HAND BOOK OF AGRICULTURAL TECHNOLOGY

Bangladesh Agricultural Research Council (BARC)

Asian Food and Agriculture Cooperation Initiative (AFACI)

Hand Book of Agricultural Technology

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Message

Greetings from the Asian Food and Agriculture Cooperation Initiative (AFACI)!

AFACI is an intergovernmental and multilateral cooperation body established by the Rural Development Administration (RDA) of the Republic of Korea, aiming to improve food production, realize sustainable agriculture and enhance extension service of Asian countries by sharing knowledge and information on agricultural technology.

RDA, a governmental organization for agricultural research and extension services, has been trying to develop and distribute the agricultural technology for last fifty years.

As a part of these efforts, I am honored to have opportunity to publish agricultural books for AFACI member countries with a special fund from RDA.

This activity aims at facilitating the publication and distribution of agricultural technology books for providing agricultural technologies directly to local farmers and sharing educational materials in their local languages or English. I believe that it is meaningless not to be distributed and practically used no matter how great the technology may be.

I truly hope that this book serves as a useful guide for farmers as well as becomes a touchstone for closer relationship between the Bangladesh and Korea.

Thank you very much.
Sincerely,

Cho, Yang-Hee
Secretary General
Asian Food and Agriculture Cooperation Initiative (AFACI) Secretariat

FOREWORD

Improved agricultural technologies are tools that empower farmers to increase productivity and thus attain higher incomes. A constant infusion of high–impact agricultural technologies into farming systems is a prerequisite for accelerating agricultural development.

It is to be noted that Bangladesh has made a significant progress in the field of agricultural research in terms of generation of farm technologies over the decades. A considerable number of new agricultural technologies have been developed. However, it is imperative to disseminate new improved technologies to targeted users especially to farmers. For that, identification and documentation of promising agricultural technologies in user friendly manner is very vital and make them available to farmers through extension services.

I am pleased to know that Asian Food and Agriculture Cooperation Initiative (AFACI) with special fund from Rural Development Administration (RDA), Korea has taken up an initiative to provide financial support for publishing books for sharing promising technology among AFACI member countries. In the context of global climate change and addressing food security, I feel this effort is timely.

I thank Md. Abeed Hossain Chowdhury, Principal Investigator, ATIN project along with his colleagues and the scientists of NARS who made valuable contribution for publishing the "Hand Book of Agricultural Technology".

I hope this hand book which includes production and management technologies of crops, fisheries and livestock would be useful for the use by extension agencies both in public and private.

Dr. Wais Kabir
Executive Chairman
Bangladesh Agricultural Research Council

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The publication is an outcome of the AFACI Pan-Asian project "Establishment of Agricultural Technology Information Network in Asia (ATIN)". The activities of the project are coordinated by Md. Abeed Hossain Chowdhury, Director (Computer & GIS), Bangladesh Agricultural Research Council and the Principal Investigator of the project ATIN. One of the activities of the project is to publish agricultural technology handbook/manuals. For that an attempt has been made for identification and documentation of promising agricultural technologies generated by National Agricultural Research System (NARS) institutes and makes them available to targeted users especially to farmers.

We highly appreciate the cooperation of all the NARS institutes in sharing their information on agricultural technology for dissemination among different stakeholders especially the farming communities at national and international level. As well as, we are grateful to the scientists for sharing their knowledge and wisdom, and the contribution made by means of comprehensive script on agricultural production technologies without which it would not have been possible to complete this publication.

We are extremely grateful to the Secretary General, Asian Food and Agriculture Cooperation Initiative (AFACI) Secretariat for providing financial support for publishing the book.

The committee members assigned with the publication of the book deserve sincere gratitude for their supportive role, constructive suggestion and valuable contribution for successful completion of the assignment. The contribution of Dr. Mian Sayeed Hassan, Principal Scientific Officer (Crops) of BARC deserves much appreciation. Also, the contribution of Dr. M.A. Quayyum for editorial support and useful suggestions to improve the quality of this publication is thankfully acknowledged. Special thanks are also to Mr. Monowar Hossain, former Senior Scientific Officer (TTMU) of BARC for support and contribution at the initial stage of the assignment.

The continuous support and guidance of the Executive Chairman of BARC Dr. Wais Kabir is gratefully recognized. Special thanks to Dr. Shahjahan, Ex-Director (R&D), BSFIC for providing valuable suggestions and corrections on the manuscript.

Lastly, special thanks are given to Dr. Md. Bazlur Rahman, Agriculture Expert of ATIN project for organizing and compiling the technology information and colleagues of Computer and GIS unit, BARC, for their help and cooperation to complete the task successfully.

Md. Abeed Hossain Chowdhury
Director (Computer & GIS)
Bangladesh Agricultural Research Council

CONTENTS

VI. FRUIT CROPS

VII. SPICES CROPS

VIII. FIBRE CROPS

IX. SUGAR CROPS

X. FISHERIES

XI. LIVE STOCK

APPENDICES

ACRONYMS & ABBREVIATIONS

AEZ	Agro-ecological Zones
AFACI	Asian Food and Agriculture Cooperation Initiative
AVRDC	Asian Vegetable Research and Development Center
AWD	Alternate Wetting and Drying
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
BCRDV	Baby Chick Ranikhet Disease Vaccine
BFRI	Bangladesh Fisheries Research Institute
BGM	Botrytis Gray Mold
BINA	Bangladesh Institute of Nuclear Agriculture
BJRI	Bangladesh Jute Research Institute
BRRI	Bangladesh Rice Research Institute
BSFB	Brinjal Shoot and Fruit Borer
BSRI	Bangladesh Sugarcane Research Institute
BW	Bacterial Wilt
CLS	Cercospora Leaf Spot
CRI	Crown Root Initiation
DAE	Days After Emergence
DAP	Days After Plantation
DAT	Days After Transplanting
DAS	Days After Sowing
DO	Dissolved Oxygen
FCR	Feed Conversion Ration
FRG	Fertilizer Recommendation Guide
GDP	Gross Domestic Product
GLH	Grass Leaf Hopper
HYV	High Yielding Variety
ICARDA	International Centre for Agricultural Research in the Dry Areas

ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IPM	Integrated Pest Management
Isd	Iswardi
Kg	Kilogramme
MHAT	Moist Hot Air Temperature
MP	Muriate of Potash
NARS	National Agricultural Research System
NGO	Non-Government Organizations
OP	Open Pollinated
PI	Panicle Initiation
PLRV	Potato Leaf Roll Virus
PRSV	Papaya Ring Spot Virus
PTM	Potato Tuber Moth
PTOS	Power Tiller Operated Seeder
PVC	Polymerized Vinyl Chloride
RDV	Ranikhet Disease Vaccine
SAARC	South Asian Association for Regional Cooperation
SBP	Stable Bleaching Powder
STP	Spaced Transplantation
t/ha	Ton/hectare
TSP	Triple Super Phosphate
TSS	Total Soluble Solid
USG	Urea Super Granules
UMS	Urea-molasses-straw
WRC	Wheat Research Centre
YLCV	Yellow Leaf Curl Virus
YVMV	Yellow Vein Mosaic Virus

INTRODUCTION

Agriculture is the mainstay of economy in terms of contribution to GDP as well as improvement of livelihood of majority people in Bangladesh. The rural economy as a whole contributes to around 60 percent of the total GDP of which around 20 percent comes from the agriculture sector and 40 percent from the non-farm sector. Agriculture contributes greatly to improve food security in spite of gradual shrinking of land resources due to non-agricultural use and ever growing population. In view of these, there is an urgent need to maintain consistent growth in agriculture sector which depends entirely on efficient and sustainable agricultural production system. Location specific, low input, eco-friendly, demand oriented and climate resilient agricultural technologies would obviously contribute for sustainable growth in agriculture.

The country has made a tremendous progress in the field of agricultural research in terms of generation of new technologies over the decades. The agricultural technology system in Bangladesh has made significant contribution to increasing yields of different crops and elevating total agricultural productivity. The country has attained almost self-sufficiency in cereal production and surplus in potato production.The production of vegetables has significantly increased. Considerable progress has also been made in fisheries and livestock sector.

The success of any technologies depends entirely on its adoption by the end users. The need is, therefore, to package the promising technologies in a simple and meaningful way and transfer them to the end users. In this context, an initiative has been taken for identification and documentation of promising technologies and makes them available to the end users especially to farmers. The “Hand Book of Agricultural Technology’’ is an outcome of this effort taken-up under AFACI Pan-Asian project “Establishment of Agricultural Technology Information Network in Asia (ATIN)”. Asian Food and Agriculture Cooperation Initiative (AFACI) is an intergovernmental and multilateral cooperation body of the Republic of Korea established with an aim to support improved food production, ensure sustainable agriculture and enhance extension services of Asian countries by sharing knowledge and information on agricultural technology. AFACI fosters transnational cooperation among national agricultural research and extension institutions and their partners in order to share experience and skills related to agricultural innovation.

