4.36	3.90
BARI Tomato-17	100.00	100.00	86.67	7.07	5.30	4.14	4.73	3.60	2.42
BARI Tomato-18	100.00	63.33	85.00	7.06	5.31	3.85	4.55	3.61	2.59
BARI Tomato-19	88.33	86.67	73.33	7.58	5.16	3.87	4.36	3.26	2.18
Binatomato-10	91.67	78.33	73.33	6.50	4.49	3.31	6.21	4.55	3.08
Binatomato-11	63.33	55.00	66.67	7.73	4.63	3.85	4.06	2.87	1.92
Binatomato-12	93.33	80.00	88.33	8.47	6.94	5.54	5.42	4.39	4.24

Stress tolerance indices (STI)

The germination stress tolerance index (GSTI) showed a similar decrease pattern with increase PEG concentration (Table 11.v.1d.2). At 10% PEG concentration the highest GSTI was observed in BARI Tomato-15 (58.749) followed by BARI Tomato-16 (58.435) and the lowest was found in Binatomato-11 (41.860). In case of RLSI, it was found decreased with the increase of drought stress level. At 10% PEG concentration the highest RLSI was observed in BARI Tomato-3 (66.938) and the lowest was found in BARI Tomato-11 (48.984; Table 11.v.1d.3). In case of SLSI

the genotypes showed gradual decrease with the increase of PEG concentration. At 10% PEG concentration, the highest SLSI value was recorded in BARI Tomato-15 (79.225) while the lowest was found in BARI Tomato-8 (45.976; Table 11.v.1d.3).

Table 11.v.1d.2: Germination Stress Tolerance Index (GSTI) of 13 Tamato Genotypes. Values are mean GSTI of 5% and 10 % PEG treatments

Genotypes	GSTI	
	5% PEG	10% PEG
BARI Tomato-2	82.357a	57.658c
BARI Tomato-3	82.795a	58.340c
BARI Tomato-8	70.341b	48.130ef
BARI Tomato-11	72.824b	44.996fg
BARI Tomato-14	73.410 b	51.514de
BARI Tomato-15	83.187a	58.749c
BARI Tomato-16	83.288a	58.435c
BARI Tomato-17	74.464 b	44.598fg
BARI Tomato-18	73.454b	45.340fg
BARI Tomato-19	75.413b	49.506ef
Binatomato-10	75.390b	44.965fg
Binatomato-11	72.228b	41.860g
Binatomato-12	84.697a	55.655cd
Level of sig.	***	***

In a column, figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.

*** = Significant at 0.1% level of probability.

Table 11.v.1d.3: Root Length Stress Index (RLSI) and Shoot Length Stress Index (SLSI) of tomato genotypes. Values are treatment mean RLSI and SLSI of 5 % and 10% PEG treatments

Genotypes	Means			
	RLSI		SLSI	
	5%	10%	5%	10%
BARI Tomato-2	86.735 a	62.625 ij	82.894 b	70.243 j
BARI Tomato-3	82.518 b	66.938 gh	86.548 a	60.744 m
BARI Tomato-8	68.796 efg	50.405 m	66.554 k	45.976 q
BARI Tomato-11	76.677 c	48.984 m	76.236 fg	63.792 l
BARI Tomato-14	72.006 de	58.944 k	78.454 def	59.675 mn
BARI Tomato-15	87.912 a	70.538 ef	81.420 bc	79.225 cde
BARI Tomato-16	80.786 b	63.164 ij	80.555 bcde	72.005 ij
BARI Tomato-17	75.063 cd	58.556 k	76.038 fg	51.095 o
BARI Tomato-18	75.261 cd	54.582 l	79.420 cde	57.033 n
BARI Tomato-19	68.089 fgh	50.989 m	74.866 gh	50.050 o
Binatomato-10	69.123 efg	50.991 m	73.234 hi	49.550 op
Binatomato-11	59.968 jk	49.882 m	70.774 ij	47.208 pq
Binatomato-12	82.012 b	65.512 hi	80.988 bcd	78.335 ef
Level of sig.	***	***	***	***

In a column, figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.
 *** = Significant at 0.1% level of probability.

Based on the above discussed parameters, it was found BARI Tomato-2, BARI Tomato-15, BARI Tomato-16, BARI Tomato-18 and Binatomato-11 performed better and these 5 genotypes was selected for hydroponics and further investigations.

11.v.1e (Expt. 1e): Effect of water stress on germination and early growth stage of foxtail millet (Kaon)

Among the 25 Genotypes, FGP levels were higher in Kaon BD 887, Kaon BD 876, Kaon BD 899, and Kaon BD 890 at different PEG concentrations (Table 11.v.1e.1). On the other hand, very low levels of FGP were observed in the genotypes BARI Kaon-2, Kaon BD 909 and Kaon BD 878 at 5% and 10% Polyethylene Glycol (PEG) treatments (Table 11.v.1e.1). The highest FGP at 10% PEG concentration was found in Kaon BD 887 followed by Kaon BD 876 whereas the lowest FGP was recorded in Kaon BD 909 followed by BARI Kaon-2 genotype.

The better FGP performing genotypes also showed higher root and shoot length at different PEG concentrations (Table 11.v.1e.1). BARI Kaon-3, Kaon BD 887 and Kaon BD 876 genotypes had the highest root length at 5 and 10 % PEG treatments, respectively. The lowest root length was recorded in BARI Kaon-2 and Kaon BD 878 at both PEG treatments. The maximum shoot length was observed in BARI Kaon-3, Kaon BD 887 and Kaon BD 889 followed by Kaon BD 876 whereas the minimum shoot length was found in BARI Kaon-3, Local-1 kurig. and Kaon BD 878 at both PEG concentrations (Table 11.v.1e.1).

The genotypes BARI Kaon-1, BARI Kaon-3, Local-2 Ulipur, Kaon BD 887 and Kaon BD 876 had the highest and Kaon-2, Kaon BD 887, Kaon BD 913 and Kaon BD 909 had the lowest GSTI values, respectively (Table 11.v.1e.2). The GSTI values of 5 and 10 % PEG are shown in Table 11.v.1e.2.

The genotypes BARI Kaon-1, BARI Kaon-3, Local-2 Ulipur, Kaon BD 887 and Kaon BD 876 had the highest and Kaon-2, Kaon BD 887 and Kaon BD 909 had the lowest RLSI and SLSI values, respectively (Table 11.v.1e.2). The RLSI and SLSI values of 5 and 10 % PEG are shown in Table 11.v.1e.2.

Table 11.v.1e.1: Final germination percentage (FGP, %), root length (mm) and shoot length (mm) of 25 Foxtail millet Genotypes at three levels (0%, 5% and 10 % PEG) of water stress

Genotypes	FGP (%)			Root length (mm)			Shoot length (mm)		
	0%	5%	10%	0%	5%	10%	0%	5%	10%
BARI Kaon-1	83.3	95.0	85.0	6.5	6	5.6	4.0	3.4	3.1
BARI Kaon-2	56.7	53.3	55.0	6.4	6.1	5.6	3.1	2.1	1.7
BARI Kaon-3	90.0	90.0	66.7	6.3	6	5.7	4.4	4.0	3.2
Local-1 kurig.	76.7	98.3	86.7	4.7	3	2.7	3.0	2.3	2.1
Local-2 Ulipur	96.7	95.0	93.3	4.8	3	2.9	4.2	3.6	3.3
Kaon BD 878	78.3	68.3	66.7	4.6	2.9	2.8	2.9	2.2	2.0
Kaon BD 879	96.7	88.3	90.0	6.2	5.9	5.5	3.5	2.6	2.0
Kaon BD 887	100.0	98.3	96.7	6.3	5.9	5.5	4.0	3.5	3.2
Kaon BD 888	93.3	100.0	91.7	6.4	5.9	5.5	3.8	2.7	2.0
Kaon BD 890	100.0	85.0	88.3	4.4	3.1	2.3	4.4	3.5	3.1
Kaon BD 860	95.0	85.0	88.3	4.3	3.2	2.4	3.1	2.1	2.0
Kaon BD 871	85.0	96.7	81.7	4.2	3.3	2.5	3.8	2.5	2.0
Kaon BD 875	95.0	96.7	75.0	6.2	6	5.8	3.8	2.4	2.0
Kaon BD 876	100.0	95.0	93.3	6.2	5.9	4.8	4.2	3.6	3.2
Kaon BD 877	93.3	88.3	85.0	6.2	5.8	4.7	3.1	2.5	2.0
Kaon BD 891	95.0	91.7	91.7	4	3.4	3	3.7	3.0	2.7
Kaon BD 892	96.7	98.3	88.3	4	3.5	3	3.8	3.0	2.0
Kaon BD 897	90.0	83.3	88.3	4	3.5	3	3.9	3.0	2.7
Kaon BD 899	100.0	93.3	81.7	5.6	5	4	2.7	2.0	1.5
Kaon BD 900	96.7	80.0	81.7	5.3	4.9	4.1	3.5	2.8	2.4
Kaon BD 901	90.0	88.3	91.7	5.4	5	4.2	3.4	2.3	2.0
Kaon BD 903	88.3	83.3	78.3	6	5.6	5.2	3.7	2.9	2.5
Kaon BD 905	85.0	80.0	60.0	6	5.6	5.2	3.9	3.0	2.7
Kaon BD 909	25.0	18.3	21.7	6	5.6	5.2	2.0	1.0	0.5
Kaon BD 913	76.7	98.3	95.0	5.2	4.8	4	3.7	2.7	2.1

Table 11.v.1e.2: Germination Stress Tolerance Index (GSTI) of 25 Foxtail millet Genotypes.
Values are mean GSTI of 5% and 10 % PEG treatments

Genotypes	Treatment means	
	5%	10%
BARI Kaon-1	89.9 a	73.6 a
BARI Kaon-2	60.8 hijk	57.5 c
BARI Kaon-3	93.4 a	65.6 b
Local-1 kurig.	66.1ghi	56.9 c
Local-2 Ulipur	86.3ab	66.4 ab
Kaon BD 878	71.6 cdefg	55.9 cd
Kaon BD 879	71.1 cdefg	55.4 cd
Kaon BD 887	88.5 a	67.1ab
Kaon BD 888	75.0 cdef	56.9 c
Kaon BD 890	75.3 cde	54.8 cd
Kaon BD 860	74.0 cdefg	56.3 cd
Kaon BD 871	79.6 bc	55.7 cd
Kaon BD 875	71.0cdefg	56.7 c
Kaon BD 876	92.2 a	71.4ab
Kaon BD 877	79.1 bc	57.0 c
Kaon BD 891	75.9cd	55.4 cd
Kaon BD 892	74.9 cdef	49.0 d
Kaon BD 897	77.7 bcd	50.4 cd
Kaon BD 899	76. cd	54.4 cd
Kaon BD 900	76.8 cd	55.0 cd
Kaon BD 901	78.3 bcd	53.6 cd
Kaon BD 903	78.425 bcd	54.4 cd
Kaon BD 905	71.646 cdefg	56.2 cd
Kaon BD 909	66.377 fgh	30.6 e
Kaon BD 913	70.104 defg	56.8 c
Level of sig.	***	***

In a column, figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.

*** = Significant at 0.1% level of probability.

Table 11.v.1e.3: Root Length Stress Index (RLSI) and Shoot Length Stress Index (SLSI) of Foxtail millet Genotypes. Values are treatment mean RLSI and SLSI of 5 % and 10% PEG treatments

Genotypes	Means			
	RLSI (%)		SLSI (%)	
	5%	10%	5%	10%
BARI Kaon-1	94.3 a	88.0 a	85.0 bc	77.6 ab
BARI Kaon-2	63.1 ef	59.6 ij	68.1 jk	53.2 hi
BARI Kaon-3	93.7a	87.3 a	90.9 a	72.0 c
Local-1 kurig.	74.4 cd	55.9 j	76.9 efg	68.2 d
Local-2 Ulipur	95.2 a	82.3 bc	85.7 b	78.6 a
Kaon BD 878	86.7 ab	75.1 efg	75.0 fgh	68.2 d
Kaon BD 879	91.4 ab	75.5 efg	74.6 ghi	57.5 f
Kaon BD 887	93.3 a	86.7 ab	86.8 b	79.3 a
Kaon BD 888	91.1 ab	75.9 efg	71.3 ij	52.2 i
Kaon BD 890	93.4 a	86.9 ab	78.7 de	70.5 cd
Kaon BD 860	68.4 de	39.5 k	68.0 jk	63.8 e
Kaon BD 871	90.9 ab	75.8 efg	65.2 kl	52.2 i
Kaon BD 875	88.9 ab	77.8 cdef	63.5 l	52.2 i
Kaon BD 876	95.0 a	87.3 a	85.0 bc	75.6 b
Kaon BD 877	93.0 a	79.1 cde	78.7 de	64.9 e
Kaon BD 891	81.7 bc	61.2 i	81.9 cd	72.0 c
Kaon BD 892	87.7 ab	78.9 cde	78.2 ef	52.2 i
Kaon BD 897	92.6 a	74.0 fgh	77.7 efg	70.0 cd
Kaon BD 899	88.8 ab	76.9 def	73.2 hi	54.9 gh
Kaon BD 900	87.4 ab	64.3 i	80.2 de	68.9 d
Kaon BD 901	88.3 ab	70.6 h	67.9 jk	58.3 f
Kaon BD 903	85.1 ab	80.9 cd	79.1 de	68.2 d
Kaon BD 905	89.8 ab	78.9 cde	77.7 efg	69.2 d
Kaon BD 909	55.8 f	18.8 l	50.0 m	25.0j
Kaon BD 913	81.7 bc	71.4 gh	73.2 hi	57.1fg
Level of sing.	***	***	***	****

Based on the above discussed parameters, it was found BARI Kaon-1, BARI Kaon-2, BARI Kaon-3, Ulipur, Kaon BD 887, Kaon BD 876 performed better, and these 6 genotypes was selected for hydroponics and further investigations.

11.v.2 (Experiment 2): Evaluation the performance of suitable genotypes of different crops based on initial growth under artificially induced drought stress condition in hydroponic system

11.v.2a (Expt. 2a): Effect of drought stress on early growth stage of maize under hydroponic culture

Root length and shoot length

Among the 6 genotypes, the highest and lowest root length (cm) was obtained in BHM 9 and Paloan, respectively when there was no application of Polyethelene Glycol (PEG) treatments (Table 11.v.2a.1). The highest root length at 10% PEG concentration was found in Gold Star (76.5) whereas the lowest root length was recorded in Paloan (54.67) genotype. The shoot length (cm) showed a decrease pattern with induced drought stress. Highest shoot length was observed in BHM-13 (78.333) followed by Paloan (61.33) when there was no stress. But BHM-9 showed lowest shoot length (45) even with no stress condition. At 10% PEG concentration the highest shoot length was observed in Pioneer (42.67) followed by BHM 13 (40.33) and the lowest was found in Bharti 981 (32.67).

Leaf area

In case of leaf area (cm²), the highest value was recorded in BHM-9 (148.14) followed by BHM-13 (104.42) and the lowest in Paloan (30) with no stress (Table 11.v.2a.1). Similarly, with 10% PEG treatment, the highest LA was 122.25 cm² in BHM-9 and the lowest was 28.28 cm², found in Paloan.

Shoot fresh weight and dry weight

A decreased pattern was found in shoot fresh weight (g) of Maize genotypes when treated with 10% Polyethelene Glycol (PEG) as compared to no PEG treatment. Highest SFW was observed in BHM-9 (11.16) followed by BHM-13 (11.01) when there was no stress (Table 11.v.2a.1). But Paloan showed lowest SFW (4.61) even with no stress condition. At 10% PEG concentration the highest shoot fresh weight was observed in BHM-9 (10.84) followed by BHM-13 (8.20) and the lowest was found in Paloan (4.05). Two genotypes of Maize showed similar shoot dry weight (g) value (0.73) which was highest among the 6 genotypes in no stress condition. The lowest value was recorded in Paloan (0.30). On the contrary, highest SDW was found in BHM 9 (0.91) followed by Gold Star (0.74) and the lowest value was 0.34g, found in Paloan at 10% PEG concentration.

Root fresh weight and root dry weight

In case of root fresh weight (g), the highest weight was recorded in BHM-9 (2.51) followed by Pioneer (2.36) with no PEG treatment (Table 11.v.2a.1). On the other hand, the lowest root fresh weight was observed in the genotype of Paloan (1.52). The highest RFW at 10% PEG concentration was found in BHM 13 (3.44) followed by BHM-9 (3.36) whereas the lowest RFW was recorded in Pioneer (1.52) followed by Paloan (1.77). Among the 6 genotypes, the highest and lowest RDW was obtained in BHM-13 (0.13) and Paloan (0.07), respectively when there was no application of Polyethelene Glycol (PEG) treatments (Table 11.v.2a.1). The highest root dry weight at 10% PEG concentration was found in BHM 13 (0.22) while the lowest in Pioneer (0.075) genotype.

SPAD value

The genotypes of maize showed a decrease in SPAD value when treated with 10% Polyethelene Glycol (PEG) as compared to no PEG treatment. Highest SPAD value was observed in Gold Star (29.77) followed by BHM-9 (28.43) when there was no stress (Table 11.v.2a.1). However, 981

showed lowest value (22.30) even with no stress condition. The highest SPAD value at 10% PEG concentration was found in BHM-13 (27.70) followed by Pioneer (25.4) whereas the lowest in Paloan (17.57) followed by Bharati 981 (19.33).

Photosynthesis and transpiration

Photosynthesis ($\mu\text{molm}^{-2}\text{s}^{-1}$) showed similar decrease pattern with induced drought stress. Highest photosynthesis was observed in terms of value in Pioneer (11.62) followed by Gold Star (10.47) when there was no stress (Table 11.v.2a.1). However, Paloan showed lowest photosynthesis (8.55) even with no stress condition. At 10% PEG concentration the highest photosynthesis was observed in Pioneer (10.23) followed by 981 (9.88) and the lowest was found in Paloan (8.24). In case of transpiration ($\text{mmolm}^{-2}\text{s}^{-1}$), the highest data was recorded in BHM-9 (1.35) followed by Pioneer (1.34) with no PEG treatment (Table 2). On the other hand, lowest transpiration was observed in the genotype of BHM-13 (0.99). The highest transpiration value at 10% PEG concentration was found in BHM-9 (1.22) followed by Pioneer (1.18) whereas the lowest in Paloan (0.66) followed by Gold Star (0.78).

Maximum Photochemical Efficiency of Photosystem-II (Fv/Fm)

Among the 6 genotypes, the highest and stomatal conductance ($\text{molm}^{-2}\text{s}^{-1}$) was obtained in Gold Star (0.080) in control treatment condition (Table 11.v.2a.1). On the other hand, two genotypes showed lowest stomatal conductance (0.037) naming Paloan and 981. Similarly highest stomatal conductance (.047) at 10% PEG concentration was observed in two genotypes, BHM-13 and Pioneer. Lowest value (.027) was also found in in two genotypes naming Paloan and 981. A decreased pattern was found in Fv/Fm value of Maize genotypes when treated with 10% Polyethelene Glycol (PEG) as compared to no PEG treatment. Highest Fv/Fm value was observed in Gold Star (0.7867) followed by BHM 13 (0.7733) when there was no stress (Table 15). However, 981 showed lowest value (0.7500) even with no stress condition. At 10% PEG concentration, the highest and lowest Fv/Fm value were (0.7567) and (0.7300) as observed in Pioneer and Gold Star, respectively.

Based on the above discussed parameters, it was found that BHM-13, Pioneer, Paloan, 981 and BHM-9 performed better, and these 5 genotypes was selected for pot trial and further investigations.

Table 11.v.2a.1: Effect of PEG induced drought stress on morpho-physiological parameters of five maize genotypes at 0 & 10 % level of PEG under hydroponics

Treatment Combinations (Variety x Drought)	Root length (cm)	Shoot length (cm)	Leaf area (cm ²)	SFW (g)	SDW (g)	RFW (g)	RDW (g)	SPAD value	Photosynthesis (Pn, A) ($\mu\text{molm}^{-2}\text{s}^{-1}$)	Transpiration (E) ($\text{mmolm}^{-2}\text{s}^{-1}$)	Stomatal conductance (gs) ($\text{molm}^{-2}\text{s}^{-1}$)	Fv/Fm
Gold Star x 0	55.00 c	56.27 bc	76.51 bcd	8.17 abc	0.53bcd	2.1 abc	0.096 cd	29.77 a	10.47 ab	1.27 a	0.080 a	0.7867 a
BHM 13 x 0	58.67 c	78.333 a	102.42abc	11.01 a	0.730 ab	3.32 ab	0.13 cd	28.10abc	9.09bc	0.99 abcd	0.053 ab	0.7733 ab
Paloan x 0	43.0 d	61.33 b	30.00 d	4.61 e	0.30 d	1.52 c	0.07 d	23.23 bcdef	8.55 bc	1.11abc	0.037 b	0.753bcd
981 x 0	51.00 cd	54.33 bcd	59.05 cd	7.75 bcd	0.48 cd	2.32 abc	0.1 cd	22.30 cdef	9.77 abc	1.120 abc	0.037 b	0.75 bcd
BHM 9 x 0	69.33 ab	45.00 def	148.14 a	11.16 a	0.73 ab	2.51 abc	0.11 cd	28.43 ab	9.76 abc	1.35 a	0.040 b	0.7633 ab
Pioneer x 0	60.00 bc	48.67 cde	63.34 cd	5.66 cde	0.44 d	2.36 abc	0.09 cd	27.33 abcd	11.62 a	1.34 a	0.053 ab	0.76 abc
Gold Star x 10 % PEG	76.5 a	38.67 efg	68.68 bcd	7.01 cde	0.74 ab	2.57 abc	0.15 bc	21.33 def	8.55 bc	0.780 cd	0.033 b	0.73 d
BHM 13 x 10 % PEG	75.33 a	40.33 efg	73.66 bcd	8.20 abc	0.69 abc	3.44 a	0.22 a	27.70 abc	8.76 bc	1.02 abcd	0.047 b	0.7467 bcd
Paloan x 10 % PEG	54.67 c	35.50 fg	28.28 d	4.05 e	0.34 d	1.77 c	0.11 cd	17.57 f	8.24 c	0.66 d	0.027 b	0.75 bcd
981 x 10 % PEG	55.00 c	32.67 g	49.53 cd	4.65 de	0.38 d	1.96 bc	0.13 cd	19.33 f	9.88 abc	0.82 bcd	0.027 b	0.733 cd
BHM 9 x 10 % PEG	74.0 a	35.00 fg	122.25 ab	10.84 ab	0.91 a	3.36 ab	0.21 ab	20.03 ef	9.42 bc	1.22 ab	0.043 b	0.75 bcd
Pioneer x 10 % PEG	59.67 bc	42.67 efg	93.53 bc	4.17 e	0.35 d	1.52 c	0.075 cd	25.4 abcde	10.23 ab	1.18 ab	0.047 b	0.7567 bcd
Level of S _{ig} .	***	***	***	***	***	***	***	***	***	***	***	***

In a column, figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test. *** = Significant at 0.1% level of probability.