In this book, an attempt has been made to present research developed technologies in a structured form and in simple and useful manner so as to make it understandable and much easier for adoption by the farmers. This book compiles important agricultural technology and production methodology, mainly of crops, fisheries and livestock with its intercultural operations, diseases and pest management, and post-

harvest management generated by the NARS institutes. The scientists of NARS institutes provided the agricultural production technologies in a prescribed format developed by the project. The name and other particulars of the scientists are presented under the List of Contributors in Appendix-1.

In Bangladesh, the crops are cultivated in three different growing seasons namely Kharif-I (Mid March to Mid July), Kharif-II (Mid July to Mid October) and Rabi (Mid October to Mid March). The 'kharif-I' (early monsoon) is transition between dry and wet seasons, 'kharif-II' is wet season and 'rabi' is dry season. Rice is the dominant crop grown in three distinct rice growing seasons namely, 'Aus' (March to June), 'Aman' (June to November) and 'Boro' (November to May). Wheat, oilseed crops, most pulses, potato and major vegetables are grown in rabi season. Jute is grown as kharif-I crop and maize, chili, groundnut, mungbean are grown in both rabi and kharif-I season. A calendar of major crops depicts the sowing/transplanting and harvesting schedules is presented in Appendix-2.

The technologies described in this book covering mainly agricultural sectors such as crops, fisheries and livestock would be a useful guide for the practitioners in enhancing agricultural production. It will also enrich the knowledge of the scientists, extension workers, farmers and other stakeholders who are directly involved in agricultural production system. The handbook containing production and management technologies of crops, fisheries and livestock would be useful for the use by extension agencies both in public and private.

One of the prime objectives of this publication is to fulfill the agenda towards making agricultural technology information available and share it with AFACI member countries. It is expected that this book will serve as a basic document for sharing promising agricultural technologies among the AFACI member countries. We also hope similar "Hand book of Agricultural Technology" will be prepared and made available by other for mutual benefit of all AFACI member countries.

I. CEREALS

Cereals or food grains, which belong to the botanical family Gramineae account for about 80 percent of the total cropped areas and 85 percent of the field crops areas in the country. These crops are rice, wheat, maize, barley, cheena, kaon, jowar and bajra. These are the food grains several of which are used as staple food for the greater portion of the human population. Per-capita per day production of cereals was highest among all kinds of food. However, the per-capita per day production of cereals in Bangladesh is the highest of all other crops like roots and tuber, vegetables and fruits. Cereals are a cheap and easy source of calorie, coming mainly from these carbohydrate rich crops. Human population, in general, fulfills their requirement of energy, mineral mainly from cereal food. It is noteworthy that hand pounded (dheki-chhata) rice contain more protein, fat, mineral and vitamins than milled rice. BRRI, BARI, BINA and other organization have developed a number of good high yielding varieties of cereal crops and their improved production technologies. Among them, the most important cereal crops are described below.

1. Rice

Rice is the principal food of our people and grown in this country from time immemorial. It contributes for about 92% of the total food grains produced in the country. Seventy-five percent of required calories and 55% of protein are met from rice in the average daily diet of the people. Bangladesh is the fourth largest rice producer in the world. It covers about 77% of agricultural land and engages about 70% of population in rice production activities. Nearly 50% of our employments are generated in rice sector. The contribution of rice to GDP is 18%. At present, rice occupies 11.42 million hectares of land and produces about 33.6 million metric ton (BBS, 2011). Nobanno (new rice harvest) is one of the joyous festivals, which is largely observed in rural areas. Different kinds of delicious foods are made from rice in different occasions. Products of the rice plant are used for different purposes, such as fuel, thatching, industrial starch, animal feed and artwork. It also ensures political stability and food security for the people.

Rice is grown year-round in Bangladesh as pre-monsoon crop, direct seeded and transplanted Aus rice from March to June (kharif-1), wet season transplanted aman rice (kharif-11), from June to November and dry season irrigated Boro (rabi) rice from November to May.

1.1 Varieties

Bangladesh Rice Research Institute (BRRI) released so far 61 high yielding rice varieties including four hybrid varieties. Bangladesh Institute of Nuclear Agriculture (BINA) released 8 varieties. Some of the popular varieties of BRRI and BINA along with their important characteristics are shown below:

Inbred Varieties and their Characteristics

Name of Varieties (Year of Release)	Important Characteristics	Crop
BR3 (1973)	**Grain type**: Medium bold and white bellied grain. It revolutionized rice production in early era of Bangladesh. **Plant height**: 95 cm (Boro) and 100 cm (Aus). **Grain yield**: 6.5 t/ha (Boro) and 4.0 t/ha (Aus) season March-June. **Duration**: 170 days (Boro) and 130 days (Aus).	
BR11 (1980)	**Grain type**: Medium bold. **Plant height**: 115 cm. Moderately resistant to tungro and tolerant to yellow stem borer and blast. Weakly photo period sensitive. It is grown in T. Aman season (June to November). **Grain yield**: 5.5 t/ha. **Duration**: 145 days.	
BR12 (1983)	**Grain type**: Medium bold and white grain. **Plant height**: 105 cm. **Grain yield**: 5.5 t/ha (Boro) and 4.5 t/ha (Aus). **Duration**: 170 days (Boro) and 130 days (Aus).	
BR16 (1983)	**Grain type**: Long, slender and white. **Plant height**: 90 cm for Boro (winter) and 110 cm for Aus (Kharif, summer) season. Resistant to tungro and blast. Diabetic rice and good for Muri (puffed rice). **Grain yield**: 6.0 t/ha (Boro) and 5.0 t/ha (Aus). **Duration**: 165 days (Boro) and 130 days (Aus).	
BR17 (1985)	**Grain type**: Medium bold. **Plant height**: 125 cm; tall statured sturdy plant and suitable for haor area. It is grown in Boro season (November to May). **Grain yield**: 6.0 t/ha. **Duration**: 155 days.	
BR18 (1985)	**Grain type**: medium bold and white. **Plant height**: 115 cm; sturdy plant and suitable for haor areas. It is grown in Boro season (November to May). **Grain yield**: 6.0 t/ha. **Duration**: 170 days.	
BR19 (1985)	**Grain type:** Medium bold. **Plant height:** 110 cm; sturdy plant, suitable for late and haor areas. Moderately resistant to bacterial leaf blight (BLB). It is grown in Boro season (November to May). **Grain yield:** 6.0 t/ha. **Duration:** 170 days.	

Name of Varieties (Year of Release)	Important Characteristics	Crop
BR22 (1988)	**Grain type:** Short, bold, white and transparent. **Plant height:** 125 cm. Resistant to tungro, blast and sheath blight, moderately tolerant to yellow stem borer. Photo period sensitive and late aman variety. **Grain yield:** 5.0 t/ha. **Duration:** 150 days.	
BR23 (1988)	**Grain type:** Long, slender and white. **Plant height:** 120 cm. Moderately tolerant to sheath blight and white backed plant hopper. Tolerant to blast. Tolerant to salinity and water stagnant condition to some extent. Photo period sensitive and late aman variety. **Grain yield:** 5.5 t/ha. **Duration:** 150 days.	
BR26 (1993)	**Grain type:** Long, slender and white grain. Amylose content low. **Plant height:** 115 cm. **Grain yield:** 4.0 t/ha. **Duration:** 115 days.	
BRRI dhan27 (1994)	**Grain type:** Medium bold, **Plant height:** 140 cm. Moderately resistant to sheath blight, brown plant hopper (BPH) and green leaf hopper (GLH) and resistant to blast and white backed plant hopper. Suitable for Barisal zone as T.Aman rice. It could be grown as transplanted Aus. **Grain yield:** 4.0 t/ha. **Duration:** 115 days.	
BRRI dhan28 (1994)	**Grain type:** Medium slender and white. **Plant height:** 90 cm; short duration Boro variety. Moderately resistant to blast. Very popular and high yielding variety. It is grown in Boro season. **Grain yield:** 6.0 t/ha. **Duration:** 140 days.	
BRRI dhan29 (1994)	**Grain type:** Medium slender and white. **Plant height:** 95 cm. Moderately resistant to leaf blight and sheath blight. Very popular and highest grain yielder. It is mainly grown in Boro season. **Grain yield:** 7.5 t/ha. **Duration:** 160 days.	
BRRI dhan31 (1994)	**Grain type:** Medium bold and white. **Plant height:** 115 cm. Resistant to brown plant hopper (BPH) and moderately resistant to leaf blight and tungro. Weakly photoperiod sensitive. Mature earlier than BR11. It is mainly grown in Aman season. **Grain yield:** 5.0 t/ha. **Duration:** 140 days.	