11.v.2b (Expt. 2b): Effect of drought stress on early growth stage of groundnut under hydroponic culture

Root length and shoot length

Among the 16 genotypes, the highest and lowest root length (cm) was obtained in BARI Chinabadam-10 and ICGV-06279, respectively when there was no application of Polyethylene Glycol (PEG) treatments (Table 11.v.2b.1). The highest root length at 10% PEG concentration was found in BARI Chinabadam-10 (30.50) whereas the lowest root length in Dhaka-1 (6.75) genotype. Highest shoot length was observed in BARI Chinabadam-10 (37.88) followed by ICGV-02125 (37.13) when there was no stress. However, Binachinabadam-4 showed lowest shoot length (18.67) even with no stress condition. At 10% PEG concentration the highest shoot length was observed in BARI Chinabadam-10 (30) followed by ICGV-97232 (27.17) and the lowest was found in BARI Chinabadam-6 (15.50).

Table 11.v.2b.1: Effect of PEG induced drought stress on root and shoot length (cm) of 16 groundnut genotypes at 0 & 10 % level of PEG under hydroponics

Genotypes	Means			
	RL (cm)		SL (cm)	
	Control	10%	Control	10%
BARI Chinabadam-9	22.33 cd	14.00 ijk	34.75 ab	22.50 hijkl
ICGV-07214	15.50 hij	15.50 hij	31.0 cd	17.25 no
BARI Chinabadam-10	32.50 a	30.50 a	37.88 a	30.0 cde
ICGV-02125	19.25 efg	13.25 jk	37.13 a	21.50 ijklm
ICGV-0504-7	20.50 def	7.125 m	26.50 efg	26.0 fgh
ICGV-95070	20.50 def	10.50 l	19.43 lmn	23.25 ghijk
ICGV-955090	27.50 b	22.75 cd	20.38 klmn	21.0 jklm
ICGV-97232	23.25 c	14.00 ijk	26.45 efg	27.17 ef
Binachinabadam -4	15.75 hi	12.99 k	18.67 mno	18.00 mno
BARI Chinabadam-8	23.25 c	20.00 ef	32.50bc	25.50 fgh
ICGV-06279	17.625 gh	18.59 fg	27.75 def	18.0 mno
Binachinabadam-8	21.0 cde	19.63 efg	24.31 fghij	25.75 fgh
ICGV-06279	13.50 ijk	12.75 kl	35.63 ab	24.63 fghij
ICGV-05158	14.75 ijk	12.63 kl	26.58 efg	22.75 hijkl
BARI Chinabadam-6	13.75ijk	12.75 kl	21.0 jklm	15.50 o
Dhaka-1	17.38 gh	6.75 m	25.0 fghi	19.87 klmn
Level of Significance	***	***	***	***

In a column, figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.

*** = Significant at 0.1% level of probability.

Root fresh weight and dry weight

In case of root fresh weight (g), the highest weight was recorded in BARI Chinabadam-10 (1.08) followed by BARI Chinabadam-9 (1.0345) with no PEG treatment (Table 11.v.2b.2). On the other hand, the lowest root fresh weight was observed in the genotype of BARI Chinabadam-8 (0.416). The highest RFW at 10% PEG concentration was found in BARI Chinabadam-9 (1.0402) followed by BARI Chinabadam-10 (1.0350) whereas the lowest RFW was recorded in ICGV-955090 (0.30) followed by Dhaka-1 (0.455). Among the 16 genotypes, the highest and lowest RDW was obtained in BARI Chinabadam-10 (0.1220) and ICGV-06279 (0.032), respectively when there was no application of Polyethylene Glycol (PEG) treatments (Table 11.v.2b.2). The highest root dry weight at 10% PEG concentration was found in Binachinabadam-4 (0.09) while the lowest was recorded in Dhaka-1 (0.003) genotype.

Table 11.v.2b.2: Effect of PEG induced drought stress on root fresh and dry weight (g) of 16 groundnut genotypes at 0 & 10 % level of PEG under hydroponics

Genotypes	RFW		RDW	
	Control	10%	Control	10%
BARI Chinabadam-9	1.0345 b	1.0402 b	0.1175 d	0.0586 k
ICGV-07214	0.615 m	0.765 h	0.705 a	0.393 b
BARI Chinabadam-10	1.08 a	1.0350 b	0.1220 c	0.044n
ICGV-02125	0.92 d	0.75 h	0.097 f	0.058 k
ICGV-0504-7	0.823 f	0.715i	0.085 h	0.0714 j
ICGV-95070	0.785 g	0.634 l	0.085 h	0.077 i
ICGV-955090	0.853 e	0.30 r	0.07 j	0.058 k
ICGV-97232	1.0275 b	0.945 c	0.11 e	0.087 gh
Binachinabadam -4	0.728i	0.685 j	0.075i	0.09 g
BARI Chinabadam-8	0.82 f	0.465 o	0.083 h	0.07 j
ICGV-06279	0.76 h	0.638 l	0.1067 e	0.06 k
Binachinabadam-8	0.416 q	0.545 n	0.085 h	0.061 k
ICGV-06279	0.445 p	0.815 f	0.032 o	0.0715j
ICGV-05158	0.685 j	0.645 kl	0.0703 j	0.047 m
BARI Chinabadam-6	0.556 n	0.655 k	0.052 l	0.06 k
Dhaka-1	0.425 q	0.455 op	0.043 n	0.003 p
Level of Sig.	***	***	***	***

In a column, figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.
*** = Significant at 0.1% level of probability.

Shoot fresh weight and shoot dry weight

A decreased pattern was found in shoot fresh weight (g) of Groundnut genotypes when treated with 10% Polyethylene Glycol (PEG) as compared to no PEG treatment. Highest SFW was observed in BARI Chinabadam-10 (5.75) followed by ICGV-0504-7 (4.67) when there was no stress (Table 11.v.2b.3). Nevertheless, BARI Chinabadam-6 showed lowest SFW (1.81) even with no stress condition. At 10% PEG concentration, the highest shoot fresh weight was observed in ICGV-0504-7 (3.62) followed by ICGV-97232 (3.02) and the lowest was found in Dhaka-1 (0.538). BARI Chinabadam-10 showed highest shoot dry weight (g) value (0.899) in no stress condition. The lowest value was recorded in Dhaka-1 (0.253). On the contrary, highest SDW was

found in ICGV-0504-7 (0.671) followed by ICGV-97232 (0.503) and the lowest value was 0.108g, found in Dhaka-1 at 10% PEG concentration.

Table 11.v.2b.3: Effect of PEG induced drought stress on shoot fresh and dry weight (g) of 16 groundnut genotypes at 0 & 10 % level of PEG under hydroponics

Genotypes	SFW		SDW	
	Control	10%	Control	10%
BARI Chinabadam-9	3.91 d	1.97 u	0.703 c	0.376 o
ICGV-07214	3.11i	1.014 x	0.523 h	0.252 v
BARI Chinabadam-10	5.75 a	2.63 n	0.899 a	0.453 k
ICGV-02125	4.13 c	1.83 v	0.628 e	0.329 r
ICGV-0504-7	4.67 b	3.62 f	0.722 b	0.671 d
ICGV-95070	2.82 l	2.41 o	0.401 m	0.348 p
ICGV-955090	2.82 l	2.08 s	0.429 l	0.351 p
ICGV-97232	3.75 e	3.02 j	0.563 g	0.503 i
Binachinabadam -4	2.35 p	2.93 k	0.382 n	0.333 qr
BARI Chinabadam-8	3.42 g	1.93 u	0.602 f	0.315 s
ICGV-06279	2.26 q	2.02 t	0.317 s	0.335 q
Binachinabadam-8	2.41 o	1.81 v	0.317 s	0.26 u
ICGV-06279	3.19 h	1.61 w	0.373 o	0.238 w
ICGV-05158	3.62 f	2.13 r	0.499 j	0.33 r
BARI Chinabadam-6	1.81 v	1.80 v	0.291 t	0.19 x
Dhaka-1	2.771 m	0.538 y	0.253 v	0.108 y
Level of sig.	***	***	***	***

In a column, figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.
*** = Significant at 0.1% level of probability.

Effect of water stress on SPAD value and RWC of groundnut

The genotypes of Groundnut showed a decrease in SPAD value when treated with 10% Polyethylene Glycol (PEG) as compared to no PEG treatment. Highest SPAD value was observed in Binachinabadam-4 (31.14) followed by BARI Chinabadam-10 (22.50) when there was no stress (Table 11.v.2b.4). However, ICGV-955090 showed lowest value (6.46) even with no stress condition. The highest SPAD value at 10% PEG concentration was found in BARI Chinabadam-9 (14.02) followed by ICGV-0504-7 (11.91) whereas the lowest was recorded in BARI Chinabadam-10 (2.83) followed by ICGV-07214 (2.97).

In case of RWC, the highest value was recorded in BARI Chinabadam-8 (0.121) followed by BARI Chinabadam-10 (0.113) and the lowest was found in Dhaka-1 (0.009) with no stress. Similarly with 10% PEG treatment, the highest RWC was found in Dhaka-1 (0.389) and the lowest was 0.036, found in BARI Chinabadam-6.

Table 11.v.2b.4: Effect of PEG induced drought stress on SPAD value and relative water content (RWC) of 16 groundnut genotypes at 0 & 10 % level of PEG under hydroponics

Genotypes	SPAD Value		RWC	
	Control	10%	Control	10%
BARI Chinabadam-9	18.02 c	14.02 h	0.094 h	0.058 mn
ICGV-07214	13.758 j	2.97 b	0.079 j	0.279 b
BARI Chinabadam-10	22.50 b	2.83 c	0.113 g	0.09 hi
ICGV-02125	16.38 f	10.55 p	0.048 p	0.174 c
ICGV-0504-7	16.68 e	11.91 m	0.052 op	0.108 g
ICGV-95070	16.88 d	8.37 t	0.076 j	0.086 i
ICGV-955090	6.46 w	5.19 a	0.032 rs	0.065 l
ICGV-97232	15.19 g	8.39 t	0.07 k	0.143 d
Binachinabadam-4	31.14 a	11.96 l	0.086 i	0.06 lm
BARI Chinabadam-8	12.84 k	9.59 s	0.121 f	0.129 e
ICGV-06279	11.92 m	6.94 v	0.017 t	0.076 j
Binachinabadam-8	9.895r	5.15 z	0.037 q	0.037 q
ICGV-06279	10.26 q	5.66 y	0.033 qr	0.122 f
ICGV-05158	10.92 o	7.05 u	0.028 s	0.054 no
BARI Chinabadam-6	13.95i	6.13 x	0.017 t	0.036 qr
Dhaka-1	11.56 n	5.13 za	0.009 u	0.389 a
Level of Sig.	***	***	***	***

Based on the above discussed parameters, it was found that ICGV-0504-7, Binachinabadaam-4, BARI Chinabadam-8, ICGV-07214 and Dhaka-1 performed better and these 5 genotypes was selected for pot trial and further investigations.

11.v.2c (Expt. 2c): Effect of drought stress on early growth stage of tomato under hydroponic culture

Shoot length

The effects of PEG on shoot length of tomato varieties differ significantly (Fig. 11.v.2c.1). In control condition, the longest shoot length (16.4 cm) was recorded from the variety BARI Tomato 15 followed by BARI Tomato-2 (15.57 cm) and the shortest shoot length (11.8 cm) was achieved from Binatomato-11 followed by BARI Tomato-16 (15.3 cm). The graph showed that, shoot length was decreased in each variety in PEG. In 8% PEG, the longest shoot length (12.5 cm) was recorded from the variety BARI Tomato-15 followed by BARI Tomato-16 (10.7 cm) and the shortest shoot length (9.2 cm) was achieved from BARI Tomato 2 followed by Binatomato-11 (9.9 cm; Fig. 11.v.2c.1).

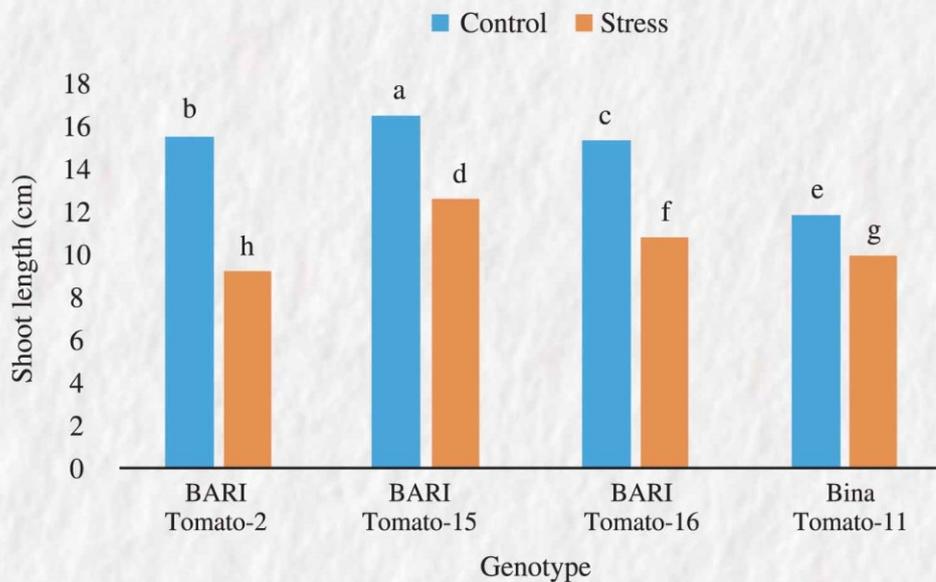


Fig. 11.v.2c.1. Effects of PEG on shoot length of tomato genotype. Figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.

Root length

In case of root length, the effects of PEG differ significantly (Fig. 11.v.2c.2). In control condition, the longest root length (15.80 cm) was recorded from the variety BARI Tomato-15 followed by BARI Tomato-16 (14.4 cm) and the shortest root length (11.5 cm) was achieved from BARI Tomato-2 followed by Binatomato-11 (13.0 cm). The graph showed that, root length was decreased in each variety in PEG. In 8 % PEG, the longest root length (13.5cm) was recorded from the variety BARI Tomato-15 followed by BARI Tomato 16 (12.5 cm) and the shortest root length (8.2 cm) was achieved from BARI Tomato 2 followed by Binatomato-11 (10.6 cm; Fig. 11.v.2c.2).

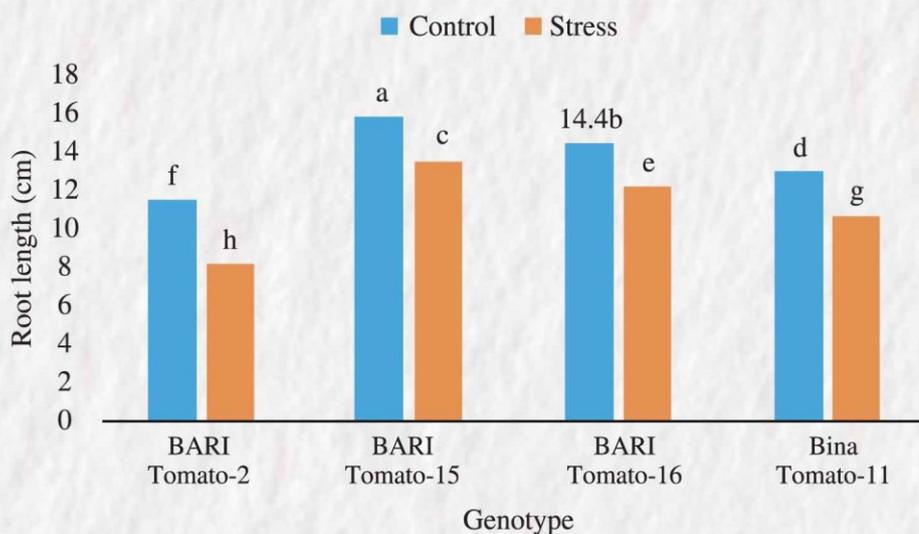


Fig. 11.v.2c.2. Effects of PEG on root length of tomato genotypes. Figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.

Number of leaves per plant

Four Tomato varieties showed different magnitude of reductions in the number of leaves due to PEG. Significant variation was observed among the varieties and treatment (Fig. 11.v.2c.3). In control condition, the maximum number of leaves (5.5) was recorded from the variety BARI Tomato-15 followed by BARI Tomato-16 (5.25) and minimum the number of leaves (4) was achieved from Binatomato-11 followed by BARI Tomato-2 (4.5). The graph showed that, number of leaves were decreased in each variety in PEG. In 8% PEG, the maximum number of leaves (5) was recorded from the variety BARI Tomato 15 followed by BARI Tomato-16 (4.25) and the minimum number of leaves (2.75) was achieved from BARI Tomato 2 followed by from Binatomato-11 (3.5; Fig. 11.v.2c.3).

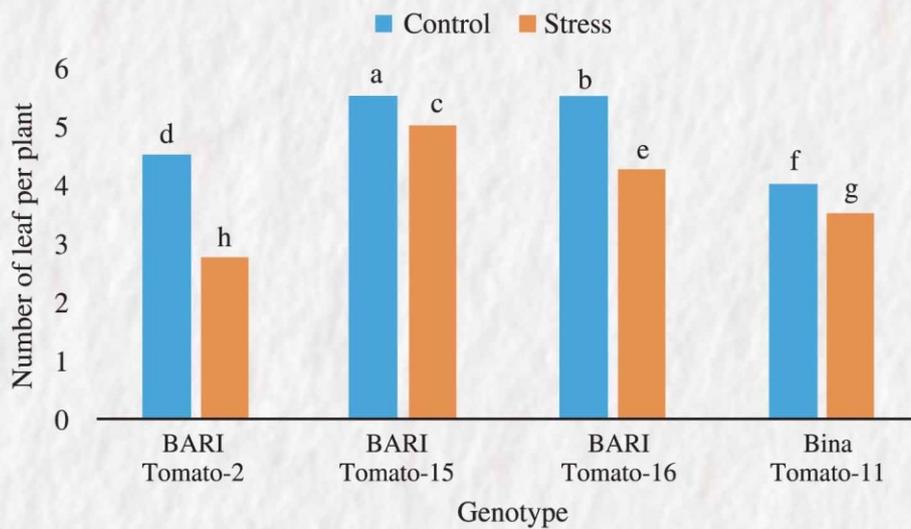


Fig. 11.v.2c.3. Effects of PEG on number of leaves per plant of four genotypes. Figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.

Root fresh weight

Four tomato varieties showed different magnitude of reductions in the root fresh weight due to PEG. Significant variation was observed among the varieties and treatment (Fig. 11.v.2c.4). In control condition, the maximum root fresh weight (0.129 g) was recorded from the variety BARI Tomato-15 followed by BARI Tomato-16 (0.111 g) and minimum the root fresh weight (0.084 g) was achieved from BARI Tomato-2 followed by Binatomato-11 (0.091 g). The graph showed that, root fresh weight was decreased in each variety in PEG. In 8% PEG, the maximum root fresh weight (0.080 g) was recorded from the variety BARI Tomato-15 followed by BARI Tomato-16 (0.071 g) and the minimum root fresh weight (0.017 g) was achieved from BARI Tomato-2 followed by Binatomato-11 (0.061 g; Fig. 11.v.2c.4).

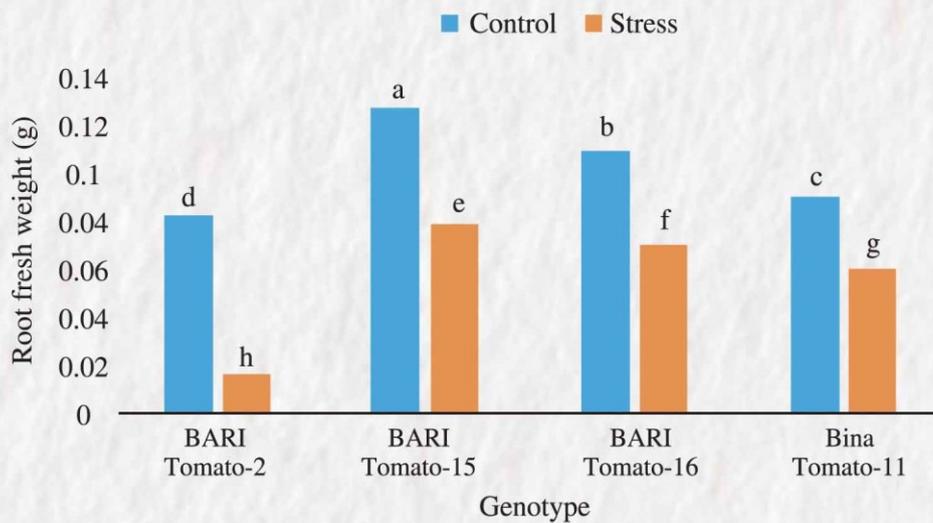


Fig. 11.v.2c.4. Effects of PEG on root fresh weight of tomato genotypes. Figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.

Relative greenness (SPAD)

The effects of PEG on relative greenness of tomato varieties differ significantly (Fig. 11.v.2c.5). In control condition, the maximum relative greenness (33.82) was recorded from the variety BARI Tomato-15 followed by BARI Tomato-16 (31.02) and the minimum relative greenness (27.6) was achieved from BARI Tomato-2 followed by Binatomato-11 (29.3). The graph showed that, relative greenness was decreased in each variety in PEG. In 8% PEG, the maximum relative greenness (26.32) was recorded from the variety BARI Tomato-15 followed by BARI Tomato-16 (22.75) and the minimum relative greenness (18.25) was achieved from BARI Tomato-2 followed by Binatomato-11 (20.97; Fig. 11.v.2c.5).

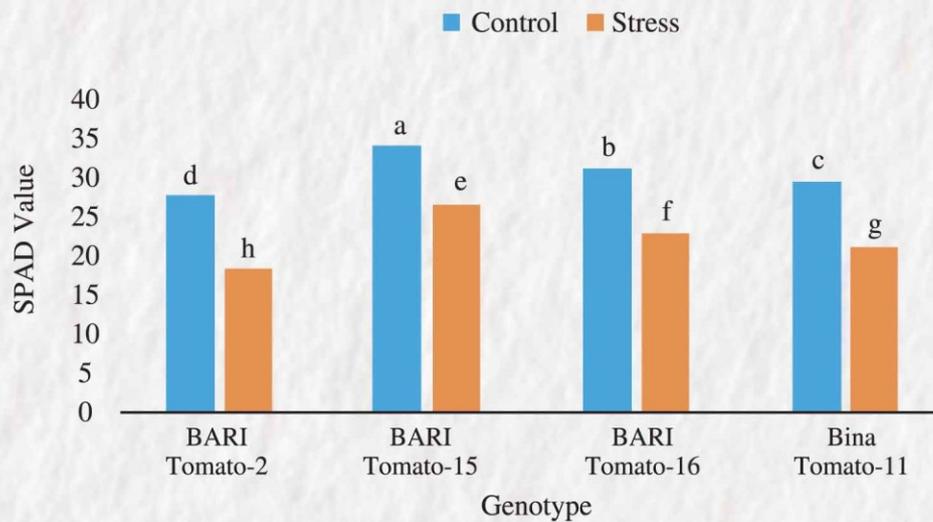


Fig. 11.v.2c.5. Effects of PEG on relative greenness (as SPAD) of tomato genotypes. Figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.

Proline content

Four tomato varieties showed wide magnitude of changes in the proline content due to PEG. Significant variation was observed among the varieties and treatment (Fig. 11.v.2c.6). In control condition, the highest proline content (3.02) was recorded from the variety BARI Tomato-15 followed by BARI Tomato-16 (2.22) and the lowest proline content (1.20) was achieved from BARI Tomato-2 followed by Binatomato-11 (1.87). The graph showed that, the proline content was increased in each variety with the increasing salinity level. In 8% PEG, the highest proline content (3.70) was recorded from the variety BARI Tomato-15 followed by BARI Tomato-16 (3.60) and the lowest proline content (2.87) was achieved from BARI Tomato 2 followed by Binatomato-11 (3.11; Fig. 11.v.2c.6).

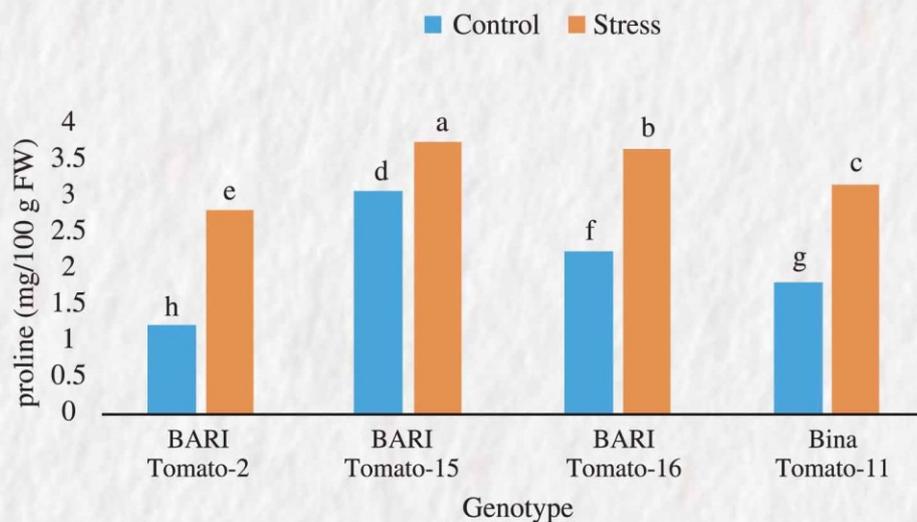


Fig. 11.v.2c.6. Effects of PEG on proline content of leaf of tomato genotypes. Figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.

Based on the above discussed parameters, as BARI Tomato-18 did not survived hydroponics therefore, all the 5 genotypes grown in hydroponics was undergone for pot trial and further investigations.

11.v.2d (Expt. 2d): Effect of drought stress on early growth stage of foxtail millet under hydroponic culture

Root length and Shoot length

Among the 6 genotypes, the highest and lowest root length (cm) was obtained in BARI Kaon-1 (26.50) and Kaon BD-887 (12.67), respectively when there was no application of Polyethylene Glycol (PEG) treatments (Table 11.v.2d.1). The highest root length at 10% PEG concentration was found in BARI Kaon-2 (22.0) whereas the lowest root length was recorded in Kaon BD-887 (10). The shoot length (cm) showed a decrease pattern with induced drought stress. Highest shoot length was observed in Kaon BD-876 (34.83) followed by BARI Kaon-2 (31) when there was no stress. But, Kaon BD-887 showed lowest shoot length (15.50) even with no stress condition. At 10% PEG concentration the highest shoot length was observed in BARI Kaon-3 (24.23) followed by Kaon BD-876 (23.50) and the lowest was found in Kaon BD-887 (13.83).

Shoot fresh weight and shoot dry weight

A decrease pattern was found in shoot fresh weight (g) of Foxtail Millet genotypes when treated with 10% Polyethelene Glycol (PEG) as compared to no PEG treatment. Highest SFW was observed in BARI Kaon-3 (1.128) followed by Kaon BD-876 (0.742) when there was no stress (Table 11.v.2d.1). But BARI Kaon-1 showed lowest SFW (0.273) even with no stress condition. At 10% PEG concentration the highest shoot fresh weight was observed in Kaon BD-887 (0.50) followed by Ulipur (0.497) and the lowest was found in BARI Kaon-1 (0.226). Among the 6 genotypes, the highest shoot dry weight (g) was obtained in BARI Kaon-3 (0.157) & the lowest (0.057) was found in BARI Kaon-1 and Kaon BD-887, respectively when there was no application of Polyethelene Glycol (PEG) treatments (Table 11.v.2d.1). The highest SDW at 10% PEG concentration was found in BARI Kaon-1 (0.198) whereas the lowest was recorded in Kaon BD-876 (0.031).

Root fresh weight and root dry weight

In case of root fresh weight (g), the highest weight was recorded in BARI Kaon-2 (0.713) followed by Kaon BD-887 (0.6153) with no PEG treatment (Table 20). On the other hand, the lowest root fresh weight was observed in the genotype of BARI Kaon-1 (0.115). The highest RFW at 10% PEG concentration was found in BARI Kaon-3 (0.54) followed by BARI Kaon-2 (0.455) whereas the lowest RFW was recorded in Ulipur (0.153) followed by Kaon BD-887 (0.214). The root dry weight (g) showed a decrease pattern with induced drought stress. Highest RDW was observed in BARI Kaon-3 (0.077) followed by BARI Kaon-2 (0.073) when there was no stress. But Kaon BD-876 showed lowest RDW (0.011) even with no stress condition. At 10% PEG concentration the highest RDW was observed in BARI Kaon-2 (0.057) followed by BARI Kaon-3 (0.053) and the lowest was found in Kaon BD-876 (0.007).

SPAD value and Fv/Fm

The genotypes of Foxtail Millet showed a decrease in SPAD value when treated with 10% Polyethelene Glycol (PEG) as compared to no PEG treatment. Highest SPAD value was observed in Kaon BD-887 (24.77) followed by BARI Kaon-1 (21.99) when there was no stress (Table 11.v.2d.1). But Kaon BD-876 showed lowest value (18.57) even with no stress condition. The highest SPAD value at 10% PEG concentration was found in BARI Kaon-1 (17.40) followed by Kaon BD-887 (11.93) whereas the lowest was recorded in Ulipur (7.87) followed by BARI Kaon-2 (9.90). Two genotypes of Foxtail Millet (Kaon BD-887, Kaon BD-876) showed similar Fv/Fm value (0.7633) which was highest among the 6 genotypes in no stress condition. The lowest value was recorded in BARI Kaon-2 (0.7500). Similarly, highest Fv/Fm value (0.7567) was found in two genotypes, named Kaon BD-887 and Kaon BD-876 and the lowest value was 0.7433, found in BARI Kaon-2 at 10% PEG concentration.

Table 11.v.2d.1: Effect of PEG induced drought stress on morpho-physiological parameters of six foxtail millet genotypes at 0 & 10 % level of PEG under hydroponics

Treatment Combinations (Variety × Drought)	Root length (cm)	Shoot length (cm)	SFW (g)	SDW (g)	RFW (g)	RDW (g)	SPAD value	F _v / F _m
BARI Kaon-1 × 0	26.50 a	29.33 bc	0.273 ef	0.057 b	0.115 h	0.023 e	21.99 b	0.7533
BARI Kaon-2 × 0	25.17 a	31.0 b	0.352 d	0.058 b	0.713 a	0.073 a	21.87 b	0.7500
BARI Kaon-3 × 0	17.0 d	28.67 c	1.128 a	0.157 ab	0.598 b	0.077 a	20.50 b	0.7533
Ulipur × 0	17.0 d	27.17 c	0.554c	0.069 b	0.414 de	0.033 d	21.77 b	0.7567
Kaon BD-887 × 0	12.67 ef	15.50 f	0.566 c	0.057 b	0.6153 ab	0.057 b	24.77 b	0.7633
Kaon BD-876 × 0	20.0 c	34.83 a	0.742 b	0.082 ab	0.563 b	0.011 fg	18.57 c	0.7633
BARI Kaon-1 × 10 % PEG	18.67 cd	23.50 d	0.226 f	0.198 a	0.228 fg	0.044 c	17.40 c	0.7533
BARI Kaon-2 × 10 % PEG	22.0 b	18.0 e	0.239 f	0.0383 b	0.455 cd	0.057 b	9.90 e	0.7433
BARI Kaon-3 × 10 % PEG	11.0fg	24.23 d	0.341de	0.063 b	0.54 bc	0.053 b	11.07 de	0.7467
Ulipur × 10 % PEG	14.0 e	23.0 d	0.497 c	0.05 b	0.153 gh	0.013 fg	7.87 f	0.7500
Kaon BD-887 × 10 % PEG	10.50 g	13.83 f	0.5 c	0.047 b	0.214 gh	0.017 ef	11.93 d	0.7567
Kaon BD-876 × 10 % PEG	12.0 fg	23.50 d	0.301 def	0.031 b	0.322 ef	0.007 g	10.93 de	0.7567
Level of Sig.	****	****	****	****	****	****	****	****

In a column, figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test. **** = Significant at 0.1% level of probability. SFW= Shoot fresh weight, RFW= Root fresh weight, SDW= Shoot dry weight, RDW= Root dry weight.

Based on the above discussed parameters, it was found that BARI Kaon-1, BARI Kaon-3, Local- Ulipur and Kaon BD-876 performed better.

11.v.3 (Experiment 3): Agronomic and physio-chemical responses of selected high-value crops genotypes at vegetative and reproductive stages under drought stress condition in pot

11.v.3a (Expt. 3a): Effect of drought stress on vegetative and reproductive stages of maize under pot culture

The effect of water stress on plant height of 5 maize genotypes were presented in the Table 11.v.3a.1. The response of genotypes towards water stress for each variety varied differently. At 50 % FC condition the highest plant height was observed in Pioneer (135.5 cm) and the lowest was observed in BHM-13 (94.50 cm). In case of root length water stress had significant effect (Table 11.v.3a.1) on the tested genotypes. Among the 4 treatments combination (0%, 50%, 75%, 100% FC) 50% FC condition of water had significant positive effect on the length of root. At 50% FC condition highest root length was observed in 981 (109.75 cm) and the lowest was observed in BHM-9 (67.50 cm).

Table 11.v.3a.1: Effect of drought stress on plant height and root length of five maize genotypes under pot culture

Genotypes	Plant height (cm)				Root Length (cm)			
	0% FC	50% FC	75% FC	100% FC	0% FC	50% FC	75% FC	100% FC
Pioneer	116.00 ghi	135.50 bcdef	113.75 hij	158.50 a	38.03 i	101.75 b	70.50 gh	93.75 c
BHM-9	134.50 cdefg	103.25 ij	143.25 abcd	140.25 abcde	30.75 j	67.50 h	73.75 g	81.25 f
Paloan	135.25 cdefg	116.25 fghi	146.25 abc	158.25 a	35.50 i	100.00 b	83.75 ef	88.00 d
BHM-13	133.75 cdefg	94.50 j	116.50 fghi	154.75 ab	36.38 i	83.00 f	87.50 de	83.50 ef
981	126.00 defgh	121.00 efghi	140.25 abcde	155.75 a	37.38 i	109.75 a	82.00 f	71.25 gh
Level of Sig.	***	***	***	***	***	***	***	***

In a column, figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.
*** = Significant at 0.1% level of probability.

Water stress had significantly affected the fresh weight of root and shoot of all the five genotypes (Table 11.v.3a.2). Among the 4 treatments combination (0%, 50%, 75%, 100% FC) 0% FC condition had drastic negative effect on the genotypes while the genotypes showed moderate to better performance in the other treatment combinations. At 50% FC condition the highest fresh weight of root was observed in 981 (32.38 g) and the highest fresh weight of shoot was observed in BHM-9 (254.87 g). On the other hand, at 50% FC condition the lowest fresh weight of root and shoot was observed in Pioneer (22.77 g and 169.93 g).

Table 11.v.3a.2: Effect of drought stress on root and shoot fresh weight (g) of five maize genotypes under pot culture

Genotypes	Root fresh weight (g)				Shoot fresh weight (g)			
	0% FC	50% FC	75% FC	100% FC	0% FC	50% FC	75% FC	100% FC
Pioneer	2.295 kl	22.77 h	16.41 i	48.07 a	66.64 o	221.48 f	169.93 j	304.78 c
BHM-9	1.24 l	25.12 g	23.00 h	39.31 d	74.69 n	287.43 d	254.87 e	316.83 b
Paloan	4.14 jk	30.02 f	32.60 e	42.280 c	100.13 k	194.45 h	204.65 g	261.75 e
BHM-13	3.23 kl	31.70 ef	43.14 bc	30.7 ef	84.16 m	165.50 j	222.20 f	421.30 a
981	5.33 j	32.38 e	44.74 b	26.097 g	92.58l	179.38 i	220.18 f	163.58 j
Level of Sig.	***	***	***	***	***	***	***	***

In a column, figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.
*** = Significant at 0.1% level of probability.

The yield showed decreasing pattern with increased water stress concentration for all the genotypes (Table 11.v.3a.3). At 100 % FC condition all the genotypes had the highest yield and at 0% FC condition no plant was survived to provide flowering and fruiting for any of the genotypes. Treatment with 50% FC condition showed highest yield in Paloan (5.9 ton/ha) and lowest yield in BHM-9 (0.6 ton/ha).

Table 11.v.3a.3: Effect of drought stress on the performance of five maize genotypes under pot culture

Genotypes	Grain yield (ton/ha)			
	0% FC	50% FC	75% FC	100% FC
Pioneer	-	2.6 f	5.5 cde	8.28 a
BHM-9	-	0.6 g	2.7 f	7.90 a
Paloan	-	5.9 cd	6.11 bcd	6.0 bcd
BHM-13	-	3.5 f	4.94 de	6.23 bc
981	-	4.6 e	6.51 bc	7.18 ab
Level of Sig.	***	***	***	***

In a column, figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.
*** = Significant at 0.1% level of probability.

Based on the above discussed morphological and yield attributes, it was found that Pioneer, BHM-9 and 981 performed better and these 3 genotypes was selected for field trial in charland conditions for further investigations.

11.v.3b (Expt. 3b): Effect of drought stress on vegetative and reproductive stages of chilli under pot culture

Water stress significantly affect the plant height of 5 chilli genotypes. All the varieties had highest plant height at 100% FC treatment where 0% FC treatment showed the lowest values (Table 11.v.3b.1). At treatment combination of 50% FC local Jhau had the highest plant height (29.6 cm) and Binamorich-1 had the lowest plant height (26.8 cm). In case of relative greenness at 50% FC the highest value was observed in BARI Morich-4 (41.8) and the lowest in BARI Morich-3 (40.3, Table 24).

A gradual increase in root length was observed with increasing water stress (Table 11.v.3b.2). At 0% FC condition all the varieties had the highest root length and the lowest were observed in 100% FC condition. At 50% FC condition BARI Morich-3 had the highest root length (22.2 cm) and BARI Morich-2 had the lowest root length (15.0 cm). On the other hand, a gradual decrease in shoot length was observed with the increase of water stress (Table 11.v.3b.2). 100% FC condition had the highest shoot length for all varieties where at 0% FC condition all the varieties had lowest shoot length. Treatment with 50% FC showed highest shoot length in BARI Morich-4 (43.0 cm) and showed lowest shoot length in Binamorich-1 (24.8 cm).

Table 11.v.3b.1: Effect of drought stress on plant height and SPAD value of five chili genotypes under pot culture

Genotypes	Plant height (cm)				SPAD			
	0% FC	50% FC	75% FC	100% FC	0% FC	50% FC	75% FC	100% FC
BARI Morich-4	27.0 h	27.8 h	31.0 efg	33.2 cde	42.31 b	41.8 bcd	41.4 bcde	41.46 bcde
Binamorich-1	27.6 h	26.8 h	28.6 gh	34.2 bcd	41.0 bcde	41.0 bcde	40.7 cde	40.7 cde
BARI Morich-3	20.2 j	28.2 gh	34.2 bcd	36.2 ab	40.2 e	40.3 de	41.4 bcde	41.41 bcde
BARI Morich-2	23.2 i	31.6d ef	34.0 bcd	35.4 abc	41.3 bcde	40.7 cde	41.1 bcde	41.1 bcde
Local (Jhau)	27.8 h	29.6 fgh	37.2 a	38.2 a	41.5 bcde	41.5 bcde	41.3 bcde	41.3 bcde
Level of Sig.	***	***	***	***	***	***	***	***

In a column, figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.
 *** = Significant at 0.1% level of probability.

Table 11.v.3b.2: Effect of drought stress on root and shoot length (cm) value of five chili genotypes under pot culture

Genotypes	Root length (cm)				Shoot length (cm)			
	0% FC	50% FC	75% FC	100% FC	0% FC	50% FC	75% FC	100% FC
BARI Morich-4	25.40 a	19.2 e	14.8 h	12.4 j	39.8 def	43.0 bcd	44.8 b	45.2 ab
Binamorich-1	22.8 b	17.8 fg	14.0 hi	12.2 j	35.2 gh	24.8 j	35.0 gh	41.0 cdef
BARI Morich-3	23.2 b	22.2 b	20.8 cd	17.0 g	30.8 i	32.6 hi	43.0 bcd	39.4 ef
BARI Morich-2	17.2 fg	15.0 h	13.4 j	12.2 j	31.4 i	33.0 hi	44.4 bc	42.0 bcde
Local (Jhau)	22.0 bc	20.6 d	18.4 ef	17.2 fg	37.8 fg	32.8 hi	45.4 ab	48.60 a
Level of Sig.	***	***	***	***	***	***	***	***

In a column, figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.
 *** = Significant at 0.1% level of probability.

In case of root and shoot fresh weight varieties didn't show any pattern of increase or decrease with increased water stress condition (Table 11.v.3b.3). At 50% FC condition highest RFW was observed in BARI Morich-2 (0.9 g) and highest SFW was observed in BARI Morich-3 (14.2 g). On the other hand, at 50% FC condition Local Jhau had the lowest RFW (0.5 g) and Binamorich-1 had the lowest SFW (8.3 g).

The yield showed a similar decreasing pattern with increased water stress concentration. At 100% FC condition, all the genotypes had the highest yield and at 0% FC condition, all the genotypes had the lowest yield. Treatment with 50% FC condition showed highest yield in BARI Morich-3 (5452 kg/ha) and lowest yield in Binamorich-1 (1063 kg/ha, Table 11.v.3b.4).

Table 11.v.3b.3: Effect of drought stress on root and shoot fresh weight of five chili genotypes under pot culture

Genotypes	Root Fresh Weight (RFW) (g)				Shoot Fresh Weight (SFW) (g)			
	0% FC	50% FC	75% FC	100% FC	0% FC	50% FC	75% FC	100% FC
BARI Morich-4	1.0 g	0.8 i	0.8 hi	1.0 fg	9.7 i	11.3 h	9.4 ij	19.3 c
Binamorich-1	0.7 j	0.8 hi	1.4 c	1.7 b	7.7i	5.3 m	8.5 k	16.7 e
BARI Morich-3	0.4l	0.7 j	1.16 e	1.4 c	9.0 j	14.2 f	19.9 b	16.3 e
BARI Morich-2	0.6 k	0.9 h	1.1 ef	2.6 a	9.6 i	9.8 i	18.2 d	26.5 a
Local (Jhau)	0.6 k	0.5 l	1.0 g	1.2 d	7.7i	8.3 k	12.7 g	11.5 h
Level of Sig.	***	***	***	***	***	***	***	***

In a column, figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.
 *** = Significant at 0.1% level of probability.

Table 11.v.3b.4: Effect of drought stress on yield of five chilli genotypes under pot culture

Genotypes	Yield (kg/ha)			
	0% FC	50% FC	75% FC	100% FC
BARI Morich-4	3262 j	4873 g	5786 ef	10597 a
Binamorich-1	534 n	1063 m	2214 k	9422 b
BARI Morich-3	3855 hi	5452 f	8910 c	6071 e
BARI Morich-2	1067 m	4126 h	6127 e	10627 a
Local (Jhau)	1722l	1898 kl	3694 i	6682 d
Level of Sig.	***	***	***	***

In a column, figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.
 *** = Significant at 0.1% level of probability.

Based on the above discussed parameters, it was found that BARI Morich-3, BARI Morich-4 performed better, and Binamorich-1 was found as sensitive one and these 3 genotypes was selected for field trial in charland conditions for further investigations and yield comparison.

11.v.3c (Expt. 3c): Effect of drought stress on vegetative and reproductive stages of groundnut under pot culture

The effect of water stress on plant height of 5 groundnut genotypes were presented in the Table 11.v.3c.1. The response of genotypes towards water stress for each variety varied differently. At 50 % FC condition the highest plant height was observed in ICGV-07214 (36.26 cm) and the lowest was observed in ICGV-0504-7 (26.8 cm). In case of root length, water stress had significant effect (Table 11.v.3c.1) on the tested genotypes. Among the 4 treatments combination (0%, 50%, 75%, 100% FC), 50% FC condition of water had significant positive effect on the length of root. At 50% FC condition highest root length was observed in BARI Chinabadam-8 (52.53 cm) and the lowest was observed in Dhaka-1 (28.49 cm).

Table 11.v.3c.1: Effect of drought stress on plant height and root length of five groundnut genotypes under pot culture

Genotypes	Plant height (cm)				Root Length (cm)			
	0% FC	50% FC	75% FC	100% FC	0% FC	50% FC	75% FC	100% FC
ICGV-0504-7	37.03 b	26.80 ij	34.48 bcd	32.09 def	14.06 ij	35.12 ef	40.89 d	37.01 ef
Binachinabadam--4	44.00 a	32.76 cde	33.26 cde	29.53 fghi	17.61 i	48.55 c	38.29 de	0.11 k
BARI Chinabadam-8	31.2 efgh	27.20 i	24.02 j	29.60 fghi	85.0 a	52.53 b	45.03 c	46.00 c
Dhaka-1	32.40 def	31.0 efgh	35.58 bc	28.91 ghi	13.97 j	28.49 g	34.51 f	29.43 g
ICGV-07214	31.7 defg	36.26 b	30.81 efgh	28.405 hi	22.44 h	33.93 f	29.00 g	29.20 g
Level of Sig.	***	***	***	***	***	***	***	***

In a column, figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.

*** = Significant at 0.1% level of probability.

Water stress had significantly affected the fresh and dry weight of shoot of all the five genotypes (Table 11.v.3c.2). Among the 4 treatment combination (0%, 50%, 75%, 100% FC) 0% FC condition had drastic negative effect on the genotypes while the genotypes showed moderate to better performance in the other treatment combinations. At 50% FC condition the highest fresh weight of shoot was observed in Dhaka-1 (22.22 g) and the highest dry weight of shoot was observed in Dhaka-1 (6.26 g). On the other hand, at 50% FC condition the lowest fresh and dry weight of shoot was observed in ICGV-0504-7 (4.971 g and 1.82 g).

Table 11.v.3c.2: Effect of drought stress on shoot fresh and dry weight of five groundnut genotypes under pot culture

Genotypes	Shoot fresh weight (g)				Shoot dry weight (g)			
	0% FC	50% FC	75% FC	100% FC	0% FC	50% FC	75% FC	100% FC
ICGV-0504-7	5.15 l	4.97 l	5.39 kl	8.50 i	3.3 k	1.82 n	2.23 m	2.99 l
Binachinabadam-4	5.28 l	12.66 g	17.64 d	22.55 bc	3.3 k	5.23 f	5.54 e	7.24 b
BARI Chinabadam-8	12.58 g	14.65 e	11.07 h	31.17 a	7.23 b	4.97 g	4.29 i	7.99 a
Dhaka-1	7.28 j	22.22 c	17.01 d	23.26 b	4.31 i	6.26 d	5.75 e	6.64 c
ICGV-07214	6.16 k	13.80 f	11.60 h	7.55 j	3.47 k	4.56 h	4.26 i	3.75 j
Level of Sig.	***	***	***	***	***	***	***	***

In a column, figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.