Name of Varieties (Year of Release)	Important Characteristics	Crop
BRRI dhan33 (1997)	**Grain type:** Short, bold, white belly marked in middle portion of grain. Early maturing variety. **Plant height:** 100 cm. Resistant to blast and white backed plant hopper (WBPH) and moderately resistant to bacterial leaf blight. It is very short duration variety. It is grown in Aman season. **Grain yield:** 4.5 t/ha. **Duration:** 118 days.	
BRRI dhan35 (1998)	**Grain type:** Short and bold. **Plant height:** 105 cm. Moderately resistant to tungro disease. Only variety recognized as BPH resistant. It is grown in Boro season. **Grain yield:** 5.0 t/ha. **Duration:** 155 days.	
BRRI dhan36 (1998)	**Grain type:** Long slender. **Plant height:** 90 cm. Moderately resistant to tungro. This variety could tolerate cold at the seedling stage. It is grown in Boro season. **Grain yield:** 5.0 t/ha. **Duration:** 140 days.	
BRRI dhan37 (1998)	**Grain type:** Medium slender and scented rice. **Plant height:** 125 cm. Resistant to tungro, moderately resistant to leaf blight. It is grown in Aman season. **Grain yield:** 3.5 t/ha. **Duration:** 140 days.	
BRRI dhan38 (1998)	**Grain type:** Long, slender and scented. **Plant height:** 125 cm. Moderately resistant to leaf blight. Scent Bashmati(D) type. It is grown in Aman season. **Grain yield:** 3.5 t/ha. **Duration:** 140 days.	
BRRI dhan39 (1999)	**Grain type:** Long, slender. **Plant height:** 106 cm. Tolerant to sheath rot, sheath blight and tungro. It is a short duration variety. It is grown in Aman season. **Grain yield:** 4.5 t/ha. **Duration:** 122 days.	
BRRI dhan40 (2003)	**Grain type:** Medium bold. **Plant height:** 110 cm. Moderately salt tolerant variety. Photoperiod sensitive and earlier. It is grown in Aman season. **Grain yield:** 4.5 t/ha. **Duration:** 145 days.	

Name of Varieties (Year of Release)	Important Characteristics	Crop
BRRI dhan41 (2003)	**Grain type:** Long, bold, white and transparent. **Plant height:** 115 cm. Moderately saline tolerant but mature 8-10 days earlier than BR23. Tolerant to tungro and sheath blight. It is grown in Aman season. **Grain yield:** 4.5 t/ha. **Duration:** 148 days.	
BRRI dhan42 (2004)	**Grain type:** Medium bold and white. Direct seeded (DS) upland rice. **Plant height:** 105 cm. Tolerant to leaf and sheath blight and tungro. Moderately drought tolerant. It is grown in Aus season (March to June). **Grain yield:** 3.5 t/ha. **Duration:** 100 days.	
BRRI dhan43 (2004)	**Grain type:** Medium bold, white and DS upland rice. **Plant height:** 100 cm. Tolerant to blast and sheath blight. Sturdy stem. It is grown in Aus season. **Grain yield:** 3.5 t/ha. **Duration:** 100 days.	
BRRI dhan44 (2005)	**Grain type:** Bold. **Plant height:** 130 cm. Tolerant to blast and bacterial leaf blight. Suitable for non-saline tidal prone area. It is grown in Aman season (June to November). **Grain yield:** 5.5 t/ha. **Duration:** 145 days.	
BRRI dhan45 (2005)	**Grain type:** Medium bold and white colour. **Plant height:** 100 cm. Tolerant to blast. Good for avoiding flash flood in the haor area. It is grown in Boro season (November to May). **Grain yield:** 6.5 t/ha. **Duration:** 145 days.	
BRRI dhan46 (2007)	**Grain type:** Medium bold. **Plant height:** 105 cm. Tolerant to blast. Photoperiod sensitive, late variety, seeding upto 15 September. It is grown in Aman season. **Grain yield:** 4.7 t/ha. **Duration:** 124 days.	
BRRI dhan47 (2007)	**Grain type:** Medium bold. **Plant height:** 105 cm. Saline tolerant upto 12-14 ds/m during seedling stage and 6 ds/m during whole time. Prone to grain shattering. It is grown in Boro season. **Grain yield:** 6.0 t/ha. **Duration:** 150 days.	

Name of Varieties (Year of Release)	Important Characteristics	Crop
BRRI dhan48 (2008)	**Grain type:** Medium bold and white. **Plant height:** 105 cm; highest grain yielder as transplanted Aus. **Grain yield:** 5.5 t/ha. **Duration:** 110 days.	
BRRI dhan49 (2008)	**Grain type:** Medium slender. **Plant height:** 100 cm. Maturity earlier than BR11 variety. It is grown in Aman season. **Grain yield:** 5.5 t/ha. **Duration:** 135 days.	
BRRIdhan50 (Banglamoti) (2008)	**Grain type:** Long, slender, white and scented Bashmati type. **Plant height:** 82 cm. Resistant to panicle blast. It is grown only in Boro season. **Grain yield:** 6.0 t/ha. **Duration:** 155 days.	
BRRI dhan51 and 2010	**Grain type:** Medium bold, transparent and white. **Plant height:** 90 cm. Tolerant to submergence. Suitable for flash flood submergence prone areas. It is grown in Aman season. **Grain yield:** 4.5 t/ha for normal and 4.0 t/ha for submergence shock. **Duration:** 142 days for normal and 154 days for submergence shock.	
BRRI dhan52 (2010)	**Grain type:** Medium slender, translucent and white. **Plant height:** 116 cm. Submergence tolerant. Suitable for flash flood submergence prone areas. It is grown in Aman season. **Grain yield:** 5.0 t/ha for normal and 4.5 t/ha after shock.	
BRRI dhan53 (2010)	**Grain type:** Medium slender. **Plant height:** 105 cm. Resistant to blast. Saline tolerant upto 8-10 ds/m during seedling stage. 20-24 days earlier than BRRI dhan 41. It is grown in Aman season. **Grain yield:** 4.5 t/ha. **Duration:** 125 days.	
BRRI dhan54 (2010)	**Grain type:** Medium slender. **Plant height:** 115 cm. Resistant to blast. Saline tolerant upto 8-10 ds/m during seedling stage. 8-10 days earlier than BRRI dhan 41. It is grown in Aman season. **Grain yield:** 4.5 t/ha. **Duration:** 135 days.	

Name of Varieties (Year of Release)	Important Characteristics	Crop
BRRI dhan55 (2011)	**Grain type:** Medium slender. **Plant height:** 100 cm. **Grain yield:** 7.0 t/ha (Boro) and 5.0 t/ha (Aus). **Duration:** 145 days (Boro) and 105 days (Aus).	
BRRI dhan56 (2011)	**Grain type:** Medium slender. **Plant height:** 115 cm. Resistant to blast. It is grown in Aman season. **Grain yield:** 4.0 t/ha. **Duration:** 106 days	
BRRI dhan57 (2011)	**Grain type:** Medium slender. **Plant height:** 100 cm. It is grown in Aman season. **Grain yield:** 4.0 t/ha. **Duration:** 105 days.	
BRRI dhan58 (2012)	**Grain type:** Medium slender. **Plant height:** 115 cm. It is grown in Boro season. **Grain yield:** 7.1 t/ha. **Duration:** 153 days.	
Bina dhan7 (2007)	**Grain type:** Long fine grain. It is early maturing high yielding variety (HYV). Resistant to blast. It is grown in Aman season. **Grain yield:** 5.2 t/ha. **Duration:** 110-115 days.	
Bina dhan8 (2012)	**Grain type:** Medium fine grain. High yielding variety (HYV). Salt tolerant. Resistant to Bacterial leaf blight. It is grown in Boro season. **Grain yield:** 5.5 t/ha. **Duration:** 130-135 days.	

Hybrids Varities and their Characteristics

Name of Varieties (Year of Release)	Important Characteristics	Crop
BRRI hybrid dhan2 (2008)	**Grain type:** Medium bold, translucent, white. Early maturing variety. **Plant height :** 105 cm. Suitable for all over Bangladesh. It is grown in Boro season (November to May). **Grain yield:** 8.0 t/ha. **Duration:** 145 days.	
BRRI hybrid dhan3 (2009)	**Grain type:** Medium bold. Early maturing variety. **Plant height:** 110 cm. Suitable for all over Bangladesh. It is grown in Boro season. **Grain yield:** 9. 0 t/ha. **Duration:** 145 days	
BRRI hybrid dhan4 (2010)	**Grain type:** Medium slender, transparent and white. **Plant height:** 112 cm. It is grown in Aman season. **Grain yield:** 6.5 t/ha. **Duration:** 118 days.	

1.2 Production Technology

Land and soil

Medium high land to lowland is suitable for rice cultivation depending on growing season. Any land type can be brought under rice cultivation; but its cultivation may not be economical. Clay and loamy, slightly acidic to slightly alkaline soils are suitable for rice cultivation.

Seed rate

Seed rate varies depending on crop establishment methods. For example, direct-seeded rice (DSR) requires more seed rate than transplanted ones. Direct seeded upland rice: 50-60 kg/ha; Transplanted rice: 8-10 kg/ha for one seedling/hill and 16-20 kg/ha for 2-3 seedlings/hill would be required.