*** = Significant at 0.1% level of probability.

The response of genotypes towards water stress for each variety varied differently. At 50 % FC condition the highest number of nodules per plant was observed in Dhaka-1 (49.4) and the lowest was observed in ICGV-0504-7(4.38, Table 11.v.3c.3). In case ofN/peg, water stress had significant effect (Table) on the tested genotypes. Among the 4 treatment combination (0%, 50%, 75%, 100% FC), 50% FC condition of water had significant positive effect on the no. of peg/plant. At 50% FC condition no. of peg/plantwas observed in BARI Chinabadam-8 (50.5) and the lowest was observed in ICGV-0504-7(2.63 Table 11.v.3c.3).

Table 11.v.3c.3: Effect of drought stress on no. of nodule per plant and N/peg of five groundnut genotypes under pot culture

Genotypes	Number of nodule/plant				Number of peg/plant			
	0% FC	50% FC	75% FC	100% FC	0% FC	50% FC	75% FC	100% FC
ICGV-0504-7	19.65 m	4.38 p	29.720 h	32.820 g	5.02 k	2.63 n	9.37 d	5.64 j
Binachinabadam-4	21.71 kl	42.40 e	32.324 g	45.110 d	4.40 l	6.02 i	14.71 b	10.32 c
BARI Chinabadam-8	20.55 lm	14.7 n	12.398 o	22.950 jk	7.02 g	6.64 h	6.47 h	4.60 l
Dhaka-1	40.22 f	49.400 b	56.362 a	50.334 b	3.13 m	5.4 j	8.99 e	5.75 ij
ICGV-07214	25.4 i	46.968c	42.614 e	24.344 ij	8.93 e	50.5 a	7.71f	6.02 i
Level of Sig.	***	***	***	***	***	***	***	***

In a column, figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.

*** = Significant at 0.1% level of probability.

The yield showed a similar decreasing pattern with increased water stress concentration. At 100% FC condition, all the genotypes had the highest yield and at 0% FC condition, all the genotypes had the lowest yield. At 50% FC condition highest yield was found in BARI Chinabadam-8 (654.4 kg/ha) and lowest yield in Binachinabadam-4 (189.0 kg/ha, Table 11.v.3c.4).

Table 11.v.3c.4: Effect of drought stress on yield of five groundnut genotypes under pot culture

Genotypes	Yield (kg/ha)			
	Control	50% FC	75% FC	100% FC
ICGV-0504-7	27.4 m	379.8 i	462.4 h	584.6 g
Binachinabadam-4	55.5lm	189.0 j	659.0 f	1177.4 b
BARI Chinabadam-8	170.3 j	654.4 f	773.0 de	1464.2 a
Dhaka-1	88.6 kl	650.2 f	759.8 e	961.6 c
ICGV-07214	123.6 k	433.6 h	619.2 fg	815.2 d
Level of Sig.	***	***	***	***

In a column, figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.

*** = Significant at 0.1% level of probability.

Based on the above discussed parameters, it was found that BARI Chinabadam-8, Binachinabadam-4 and Dhaka-1 performed better, and so field trial was done in charland conditions for further investigations.

11.v.3d (Expt. 3d): Effect of drought stress on vegetative and reproductive stages of tomato under pot culture

From the experiment of hydroponic culture five (5) tomato genotypes were selected for pot culture. These genotypes were undergone pot trial following CRD design with three replications using three treatments of drought i.e., control (25% FC), moderate (50% FC) and severe drought (75% FC) at BAU, Mymensingh.

Leaf greenness (SPAD)

The combined effects of drought level of five tomato cultivars on leaf greenness was not statistically significant. In control condition, the maximum leaf greenness was recorded in BARI Tomato-16 (50.30) followed by BARI Tomato-15 (48.83), BARI Tomato-2 (48.47), Binatomato-11 (48.23) and BARI Tomato-18 (47.57), respectively. In moderate stress, the maximum leaf greenness was recorded in Binatomato-11 (44.73) followed by BARI Tomato-16 (44.63), BARI Tomato-2 (44.20), BARI Tomato-15 (43.97) and BARI Tomato-18 (42.77), respectively. In severe stress, the maximum leaf greenness was recorded in Binatomato-11 (41.70) followed by BARI Tomato-16 (41.47), BARI Tomato-2 (41.23), BARI Tomato-15 (41.00) and BARI Tomato-18 (40.33), respectively (Fig. 11.v.3d.1).

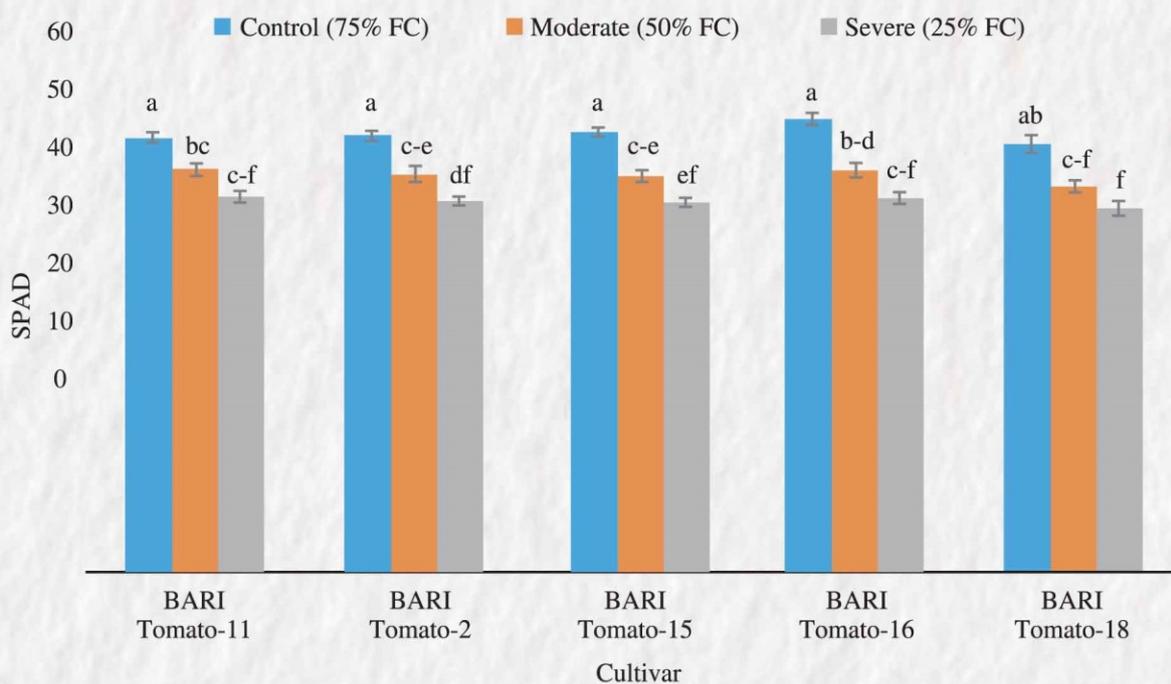


Fig. 11.v.3d.1. Leaf greenness (SPAD values) in five tomato cultivars under three drought levels. Each data point is the average of three replicates, vertical bars represent SEM (n=3). Bars with different letters were significantly different (P<0.05)

Net photosynthesis (A) ($\mu\text{mol CO}_2 \text{ m}^{-2}\text{s}^{-1}$)

Five tomato cultivars showed wide magnitude of changes in the net photosynthesis. Significant variation was observed among the cultivars and treatment. In control condition, the highest rate of net photosynthesis (10.4) was recorded from the cultivar Binatomato-11 followed by BARI Tomato-15 (9.4), BARI Tomato-16 (8.6), BARI Tomato-18 (8.6) and BARI Tomato-2 (8.3), respectively. In moderate stress condition, the highest rate of net photosynthesis (6.8) was recorded from the cultivar BARI Tomato-16 followed by Binatomato-11 (5.4), BARI Tomato-15 (5.3), BARI Tomato-18 (5.3) and BARI Tomato-2 (5.3), respectively. In severe stress condition, the highest rate of net photosynthesis (4.5) was recorded from the cultivar BARI Tomato-16 followed by Binatomato-11 (4.1), BARI Tomato-15 (3.7), BARI Tomato-18 (2.9) and BARI Tomato-2 (2.9), respectively (Fig. 11.v.3d.2).

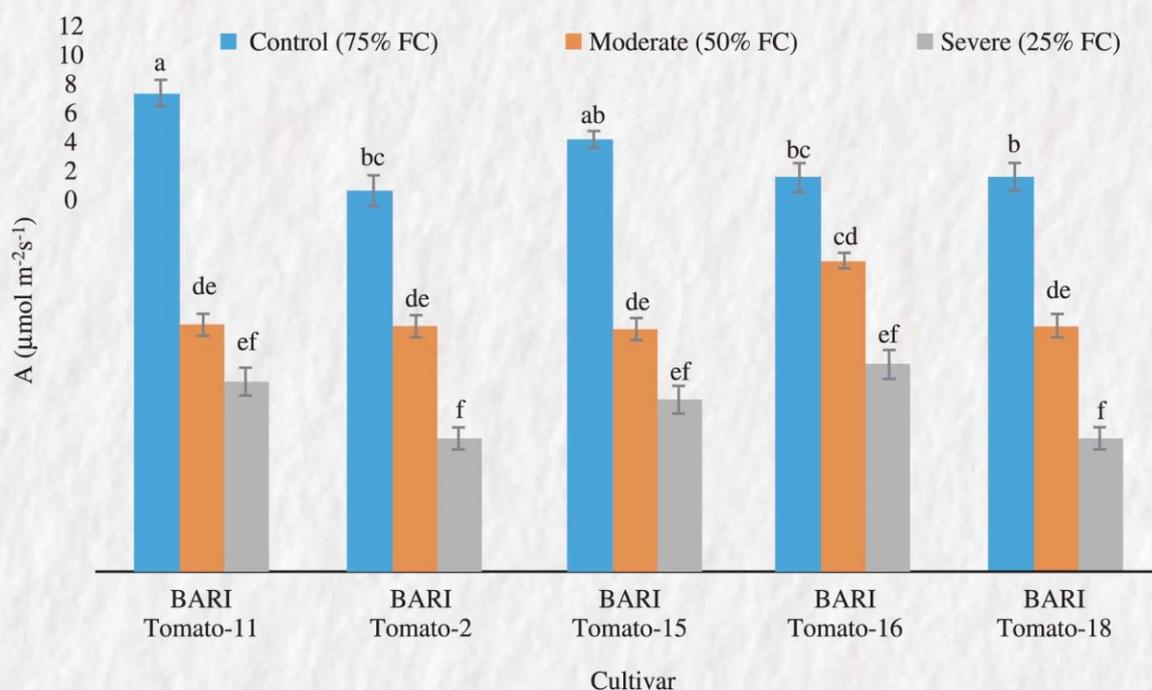


Fig. 11.v.3d.2. Net photosynthesis (A) in five tomato cultivars under three drought levels. Each data point is the average of three replicates, vertical bars represent SEM ($n=3$). Bars with different letters were significantly different ($P < 0.05$)

Transpiration rate (E mmol H_2O $m^{-2}s^{-1}$)

The rate of transpiration showed significant variation on cultivars and water stress levels, respectively. The combined effect of drought and cultivar was found non-significant. In control condition, the highest rate of transpiration (2.8) was recorded from the cultivar BARI Tomato-16 followed by BARI Tomato-18 (2.7), BARI Tomato-2 (2.5), Binatomato-11 (2.2) and BARI Tomato-15 (1.7), respectively. In moderate stress condition, the highest rate of transpiration (2.1) was recorded from the cultivar BARI Tomato-16 followed by BARI Tomato-18 (2.0), BARI Tomato-15 (1.3), BARI Tomato-18 (1.3) and BARI Tomato-2 (1.0), respectively. In severe stress condition, the highest rate of transpiration (0.8) was recorded from the cultivar Binatomato-11 followed by BARI Tomato-16 (0.7), BARI Tomato-2 (0.7), BARI Tomato-18 (0.5) and BARI Tomato-15 (0.2), respectively (Fig. 11.v.3d.3).

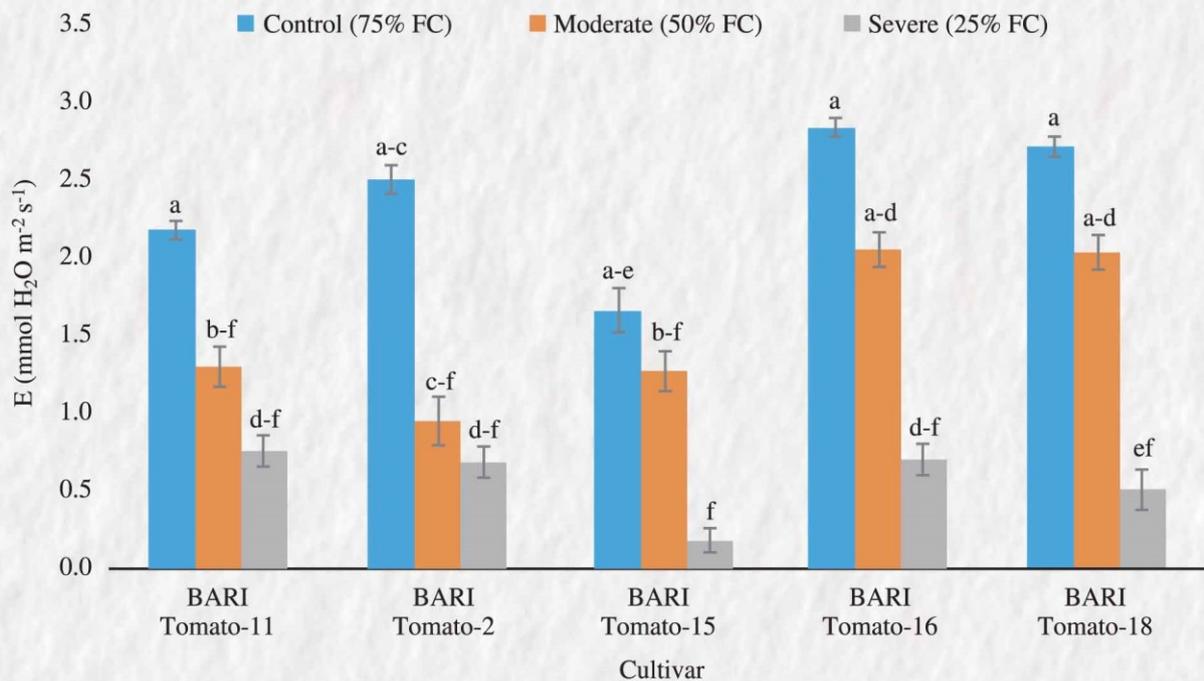


Fig. 11.v.3d.3. Transpiration (E) rate in five tomato cultivars under three drought levels. Each data point is the average of three replicates, vertical bars represent SEM ($n=3$). Bars with different letters were significantly different ($P < 0.05$)

Stomatal conductance ($\text{gs mol H}_2\text{O m}^{-2}\text{s}^{-1}$)

Stomatal conductance became significant among the combination effect of cultivars and treatment. In control condition, the highest rate of stomatal conductance (0.27) was recorded from the cultivar BARI Tomato-18 followed by BARI Tomato-16 (0.20), Binatomato-11 (0.18), BARI Tomato-2 (0.15) and BARI Tomato-15 (0.09), respectively. In moderate stress condition, the highest rate of stomatal conductance (0.13) was recorded from the cultivar BARI Tomato-18 followed by BARI Tomato-16 (0.07), BARI Tomato-15 (0.06), BARI Tomato-11 (0.06) and BARI Tomato-2 (0.04), respectively. In severe stress condition, the highest rate of stomatal conductance (0.06) was recorded from the cultivar BARI Tomato-15 followed by BARI Tomato-16 (0.05), Binatomato-11 (0.05), BARI Tomato-18 (0.03) and BARI Tomato-2 (0.03), respectively (Fig. 11.v.3d.4).

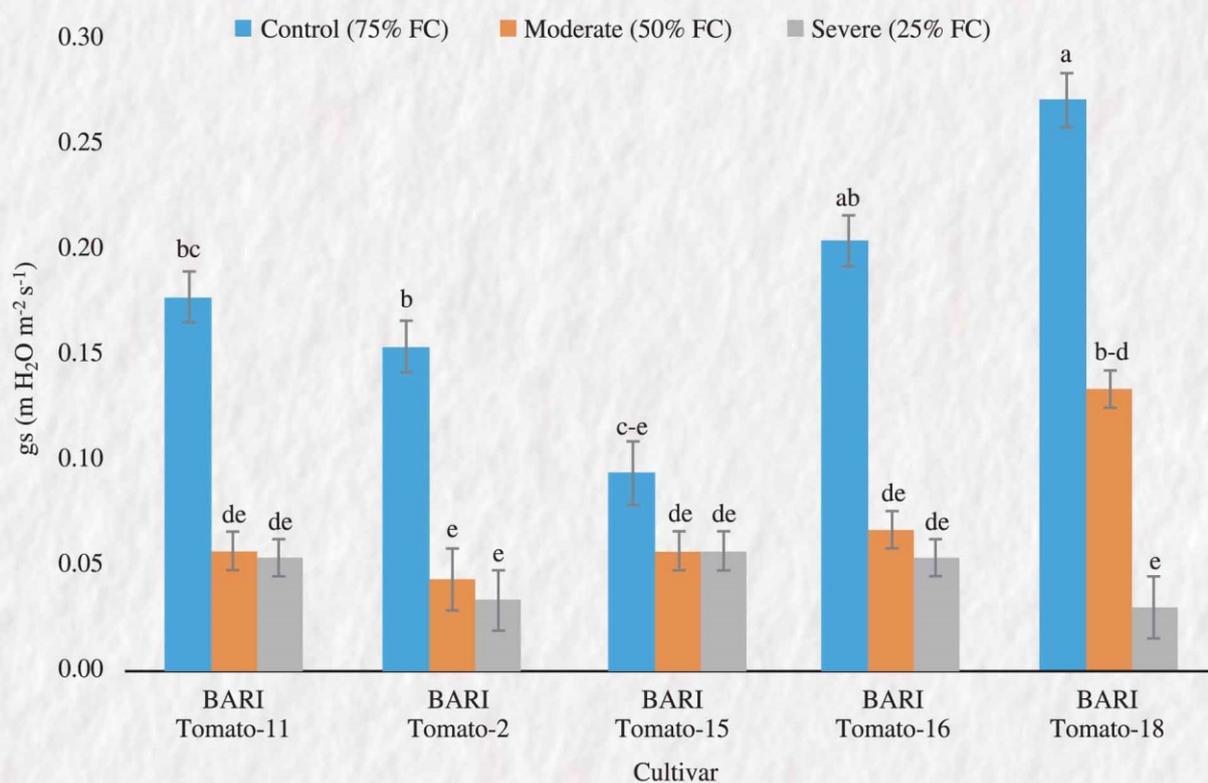


Fig. 11.v.3d.4. Stomatal conductance (gs) in five tomato cultivars under three drought levels. Each data point is the average of three replicates, vertical bars represent SEM ($n=3$). Bars with different letters were significantly different ($P < 0.05$)

Total chlorophyll content

The interaction effects of drought levels and cultivars in relation to total chlorophyll was not significant. In control condition, the maximum total chlorophyll (a+b) was recorded in BARI Tomato-18 (14.5) followed by BARI Tomato-15 (13.7), BARI Tomato-16 (12.6), BARI Tomato-2 (12.3) and Binatomato-11 (11.3), respectively. In moderate stress, the maximum total chlorophyll (a+b) was recorded in BARI Tomato-18 (11.2) followed by BARI Tomato-15 (10.2), Binatomato-11 (8.0), BARI Tomato-16 (7.9) and BARI Tomato-2 (7.8), respectively. In severe stress, the maximum total chlorophyll (a+b) was recorded in BARI Tomato-15 (7.6) followed by BARI Tomato-16 (7.3), BARI Tomato-2 (6.9), BARI Tomato-18 (6.8) and Binatomato-11 (5.3), respectively (Fig. 11.v.3d.5).

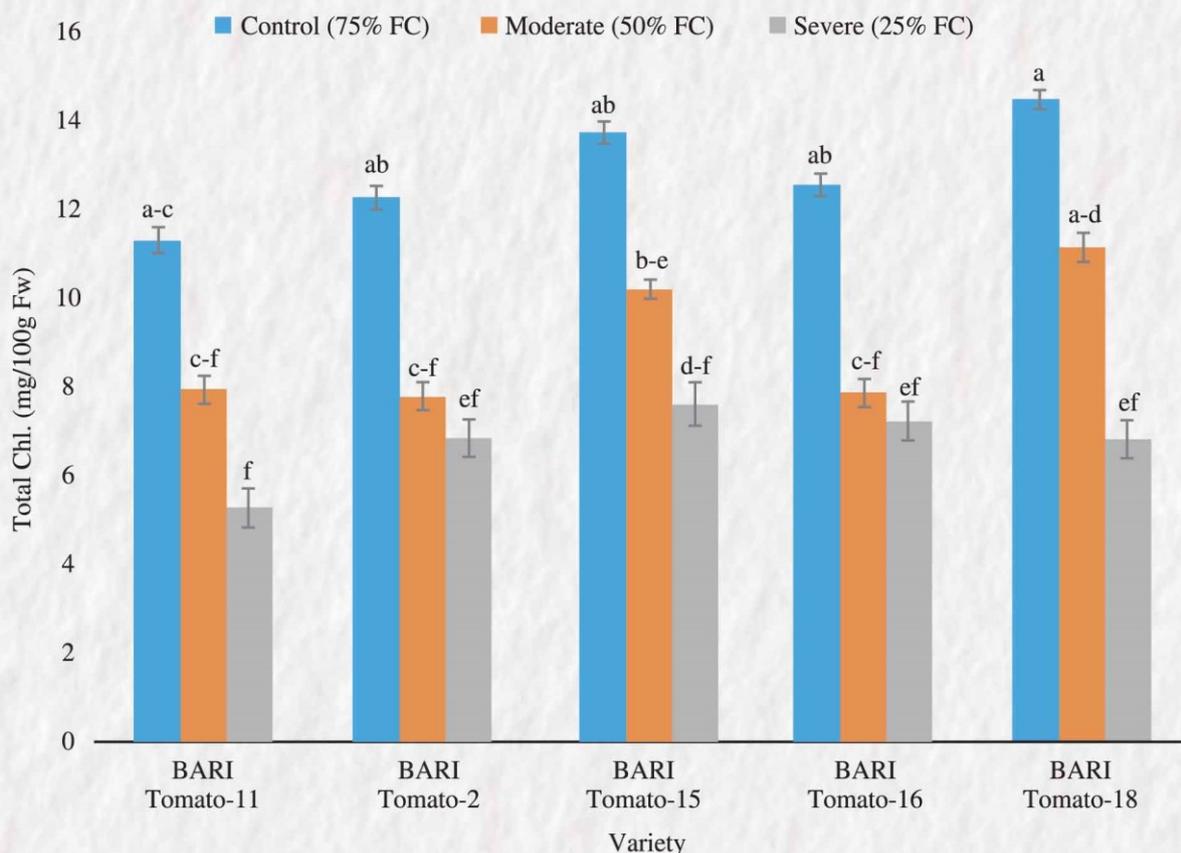


Fig. 11.v.3d.5. Total chlorophyll (a+b) content in five tomato cultivars under three drought levels. Each data point is the average of three replicates, vertical bars represent SEM (n=3). Bars with different letters were significantly different (P<0.05)

Fruit yield plant⁻¹

The combined effect of water stress and five tomato cultivars on fruit yield plant⁻¹ was statistically significant. In control condition, the highest fruit yield plant⁻¹ was observed at Binatomato-11 (1923.3 g) followed by BARI Tomato-16 (1805.7 g), BARI Tomato-2 (1565.8 g), BARI Tomato-15 (1359.5 g) and BARI Tomato-18 (1358.2 g), respectively. In moderate water deficit condition, the highest fruit yield plant⁻¹ was observed at Binatomato-11 (987.4 g) followed by BARI Tomato-2 (901.0 g), BARI Tomato-16 (888.9 g), BARI Tomato-15 (707.9 g) and BARI Tomato-18 (706.6 g), respectively. In severe stress condition, the highest fruit yield plant⁻¹ was observed at BARI Tomato-16 (481.1 g) followed by Binatomato-11 (474.4 g), BARI Tomato-2 (444.2 g), BARI Tomato-15 (419.2 g) and BARI Tomato-18 (289.4 g), respectively. So, the maximum fruit yield was observed at Binatomato-11 (1923.3 g) in control condition and the minimum fruit yield was observed in BARI Tomato-18 (289.4 g) at severe water stress condition (Fig. 11.v.3d.6 & Fig. 11.v.3d.7).