Seed treatment and soaking

Good quality seed is the prime requirement for a good harvest. Use of properly filled, healthy seeds would ensure 5-20% higher yields than poor quality seeds. Good seeds can be sorted out easily. Dissolve 375g urea in 10 litres of water and put 10 kg seed into the container and stir seeds by hand. Fully filled seeds will be deposited at the bottom of the container. Discard unfilled floated seeds from the top. Remove good

seeds from the container; wash it 3-4 times with clean water. If the sorted seeds are spotless, seed treatment is not essential. However, seed may be treated in 52-55^{0}C hot water for 15 minute. Seed may also be treated with Carbendazim fungicide @ 2-3 g/l of water for 12 hours. One kilogram seeds should be used for each litre of water. After 12 hours of seed treatment, it should be washed with clean water.

Seed soaking: Seed soaking time is 12-24 hours depending on water temperature followed by incubation for germination. Incubation period for germination in Aus and Aman season is about 48 hours and for Boro season is 72 hours.

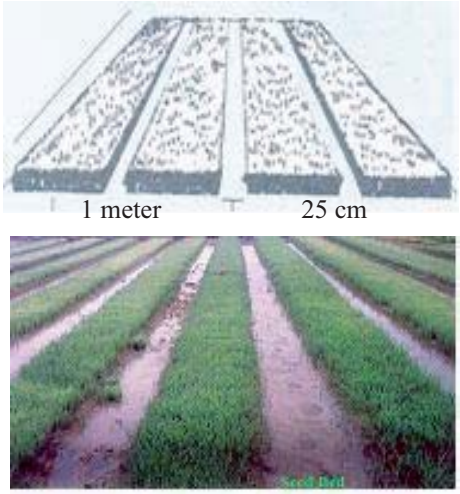
Time of sowing

Time of sowing and its subsequent management greatly influence grain yield of rice in different growing seasons. Seeds can be sown directly in the main field for direct-seeded rice (DSR); but transplanted culture requires sowing seeds in seedbed. A generalized sowing time is shown below:

Type of rice culture	**Sowing time**
Direct-seeded upland	15 March to 30 April
Transplanted Aus (T. Aus)	30 March to 20 April
Transplanted Aman (T. Aman)	
• Photoperiod insensitive varieties	15 June to 15 July
• Photoperiod sensitive varieties	20 July to 30 July[1]
Dry season irrigated (Boro)	
• Short duration varieties	15 November to 30 November (in seedbed)
• Long duration varieties	01 November to 20 November (in seedbed)

Seedbed preparation

Clay and loamy fertile soils are essential for seedling raising. However, if fertile soil is not available then 2 kg organic fertilizer, 4g triple super phosphate, 7 gm muriate of potash per square meter needs to be added. After 10 days of seeding, 7g urea and 10 gm gypsum may require for healthy seedling raising. Land should be plowed and cross plowed 3-4 times followed by laddering and keep the soil submerged by 5-6 cm water for 7-10 days. Finally bed soil is made soft and muddy by plowing and laddering. One meter wide bed is prepared lengthwise of the land. There should



Standard seedbed for growing rice seedlings

[1]Seeding for BRRI dhan46 can be done up to 10 August

be 25-30 cm space in between two beds from which soil is removed at 5-7 cm depth and spread over the bed. Similar way soil of border areas is removed and spread over the bed. Finally, bed soil is leveled by a flat wooden plank and kept undisturbed for about 3-4 hours for seeding pre-germinated seeds. Fifty to 60 gm seed/m^2 is used in the seed bed. The canal formed in between two beds can be used for irrigation and drainage purposes.

Land preparation and transplanting

Land for direct-seeded upland rice is generally prepared either in dry or optimum soil moisture conditions. Three to four plowing followed by laddering or harrowing may require for a good tilth depending on soil types. Land for transplanted culture is prepared in wet conditions to make the soil soft and muddy. Three to four plowing and cross plowing followed by laddering may require for transplanting. However, rice can also be transplanted in zero tillage conditions, provided that the soil is soft and there are no weeds or stubbles. At final plowing and laddering, land should be properly leveled for keeping similar water depth throughout the field.

Transplanting: Seedlings are uprooted carefully before transplanting. In general, 20-25 day-old seedlings are transplanted in Aus season, 25-35 day-old in Aman season and 35-45 day-old in Boro season. One vigorous healthy seedling can be used in a hill. However, 2-3 seedlings/hill may be utilized at 2-3 cm depth. Transplanting should be done in rows to facilitate intercultural operations. Row to row distance should be 20-25 cm and plant to plant, 15-20 cm. If seedlings are dead or hills are missing, re-transplanting should be done within 7-10 days.

Fertilizer application

Balanced use of fertilizers is essential for satisfactory grain yield. Fertilizer rate depends on weather, indigenous soil fertility, variety, growth duration and yield potential etc. Depending on growth duration, yield and season variable amounts are needed for satisfactory grain yield (Table 1).

Table 1. Fertilizer rates and application methods

Season	Growth duration	Urea-TSP-MP-Gypsum-Zinc sulphate (kg/ha)	Method of application
Boro	More than 150 days	300-97-120-112-10	**Low fertile land**[2] One third urea at basal, 1/3rd at 4-5 tillering/hill stage and 1/3rd at 5-7 days before panicle initiation (PI) stage. **Medium fertile land**[3] Urea in three equal splits at 15-20, 30-35 days after transplanting (DAT) and the rest amount at 5-7 days before PI. Whole amount of triple super phosphate (TSP), muriate of potash (MP), Gypsum and Zinc fertilizers at final land preparation for both low fertile and medium fertile lands. *N.B. If N deficiency exists after PI, 30-37 kg urea/ha may be added.*
	Less than 150 days and BRRI dhan50	260-97-120-112-10	
	Haor areas	200-90-120-60-10	
Aus	100-115 days	127-52-60-0-0	Whole amount of TSP, MP, Gypsum and Zinc fertilizers at final land preparation. One third urea at basal, 1/3rd at 4-5 tillerings stage and 1/3rd 5-7 days before PI.
Aman	More than 145 days excluding scented rice	195-52-82-60-0 172-52-82-60-0	**Low fertile land** One third urea at basal, 1/3rd at 4-5 tillering/hill stage and 1/3rd at 5-7 days before PI. **Medium fertile land** Urea in three equal splits at 7-10, 25-30 DAT and the rest amount at 5-7 days before PI.Whole amount of TSP, MP, Gypsum and Zinc fertilizers at final land preparation for both low fertile and medium fertile lands.
	Less than 125 days	127-52-82-60-0	Whole amount of TSP, MP, Gypsum and Zinc fertilizers at final land preparation. One third urea at basal, 1/3rd at 4-5 tillerings stage and 1/3rd 5-7 days before PI.
	Photoperiod sensitive	172-52-82-60-0	Whole amount of TSP, MP, Gypsum and Zinc fertilizers at final land preparation. Two third urea at basal and 1/3rd at 5-7 days before PI.
	Scented rice and BRRI dhan32	90-52-60-30-0	Whole amount of TSP, MP, Gypsum and Zinc fertilizers at final land preparation. One third urea at basal, 1/3rd at 4-5 tillerings stage and 1/3rd 5-7 days before PI.

[2]Those land which can give less than 1.0-1.5 t/ha grain yield in Boro season and less than 2.0-2.5 t/ha in T. Aman season without fertilization

[3]Those land which can give less than 3.0-3.5 t/ha grain yield in Boro season and less than 3.5 t/ha in T. Aman season without fertilization

Some additional points on fertilizer application time and methods:

- Organic fertilizers should be added at first plowing during wet season.
- In light textured soils, potash fertilizer should be added in two splits- two third at final land preparation and 1/3rd at 5-7 days before panicle initiation (PI).
- Carry over effect of zinc sulfate may be observed in succeeding two crops.
- Urea fertilizer needs to be added in every cropping season. It should be applied in four equal splits for light textured soils. It is better to apply urea in 2-5 cm water followed by incorporation mechanically.
- Zinc and sulfur fertilizers are to be added during final land preparation for Zn and S deficient soils. However, they can be utilized after transplanting for correcting deficiency symptoms in rice.

Use of urea super granules

Urea super granule

Urea super granule placement

Urea super granule (USG) is made from urea, which looks like tablet. Use of USG improves urea use-efficiency by 20-25%. Rice should be transplanted in rows at 20 cm apart for using USG in between four hills. USG is placed at 7-10 cm deep into soil at 15-20 and 7-10 DAT during Boro and Aus and Aman seasons, respectively. In general, one grainule of 1.8 gm is used in Aus and Aman seasons; on the other hand, one grainule of 2.7 gm is used in Boro season. So, it supply 110 kg urea/ha in Aus and Aman seasons and 165 Kg urea/ha in Boro season. However, USG rate adjustment may be required depending on soil fertility and yield potential of rice variety.

Irrigation

Perforated PVC and installed pipe in rice field.

Rice can be grown without continuous standing water. Generally, 2-4 cm standing water can be kept up to 10-12 DAT and then reduced amount to facilitate tillering and reduction of irrigation cost. Since rice is mainly grown as irrigated crop during Boro season, loss of irrigation water can be minimized by using plastic and PVC pipes. Alternate wetting and drying (AWD) technique can be employed to save irrigation water. In this system 25 cm long and 7-10 cm dia PVC pipe is used in which 15 cm is perforated. This perforated 15 cm is placed into soil vertically followed by removal of inside soil. When water is seen at the bottom of the pipe, the land is irrigated at 5-7 cm water depth. This technique is followed after crop establishment and continues upto vegetative stage. Standing water should be maintained at PI to milking stage.

1.3 Intercultural Operation

Intercultural operations are to be done in between transplanting and harvesting. It

includes gap filling within 7-10 DAT, fertilizer management, pest management, water management, rouging and mowing. These have been discussed in separate headings. Some of the important issues of intercultural operations are stated below:

Fertilizer management and pest control

- Excessive use of N fertilizer favors fungal and bacterial disease development along with increased infestation of brown plant hopper, leaf folder, stem borer, gall midge, etc.
- Balanced use of potash fertilizer helps in controlling whorl maggot, green leafhopper, yellow stem borer, brown plant hopper, etc.

Water management and pest control

- Plant hoppers and army worms could be controlled by draining field water.
- Alternate wetting and drying helps in controlling black bugs, plant hoppers, gall midge, hispa, and most stem borers.
- Irrigation water helps in controlling grasshoppers, thrips, ants, white grubs, mole crickets, root aphids, termites, root weevils and seedling maggots.

Pest Management

Weed Control

Grain yield loss of rice can be mitigated if weeds, insect pests and diseases are controlled at the right time. As a thumb role, if rice fields are kept weed free for initial one third of field duration (planting to maturity) of a rice variety, then crop loss could be avoided. Weeds are generally controlled mechanically (hand pulling, use of weeder, etc) and chemically. Weed control by herbicides is more profitable than hand weeding. Pre-emergence and post emergence herbicides can be used for weed control. Examples of herbicides are provided.

Table 2. Herbicides used for weed control in rice field

Name of herbicide	Time of application	Quantity /ha	Remarks
Machete 5G (Butachlor)	3-6 DAT	25 kg	
Miracle 25EC (Oxadiazon)	3-6 DAT	2 L	
Hunter (Pretylachlor)	3-6 DAT	1 L	
Panida 33EC (Pendamethylin)	2-5 DAT	2.5 L	Toxic for direct weeded rice
Topstar 400EC (Oxadiazyl)	3-6 DAT	188 ml	
MCPA 500EC	3-5 leaved weeds	105 ml	Toxic for direct weeded rice
MCPA 600EC	3-5 leaved weeds	105 ml	Toxic for direct weeded rice
Sathi 10WP (Pyrajosulfuran ethyl)	3-5 leaved weeds	150 gm	
Vachete 5G (Butachlor)	3-6 DAT	25 kg	
Serius 10WP (Pyrajosulfuran ethyl)	3-5 leaved weeds	150 gm	

Major diseases and control measures:

Bacterial leaf blight: This disease can infect rice plant at any stage. Diseased seedlings die off in the bed known as krisek. If diseased stem is pressed at the base, sticky bad odorous ooze can be noticed easily. Older leaves are infected at PI stage. Watery symptom initiated from the tip of the leaves that gradually turns to yellow and finally as dried straw. Stormy weather and rainfall favor this disease development.


Bacterial leaf blight

Control measures:

- Use of balanced fertilizers.
- Use of additional 35-40 kg/ha potash fertilizer may cause disease symptom.
- Urea should not be top-dressed after hailstorms and disease development.
- If krisek develop, drain out water from the field and irrigate after 7-10 days.
- Burn straw after harvesting of diseased crop.

Ufra: This disease is caused by small thread worm like organism, can not be seen by naked eyes. They infect collar of young rice leaves. The micro organism suck sap, develop small white spot, which gradually become brown and leaf blade die out. Plant growth stunted depending on severity of infestation. If disease develops at booting stage, twisted panicles remain inside leaf sheaths.


Ufra infected panicle

Control measures:

- Apply 20 kg/ha Furadan 5G or Curator 5G.
- Burn straw after harvest.
- Keep land fallow for 15-20 days after plowing.
- No seedbed preparation in infested field.
- Follow rice-non rice cropping rotation.

Tungro: It is a virus disease, which can occur at seedling to flowering stage. Green leaf hopper (GLH) is responsible for the spread of this disease. Light green line alternate with light yellow one appear parallel to veins in young leaves followed by deep yellow or yellow-orange coloration of the upper leaves. The infected leaves twisted slightly, plant growth stunted with reduced tillering. Diseased plants are comparatively shorter than healthier ones.


Tungro affected rice plants and virus carrier

Control measures:

- Initially remove diseased plants and burry into mud.
- Destroy GLH through light trapping.
- Control GLH by spraying Melathion 57EC at 1 L/ha, MIPC 75WP at 1.12 kg/ha, etc.

Sheath rot: A fungus disease develop on flag leaf sheath as round or irregular brown spot. The spot gradually increase in size and turn into dark grey color. Panicle emergence is impaired at variable degree depending on severity of the disease.


Sheath rot

Control measures:

- Burn affected stubbles.
- Use balanced fertilizers.
- Spray Nativo, Folicur, exaconazole.

Sheath blight: A fungal disease generally found at tillering stage. Initially grayish watery mark develops on leaf sheath. Centre of the speck become gray surrounded by brown margin. The spot gradually enlarged in whole sheath and parts of leaf. Hot humid weather, excessive urea application and densely populated plants favor disease development.


Sheath blight

Control measures:

- Floating stubbles after final land preparation should be removed and buried into soil.
- Apply potash fertilizer in equal two splits at final land preparation and at last urea top dressing.
- Spray Nativo, Folicur or exaconazole.

Blast: A fungus disease, which may develop in the leaf (leaf blast), node (node blast) and neck of panicle (neck blast). Oval shaped brown spot, whitish or ash color at the centre develop on leaves. Many spots merge together resulting in dead leaf. Whole plot may be damaged because of this disease. Low night temperature, high day temperature and dew in the morning favor blast disease development.


Leaf blast

Control measures:

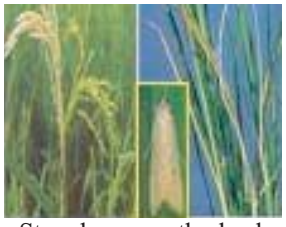
- Add organic fertilizer.
- Keep standing water.
- Use seed from disease free field.
- Use balanced fertilizer. Suspend urea top dressing
- Apply 400 gm/ha Trooper, Nativo twice in 10-15 days.

Major insects and control measures:

Rice varieties tolerant to insect pests should be cultivated. There are many insects in the rice field- some of them are predators, some are parasitoids and others are pest for the rice crop. So, integrated pest management (IPM) technique should be adopted to save beneficial insects. Control measures of some important insect pests are discussed

and some insecticides and rates for controlling rice insects are presented in Table 2.

Stem borer: Stem borer affected plants produce dead heart or white head symptom depending on growth stage of rice plants.


Stem borer moth, dead hart and white head

Control measures:
- Destroy egg mass.
- Control moth through light trapping.
- Use perching technique.
- Spray insecticide if 10-15% dead heart or 5% white head is observed.
- Burn stubbles.

Gall midge: This insect infests growing tillers, which turns into onion shoot.


Gall midge and onion shoot

Control measures:
- Regular observation of field.
- Destroy adult insects through light trap.
- Use insecticide if 5% onion shoots are observed.

Rice hispa: Grub destroys internal leaf tissue and adult feed on green leafy parts resulting in whitish leaf.


Rice hispa and damage

Control measures:
- Using sweeping net for destroying adults.
- Use insecticides if 35% leaves are damaged or 4 adults/hill or 5 grubs/tiller are observed.

Rice caseworm: This insect makes small cages by cutting upper portion of leaves. Leaves of infested field are white. These cages float on water in day time.


Rice caseworm

Control measures:
- Destruction of moths by light trap.
- Collect cages from water by hand net and destroy them.
- Drain water from the field.
- Use insecticides if 25% leaves are damaged.

Leaf roller: Larvae of this insect folds leaf and feeds on internal green parts. Burning symptom appears when leaves are severely damaged.


Leaf roller moth, larva and damaged leaf

Control measures:
- Destroy moth through light trap.
- Perching.
- Use insecticides if 25% leaves are damaged at or before PI stage.

Brown planthopper: This insect sucks cell sap from the base of the plant. Plants dry up showing burning symptom which is known as hopper burn.


Brown planthopper and hopper burn

Control measures:

- Transplant at 25 cm x15cm or 20 cm x 20cm spacing for allowing light and air in the field followed by regular inspection.
- Use balanced amount of urea.
- Drain water if insect is seen.
- Short duration variety may be cultivated.
- Use insecticides if 4 gravid females or 10 grubs or both are found in most hills. Comm unity based control measures are effective.

Green leafhopper: This insect sucks leaf cell sap resulting in reduced plant growth. It is a virus disease carrier.


Green leafhopper

Control measures:

- Use of light trap.
- Use insecticides if green leafhopper is found in every sweeping net and nearby existence of tungro affected plants.