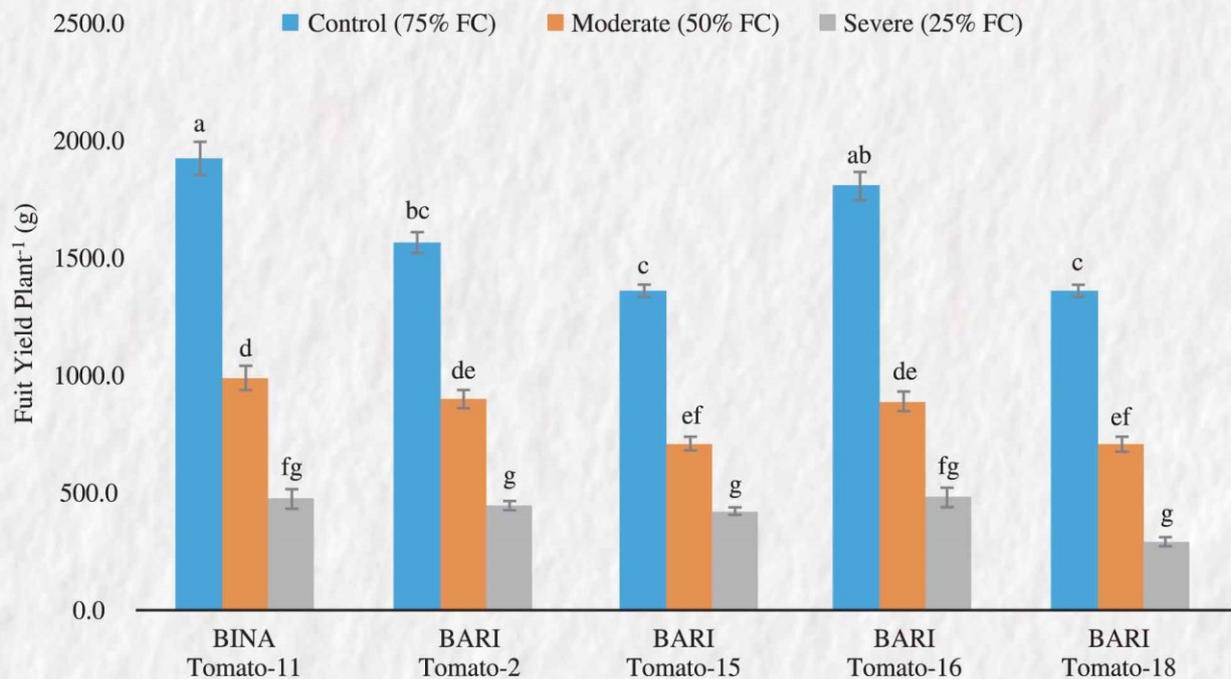


Fig. 11.v.3d.6. Fruit yield plant⁻¹ in five tomato cultivars under three drought levels. Each data point is the average of three replicates, vertical bars represent SEM (n=3). Bars with different letters were significantly different (P<0.05)

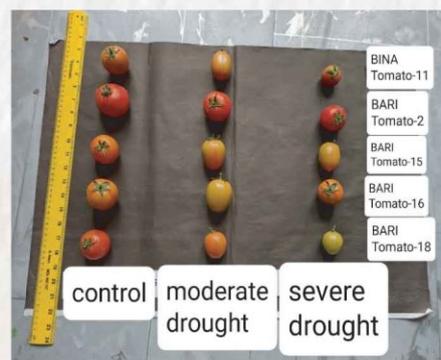


Fig. 11.v.3d.7: Combined effect of cultivars and three drought levels on tomato fruit

Based on the above parameters, it was found that BARI Tomato-2, Binatomato-11, BARI Tomato-16, and BARI Tomato-15 performed better which needs further investigation.

11.v.4 (Expt. 4): Agronomic and physio-chemical responses of primarily selected different high-value crops at charlands

11.v.4a (Expt. 4a): Agronomic and physio-chemical responses of primarily selected maize genotypes at charlands

Field performance of three maize genotypes were evaluated based on yield contributing characteristics i.e. plant height, ear length, stover yield, 1000 grain weight, cob fresh wt., cob dry weight, grain/cob and grain yield. Genotype BHM-9 had the highest plant height (210.57 cm), ear length (99.06 cm) and stover yield (30.79 cm) whereas genotype 981 had the lowest plant height (198.93 cm), ear length (75.93 cm) and stover yield (26.31 cm), respectively. In case of 1000-grain weight, 981 showed the highest value (60.0 g) and BHM-9 showed the lowest value (44.8 g). Cob fresh wt. was highest for genotype Pioneer (267.73 g) while cob dry wt. was highest for 981 (201.87 g). On the other hand, 981 had the lowest cob fresh wt. (246.27 g) and BHM-9 had the lowest cob dry wt. (193.43g). In case of grain/cob and yield parameters, 981 had the highest values 476.93 and 12.15 t/ha while BHM-9 had the lowest values 442.00 and 10.33 t/ha, respectively (Table 11.v.4a.1).

Based on the above parameters, it was found that 981 performed better infield trial in charland conditions, which needs for further investigations.

Table 11.v.4a.1: Morphological and yield attributes of selected three maize genotypes at charland condition under field performance

Genotypes	Plant height (cm)	Ear length (cm)	Stover yield (t/ha)	1000 grain wt (g)	Cob Fresh wt (g)	Cob Dry weight (g)	Grain/cob	Grain yield (t/ha)
Pioneer	206.67 a	77.26 b	26.88 b	59.3 a	267.73 a	198.67 ab	452.20 a	10.4 a
BHM 9	210.57 a	99.06 a	30.79 a	44.8 b	258.6 a	193.43 b	442.00 a	10.33 a
981	198.93 a	75.93 b	26.317 b	60.0 a	246.27 a	201.87 a	476.93 a	12.15 a
CV %	2.56	8.45	4.58	3.59	21.74	1.20	9.30	8.42
Level of Sig.	***	***	***	***	***	***	***	***

In a column, figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.

*** = Significant at 0.1% level of probability.

11.v.4b (Expt. 4b): Agronomic and physio-chemical responses of primarily selected chilli genotypes at charlands

Yield contributing characters i.e. Plant height (cm), branch/plant, pod/plant, pod breadth (cm), pod length (cm), yield/plant (g) and yield (T/ha) were evaluated for three chilli genotypes. BARI Morich-3 showed the highest plant height (62.26 cm), branch/plant (21.10) and pod/plant (9.07), respectively. In case of pod breadth and pod length, Binamorich-1 had the highest values 1.33 and 9.52 cm, while BARI Morich-3 had the lowest values 0.58 and 6.96 cm, respectively. In terms of yield BARI Morich-3 and BARI Morich-4 showed the statistically highest yield (16.683 and 16.21 and t/ha) and Binamorich-1 showed the lowest yield (10.683 t/ha, Table 11.v.4b.1).

Table 11.v.4b.1: Morphological and yield attributes of three selected chili genotypes at charland condition under field performance

Genotypes	Plant height (cm)	Branch /plant	Pod/ plant	Pod breadth (cm)	Pod Length (cm)	Yield/ plant (g)	Yield (T/ha)
BARI Morich-3	62.26 a	21.10 a	9.07 a	0.58 b	6.96 a	313.67 a	16.683a
Binamorich-1	42.41 b	14.33 b	8.50 a	1.33 a	9.52 a	264.81 b	13.217b
BARI Morich-4	48.287 b	12.38 c	8.93 a	1.10 a	7.58 a	324.57 a	16.21 a
CV %	7.53	4.76	5.34	12.06	18.40	3.16	3.18
Level of Sig.	***	***	***	***	***	***	***

In a column, figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.
*** = Significant at 0.1% level of probability.

Based on the above discussed parameters, it was found that BARI Morich-3 and BARI Morich-4 performed better in field trial in charland conditions which needs for further investigations.

11.v.4c (Expt. 4c): Agronomic and physio-chemical responses of primarily selected groundnut genotypes at charlands

Field performance of three groundnut genotypes were done based on yield contributing characteristics i.e. shoot length, root length, shoot fresh weight, root fresh weight, leaf fresh weight, no. of leaf/plant, no. of nodule/plant, SPAD, stover yield (t/h) and nut yield (t/h). Genotype Binachinabadam-4 had the highest shoot length (73.80 cm) and root length (17.61 cm). BARI Chinabadam-8 had the highest SFW (197.55g) and LFW (62.46g) whereas Dhaka-1 had the lowest SFW (114.64g) and LFW (35.77g), respectively. In case of number of nodule/plant, Dhaka-1 showed the highest value (86.81) and BARI Chinabadam-8 showed the lowest value (34.85). In terms of stover yield BARI Chinabadam-8 had the highest values 9.71 t/ha. On the other hand, stover yield was lowest for Dhaka-1 (6.03 t/ha). The highest nut yield (2.97 t/ha, Table 11.v.4c.1) was recorded from the BARI Chinabadam-8 whereas other two genotypes (Binachinabadam-4 and Dhaka-1) were identical but lower than former one (2.24 and 2.37 t/ha respectively, Table 11.v.4c.1).

Table 11.v.4c.1: Morphological and yield attributes of three selected groundnut genotypes at charland condition under field performance

Genotypes	SL (cm)	RL (cm)	SFW (g)	LFW (g)	RFW (g)	No. of leaf/ plant	No. of Nodule /plant	SPAD	Stover Yield (t/h)	Nut Yield (t/h)
BARI Chinabadam-8	70.53 a	16.72 b	197.55 a	62.46 a	7.15 b	103.30 a	34.85 b	35.31a	9.71 a	2.97 a
Bina Chinabadam-4	73.80 a	17.61 a	128.43 b	42.03 b	15.15 a	69.2 b	80.66 a	34.03a	6.40 b	2.24 b
Dhaka-1	71.44 a	15.19 c	114.64 c	35.77 c	7.84 b	58.8 c	86.81 a	35.76a	6.03 c	2.37 b
CV %	4.31	2.11	1.13	4.29	8.09	3.24	6.76	6.56	1.38	7.68
Level of Sig.	***	***	***	***	***	***	***	***	***	***

In a column, figure (s) with the same or without letter (s) do not differ significantly at a 5% level by LSD Test.
*** = Significant at 0.1% level of probability. SL=Shoot length, RL=Root length, SFW= Shoot fresh weight, LFW= Leaf fresh weight, RFW= Root fresh weight.

Based on the above parameters, it was found that BARI Chinabadam-8 performed better in field trial in charland conditions, which needs for further investigations.

12. Research Highlights

Component-1 (OFRD, BARI)

FEASIBILITY OF HIGH-VALUE CROPS PRODUCTION IN NORTHERN CHARLAND OF BANGLADESH

Background

The total charland area in Rangpur, Kurigram, Gaibandha and Lalmonirhat districts are 77895 hectares and among them about 79% are cultivable (DAE, 2016), but unfortunately those are mostly underutilized or used for low-value crops production. The farmers of char lands are poor and they do not know about the possibility of high value crops production. Bangladesh Agricultural Research Institute (BARI) has released a large number of varieties of different crops, such as cereals, roots and tuber, pulses, oilseeds, vegetables, spices, etc. Among the crops and varieties, some have potentiality to grow successfully in charland area, which needs to test for their suitability in the northern charland area. In general, the agricultural productivity in charland is less due to low fertility, riverbank erosion, poverty, less intervention of modern agricultural technologies/varieties and also minimal services from government and NGOs. Therefore, addressing the above situation, utilization of vast northern charland with high-value crops production would be possible by identifying appropriate crops and varieties.

Objectives

- i) To identify the suitable high value crops and varieties for northern charland.
- ii) To see the profitability of selected crops.

Methodolog

The programs were executed during 2018-19 in 03 rivers based charland area (stable and unstable) of 03 Northern districts, i.e. Char Dhorola river under Kurigram district (Char Begumganj); Char Tista river under Lalmonirhat district (Char Jagatber) and Char Bangali river under Gaibandha district (Char Saghata). A total of ten types of crops were tested at each char location, where each crop was replicated in 03 dispersed farmers field including 02 varieties of each crop (one improved variety and one local variety/practice as check) maintaining RCB design. A total of 90 farmers (30 from each location) were involved in the program conducting research with 10 crops.

List of different crops and varieties used under suitability study against local variety/practice in different char lands during 2018-19.

Crop group	Crop	Crop variety considered	
		Improved variety	Local
Cereal crops	Maize	BARI Hybrid Maize-9	Commercially grown hybrid
	Foxtail millet	BARI Kaon-2	Locally grown kaon
Vegetables	Sweet gourd	BARI Hybrid Mistikumra-1	Locally adapted Mistikumra
	Bitter gourd	Popular variety	Local variety Ucche
Tuber crops	Potato	BARI Alu-77	BARI Alu-25
	Sweet potato	BARI Mistialu-8	Local variety
Pulse crops	Blackgram	BARI Mash-3	Local variety
	Lentil	BARI Mosur-8	Local variety
Oil Seed	Groundnut	BARI Chinabadam-9	Local variety (Dhaka-1)
Spices crops	Chilli	BARI Morich-2 & 3	Local variety
	Onion	BARI Pijaj-1	Local variety

Key findings

- **Potato:** In the 3 (Three) char sites, BARI Alu-77 performed better than the char farmers who adopted potato variety BARI Alu-25. BARI Alu-77 produced an average tuber yield (22.36 t ha⁻¹) which was 15.61% higher than BARI Alu-25 (Average yield: 19.34 t ha⁻¹). From the cost and return analysis, BARI-77 was found profitable as it showed the average highest gross margin (77,289Tk ha⁻¹) which was 47,026Tk. higher than control (BARI Alu-25).
- **Sweet potato:** BARI Mistialu-8 performed better than the local sweet potato cultivar in all char areas. BARI Mistialu-8 (29.75 t ha⁻¹) produced an average of 48.45% higher root yield than the local sweet potato cultivar (20.04 t ha⁻¹). From the cost and return analysis, BARI Mistialu-8 was found profitable as it showed the average highest gross margin (171,929 Tk ha⁻¹) which was 72,140 Tk. higher than control (local sweet potato cultivar).
- **Maize:** BARI Hybrid Maize-9 achieved a little bit better than commercial hybrid maize variety in all three locations. The average higher maize grain yield was obtained from BHM-9 (9.28 t ha⁻¹) compared to commercial hybrid maize variety (9.11 t ha⁻¹). From the cost and return analysis, BHM-9 was found profitable as it showed that the average highest gross margin (48,908 Tk ha⁻¹) which was 2291 Tk. higher than locally available commercial maize variety.
- **Sweet gourd:** BARI Hybrid Mistikumra-1 achieved an exceptional performance in the char areas than local sweet gourd cultivar. The average higher fruit yield of BARI Hybrid Mistikumra-1 (24.29 t ha⁻¹) produced an average of 23.0% higher fruit yield than the local sweet gourd cultivar (19.89 t ha⁻¹). The cost and return analysis showed that the average highest gross margin was accounted for from BARI Hybrid Mistikumra-1 (200,784 Tk ha⁻¹) which was 44,066 Tk. higher than locally adapted sweet gourd cultivar.
- **Bitter gourd:** The local bitter gourd cultivar (Ucche Korola) achieved an extraordinary performance in the Char area of Begumganj, Kurigram. The fruit yield of the Ucche Korola was ranged from 3.5 to 4.5 t ha⁻¹ with an average of 4.0 t ha⁻¹. From the cost return analysis, Ucche Korola production in the char lands of Begumganj was found profitable where the gross margin was 200757 Tk. ha⁻¹.

- **Lentil:** The seed yield of BARI Mosur-8 was ranged from 1.13 to 1.38 t ha⁻¹ with an average of (1.28 t ha⁻¹) which produced 31.95% more yield than locally adapted lentil variety (0.97 t ha⁻¹). The cost and return analysis showed that the average highest gross return and margin was accounted from BARI Mosur-8; 57758 Tk ha⁻¹ & 32,425 Tk ha⁻¹, respectively than locally adapted lentil variety.
- **Onion:** The bulb yield of BARI Piaj-1 was ranged from 3.60 to 8.56 t ha⁻¹ with an average of 6.87 t ha⁻¹ which produced 15.07% higher bulb yield than the local onion cultivar (5.97 t ha⁻¹). The cost and return analysis showed BARI Piaj-1 was found profitable and the average highest gross return and margin was for BARI Piaj-1; 116,832 Tk ha⁻¹ & 33,989 Tk ha⁻¹, respectively.
- **Blackgram:** The yield of BARI Mash-3 was ranged from 1.12 to 1.68 t ha⁻¹ with an average of 1.38 t ha⁻¹ which produced 24.32% higher yield than locally adapted Mash cultivar (1.11 t ha⁻¹). The average highest gross return and margin were accounted from BARI Mash-3; 62,012 Tk ha⁻¹ & 36,737 Tk ha⁻¹, respectively and was found profitable for char land areas.
- **Chilli:** The yield of BARI Morich-3 was ranged from 8.46 to 8.60 t ha⁻¹ with an average of 8.53 t ha⁻¹ where the highest yield was recorded from Lalmonirhat site. The average higher chilli yield was obtained from BARI Morich-3 (8.53 t ha⁻¹) compared to the locally adapted Chilli variety (8.11 t ha⁻¹). The average highest gross return and margin were accounted from BARI Morich-3; 85,301 Tk ha⁻¹ & 14,466 Tk ha⁻¹, respectively.
- **Groundnut:** The yield of BARI Chinabadam-8 was ranged from 2.10 to 3.05 t ha⁻¹ with an average of 2.48 t ha⁻¹. The average highest groundnut yield was obtained from BARI Chinabadam-8 (2.48 t ha⁻¹) which was 13.24% higher than locally adapted groundnut cultivar (2.19 t ha⁻¹). The cost and return analysis showed that the average highest gross return and margin were accounted from BARI Chinabadam-8; 117837 Tk ha⁻¹ & 56453 Tk ha⁻¹, respectively.
- **Foxtail millet:** BARI Kaon-2 showed a unique presentation in the char areas than local Kaon cultivar. The average higher kaon yield was obtained from BARI Kaon-2 (2.32 t ha⁻¹) which was 50.64% higher than locally adapted kaon (1.54 t ha⁻¹). The cost and return analysis showed that the highest gross return and gross margin were obtained from BARI Kaon-2 variety; 56600 Tk. ha⁻¹ and 33400 Tk. ha⁻¹, respectively in the Charland's of Gaibandha where the average highest gross return and margin was accounted from BARI Kaon-2; 38757 Tk ha⁻¹ & 18015 Tk ha⁻¹, respectively.

Key words: Group approach, pilot production, char profitable crops

IMPROVEMENT OF MARKETING SYSTEM FOR HIGH-VALUE CROPS IN NORTHERN CHARLAND OF BANGLADESH

Background: Bangladesh has acquired 5471 square kilometres of new land until 2010 since independence in riverine areas (Hasan et al., 2013). This has been a blessing for the small country where agricultural land is less than 14 decimals/capita (Ministry of Land, 2015) and it is shrinking every year at an alarming rate of 0.005 ha/capita/year since 1989 (Hossain and Bari, 1996). The total charland area in Rangpur, Kurigram, Gaibandha and Lalmonirhat districts are 77895 hectares and among them about 79% are cultivable (DAE, 2016), but unfortunately those are mostly underutilized or used for low-value crops production. One of the major causes of less production in charland is poor marketing channel. The farmers are also getting less product price due to non-diversified and low-value crops, improper marketing channel, middleman, inefficient transportation system etc. Therefore, addressing the above situation, utilization of vast northern

charland for increased high-value crops production, income generation and livelihood improvement would be possible by generating and adopting appropriate technologies/approaches including promotion of business.

Objectives

To develop marketing system for improving char farmers' livelihood in northern Bangladesh.

Methodology: The study was conducted in three districts namely Kurigram, Lalmonirhat and Gaibandha of Rangpur Division, Bangladesh. A total of 155 respondents, 80 were the farmers of pilot production program from which 60 came from Kurigram and Lalmonirhat, and 20 from Gaibandha. From the remaining 75 respondent 10 were faria, 10 were Bepari, 10 were wholesaler, 10 were retailer, 10 were arothders (Commission Agents), 10 were members of the local service providers, 5 were processors and remaining 10 were Consumers. Data were collected through survey method using a pre- designed and pre - tested questionnaire during 2020-2021. The collected data were then edited, summarized, tabulated and analyzed to achieve the objectives of the study. From the data existing and improved marketing channels developed. Tabular analysis also used for marketing cost and margin. The following supports, services and inputs were provided for the developing of marketing channels.

- Formation of Agro-Centre
- Formation of demand based producer group
- Capacity building,
- Local Service Provider (LSP) development,
- Mini transporter improvement,
- Improvement of post-harvest processing,
- Technical backstopping,
- Development of storage opportunity,
- Linking with good seed source,
- Linking with agricultural product buyer,
- Strengthening linkage between farmers and marketing channels, etc.

Key findings: Three or four existing marketing channels were observed in each of sweet potato, foxtail millet, chilli, groundnut, bitter gourd, sweet gourd, blackgram and onion. Most effective existing marketing channel were Farmer-Bepari-Arothder -Retailer-Consumer for sweet potato, Farmer-Faria-Bepari-Processing Centre-Wholesaler-Retailer-Consumer for foxtail millet and lentil, Farmer-Bepari-Processing Centre-Whole Saler-Retilar-consumer for ground nut, Farmer-Faria-Bepari-Commission Agent- Retilar-consumer for bitter gourd, sweet gourd and onion and Farmer-Faria-Bepari-Processing mill-Whole Saler-Retailer-Consumer for blackgram. Again, improved marketing channel includes farmers group or local service provider for getting higher price to the farmers. Out of some improved marketing channels, most effective marketing channel were Farmer-Local Service Provider-Aratders/commission agents-Retailer-Consumer for sweet potato, bitter gourd, sweet gourd and onion, Farmer-Local Service Provider- Processing Centre - Wholesaler-Retailer-Consumer for foxtail millet, lentil, ground nut and blackgram. Farmers can earn more profit by producing, storing, grading and marketing their seeds. This project helps farmers in this regard. So, some seed marketing channels were developed by LSP. The most effective seed marketing channel were Farmer-Local Service Provider- Grower for foxtail millet, Farmer-LSP-Retailer-Growers for lentil, ground nut and blackgram and Farmer-LSP-Whole Saler-Retailer-Growers for onion.