Rice bug: This insect infest rice field at the milking stage of rice plant. Pungent smell emit from the adult insect.


Rice bug

Control measures:

- Use light trap.
- Use insecticides in the afternoon if 2-3 rice bugs/hill are found.

Thrips: This insect infests at seedling and tillering stage of rice plant. Thrips make lesion on leaves and sucks cell sap resulting in leaf folding longitudinally.

Control measures:

- Irrigate seedbed/field followed by urea topdressing.
- Use insecticides if severely infested.

Table 3. Name of some insecticides and rates for controlling rice insect pests

Insecticide	Rate/ha	Insecticide	Rate/ha
	Stem borer and Gall midge		
Diazinon 60EC	1.70 L	Diazinon 10G	16.80 kg
Carbosulfan 20EC	1.50 L	Carbofuran 3G	16.80 kg
Fenthoit 50EC	1.70 L	Carbofuran 5G	10.00 kg
Chlorpyrifos 20EC	1.00 L	Fipronil 3G	10.00 kg
	Rice hispa		
Dimethoit 40EC	1.12 L	Carbaryl 85WP	1.70 kg
Malathion 57EC	1.00 L	MIPC 75WP	1.12 kg
Fenthion 50EC	1.00 L	Chloropyriphos 25EC	1.00 L
Diazinon 60EC	1.00 L	Carbosulfan 20EC	1.12 L
	Leaf roller and Rice caseworm		
Malathion 57EC	1.00 L	Carbaryl 85WP	1.70 kg
Fentrothion 50EC	1.00 L	MIPC 75WP	1.12 kg
Fozalon 35EC	1.00 L	Diazinon 10G	16.80 kg
	Brown planthopper		
Carbosulfan 20EC	1.00 L	Diazinon 10G	16.80 kg
Diazinon 60EC	1.00 L	Carbaryl 85WP	1.5 kg
Malathion 57EC	1.00 L	Pymetrogin 50WG	0.5 kg
Carbofuran 5G	10.00 kg	Cartap 50WP	1.2 kg
	Green leafhopper, Thrips, Rice bug		
Malathion 57EC	1.00 L	MIPC 75WP	1.12 kg
Fenitrothion 50EC	1.00 L	Carbaryl 85WP	1.70 kg
Dimethoit 40EC	1.12 L	Formothion 25EC	1.12 L

1.4 Harvesting and Seed Preservation

Rice should be harvested at proper ripening stage. If 80% grains in a panicle turn yellow, it is ready for harvesting. Threshing should be completed immediately to preserve quality of grains. Concrete threshing floor is better, but if is not available then use thin jute/bamboo mat or polyethylene on top of soil. Rice should be sun dried for 4-5 days followed by winnowing and storage.

Seed preservation

Preservation of good quality seed is the prime requirement for better harvest in the coming season. Rice field having no weed infestation, no disease and insect pest attack and free from off types is the right choice for seed collection. Harvest rice at the proper ripening stage, thrash, dry, winnow and store at right relative humidity and temperature. Consider following points during seed storage-

- Dry seed to reduce seed moisture content below 12%.
- Sort out fully filled grains while winnowing.
- Preserve seed in air sealed container.
- If earthen pot is used, coal tar may be used to coat outer surface of the container.
- Thick polyethylene bag can be used for seed storage.
- Sun dried seeds should be put into container in full after cooling in shadow place.
- Make the container air tight and keep it above ground.
- Use dried leaves of *Azadiracta indica* @ 3.25 kg/ton rice seed for preventing insect attack.

2. Wheat

More than 80% of wheat in Bangladesh is grown in rice-wheat rotation of which about 50% is planted late. Late planting causes a significant yield loss in every year. Wheat is often late because of delayed harvesting of T. Aman rice, longer time for land preparation, unavailability of labourers, late monsoon and some cases of excess moisture in the soil. The optimum growing mean temperature is about 25^0C. It favours range of temperatures between 20^0 and30^0C with minimum temperature of 3-4^0C and maximum of 30-32^0C. Well distributed rainfall ranging from 40-110 cm is optimum for wheat growth. The area of wheat during 2011-12 is 3.58 lac hectares with total production of about 10 lac tones with an average yield of about 2.78 t/ha. The yield of wheat can be further increased through HYV wheat and improve production technology.

2.1 Varieties

Wheat Research Centre (WRC), BARI has so far released 28 wheat varieties. The salient features of these newly released and 6 popular wheat varieties are stated below:

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Gom-23 (Bijoy) (2005)	It is a semi-dwarf high yield potential wheat variety. Leaves are broad, droopy and dark green in colour. It is an early maturing variety. **Grains per spike:** 35-40. Grains are white-amber and larger in size. **1000-grain weight:** 47-52g. The variety is tolerant to high temperature and gives 10-20% higher yield under late seeding. Flour is suitable for chapati making. The variety is tolerant to leaf blight and resistant to leaf rust diseases and moderately tolerant to terminal heat stress. **Grain yield:** 4.3-5.0 t/ha. **Duration:** 103-112 days.	
BARI Gom-24 (Prodip) (2005)	It is a semi-dwarf high yielding variety. The variety is tolerant to terminal heat stress and suitable for growing under both optimum and late sown conditions. This is a early maturing variety. Grains are white and amber. **1000-grain weight:** 48-55g. **Grains per spike:** 45-50. The flour is most suitable for bread making due to its strong gluten. It can be grown successfully throughout the country except in saline areas more than 6 mmhos. **Grain yield:** 4.3-5.1 t/ha. **Duration:** 102-110 days	

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Gom-25 (2010)	The variety is semi-dwarf, early maturing and high yielding. **Plant height:** 95-100 cm. Leaves are deep green and broad. It takes 57-62 days to heading. **Grains per spike:** 45-55. Grains are amber in colour and bright. **1000-grain weight:** 54-58g. It shows moderate level of tolerance to terminal heat stress giving 6-10% higher yield under late seeding. The variety is highly tolerant to bipolaris leaf blight and resistant to leaf rust diseases. It can be grown under both optimum and late seeding conditions. The variety is moderately tolerant to salinity. Therefore, it can be grown in southern region having salinity level below 10 dS/m. **Grain yield:** 3.6-4.6 t/ha. **Duration:** 102-110 days.	
BARI Gom-26 (2010)	The variety is semi-dwarf in height with high yield potential. **Plant height:** 92-96 cm. It requires 60-63 days to heading. **Grains per spike:** 45-50. Grains are amber in colour and bright. **1000-grain weight:** 48-52g. The variety is tolerant to terminal heat stress giving 10-12% higher yield under late seeding. The variety is tolerant to bipolaris leaf blight and resistant to leaf rust diseases with moderate level of resistance to stem rust race (Ug99). The variety is suitable for growing both in optimum and late seeding condition. It can also be grown successfully throughout the country except in areas with salinity level less than 6 dS/m. **Grain yield:** 3.5-4.5 t/ha. **Duration:** 104-110 days.	
BARI Gom-27 (2012)	This is a high yielding, short stature variety. **Plant height:** 93-95 cm. It takes about 60-65 days for heading. Grains are white amber in colour and medium in size. **1000-grain weight:** 42-46g. It gives higher yield than other varieties although it is grown upto December 15-20. **Grains per spike:** 45-50. The variety is resistant to stem rust race (Ug99) and leaf rust and moderately resistant to bipolaris leaf blight. **Grain yield:** 3.5-5.4 t/ha. **Duration:** 105-110 days.	

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Gom-28 (2012)	This is a high yielding, short stature and early maturing variety. **Plant height:** 95-100 cm. It takes 60-65days for heading It is highly tolerant to terminal heat stress due to its earliness and grain yield 15-20% higher under late seeding. **Grains per spike:** 45-50. Grains are white, amber in colour and medium in size. **1000-grain weight:** 35-40g. The variety is resistant to leaf rust and moderately tolerant to bipolaris leaf blight. It also shows adult plant resistance (APR) to Ug99 race of stem rust. Due to its earliness and heat tolerance capacity it could fit well in the rice-wheat cropping system of Bangladesh. It could also be grown in southern part with salinity level up to 8.0 dS/m. **Grain yield:** 3.5-5.4 t/ha. **Duration:** 105-110 days.	

2.2 Production Technology

Land and soil

Wheat may be grown in high land and medium high land, and also in medium low land where water receding takes place before November. Land and soil should be well drained. Generally loam, sandy loam and clay loam soils are suitable for wheat cultivation. For rainfed wheat cultivation or cultivation with residual moisture clay soil is preferable. All the varieties could be grown in low salinity (<6 dS/m during seedling stage). However, variety BARI Gom 25 can tolerate salinity of 8-10 dS/m and suitable for growing in southern Bangladesh. The varieties BARI Gom 24 (Prodip), BARI Gom25 and BARI Gom 26 are to some extent tolerant to sterility and suitable for Boron deficient soils.

Seed rate

Considering seed germination of 80% or more, 120 kg seed per hectare is recommended. However, for the large seeded variety (BARI Gom 24), 15-20 kg more seed per hectare is recommended to maintain standard plant population.