Key words: improved marketing channel, marketing margin, flow chart

SCREENING AND EVALUATION OF DIFFERENT HIGH-VALUE CROPS FOR CHARLAND ECOSYSTEM BASED ON AGRO-PHYSIOLOGICAL CHARACTERISTICS

Background

Charlands are highly dynamic, and no systemic crop cultivation is practiced in this area due to unavailability of seeds of early & short duration drought tolerant crop varieties. Scarcity of water is a severe environmental constraint to plant productivity. Drought-induced loss in crop yield probably exceeds losses from all other causes, since both the severity and duration of the stress are critical. In addition, the farmers are also getting less product price due to non-diversified and low-value crops in the charland areas. For this, it is necessary to find out short duration drought tolerant and high value crop varieties for the charland areas. Therefore, our objective was to screen and evaluation of different high-value crops for charland ecosystem based on agro-physiological characteristics.

Objectives

Screening and evaluation of different high-value crops for charland ecosystems based on agro-physiological characteristics

Methodology

For this, the genotypes of five crops viz., Chilli (9 genotypes); Groundnut (45 genotypes); Maize (30 genotypes), Foxtail millet (25 genotypes); Tomato (13 genotypes) were collected from BARI, BADC and other sources and these genotypes were subsequently evaluated through germination, hydroponics, pot and field trial. Seed quality assessment of different genotypes of different crops was done with different level of polyethylene glycol (PEG) induced drought stress. After that, selected genotypes of all crops were subsequently investigated in hydroponic culture with different level of polyethylene glycol (PEG) induced drought stress and pot culture based on morpho-physiological attributes. Based on previous seed quality, hydroponic culture and pot culture, potential genotypes of different crops were selected. Finally, three genotypes (selected from seed quality, hydroponic culture and pot culture) of groundnut, maize and chilli were undergone for field trial to evaluate their agro-physiological performance at charland of Lalmonirhat.

Key Findings

From the germination (experiment-1), based on the different stress tolerance indices like GSTI, RSLI and SLSI six maize genotypes (Gold Star, BHM-13, Paloan, 981, BHM-9 and Pioneer), five chilli genotypes (Local (Jhau), BARI Morich-3, BARI Morich-2, Binamorich-1, BARI Morich-4), five tomato genotypes (BARI Tomato-2, BARI Tomato-15, BARI Tomato-16, BARI Tomato-18 and Binatomato-11), sixteen groundnut genotypes (BARI Chinabadam-9, ICGV-07214, ICGV-0504-7, ICGV-02125, ICGV-95070, ICGV-955090, Binacinabadam-4, BARI Chinabadam-8, ICGV-06279, Dhaka-1, ICGV-07245, ICGV-05158, BARI Chinabadam-6, Binacinabadam-8, BARI Chinabadam-10, ICGV-97232), six foxtail millet genotypes (BARI Kaon-1, BARI Kaon-2, BARI Kaon-3, Ulipur, Kaon BD 887, Kaon BD 876) performed better and selected for hydroponics and further investigations.

From the hydroponics experiment (Experiment-2), according to different morpho-physiological attributes, five maize (BHM-13, Pioneer, Paloan, 981 and BHM-9), five groundnut genotypes (ICGV-0504-7, Binacinabadam-4, BARI Chinabadam-8, ICGV-07214 and Dhaka-1), five tomato genotypes (BARI Tomato-2, BARI Tomato-15, BARI Tomato-16, BARI Tomato-18 and Binatomato-11) and

four foxtail millet (BARI Kaun-1, BARI Kaun-3, Local- Ulipur and Kaun BD-876) exhibited better performance and these genotypes were selected for pot trial and further investigations. From the pot experiment (Exp. 3), on the basis of different morpho-physiological traits, three maize genotypes (BHM-9, Pioneer and 981), three chilli genotypes (Binamorich-1, BARI Morich-3, BARI Morich-4) and three groundnut genotypes (BARI Chinabadam-8, Binachinabadam-4 and Dhaka-1) showed better results and these genotypes were undergone for field trial in the charland of Lalmonirhat.

During field trial (Exp. 4), based on yield and yield attributes 981 (maize genotype), BARI Morich-3 and BARI Morich-4 (Chilli genotypes) and BARI Chinabadam-8 (groundnut genotype) performed better at charland conditions and exhibited considerable amount of yield.

However, these three potential high value crop genotypes i.e. 981 (maize genotype), BARI Morich-3 and BARI Morich-4 (Chilli genotypes) and BARI Chinabadam-8 (groundnut genotype) can be directly cultivated in the charland areas. Therefore, utilization of vast northern charland for increased high-value crops production, income generation and livelihood improvement would be possible by adopting the selected potential high value crop genotypes.

Keywords: Charlands, hydroponics, crop production, morph-physiological attributes, yield.

B. Implementation status

1. Procurement (Component wise)

Table B.1.1. Procurement status of Component-1 (OFRD, BARI)

Description of equipment and capital items	PP Target		Achievement		Remarks
	Physical (No.)	Financial (Tk.)	Physical (No.)	Financial (Tk.)	
(a) Office equipment					
-Laptop computer	2	120000	2	120000	100%
-Laser Printer	1	20000	1	20000	100%
-Scanner	1	10000	1	10000	100%
(b) Lab &field equipment					
-Grain moisture meter	1	25000	1	25000	100%
-pH meter (Portable)	1	35000	1	35000	100%
-EC meter (Portable)	1	50000	1	50000	100%
-Camera	1	25000	1	25000	100%
(c) Other capital items					
-Motorcycle	1	160000	1	160000	100%

Table B.1.2. Procurement status of Component-2 (BAU)

Description of equipment and capital items	PP Target		Achievement		Remarks
	Physical (No.)	Financial (Tk.)	Physical (No.)	Financial (Tk.)	
(a) Office equipment	5	160000	5	160000	100%
(b) Lab & field equipment	18	410200	18	410200	
(c) Other capital items					
Seed	-	232850	-	232850	100%
Fertilizers	-	42300	-	42300	100%
Pesticides	-	51850	-	51850	100%
Others	-	202500	-	202500	100%

2. Establishment/renovation facilities: Not applicable.

Table B.2. 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:

Table B.3.1. Training, Workshop, meeting under Coordination component

Description	Number of participant			Duration (Days /weeks/months)	Remarks
	Male	Female	Total		
(a) Training	-	-	-	-	-
(b) Workshop					
i) Inception workshop	24	6	30	1 day	One workshop
(c) Others (Networking meeting)	15	0	15	1 day	One meeting

Table B.3.2. Training, Workshop, Field day under Component-1 (OFRD, BARI)

Description	Number of participant			Duration (Days /weeks/months)	Remarks
	Male	Female	Total		
(a) Training					
i) Farmer-5	82	68	150	1 day	Five farmer training
ii) SA/SAAO-1	29	1	30	1 day	One SA/SAAO training
(b) Workshop (Stakeholder-1)	29	01	30	1 day	One workshop
(c) Others					
i) Field day-1	73	47	100	1 day	One field day
ii) Baseline survey-3	228	72	300	-	Survey at three locations



Fig. B.3.1: Training and field day activities at different char locations



Fig. B.3.2: Inception workshop



Fig. B.3.3: Networking meeting

Table B.3.3. Training, Workshop, Networking meeting under Component-2 (BAU)

Description	Number of participants			Duration (Days /weeks/months)	Remarks
	Male	Female	Total		
(a) Training	-	-	-	-	-
(b) Workshop	15	1	16	1 day	One meeting
i) Inception Meeting					
(c) Others (if any)	33	0	33	1 day	One workshop

C. Financial and physical progress (Combined and Component wise)

Table C.1. Total fund received and expenditure (component-1, component-2 & co-ordination component)
Figure in Tk.

Items of expenditure /activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
a. Contractual staff salary	2311911	2296911	2291911	5000	99.13491	
b. Field research/lab expenses and supplies	4083890	3883890	3883890	0	95.10271	
c. Operating expenses	1138850	1086638	966482.5	124531.5	84.86478	
d. Vehicle hire and fuel, oil & maintenance	695824	627565	612565	68259	88.03447	
e. Training/workshop/seminar etc.	511500	511500	474500	37000	92.76637	
f. Publications and printing	160000	60000	60000	0	37.5	
g. Miscellaneous	283426	261060	261060	17366	92.1087	
h. Capital expenses	814600	814600	814600	0	100	
Total	10000001	9542164	9365009	252156.5	93.65008	

Table C.2. Fund received and expenditure under Co-ordination component

Figure in Tk.

Items of expenditure /activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
a. Contractual staff salary	180000	165000	160000	5000	88.89	
b. Field research/lab expenses and supplies	0	0	0	0	0.00	
c. Operating expenses	300000	252500	132870.50	119629.50	44.29	
d. Vehicle hire and fuel, oil & maintenance	130000	115000	100000	15000	76.92	
e. Training/workshop/seminar etc.	112000	112000	75000	37000	66.96	
f. Publications and printing	120000	20000	20000	0	16.67	
g. Miscellaneous	50000	45000	45000	0	90.00	
h. Capital expenses	0	0	0	0	0.00	
Total	892000	709500	532870.5	176629.5	59.74	

Table C.3. Fund received and expenditure under Component-1 (OFRD, BARI)

Figure in Tk.

Items of expenditure /activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
a. Contractual staff salary	876772	876772	876772	0	100	
b. Field research/lab expenses and supplies	2463440	2463440	2463440	0	100	
c. Operating expenses	546335	541959	541959	4376	99.20	
d. Vehicle hire and fuel, oil and maintenance	265824	212565	212565	53259	79.96	
e. Training/workshop/seminar etc.	332500	332500	332500	0	100	
f. Publications and printing	20000	20000	20000	0	100	
g. Miscellaneous	118426	101060	101060	17366	85.33	
h. Capital expenses	445000	445000	445000	0	100	
Total	5068297	4993296	4993296	75001	95.56	

C.4. Fund received and expenditure under Component-2 (BAU Component)

Figure in Tk.

Items of expenditure /activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
a. Contractual staff salary	1255139	1255139	1255139	0	100	
b. Field research/lab expenses and supplies	1620450	1420450	1420450	0	100	
c. Operating expenses	292515	292179	291653	526	99.82	
d. Vehicle hire and fuel, oil and maintenance	300000	300000	300000	0	100	
e. Training/workshop/seminar etc.	67000	67000	67000	0	100	
f. Publications and printing	20000	20000	20000	0	100	
g. Miscellaneous	115000	115000	115000	0	100	
h. Capital expenses	369600	369600	369600	0	100	
Total	4039704	3839368	3838842	526	99.99	

D. Achievement of Sub-project by objectives (Tangible form): Technology generated/developed

Component-1 (OFRD, BARI)

General/specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output (i.e., product obtained, visible, measurable)	Outcome (short term effect of the research)
<p>a) General objective: Farmers livelihood improvement through introduce of high value crops and development of marketing system in northern charland.</p> <p>b) Specific objective: i) To identify the suitable high value crops for different char ecosystems.</p>	<p>Identification of suitable and profitable high value crops in the northern charland and development of marketing channel.</p> <p>A total of 10 types of crops (including 1 improved and 1 local variety of each crop) were tested at each char area in 2018-19.</p>	<p>Total 8 types of high value crops were identified and 3 types of crops for each char area.</p> <p>A total of 8 types of high value crops have been identified for the 3 char areas (3-4crops for each char). Yield increment by Char-ecosystem wise selected crops varieties are-</p> <p>Char Jagatber: 1. Sweet gourd var. BARI Hybrid Mistikumra-1: 12% 2. Groundnut var. BARI Chinabadam-9: 6% 3. Chilli var. BARI Morich-3& Local: 14%</p> <p>Char Begunganj: 1. Bitter gourd var. Ucce (Local): 40% 2. Groundnut var. BARI Chinabadam-9: 28% 3. Onion var. BARI Piaj-1: 14% 4. Blackgram var. BARI Mash-3: 27%</p> <p>Char Saghata: 1. Sweet potato var. BARI Mistialu-8: 56% 2. Chilli var. BARI Morich-3& Local: -2% 3. Foxtail millet var. BARI Kaon-2: 110%.</p>	<p>Proper utilization of charland and income enhancement of farmers through high value crops.</p> <p>Suitable and profitable crops for northern char area have been identified with high yield</p>

Component-2 (BAU)

General/specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output (i.e. product obtained, visible, measurable)	Outcome (short term effect of the research)
To screen and evaluation of different high-value crops for charland ecosystem based on agro-physiological characteristics.	Screening and evaluation of different high-value crops (Groundnut, maize, tomato, chilli and foxtail millet) during germination based on agro-physiological characteristics.	Selected genotypes from germination: 9 Chilli genotypes; 16 groundnut genotypes; 6 Maize genotypes; 6 Foxtail millet genotypes; 6 Tomato genotypes.	Knowing the performance of different high-value crops during germination in laboratory conditions.
To evaluate the agro-physiological performance of different high value crops under water stress condition in pot and hydroponic systems.	Evaluation of the agro-physiological performance selected (from early growth performance) genotypes of the studied high value crops under artificially induced drought condition in hydroponic systems and pot.	Selected genotypes from hydroponics and pot: 3 Chilli genotypes; 3 Groundnut genotypes; 3 Maize genotypes.	Realizing the performance of different high-value crops during hydroponics and pot culture.
To see the agro-economic performance of different high value crops under improved management in different char ecosystems	Agro-economic performance of the selected genotypes (From early growth, hydroponics and pot performance) of groundnut maize and chilli under improved management in char ecosystems	Selected genotypes from field trial: Maize: 981 Chilli: BARI Morich-3 & BARI Morich-4 Groundnut: BARI Chinabadam-8.	Utilization of vast northern charland Increased high-value crops production.

E: Information/knowledge generated/policy generated

Component-1 (OFRD, BARI)

General/specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output	Outcome (short term effect of the research)
<p>ii) To expand cultivation of selected crops through group approach with improved management system in northern charland.</p>	<p>Based on the previous year adaptive trial results, a total of 8 types of crop's varieties (3-4 crops per char location) were brought under pilot production program following farmers group approach in 2019-20 & 2020-21.</p>	<p>Farmers group-based two years production area (ha) and yield (t ha-1) of high value crops in 3 char areas are:</p> <ol style="list-style-type: none"> 1. Sweet gourd var. BARI Hybrid Mistikumra-1: area = 6.78, fruit yield = 32.67 2. Bitter gourd var. Ucche korola: area = 7.25, fruit yield = 4.11 3. Groundnut var. BARI Chinabadam-9: area = 8.68, nut yield = 2.16 4. Onion var. BARI Piaj-1: area = 6.56, bulb yield = 11.20 5. Black gram var. BARI Mash-3: area = 3.97, seed yield = 1.35 6. Sweet potato var. BARI Mistialu-8: area = 4.51, root yield = 31.64 7. Onion var. BARI Morich-3 & Local: area = 9.02, green fruit yield = 9.14 8. Foxtail millet var. BARI Kaon-2: area = 5.0, grain yield = 2.26. 	<p>Char-wise suitable and profitable high value crop's varieties have been expanded and farmers group-based production system also developed</p>
<p>iii) To develop marketing system for improving char farmers' livelihood in northern Bangladesh.</p>	<p>For improving marketing system the below activities were done-</p> <ul style="list-style-type: none"> - Formation of Agro-Centre, - Formation of demand based producer group - Local Service Provider (LSP) development - Mini transporter improvement, - Improvement of post-harvest processing - Development of storage opportunity - Linking with good seed source - Linking with agricultural product buyer - Capacity building - Strengthening linkage between farmers and marketing channels 	<p>Improved marketing channel for sweet gourd, groundnut, onion, blackgram, bitter gourd, sweet potato, chilli and foxtail millet were developed. Seed production and storage system also established.</p>	<p>Production of selected crops (sweet gourd, groundnut, onion, blackgram, bitter gourd, sweet potato, chilli and foxtail millet) and also farmers income have been increased.</p>

Component-2(BAU)

General/specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output	Outcome (short term effect of the research)
To screen and evaluation of different high-value crops for charland ecosystem based on agro-physiological characteristics	Screening and evaluation of different high-value crops (Groundnut, maize, tomato, chilli and foxtail millet) during germination based on agro-physiological characteristics.	Selected genotypes from germination: 9 Chilli genotypes; 16 Groundnut genotypes; 6 Maize genotypes; 6 Foxtail millet genotypes; 6 Tomato genotypes	Knowing the performance of different high-value crops during germination
To evaluate the agro-physiological performance of different high value crops under water stress condition in pot and hydroponic systems.	Evaluation of the agro-physiological performance selected (from early growth performance) genotypes of the studied high value crops under artificially induced drought condition in hydroponic systems and pot.	Selected genotypes from hydroponics and pot: 3 Chilli genotypes; 3 Groundnut genotypes; 3 Maize genotypes	Realizing the performance of different high-value crops during hydroponics and pot culture
To see the agro-economic performance of different high value crops under improved management in different char ecosystems.	Agro-economic performance of the selected genotypes (From early growth, hydroponics and pot performance) of groundnut maize and chilli under improved management in char ecosystems.	Selected genotypes from field trial: Maize: 981 Chilli: BARI Morich-4 Groundnut: BARI Chinabadam-8	Utilization of vast northern charland. Increased high-value crops production.

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

Coordination component

Publication	Number of publications		Remarks (e.g., paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/booklet/leaflet/flyer etc.	-	Booklet-01	1. Production of vitamin-A enriched sweet potato suitable for char agro-ecosystem and its marketing system development.
Other publications, if any	PCR	-	-

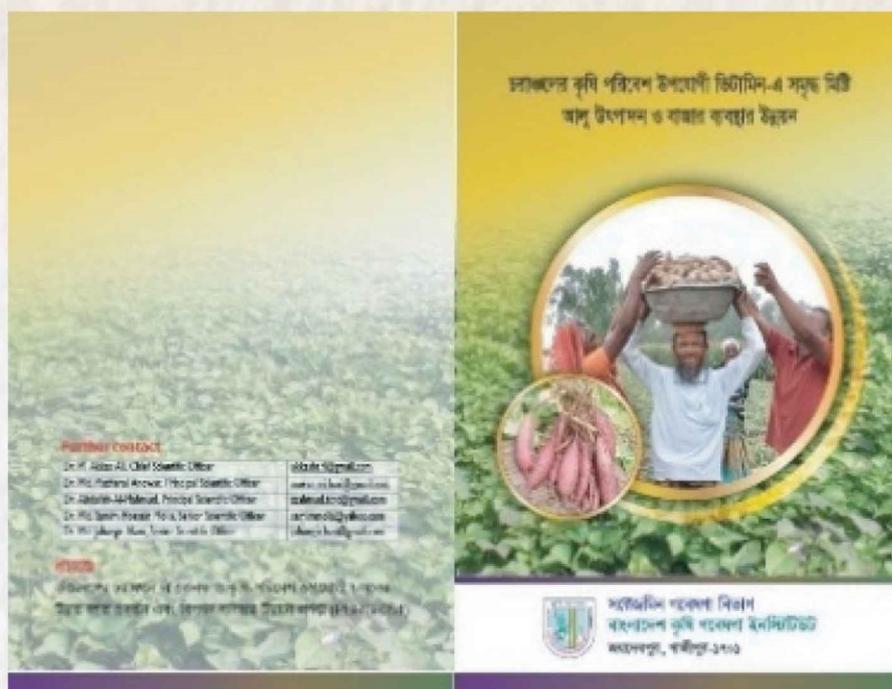
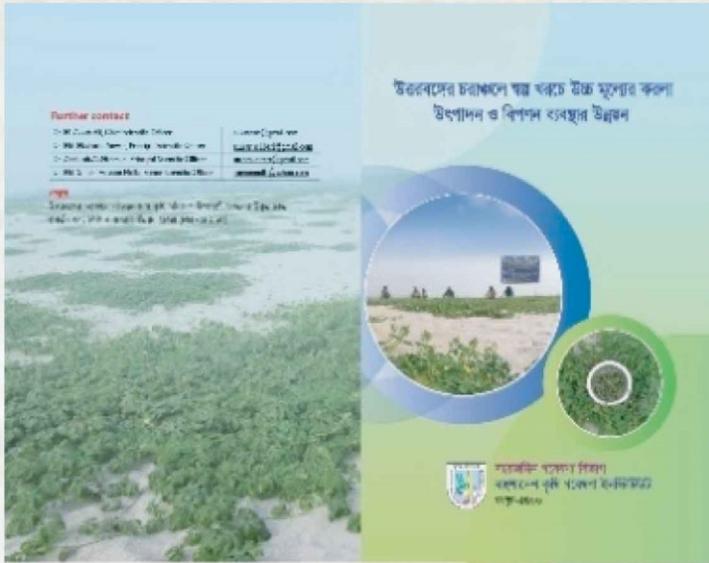


Fig. F.1: Print and Electronic media coverage

Component-1 (OFRD, BARI)

Publication	Number of publications		Remarks (e.g., paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc.	-	Booklet-01	1. Low cost production and marketing system development for high value bitter melon in northern charland of Bangladesh.
Journal publication	-	-	-
Video clip/TV program	-	TV program-05	Channel i, Bangla vision, Joyjatra TV
News Paper/Popular Article	-	News Paper-01	Daily Juger Alo
Other publications, if any	-	-	-



Booklet & Newspaper

TV media

Fig. F.2: Print and Electronic media coverage

Component-2 (BAU)

Publication	Number of publications		Remarks (e.g., paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Journal publication	2	-	1. Polyethylene glycol (PEG) induced drought stress on groundnut cultivars at early seedling stage. 2. Drought tolerance of maize based on more pho-physiological and biochemical traits.
Other publications (MS and PhD thesis)	4+1 (MS+PhD)	1	Completed MS thesis title: Drought tolerance of groundnut cultivars based on physiological and biochemical attributes.

G. Description of generated technology/knowledge/policy

i. Technology Fact Sheet

Component-1 (OFRD, BARI)

Fact sheet-1

Title of the technology: Development of low-cost bitter gourd production and marketing system in the char areas of Northern Bangladesh

Introduction

In the northern region, especially in Rangpur, Kurigram, Lalmonirhat and Gaibandha districts, there are about 77895 hectares of chars, of which 79% are cultivable. However, due to unconventional, low-value crops and sporadic cultivation under low management, char agriculture in North Bengal is relatively backward. The fertility and water holding capacity of the sandy char soils are low but digging to a depth of one to two feet reveals that the soil has available water as well as a layer of silt also. After the floodwaters recede, profitable Bitter gourd (Uchhe) can be cultivated. Bitter gourd (*Momordica charantia*) is important for its quick growing nature. Its fruits are low in calories but rich in phytonutrients like dietary fiber, minerals, vitamins and also contains a plant insulin known to lower blood sugar levels. Bitter gourd can be cultivated by digging holes in such sandy pastures in October. The depth of the hole for cultivating such in chars depends on the level of soil moisture and silt. After digging the hole up to the level of silt with the help of round digger, it is filled with sand again and it is seen that the mouth of the hole is wet the next day. In this situation, 3-4 seeds of Uchhe cultivar are planted at a depth of 1 inch. After a few days the seedling emerge and spread the vine over the dry sand and thereafter it produces flower and fruits.

The farmers are also getting less product price due to non-diversified and low-value crops, improper marketing channel, middleman, inefficient transportation system etc. Therefore, addressing the above situation, utilization of vast northern charland for increased high-value crops production, income generation and livelihood improvement would be possible by adopting bitter gourd technologies including improved marketing system.

Description

Items	Description
Crop	Bitter gourd
Variety	Uchhe (local cultivar)
Planting method	Pit Method
Time of sowing /planting	1 st -2 nd week of October (3 rd to 4 th week of Ashwin in Bengali month) is suitable.
PGR and its application method	Plant growth regulators like Biofol Super (0.5 ml per liter of water) can be sprayed. The plants need to be sprayed once in the flowering stage and once in every month with PGR 0.5 ml per liter of water.
Fertilizer (kg ha ⁻¹)	No need to use any chemical fertilize
Irrigation and drainage	Generally, no need of irrigation. However light irrigation may be applied if there is a shortage of water in the land.
Intercultural operation	<ul style="list-style-type: none">• With the vegetative growth, the vines spread continuously. To prevent these vines/branches from getting knotted together due to wind, a piece of stick or thin twig should be made in the shape of a V and encircle the branch and put in the sand.• The fungicide needs to be sprayed once during the growth stage and at least once during fruiting stage.
Disease and insect control management	<ul style="list-style-type: none">• Generally, field diseases are very less in Uchhe in Char land conditions. However, fungicide may need to be sprayed once during the growth stage and once during fruiting stage against blight disease.• Fruit borer is also very less in char condition. However, the use of pheromone traps can reduce the number of male insects, thereby reducing the growth of fruit borers.
Harvesting time	February to April.
Fertilizer (kg ha ⁻¹)	4.15

Suitable location/ecosystem: Sandy char areas of Kurigram and other areas of Northern Bangladesh.

Benefits

Gross return: Tk. 228,250 ha⁻¹

Production cost: Tk. 56625 ha⁻¹

Gross margin: Tk. 171,625 ha⁻¹ (46% higher than conventional method) Ensuring the use of technology will increase crop intensity and productivity using fallow sandbanks. Cultivation without fertilizers and toxic pesticides is completely safe and beneficial for human health. It will not be a threat to the environment.

Marketing system

Uchee are produced in a community-based farmers and were brought it to a collection point. After sorting and processing it was marketed through a local service provider (LSP) resulted decreased the number of middlemen and increased the farmer's benefit.

Conventional practice

Farmer-Faria-Bepari-Warehouse-Wholesaler-Retailer-Consumer.

Improved practice:

Fruit purpose: Farmer-LSP (Collection Point)-Commission agent-Whole seller- Retailer-Consumer.

Seed purpose: Seed producer-Farmer

- Farmers can sell their product by 4% higher price and consumer can purchase by 7% lower price under improved marketing system.



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Fact sheet-2

Title of the technology: Development of high-value sweet gourd production and marketing system in char areas of Northern Bangladesh

Introduction

In the northern region, especially in Rangpur, Kurigram, Lalmonirhat and Gaibandha districts, there are about 77895 hectares of chars, of which 79% are cultivable. However, due to unconventional, low-value crops and sporadic cultivation under low management, char agriculture in North Bengal is relatively backward. Sweet gourd is one of the selected crops in the char area of 11 types of crops based on char suitable, profitable, local demand and farmer's choice. Sweet gourd is quite hardy, prolific bearer and highly remunerative even without much cares. These vegetables can specially be grown in charland areas. The fertility and water holding capacity of the sandy char soils are low but digging a little deeper show that the availability of soil water. After the floodwaters recede, a circular hole must be made with the help of a spade in the sandy pastures in October. The depth of the hole depends on the level of wetness received at the bottom (one and a quarter to one and a half feet). Apply the required fertilizer with soils in such holes and sow 3-4 sweet pumpkin seeds in each hole.

The farmers are also getting less product price due to non-diversified and low-value crops, improper marketing channel, middleman, inefficient transportation system etc. Therefore, addressing the above situation, utilization of vast northern charland for increased high-value crops production, income generation and livelihood improvement would be possible by adopting sweet gourd technologies including improved marketing system.

Description

Items	Description
Crop	Sweet gourd
Variety	BARI Hybrid Mistikumra-1
Planting method	Down pit method (Pit to pit distance 500 cm; 150 cm x 200 cm)
Time of sowing /planting	1 st -2 nd week of October (3 rd to 4 th week of Ashwin in Bengali month) is suitable.
Irrigation and drainage	Timely irrigation increases the yield, weight and quality of sweet gourd. Due to sandy soil, fertilizer and irrigation must be applied several times. Water can be easily pumped by installing a boring pipe for irrigation and water can be provided by making small ponds (reservoirs) using polythene without running the irrigation pump repeatedly.
Fertilizer (per pit)	Basal = Cowdung - 10k g, Urea - 30g, TSP - 30 g, MoP - 40 g; Top - dress = Urea - 15 g & TSP - 15 g at 20 days interval.
Intercultural operation	Intercultural operation of the crops depends on the condition of the soil moisture availability. It is necessary to irrigate 1-2 times per week. In addition, light irrigation should be given after each application of fertilizer. Water can be conserved by making mini-ponds (reservoirs) using polythene to facilitate water for irrigation.
Disease and insect control management	Fruit Borer is a known pest in sweet gourd. The use of pheromone traps can reduce the number of male insects, thereby reducing the growth of fruit borers.
Harvesting time	Mid - January to Mid - April ((Magh to Choitra in Bengali month).
Fertilizer (t ha ⁻¹)	35.90

Suitable location/ecosystem: Sandy char areas of Lalmonirhat and other areas of North Bengal.

Benefits

Gross return: Tk. 536,500 ha⁻¹

Production cost: Tk. 78,150 ha⁻¹

Gross margin: Tk. 480350 ha⁻¹ Cultivation of BARI Hybrid Mistikumra-1 under improved management increased the yield by 42% and gross margin by 41% as compared to conventional varieties and methods. Safe without toxic pesticides and carotene-rich sweet gourd is beneficial for human health. It will not be a threat to the environment.

Marketing system

In charlands, sweet gourd was cultivated in community approaches and brought the harvested fruits to a collection point. Fruits were marketed after sorting and processing through a local service provider (LSP) which decreased the number of middlemen in the process and increased the farmer's benefit.

Conventional practice

Farmer-Faria-Bepari-Warehouse-Wholesaler-Retailer-Consumer.

Improved practice:

Fruit purpose: Farmer-LSP (Collection Point) -Commission agent - Retailer-Consumer.

- Farmers can sell their product by 4% higher price and consumer can purchase by 5% lower price under improved marketing system.



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Fact sheet-3

Title of the Technology: Development of Blackgram production and marketing system in the char areas of Northern Bangladesh

Introduction

In the northern region, especially in Rangpur, Kurigram, Lalmonirhat and Gaibandha districts, there are about 77895 hectares of chars, of which 69% is cultivable. However, due to unconventional, low value crops and sporadic cultivation under low management, char agriculture in North Bengal is relatively backward. Blackgram (Maskalai) is one of the selected crops in the char area out of 11 types of crops based on their suitability, profitability, local demand, and farmer's choice. River water carries silt as well as sand from upstream and forms silt-rich chars. This is a source of various plant nutrients. As a result, Blackgram (Masakalai) can be cultivated profitably by seeding without cultivation and applying a small amount of fertilizer on the soft soil of the silt-rich char that appears after the river water recedes.

Description

Items	Description
Crop	Blackgram
Variety	BARI Mash-3
Planting method	Broadcasting
Time of sowing /planting	September (Vadra-Ashwin in Bengali month)
Fertilizer doses (kg ha ⁻¹) and application	Urea-40, TSP-80, MoP-40, Gypsum-50 and Boric acid-7. All fertilizers should be applied on the land before sowing.
Irrigation and drainage	Generally, irrigation is not required in charland condition. Well drainage system should be maintained.
Intercultural operation	To control powdery mildew disease, fungicides like Tilt or Thiovit should be sprayed 2-3 times at intervals of 10-12 days. Infected plants should be uprooted and burnt to control yellow mosaic disease and regular pesticides should be applied to control whitefly insects.
Harvesting time	November-December (Kartik-Agrohayon in Bengali month)
Seed yield (t ha ⁻¹)	1.35

Suitable location/ecosystem: Silty char areas of Kurigram and other areas of North Bengal.

Benefits

Gross return: Tk. 81,000 ha⁻¹

Production cost: Tk. 24987 ha⁻¹

Gross margin: Tk. 56,013 ha⁻¹

Cultivation of BARI Maskalai-3 under improved management increases the yield by 59% and net income by 54% as compared to conventional varieties and methods. Ensuring the use of technology will increase crop intensity and productivity using fallow chars. Soil productivity will be maintained because of legume crop production. It will not be a threat to the environment.

Marketing system

Crop-based farming of blackgram in chars and marketing the produce from a collection point through a local service provider (LSP) a few days after sorting, processing, and storage can increase the farmers profit by decreasing the middle-man's activities in the whole system.

Conventional practice

Faria-Bepari-Processing Mill /Factory-Wholesaler-Retailer-Consumer.

Improved practice:

Farmer-LSP (Collection Point) -Processing mill- Retailer-Consumer.

As Seed

Farmer - LSP (Collection Point) - Wholesaler - Retailer - Producer Farmer. Farmers can sell their product by 9% higher price and consumer can purchase by 2% lower price.



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Fact sheet-4

Title of the technology: Development of groundnut production and marketing system in the char areas of Northern Bangladesh

Introduction

In the northern region, especially in Rangpur, Kurigram, Lalmonirhat and Gaibandha districts, there are about 77895 hectares of chars, of which 79% are cultivable. However, due to unconventional, low-value crops and sporadic cultivation under low management, char agriculture in North Bengal is relatively backward. Groundnuts is one of the selected crops in the char area out of 11 types of crops based on their suitability, profitability, local demand, and farmer's choice. River water carries sand and silt from upstream and creates vast chars. Most of the crops do not do well in this accumulated sandy, sandy loam, or alluvial soils, but groundnuts as a legume crop can be cultivated very easily.

Description

Items	Description
Crop	Groundnut
Variety	BARI Chinabadam-8
Planting method	Line sowing 30 x 15 cm
Time of sowing /planting	October-November (Kartik-Agrohayon in Bengali month)
Fertilizer doses (kg ha ⁻¹) and application	Urea-25; TSP-160; MOP-85; Gypsum-300; Zinc sulphate-6 and Boric acid-10. Half of urea and other fertilizers should be applied to the land at the time of last cultivation before sowing the seeds. The remaining half of urea should be applied 40-45 days after sowing at the time of flowering.
Intercultural operation	When the soil becomes hard and during flowering, earthing up the soil at the base of the plant. Depending on the soil condition, 3-5 irrigations need to provide. Fungicides such as Autostin can be sprayed 2-3 times at 10-12 days intervals as soon as leaf spot disease appears on the leaves.
Harvesting time	March-April (Falgun-Choitra in Bengali month)
Yield (t ha ⁻¹)	2.11-2.45

Suitable location/ecosystem: Sand or silt-rich char areas of North Bengal including Kurigram and Lalmonirhat.

Benefits

Gross return: Tk. 189,800 ha⁻¹

Production cost: Tk. 60,650 ha⁻¹

Gross margin: Tk. 11,750 ha⁻¹

Cultivation of BARI Chinabadam-8 under improved management increases the yield by 6-79% and net income by 74-77% as compared to conventional varieties and methods. Ensuring the use of technology will increase crop intensity and productivity with fallow chars. Soil productivity will be maintained because of legume crop production. It will not be a threat to the environment.

Marketing system

Crop-based farming of groundnut in chars and marketing the produce from a collection point through a local service provider (LSP) a few days after sorting, processing, and storage can increase the farmers profit by decreasing the middle-man's activities in the whole system .

Conventional practice

Farmer - Faria - Bepari - Processing Factory - Wholesaler - Retailer - Consumer.

Improved system:

As food: Farmer - LSP (Collection Point) - Processing centre - Whole seller - Retailer - Consumer.

As Seed: Farmer - LSP (Collection Point) - Wholesaler - Retailer - Producer Farmer.

Farmers can sell their product by 5% higher price and consumer can purchase by 3% lower price.



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Fact sheet-5

Title of the technology: Development of onion production and marketing system in the char areas of Northern Bangladesh

Introduction

In the northern region, especially in Rangpur, Kurigram, Lalmonirhat and Gaibandha districts, there are about 77895 hectares of chars, of which 69% are cultivable. However, due to unconventional, low-value crops and sporadic cultivation under low management, char agriculture in North Bengal is relatively backward. Onion is one of the selected crops in the char area out of 11 types of crops based on their suitability, profitability, local demand, and farmer's

choice. River water carries sand and silt from upstream and creates vast chars. This accumulated sandy loam or sedimentary soil has many potentials for cultivation but often falls due to negligence. Onions can be produced in this soil either by sowing seeds directly or by planting seedlings. In case of direct seed sowing (broadcasting), after the floodwaters recede, in the month of October-November, Joe condition prevails in char land. After sowing of the seeds has been lightly covered with a layer of coarse sand. After digging a hole in one corner of the land and digging a few feet deep, a layer of coarse sand is found which is lifted and spread on the onion seeds. This maintains the balance of soil water and make a proper environment for onion seed germination. It also protects the seeds from the intensity of sunlight which ultimately increased the germination rate.

Description

Items	Description
Crop	Onion
Variety	BARI Piaj-1
Planting method	Broadcasting/Transplanting
Time of sowing /planting	October-November (broadcasting); November-December (Transplanting)
Fertilizer doses (kg ha ⁻¹) and application	Urea-240; TSP-260; MOP-150; Gypsum-112; Zinc sulphate-7 and Cowdung-5000 kg. Half of urea and MOP and the whole of other fertilizers should be applied to the land at the time of last cultivation before sowing the seeds. The remaining half of urea and MOP should be applied in 2 installments 25 and 50 days after sowing or planting.
Intercultural operation	After sowing the seeds should be covered with a light layer of granular sand. If the soil does not have the required sap, watering is required every 10-15 days. If the age of the plant is 40-45 days, it is necessary to spray fungicides like Rovral and Ridomil 2-3 times every 15 days if necessary.
Harvesting time	February-March (Falgun-Choitra in Bengali month)
Yield (t ha ⁻¹)	10.85-11.75

Suitable location/ecosystem: Sand or silt-rich char areas of North Bengal including Kurigram and Lalmonirhat.

Benefits

Gross return: Tk. 651,000 ha⁻¹

Production cost: Tk. 85,895 ha⁻¹

Gross margin: Tk. 565,015 ha⁻¹

Cultivation of BARI Piaj-1 under improved management increases the yield by 32% and gross margin by 30% as compared to conventional varieties and methods. Ensuring the use of technology will increase crop intensity and productivity through proper use of chars. Soil productivity will not be affected. It will not be a threat to the environment.

Marketing system

Crop-based farmers produce onion in groups and bring it to a collection point and market it through a local service provider (LSP) a few days after sorting, processing, and storage.

Conventional practice

Farmer - Faria - Bepari - Warehouse - Wholesaler - Retailer - Consumer.

Improved system:

Farmer - LSP (Collection Point) - Wholesaler - Retailer - Consumer

Farmers can sell their product by 4% higher price and consumer can purchase by 3% lower price.



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Fact sheet-6

Title of the technology: Development of production and marketing system of sweet potato in char areas of Northern Bangladesh

Introduction

Indigenous varieties and white-fleshed sweet potato have been cultivated since ancient times in the rain-fed adverse environment in the char area. Although it is cultivated in char areas, it is generally called the crop of the poor, but considering its nutritional value, it cannot be neglected. Sweet potatoes can provide energy quickly. Bangladesh Agricultural Research Institute developed BARI Mistialu-8 is rich in an antioxidant called beta carotene. It contains Vitamin C, Vitamin B-Complex, Iron and Phosphorus. Therefore, it can be said that sweet potatoes are beneficial for the

immune system and can protect against various diseases. Sweet potatoes are also beneficial for diabetics. Surprising but true is the fact that the glycemic index of sweet potatoes is relatively low which slowly supplies sugar to the blood. Sweet potatoes play a vital role in controlling blood sugar levels by helping to regulate insulin secretion.

Sweet potato is a drought-tolerant crop and can be easily cultivated in alluvial char soils. With the onset of floodwaters, sweet potato can be planted on cultivable land from mid-October to mid-November. To plant and cultivate sweet potatoes in the char area at the right time, it is necessary to produce sweet potato vine separately in the nursery near the farmer's home. About 40000 to Taka 50000 can be earned from 5 decimal of land through sweet potato vine producing in nursery. It is possible to meet the daily requirement of vitamin A of a person by eating 125 grams of orange-fleshed sweet potato rich in high-yielding nutritious vitamin A (beta carotene) developed by the Bangladesh Agricultural Research Institute. Moreover, as the yield is comparatively higher, the farmers of the char areas will be able to benefit more by cultivating this improved variety. Besides, their importance in the agricultural economy of the char area is increasing day by day due to the versatile use of sweet potatoes.

Description

Items	Description
Crop	Sweet potato
Variety	BARI Mistialu-8
Planting method	<ul style="list-style-type: none"> ● Cutting of sweet potato vines can be planted in flatbeds or in the high valley method. However, the yield is higher in the high valley system. Usually, when cultivating in char areas and without irrigation, vine cuttings are planted on flatlands. ● Row to row spacing is 80 cm (2 feet) and row to row spacing is 30 cm (1 foot). ● The tip of the vine should be placed on the ground and two to three nodes should be placed parallel to the ground 4 to 6 cm below.
Time of sowing /planting	October-November (Kartik-Agrohayon in Bengali month) is best.
Fertilizer doses (kg ha ⁻¹) and application	Cowdung/Compost-10 t, Urea-180 kg, TSP-150 kg, MoP-200 kg, Zinc Sulphate-10-12 kg and Boric acid-6-7.5 kg. (Fertilizer levels may vary depending on soil fertility).
Fertilizer application method	<ul style="list-style-type: none"> ● The total amount of cowdung/compost, TSP, Zinc and Boron and half of MoP should be applied during the final land preparation. ● The rest of MoP and half of urea should be applied at 35-40 days after plantation (DAP) of sweet potato vines. The remaining half of urea should be applied between the rows after 50-55 days. The applied fertilizer should be well mixed with the soil and lifted on both sides of the drain.
Irrigation and drainage	<ul style="list-style-type: none"> ● Timely irrigation increases the yield, weight and quality of sweet potatoes suitable for marketing. ● Light irrigation should be applied if there is a shortage of water in the land at the time of sweet potato vine plantation. ● Irrigation should be applied 3 times 30, 60 and 90 days after planting.

Intercultural operation	<ul style="list-style-type: none"> ● Sweet potato is a quick-growing crop and covers the soil very fast and does not allow weeds to grow. Weeding may be required once during the initial growth of vines. For good yield, two weeding should be done once after vine plantation and twice before application of fertilizer. ● 50-60 days after planting the seedlings/vines should be shaken at least twice a month. This makes it possible to avoid the production of unsuitable sweet potatoes from the node of the vine. As a result, the size and yield of sweet potatoes could increase.
Disease and insect control management	<ul style="list-style-type: none"> ● Field diseases are less common in sweet potato. ● Weevil is common pest in sweet potato. ● The use of pheromone traps can reduce the number of male insects, thereby reducing the growth of weevils. ● It is possible to reduce the infestation of insects by earthing up during the growing season.
Harvesting time	<ul style="list-style-type: none"> ● February to March (Falgun-Choitra in Bengali month). ● Harvesting is done within 120-130 days after planting of sweet potato vines. When sweet potato is cut with a knife or broken by hand, usually white glue or latex is released from the broken part. When young, it is dense. While at maturity, the amount of latex and viscosity decreases. ● In addition when the sweet potato becomes mature the soil of the valley goes broken.
Storage	<ul style="list-style-type: none"> ● When collecting sweet potatoes, the soil should be in normal 'joe' condition i.e. the soil should not be muddy. ● Before harvesting, the vine should be cut with scissors without pulling. ● After collection, sweet potato should be spread in the shade for 8-10 days and cured. ● Diseased cut or crushed and weevil infected sweet potatoes should be sorted quickly. ● All activities from harvesting to storage should be done carefully so that the skin of the tuber is not injured. ● Curried selected sweet potatoes are spread on dry sand in a well-ventilated room and a layer of sweet potatoes (75 cm) and a layer of sand (10 cm) are stored in 5-6 layers. ● Ventilated house where the temperature is 16-160C. Sweet potatoes can be stored there for 3-4 months.
Uses	<ul style="list-style-type: none"> ● Sweet potatoes are eaten as young tip vegetables. It is a delicious and nutritious vegetable. ● Sweet potato tubers are usually eaten burnt or boiled. ● Jams, jellies, and marmalades can be prepared from sweet potato pectin. It is also widely used in starch/sugars, syrups, alcohols and in the baking and confectionery industries. ● It is possible to make high-quality chips and french fries. Boiled sweet potatoes can be mixed with milk or made into Payesh.

- It is also possible to feed sweet potatoes to children by cooking khichuri in pieces or by making bread by mixing it with flour.
- Sweet potato vine can be used as fodder.

Yield (t ha⁻¹) 31.50

Suitable location/ecosystem: Gaibandha and other sandy char areas of North Bengal.

Benefits

Gross return: Tk. 472500 ha⁻¹

Production cost: Tk. 122440 ha⁻¹

Gross margin: Tk. 350060 ha⁻¹

Cultivation with improved management practices increased the net income by 35% as compared to conventional methods.

Ensuring the use of technology will increase crop intensity and productivity through proper use of chars. Soil productivity will not be affected. It will not be a threat to the environment.

Marketing system

Crop-based farmers produce in groups and bring to a collection point and after sorting and processing and marketing through a local service provider (LSP), the number of middlemen decreases and the farmer benefits.

Conventional practice

Farmer - Faria - Bepari - Warehouse - Wholesaler - Retailer - Retailer - Consumer.

Improved practice:

Farmer-LSP (Collection Point) - Aratder - Retailer - Consumer.

Farmers can sell their product by 8% higher price and consumer can purchase by 15% lower price.



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Fact sheet-7

Title of the technology: Development of production and marketing system of chilli in the char areas of Northern Bangladesh

Introduction

Pepper is one of the spice crops produced in the char areas. Pepper cultivation is gradually increasing the char areas due to its profitability. Every year after the flood, a silt layer is added to the char. Mid Ashwin to Mid Kartik (October) can be easily sprinkled and cultivated at low cost on cultivable lands where flood water recedes. Late weeding increases the attack of insects on the crop and reduces the yield. The pepper produced in the char areas is being supplied to the capital Dhaka besides meeting the demand in the local market. Women in the char areas are widely involved especially when it comes to chilli picking, which creates opportunities for women to earn extra income. It is possible to increase the farmer's income by using the modern production techniques of the improved BARI Morich-3 variety developed by the Bangladesh Agricultural Research Institute.