Seed treatment

Seed treatment with Provax-200 @ 3g per kg seed before sowing is recommended. It increases plant population by 20-25% and grain yield by about 10-12%.

Time of sowing

The optimum sowing time for wheat is 15-30 November. Since the winter is

prolonged to some extent in the northern region, seeds could be sown up to first week of December for optimum yield. If seeds are sown beyond this time, yield may be decreased by 1.3% for each day delay. However, varieties like BARI Gom 23, BARI Gom 24, BARI Gom 25, BARI Gom 26, and BARI Gom 28 possess good level of heat tolerance and can be sown up to mid December with moderate yield.

Land preparation

Land should be prepared by country plough, Power Tiller (2-Wheel Tractor) or 4-Wheel Tractor if the land is at optimum"Zoe" (appropriate moisture level) condition. Land may be prepared by Power tiller operated seeder (PTOS) along with seeding.

PTOS in operation

PTOS sown field

PTOS performs 3 functions i.e. ploughing, seeding in rows and laddering, simultaneously. Excess ploughing may reduce soil moisture, which may affect germination of seeds. If there is shortage of moisture in the soil, irrigation should be given before ploughing. Further, if there is shortage of moisture in the soil and also there is not enough time to allow soil to reach "Zoe" (appropriate moisture level) condition after the pre-sowing irrigation, a light irrigation should be applied after sowing seeds for proper germination. Wheat can also be planted using a bed planter in raised bed system.

Bed planter in operation

Field view

Sowing method

Seed could be sown 20 cm apart in solid line for better germination and intercultural practices.

Fertilizer application

Fertilizers like Urea, TSP, MP, Gypsum and Boric acid is recommended @ 220, 150, 100, 100, 6-7 kg per hectare, respectively. Two-third (2/3) of urea and all other fertilizers should be applied at the final land preparation as basal and the rest 1/3 urea would be top dressed at 1st irrigation (17-20 days after sowing). In case of acid soil (pH 4.5-5.5),

Plot without Lime Plot with Lime

Lime (Dolomite) is recommended to apply @ 1.0 ton/ha once in 3 years cycle. Lime should be mixed with soil by ploughing 1-2 weeks before seeding.

Irrigation

Two or three irrigations are essential depending on the soil moisture condition. Generally, first irrigation is applied at 3-leaves stage i.e., 17-21 DAS at Crown Root Initiation stage. If the soil is too dry, irrigation should be given as early as at 15 DAS. First irrigation should be very light and excess water should be drained out immediately. If there is enough moisture in the soil, irrigation should be delayed for some days. Second and third irrigations should be applied at maximum tillering stage (50-55 DAS) and early stage of grain filling (70-80 DAS), respectively. An additional irrigation before or after sowing may be essential if there is not enough soil moisture for seed germination. Before starting irrigation, weather condition should be observed. If there is a possibility of rain, irrigation should be delayed. Third irrigation should also be light to avoid lodging.

1st irrigation at CRI stage

2nd irrigation at 50-55 days after sowing

3rdIrrigation at 70-80 days after sowing

2.3 Intercultural Operation

One weeding at 25-30 DAS is recommended for good yield. Weeds may be controlled by hand weeding after first irrigation. Some herbicides *viz*., 2, 4-D Amine, Affinity or Fielder could be applied at the rate of 35ml herbicide in 10 litres of water for controlling broad leaf weeds and must be sprayed between 25 and 30 DAS in sunny days. For chemical weed control, accurate dose of herbicide and spraying need special attention.

Pest management

Major diseases and control measures:

Bipolaris leaf blight and leaf rust are the two major diseases of wheat in Bangladesh. Black point disease also occurs in some developed years due to rains at maturity stage. Newly developed varieties of wheat are resistant to leaf rust and tolerant to leaf blight diseases.

Leaf blight and rust infection

Healthy seed Black pointed seed

Control measures:

- Use resistant variety.
- Spraying of Tilt 250 EC 2 times (at heading and 15 days later) @ 0.5 ml per litre of water is effective to control the incidence of bipolaris leaf blight disease and also leaf rust in case of late sown wheat. It also controls black point disease and improves the quality of seed.
- Seed treatment with Provax-200 @ 3g per kg of seed could reduce the incidence of seed borne diseases like Bipolaris leaf blight, black point, etc.

Major pests: Bird and Rat

Control measures:

- Bird should be kept away for 10-12 days after sowing.
- Rat should be controlled using traps or poison (Zinc phosphide, Racumin, etc.) or by any other traditional means.

2.4 Harvesting and Seed preservation

In case of seed plot, the off type plants should be rouged out at least 3 times starting from flowering up to maturity stage to ensure varietal purity. Crop should be harvested at full maturity in a sunny day. Usually, wheat is harvested by hand. Wheat should be threshed by paddle thresher or power thresher. Wheat seeds should be dried up under sun to bring the moisture below 12%. It may be confirmed by chewing the dried grain. Grain should be cleaned and graded. For cleaning, paddle or power winnower can be used.

Metallic drum Plastic drum Ploythene bag

After final sunning, seeds should be cooled in a shady place. Then the seeds are to be stored in metallic or plastic drum and polythene bag. All the drums or bags should be air-tight. Polythene bags should be kept inside gunny bags. All the containers should be placed on wooden “Danish” or “Matcha”away from the wall.

3. Maize

Maize is one of the most important cereal crops in the country and the leading crop of the world after rice and wheat. It has high productivity due to its large leaf area and being a C4 plant has one of the highest photosynthetic rates of all food crops. Maize has the highest potential for carbohydrate production per unit area per day. It can be grown throughout the year because of its photo-insensitiveness. The maize seed crop contains 11% protein and its nutrient value is higher in comparison to rice and wheat. In Bangladesh, it occupies 1.68 lac hectares land and produces10.38 lac metric tons with an average yield of 6.27t/ha (BBS, 2011). It can be grown for various uses such as fodder, sweet corn, baby corn, boiled, roasted cobs, pop corn, as field corn for feed and human consumption and various industrial processed products. Maize can be intercropped profitability with mungbean, soybean, groundnut, vegetables and potatoes etc. Maize has become very popular in the country because of its diversified uses, increasing demand from poultry industry, higher nutritive value, higher per hectare yield and net benefit than other cereals. The area and production of maize is increasing rapidly in the country.

3.1 Varieties

Bangladesh Agricultural Research Institute (BARI) has so far developed 8 (eight) high yielding variety of maize (composite) and 11 (eleven) hybrid maize through collection and selection. A brief discussion of these popular varieties (both in composite and hybrid maize) along with important features is given below:

MAIZE (COMPOSITE)

Name of Varieties (Year of Release)	Important Characteristics	Crop
Barnali (1986)	It is a open pollinated variety. Its cobs are large in size and pointed at the tip. **Grain:** Semi flint type with golden yellow in colour. **Anthocyanin colouration in 1st leaf sheath:** Medium. Almost resistant to diseases and pests. **Plant height in rabi:** 200-210 cm. **1000-grain weight:** 270-300g. **Grain yield:** 5.5-6.0 t/ha (rabi) and 4.0-4.5 t/ha (kharif). **Duration:** 140-145 days (rabi) and 95-100 days (kharif)	
Shuvra (1986)	It is a open pollinated variety. Ears are conical shape. **Grain type:** Semi flint type with golden white in colour. **Anthocyanin colouration in 1st leaf sheath:** Medium. Almost resistant to diseases and pests. **Plant height in rabi:** 180-200 cm. **1000-grain weight:** 300-310g. **Grain yield:** 4.5-5.5 t/ha (rabi) and 3.5-4.5 t/ha (kharif). **Duration:** 135-145 days (rabi) and 95-110 days (kharif).	

Name of Varieties (Year of Release)	Important Characteristics	Crop
Khoibhutta (1986)	It is a open pollinated variety. The variety is especially suited for its high popping percent (>95%) and popping quality. **Grain:** Flint type with bright yellow in colour**. Anthocyanin colouration in 1st leaf sheath:** Strong. Almost resistant to diseases and pests**. Plant height in rabi:** 165-180 cm. **1000-grain weight:** 140-150g. **Grain yield:** 3.5-4.0 t/ha (rabi) and 2.5-3.5 t/ha (kharif). **Duration:** 125-130 days (rabi) and 80-90 days (kharif).	
Mohar (1991)	It is a open pollinated variety. This variety is suitable for fodder purpose. Cob girth of this variety is large. **Grain type:** Flint type with bright yellow in colour. **Anthocyanin colouration in 1st leaf sheath:** Strong. Almost resistant to diseases and pests. **Plant height in rabi:** 175-195 cm. **1000-grain weight:** 28-300g. **Grain yield:** 5.0-5.5 t/ha (rabi) and 4.0-4.5 t/ha (kharif). **Duration:** 135-145days (rabi) and 95-105days (kharif).	
BARI Maize- 5 (BM5) (1998)	It is a open pollinated variety. **Grain:** Flint type and bright yellow in colour. **Anthocyanin colouration in 1st leaf sheath:** Strong. Almost resistant to diseases and pests. **Plant height in rabi:** 170-180 cm. **1000-grain weight:** 290-310g. **Grain yield:** 5.0-5.5 t/ha (rabi) and 3.5-4.5 t/ha (kharif). **Duration:** 145-155 days (rabi) and 100-105 days (kharif).	
BARI Maize- 6 (BM6) (1998)	It is a open pollinated variety. This variety is comparatively resistant to lodging. **Grain:** Semi flint type and yellow in colour**. Anthocyanin colouration in 1st leaf sheath:** Medium. Almost resistant to diseases and pests. **Plant height in rabi:** 175-180cm**. 1000-grain weight:** 315-325g. Grain yield: 6.5-7.0 t/ha (rabi) and 5.0-5.5 t/ha (kharif). **Duration:** 145-150 days (rabi) and 95-105 days (kharif).	
BARI Maize- 7 (BM7) (2002)	It is a open pollinated variety. This variety is the highest yielder among the open pollinated varieties. **Grain:** Dent type and yellow in colour. **Anthocyanin colouration in 1st leaf sheath:** Strong. Almost resistant to diseases and pests. **Plant height in rabi:** 190-195 cm. **1000-grain weight:** 350-360g. **Grain yield:** 6.5-7.5 t/ha (rabi) and 5.0-6.0 t/ha (kharif). **Duration:** 145-155 days (rabi) and 95-105 days (kharif).	