Description

Items	Description
Crop	Pepper
Variety	BARI Morich-3
Seed rate and sowing distance (cm)	<ul style="list-style-type: none">● In Chars, chilli seeds are mainly sown by scattering and also in rows.● Seed rate: 2.0-3.0 kg ha⁻¹ (Broadcasting) and 1.0-1.5 kg ha⁻¹ (line).● Spacing: 50 cm × 50 cm.● Plant density: 40000 plant ha⁻¹.
Time of sowing/ planting	October (Mid Ashwin to Mid Kartik) is good but can be planted up to Mid-November (end of Kartik).
Fertilizer (kg ha ⁻¹)	Cowdung/Compost: 10 t, Urea- 210 kg, TSP-300 kg, MoP-200 kg, Gypsum-110 kg, Zinc Sulphate-12 kg and Boric acid-10 kg.
Fertilizer application method	The total amount of cowdung/compost, TSP, Zypsum, Zinc and Boron, and 125 kg of MoP should be applied during the final land preparation. The rest of MoP and all the urea should be applied at 25, 50, and 75 days after sowing (DAS) maintaining a 10-15 cm distance from the base of the plant.
Intercultural operation	<ul style="list-style-type: none">● No weeds can be kept in the land.● In case of broadcasting, seedlings should be thinned in 2-3 steps at 20-25 DAS maintaining 15-20 cm plant spacing.● It is better to have 35-40 seedlings per square meter.● Required 5-6 irrigations in char areas.

Diseases and remedies	<p>Bacterial wilting, fruit rot and Bacterial leaf spot are the major diseases of chilli that can be controlled by the following measures:</p> <ul style="list-style-type: none"> ● Seeds should be treated with 2.5 g of Autostin per kg. ● Plants should be removed from the ground appearing in 1 or 2 plants. ● Spray with 2 g Autostin or Captan per litre of water (wilting). ● Spray Tilt 250 EC@0.5 ml/L of water (Die back/Anthracnose/Fruit rot). ● Spray Cuper oxychloride @ 7 g/L of water (Bacterial leaf spot).
Insect and control measures	<p>Thrips, aphid, cut worm, mite, whitefly and fruit borer are the major insects of chill that can be easily controlled by the following measures:</p> <ul style="list-style-type: none"> ● Spray Lebacid/admire/ success @ 2 ml/L of water (Thrips). ● Spray Vertimec 1.8 EC@1.2ml/L or Omite 57 EC@2ml/L of water (mite). ● Spray Malathion 57 EC or Quinalphos 25 EC or Dimethoyet @ 1 ml/L of water (Aphid). ● Spray Spinosad 45 SC @ 0.4 ml/L of water (Fruit borer).
Harvesting time	December to February (Mid Agrahayan to Mid Falgun)
Storage	<ul style="list-style-type: none"> ● Chillies should be stored in a cool and shady place after drying. The color of the peeper remains good if kept in polythene or tin containers. In that case, it can be saved 6 months to 1 year. ● Preserved chillies should be exposed to the sun from time to time and care should be taken so that the stalks do not fall off. ● Pepper will remain better if put a few pieces of coal or charcoal in the preserved ones.
Food quality and use	<ul style="list-style-type: none"> ● Raw peppers are rich in vitamin A and C. ● Pepper is one of the major spices crops in Bangladesh and women cannot think of cooking any curry without it. There is a demand for pepper in both raw and ripe conditions. ● Pepper is an essential ingredient in everyday cooking to varying in color, taste and flavor. Moreover, chilli sauce is used to enhance the taste of various foods. In addition to nutritional value, pepper also has medicinal properties.
Yield (t ha ⁻¹)	9.10

Suitable location/ecosystem: Charland of North Bengal including Gaibandha & Lalmonirhat.

Benefits

Gross return: Tk. 273000 ha⁻¹

Production cost: Tk. 112500 ha⁻¹

Gross margin: Tk. 160500 ha⁻¹

Cultivation with improved management increases the net income by 27% as compared to conventional methods.

Ensuring the use of technology will increase crop intensity and productivity through proper use of chars. Soil productivity will not be affected. It will not be a threat to the environment.

Marketing system

Char farmers produce chillies in groups and market them through a local service provider (LSP) after sorting and processing at a collection point, which reduces the number of middlemen and benefits the farmer.

Conventional practice

Farmer - Faria - Bepari - Warehouse - Wholesaler - Retailer - Retailer - Consumer.

As seed:

Farmer - wholesaler - producer farmer

Farmers can sell their product by 4% higher price and consumer can purchase by 3% lower price.



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Fact sheet-8

Title of the technology: Development of low cost non-conventional high-value foxtail millet production and its marketing system in Northern char areas of Bangladesh

Introduction

Foxtail millet has established its position as a minor grain crop in the rainfed hostile environment in the northern char areas of Bangladesh. Although it is a minor grain crop, but its importance in the agricultural economy of the char area is increasing day by day due to its versatility and nutritive value. The soil fertility and water holding capacity of sandy char are low. Every year after the flood, a silt layer is added to the char. From mid-November to mid-February, such chars can be easily broadcasted on low-lying floodplains to cultivate unconventional grain crops like foxtail millet. Late sown can lead to crop drought and increase the risk of flood damage. It is possible to increase the income of the farmers by increasing the production in the northern char areas using the modern production techniques with improve variety BARI Kaon-2 developed by BARI.

Description

Items	Description
Crop	Foxtail millet
Variety	BARI Kaon-2
Seed rate	In case of broadcasting, 10 kg seed is required per hectare.
Time of sowing/ planting	<ul style="list-style-type: none">● Planting time is mid-November to mid-February (Agrohayon-Magh in Bengali month) but best from mid-January to 1st week of February.● October (Mid Ashwin to Mid Kartik) is good but can be planted up to Mid-November (end of Kartik).
Fertilizer (kg ha ⁻¹)	Urea: 130-170; TSP: 100-125; MOP: 80-90, Gypsum-45-55; Zinc sulphate: 15; Boric acid: 6-7.5 (Fertilizer levels may vary depending on soil fertility).
Fertilizer application method	In non-irrigation cultivation, all the fertilizers should be applied during the last cultivation. If irrigation is available, apply half of urea and all of TSP, MP, zinc sulphate and boric acid fertilizers during the last tillage. The remaining half of urea should be applied 35-40 days after sowing.
Intercultural operation	<ul style="list-style-type: none">● Weeding may be required in foxtail millet lands in char areas. If the weed infestation is high, the seedlings should be thinned and weeded within 14-21 days.
Diseases and Remedies	<ul style="list-style-type: none">● Usually no disease was recorded
Insect and control measures	No major pest of Kaon recorded in the char area. However, in case of infestation of borer/any other insects, arrangements should be made to apply pesticides.
Harvesting time	Mid-April to mid-May (Choitra in Bengali month)

Storage	<ul style="list-style-type: none"> ● Seeds should be stored in airtight condition after cooling in the shade after drying in the sun. ● Moisture content should be 10-12% during storage. ● Well-dried seeds can be stored in airtight containers made of tin or plastic drums or wrapped in thick polythene bags in gunny sacks. ● Store it at room temperature.
Food quality and use	<ul style="list-style-type: none"> ● Kaon has many medicinal properties. ● Khichuri, Payesh, Moya, Laddu and Pitha are made by Kaon in the char areas and are part of the food of the char basis.
Yield (t ha ⁻¹)	2.24

Suitable location/ecosystem: Chai land of North Bengal including Gaibandha & Lalmonirhat.

Benefits

Gross return: Tk. 56000 ha⁻¹

Production cost: Tk. 24300 ha⁻¹

Gross margin: Tk. 31700 ha⁻¹

Cultivation under improved management can increase the net income by 46% as compared to conventional methods.

Ensuring the use of technology could increase crop intensity and productivity through proper use of chars. Soil productivity could not be affected as well as not a threat to the environment.

Marketing system

Farmers produced millets in groups, brought them into a collection point. It was marketed after processing (sorting and grading) through a local service provider (LSP), that was ultimately decreased the middlemen intervention in the system and increased the farmer's benefit.

Conventional practice

Farmer - Faria - Bepari - Warehouse - Wholesaler - Retailer - Consumer.

As seed:

Farmer - wholesaler - producer farmer

Farmers can sell their product by 10% higher price and consumer can purchase by 5% lower price.





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Component-2 (BAU)

Fact sheet-9

Title of the technology: 981: A suitable cereal for northern charland

Introduction

981 is a suitable hybrid maize variety for charland because high-yielding potential with robust and big sized cob with the low requirement of water (drought tolerant).

Description

- Drought tolerant; more vigorous; robust and shaped cob.
- High chlorophyll content, stable and high yielding hybrid.
- Good management ensures maximum yield.
- Sowing time: 8-12 November.
- Fertilizer dose: As per FRG' 2018.
- Irrigation and weeding: 3 times.
- Yield: About 12 ton/ha.

Suitable areas/ location: Northern charland areas specially Lalmonirhat districts.

Benefits: Yield potential is very higher (About 12 ton/ha) than the average yield of hybrid maize (8-10 ton/ha) in charland areas.



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Fact sheet-10

Name of the technology: **BARI Chinabadam-8: A suitable oilseed crop for northern charland**

Introduction

BARI Chinabadam-8 is a suitable variety of groundnut for charland area because of its higher plant establishment and higher yielding potential even in lower water availability (drought tolerant).

Description

- Drought tolerant.
- Planting time: 8-12 November.
- Higher plant establishment; higher chlorophyll contents.
- Fertilizer dose: As per FRG' 2018.
- Weeding: 3 times.
- Irrigation requirement: 3-4 times.
- Bold sized seeds, 1000 seed weight about 55-60 g.
- Yield potential nearly about 3.0 ton/ha.

Suitable areas/ location: Northern charland areas specially Lalmonirhat districts.

Benefit of the technology with BCR: Yield potential about 3 ton/ha whereas local variety produces on an average 2.0 ton/ha charland areas



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Fact sheet-11

Name of the technology: BARI Morich-3 & BARI Morich-4: suitable spices crop for northern charland

Introduction

BARI Morich-3 and 4 is a winter variety of chilli for northern charland because of its good plant establishment and high yielding ability even though in lower water supply (tolerant to drought).

Description

- Drought tolerant.
- Higher plant establishment.
- Sowing time: 8-12 November.
- Fertilizer management: As per FRG' 2018.
- Irrigation: 6 times; weeding: 3-4 times.
- Chili/plant: 480-520; weight: 1200-1400 g.
- 1000 seed weight about 4.5-5.0 g.
- Yield: about 16 ton/ha (green chilli).

Suitable areas/location: Northern charland areas specially Lalmonirhat district.

Benefit of the technology with BCR: Yield potential about 16 ton/ha whereas local variety produces on an average 6.0-8.0 ton/ha charland areas.



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ii) Effectiveness in Policy Support (if applicable)

Increasing crop productivity through cultivation of high yielding and high value crops in underutilized charland and marketing channel development could help to achieve the target under SDG goal-2 "By 2030, and double the agricultural productivity and incomes of small scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, through secure and equal access to land, other productivity resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment".

H. Technology/Knowledge generation/Policy Support (as applied)

i. Immediate impact on generated technology (commodity and non-commodity)

Component-1 (OFRD, BARI)

- Increases high value crops [Sweet gourd (var. BARI Hybrid Mistikumra-1), Groundnut (var. BARI Chinabadam-8), Onion (var. BARI Piaj-1), Bitter gourd (var. Ucche), Black gram (var. BARI Mash-3), Chilli (var. BARI Morich-3 & Local), Sweet potato (var. BARI Misti Alu-8), Foxtail millet (BARI Kaon-2)] production as well as farmers' income.
- Creates employment opportunities for char farmers and day labors.
- Underutilized and low fertile sandy charlands are turned into productive land.
- Opportunity created for the char farmers to get optimum product price through minimizing the middleman in marketing system.

Component-2 (BAU)

Agro-ecologically suitable genotypes of one maize genotype (981), two-chilli genotypes (BARI Morich-3 and BARI Morich-4) and one groundnut genotype (BARI Chinabadam-8) identified for harsh charland areas especially for Charland of Lalmoirhat.

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

Component-1 (OFRD, BARI)

- Improve management system in crop production especially seed sowing, fertilization, irrigation and pest management system boost the high value crop production in northern charland. Char-based more research on crops suitability and management system could enhance crop productivity.
- Developed low-cost production system of bitter gourd in winter season using minimum tillage, fertilizer and irrigation could help to plan for other crops production in future in charland.
- Char based suitable crops are identified which could help in future planning for large scale production.
- Crop based farmers group formation and pilot production system helps to attract the buyers. In future char-based crop branding may help for development of more successful marketing channel.
- Local service provider (LSP) is developed for collecting and marketing the char farmers product from a collection point. In future, different crop production related inputs e.g. seed, seedling, fertilizer, pesticide, irrigation and cultivation equipment etc. can be made available through LSP.

Component-2 (BAU)

Agro-ecologically suitable genotypes of including one maize genotype (981), two-chilli genotypes (BARI Morich-3 and BARI Morich-4) and one groundnut genotype (BARI Chinabadam-8) can be directly exploited or further used as genetic material in future improvement of the genotypes for ensuring more productivity, which will ensure the national food security especially for Charland ecosystem farmers.

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

- Three northern Char specific suitable and profitable crops have been identified.
- High yielding and profitable varieties of Sweet gourd (var. BARI Hybrid Mistikumra-1), Groundnut (var. BARI Chinabadam-8), Onion (var. BARI Pijaj-1), Bitter gourd (var. Ucce), Black gram (var. BARI Mash-3), Chilli (var. BARI Morich-3 & Local), Sweet potato (var. BARI Misti Alu-8) and Foxtail millet (BARI Kaon-2) have been selected for northern three charland of Kurigram, Lalmonirhat and Gaibandha district.
- Improved production technologies for Blackgram, Ground nut, Foxtail millet, Sweet gourd, Sweet potato, Bitter gourd, Chilli and Onion have been developed, which could help to increase productivity in charland.
- Low-cost production system of bitter gourd (var. Ucce) in winter season in sandy charland could help to bring sandy char area under profitable cultivation.
- Crop-wise farmers group formation and production system is very helpful for management of crops at field level as well as at post-harvest level.
- Collection point has been established which could help to collect a reasonable amount of quality crops for marketing.
- Post-harvest processing technologies of different crops have been transferred which could help to produce and store more quality seeds of different high value crops at char farmers' level.
- Local service provider (LSP) is developed for collecting and marketing the char farmers product. It helps to get judicious product price by the char farmers.
- Improved marketing channel developed through minimizing of middleman for crops: Blackgram, Ground nut, Foxtail millet, Sweet gourd, Sweet potato, Bitter gourd, Chilli and Onion. It would help to minimize marketing cost and increase profitability.

ii. Policy Support

- Cultivation of vitamin-A enriched sweet potato and sweet gourd; minerals enriched onion and chilli; fiber enriched foxtail millet, oils and minerals enriched groundnut; protein and calcium enriched blackgram and medicinal crop bitter gourd would help to bring food and nutritional security for the char farmers.
- The total charland area in Rangpur, Kurigram, Gaibandha and Lalmonirhat districts are 77895 hectares and in greater Rangpur region the char area is about 121309 hectares. If the identified suitable and profitable high value crops could be expanded in all the northern char areas, which could boost the productivity and help to achieve the SDG goal-2.
- Local Service Provider (LSP) system may be recommended for maintaining the input supply chain as well as marketing system.

I. Information regarding Desk and field Monitoring

i. Desk Monitoring [description and output of consultation meeting, monitoring workshops/seminars etc.): N/A

ii. Field monitoring

Component-1 (OFRD, BARI)

Char Begumganj, Kurigram

Sl. No.	Date	No. of visit	Name and addresses of team visit	Output
01.	19.01.2020	01	<ul style="list-style-type: none"> i. Dr. Md. Nowser Ali Sardar, Monitoring & Evaluation specialist, PIU-BARC, NATP-2 ii. Mr. Abdur Rahman, NATP-2, BARC, Farmgate, Dhaka iii. Dipok Kumar, NATP-2, BARC, Farmgate, Dhaka 	The team sharing opinion with farmers and BARI team and provided valuable suggestions for further improvement of char activities.
02.	21.03.2020	01	<ul style="list-style-type: none"> i. Dr. M. Akkas Ali, Chief Scientific Officer, OFRD, BARI, Joydebpur, Gazipur ii. Dr. Md. Faruque Hossain, Senior Scientific Officer, OFRD, BARI, Joydebpur, Gazipur 	The team sharing opinion with farmers and BARI team and provided valuable suggestions for dissemination of char technologies.

Char Jagatber, Lalmonirhat

Sl. No.	Date	No. of visit	Name and addresses of team visit	Output
01.	19.01.2020	01	<ul style="list-style-type: none"> i. Dr. Md. Nowser Ali Sardar, Monitoring & Evaluation specialist, PIU-BARC, NATP-2 ii. Mr. Abdur Rahman, Monitoring Associate, PIU-BARC, NATP-2 iii. Dipok Kumar, Monitoring Associate, PIU-BARC, NATP-2 	The team sharing opinion with farmers as well as BARI team and provided valuable suggestions for further improvement of char activities.

Char Saghata, Gaibandha

Sl. No.	Date	No. of visit	Name and addresses of team visit	Output
03.	25.03.2020	01	<ul style="list-style-type: none"> i. Dr. M. Akkas Ali, Chief Scientific Officer, OFRD, BARI, Joydebpur, Gazipur 	CSO have opinion with farmers, BARI team and provided valuable suggestions for dissemination of char technologies.

Component-2 (BAU)

Sl. No.	Date	No. of visit	Name and addresses of team visit	Output
01.	19.03.2019	01	Dr. A.S.M Anowarul Hoque, Member Director (Admin and Finance), BARC Dr. Md. Mosharraf Uddin Molla, CSO (HRC), BARC Dr. Ajit Kumar Chakrabarty, Director (Finance), BARC Dipak Kumar, Monitoring Associate, PIU-BARC, NATP-2	At the time to field monitoring, progress of the research activities was quite slow. Members of the monitoring team recommended to accelerate the research activities and suggested some criteria for germplasm evaluation and selection.

iii. Weather data, Flood/salinity/drought level (if applicable) and natural calamities:

Flood: Continuous rainfall in September 2020 and severe flood occurred during late September 2020.

Weather data of Rangpur during 2018-19 to 2020-21.

Month	Temperature (oC)						Avr. RH (%)			Total rainfall (mm)		
	Avr. Max			Avr. Min			2018-19	2019-20	2020-21	2018-19	2019-20	2020-21
	2018-19	2019-20	2020-21	2018-19	2019-20	2020-21	2018-19	2019-20	2020-21	2018-19	2019-20	2020-21
February	26.77	26.35	26.08	14.16	14.45	12.93	69.59	70.82	70.59	0	119.60	0
March	30.99	30.14	30.09	18.98	17.56	17.94	6579	64.23	68.45	13.40	11.0	31.10
April	30.60	30.89	31.42	21.67	21.70	20.60	75.10	73.25	70.82	152.20	140.0	190.0
May	31.17	32.05	31.45	22.98	23.31	23.15	77.45	77.12	79.35	324.50	346.30	347.40
June	33.35	33.74	32.94	25.82	25.53	25.96	79.63	90.33	81.83	321.40	277.50	389.70
July	33.26	32.44	32	27.14	26.41	16.14	79.92	83.03	84.69	143.20	595.60	748.80
August	33.60	34.25	34.12	27.02	27.36	27.12	79.29	78.53	78.90	207.30	336.20	182.50
September	32.99	31.59	31.15	26.08	25.79	26.08	79.52	85.45	85.82	147.70	604.80	1036.60
October	30.80	30.53	33.10	22.30	23.15	24.80	77.02	79.76	78.03	32.30	174.40	119.0
November	29.25	29.44	29.48	17.38	19.51	17.93	71.07	74.87	68.72	0	0	0
December	25.68	23.55	25.08	12.62	12.71	14.34	70.26	75.84	75.72	7.6	0	0
January	25.69	22.50	24.12	11.79	11.92	12.71	66.85	77.26	72.14	0	8	0

J. Sub-project auditing (covers all types of audit performed)

Types of audit	Major observation/issues/objections raised; if any	Amount of Audit (Tk.)	Status at the sub-project end	Remarks
GoB	No observation raised.		31 October 2021	Satisfactory

K. Lessons Learned

Component-1 (OFRD, BARI)

- i. High value crops under vegetables, tuber crops, spices, cereal, oils production in charland could enhance the production & impart on national economy.
- ii. For successful crop cultivation in charland, seeds and other inputs need to supply early season i.e., just after flood water remove.
- iii. There is plenty scope to utilize the underutilized northern charland to produce char suitable high value crops and increase farm income.
- iv. Inclusion of suitable variety, quality seed and improved crop management can enhance cropping intensity and productivity compared to existing cropping practice.
- v. Crops produced in sandy charlands are required less pesticide due to less disease and insect infestation. So, the crops produced in sandy charland are relatively safe to consume.
- vi. Irrigation with portable pump using plastic pipe or making mini pond is essential for high value crops production.
- vii. Farmers group-based production system is very effective especially for pest control and marketing.
- viii. Post-harvest crop processing and grading is important for value addition.
- ix. LSP development is essential for timely and smoothly marketing of the farmers products.

Component-2 (BAU)

- i) Charland ecosystem exploitation by bringing under crop production
- ii) Soil health improvement through introducing groundnut
- iii) Crop diversification through introducing high value crops would reduce pest infestation

L. Challenges (if any)

Component-1 (OFRD, BARI)

- Flash flood
- Drought
- Hail storm
- River bank erosion
- Soil erosion
- Low soil fertility
- Poor communication system (road, transport)
- Hot and dry soil
- Less scope for irrigation
- Poor socio-economic condition
- Lack of early varieties of different crops
- Lack of quality seeds and planting materials
- Lack of technical knowledge of framers
- Scarcity of agricultural labor
- Lack of climate change resilient technology
- Lack of seed production and storage facilities
- Unstable market price of the inputs and outputs
- COVID-19 is the major constraint for proper marketing system development for the subproject period.

Componen-2 (BAU)

Due to the impact of corona pandemic, different activities had faced a little bit problem. Few experiments had been back pedaled. Harvesting of chili from the pot culture in the early April, labor management was quite problematic but harvested successfully.

M. Suggestions for future planning (if any)

Componen-1 (OFRD, BARI)

- Suitable mechanization system needs to develop for sandy char area.
- Road and other infrastructure should be improved.
- Char suitable transport system (vehicle) should be considered.
- Low-cost mini solar water pump should be made available.
- Seed and other product storage facilities should be improved.
- Digitalization needs to introduce in areas.
- Farmers capacity on char agricultural technologies needs to develop through hands on training.
- Local Service Provider (LSP) needs to establish at each char location for production and marketing system development.
- Credit facilities should make easiest for char farmers.
- Provision of special subsidies should provide for cultivation in charland.
- Quality seed and other input should make available in time.
- Suitable drought tolerant crops need select for cultivation in charland.
- Early varieties of vegetables, pulses, oil seed and cereal crops should be considered.
- More Char climate SMART technologies should be developed.
- More cooperation needed from DAE personnel to disseminate the technologies.
- Women empowerment should be ensured through different practices.

Componen-2 (BAU)

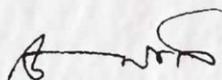
The selected genotypes of different high value crops can be directly exploited in the charland areas and also needed for further investigation of the selected high value crops in other northern charlands.

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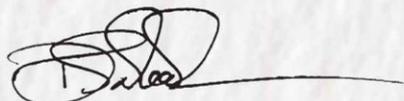
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