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Sweet Corn- 1 (BSC1) (2002)	It is a open pollinated variety. This variety is suitable for table purpose at green stage having sugar of about 18%. When mature seed is light yellow in colour and shrunken. Almost resistant to any diseases and pests. Plant height in rabi season is 150-155 cm. **1000-grain weight:** 125-130g. It produces about 14.4 t/ha and 10.3 t/ha green cob, respectively, with and without husk. It also produces about 23-25 t/ha green biomass suitable for fodder. **Duration:** In rabi, edible green cob can be harvested between 113-120 days but seed mature at 140-145 days.	

MAIZE (HYBRID)

BARI Hybrid Maize- 1 (BHM1) (2002)	It is a three way cross hybrid variety. Grain is filled upto the tip of the ear/cob. **Grain:** Flint type with orange yellow in colour**. Anthocyanin colouration in 1st leaf sheath**: Weak. Resistant to diseases and pests. **Plant height in rabi:** 190-210 cm. **1000-grain weight:** 350-375g. **Grain yield:** 8.5-9.5 t/ha (rabi) and 6.5-7.5 t/ha (kharif). **Duration:** 140-150 days (rabi) and 100-110 days (kharif).	
BARI Hybrid Maize- 2 (BHM2) (2002)	It is a single cross hybrid variety. Its cobs are large in size and tightly covered by husk cover. **Grain:** Semi flint type and yellow in colour**. Anthocyanin colouration in 1st leaf sheath**: Medium. Resistant to diseases and pests. **Plant height in rabi:** 200-210 cm. **1000-grain weight:** 370-390g. **Grain yield:** 8.0-9.0 t/ha (rabi) and 7.0-7.5 t/ha (kharif). **Duration:** 145-150 days (rabi) and 100-105 days (kharif).	
BARI Hybrid Maize- 3 (BHM3) (2002)	It is a single cross hybrid variety. This variety has excellent husk cover and resistant to lodging. **Grain:** Dent type and yellow in colour**. Anthocyanin colouration in 1st leaf sheath:** Strong. Almost resistant to diseases and pests**. Plant height in rabi:** 220-230 cm and in kharif (110-115 cm). **1000- grain weight:** 375-390g. **Grain yield:** 9.5-10.0 t/ha (rabi) and 7.0-8.0 t/ha (kharif). **Duration:** 144-150 days (rabi) and 95-100 days (kharif).	
BARI Hybrid Maize- 4 (BHM4) (2002)	It is a top cross hybrid variety. **Grain:** Flint type and Orange yellow in colour**. Anthocyanin colouration in 1st leaf sheath:** Strong. Almost resistant to diseases and pests. **Plant height in rabi:** 190-200 cm**. 1000-grain weight:** 350-360g. **Grain yield:** 7.5-8.5 t/ha (rabi) and 6.0-6.5 t/ha (kharif). **Duration:** 142-146 days (rabi) and 105-115 days (kharif).	

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Hybrid Maize- 5 (BHM5) (2004)	It is a single cross Quality Protein Maize (QPM) hybrid variety. This hybrid contains two essential amino acids (Tryptophan and Lysine) almost double than the normal (non-QPM) maize and also higher protein percentage. **Grain:** Flint type with orange yellow in colour**. Anthocyanin colouration in 1st leaf sheath:** Strong. Almost resistant to diseases and pests**. Plant height in rabi:** 195-200 cm. **1000-grain weight:** 290-310g. **Grain yield:** 9.5-10.5 t/ha (rabi) and 7.0-7.5 t/ha (kharif). **Duration:** 140-145 days (rabi) and 95-105 days (kharif).	
BARI Hybrid Maize- 6 (BHM6) (2006)	It is a three way cross hybrid variety. **Grain:** Flint type and yellow in colour**. Anthocyanin colouratio in 1st leaf sheath:** Medium. Almost resistant to diseases and pests**. Plant height in rabi:** 200-210 cm. **1000-grain weight:** 380-390g. **Grain yield:** 9.8-10.0 t/ha (rabi) and 7.0-7.5 t/ha (kharif) **Duration**: 140-145 days (rabi) and 95-100 days (kharif).	
BARI Hybrid Maize- 7 (BHM7) (2006)	It is a single cross hybrid variety. **Grain:** Flint type and yellow in colour**. Anthocyanin colouration in 1st leaf sheath:** Medium. Almost resistant to diseases and pests**. Plant height in rabi:** 190-200 cm. **1000-grain weight:** 370-390g. **Grain yield:** 10.5-11.2 t/ha (rabi) and 8.0-8.5 t/ha (kharif). **Duration:** 140-145 days (rabi) and 95-100 days (kharif).	
BARI Hybrid Maize- 8 (BHM8) (2007)	It is single cross hybrid variety. **Grain:** Semi flint type with golden yellow in colour**. Anthocyanin colouration in 1st leaf sheath:** Medium. **Anthocyanin colouration in silk:** Weak. **Anthocyanin colouration in glume:** Strong. Almost resistant to diseases and pests**. Plant height in rabi:** 200-222 cm. **1000-grain weight:** 280-300g. **Grain yield:** 0.5-11.5 t/ha (rabi) and 8.0-8.5 t/ha (kharif). **Duration:** 142-146 days (rabi) and 95-105 days (kharif).	
BARI Hybrid Maize- 9 (BHM9) (2007)	It is a single cross hybrid variety. **Grain:** Dent type with orange yellow in colour**. Anthocyanin colouration in 1st leaf sheath:** Strong. Anthocyanin colouration in silk and glume: Strong. Almost resistant to diseases and pests**. Plant height in rabi:** 205-230 cm. **1000-grain weight:** 370-375g. **Grain yield:** 11.5-12.5 t/ha (rabi) and 8.5-9.0 t/ha (kharif). **Duration:** 145-150 days (rabi) and 105-110 days (kharif).	

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Hybrid Maize- 10 (BHM10) (2009)	It is a top cross hybrid variety. **Grain:** Flint type and yellow in colour**. Anthocyanin colouration in 1st leaf sheath:** Medium. Almost resistant to diseases and pests**. Plant height in rabi:** 185-225 cm. **1000-grain weight:** 370-390g. **Grain yield:** 9.0-11.5 t/ha (rabi) and 7.0-7.5 t/ha (kharif). **Duration:** 145-150 days (rabi) and 100-110 days (kharif).	
BARI Hybrid Maize- 11 (BHM11) (2009)	It is a single cross hybrid variety. **Grain:** Flint type and yellow in colour. **Anthocyanin colouration in 1st leaf sheath:** Medium. Almost resistant to diseases and pests. **Plant height in rabi:** 170-205 cm**. 1000-grain weight:** 375-390g. **Grain yield:** 10.5-12.5 t/ha (rabi) and 7.5-8.0 t/ha (kharif). **Duration:** 147-153 days (rabi) and 100-105 days (kharif).	

3.2 Production Technology

Land and soil

A deep loamy soil, high in organic matter and plant nutrients is the best soil for maize production. However, with proper management and fertilizer practices, the variety can be grown successfully on any soil from loamy sand to clay. The soil should be free from salinity and water logging. It can be grown successfully on soils with a P^H from 5.0- 8.0, but 6.0-7.0 is optimum. If the soil P^H is low (below 5), liming might be necessary.

Seed rate

The recommended seed rate is 20-22 kg/ha for grain crop but for a fodder crop seed rate would be increased to 70-90 kg/ha. In Bangladesh, farmers use between 20 to 30 kg/ha seed. For Khoibhutta and Sweet Corn the recommended seed rate is 10-12 kg/ha.

Seed treatment

The most common fungicides used for seed treatment are Furadan and Arasan M. Seed could be treated by 50 ml of Furadan 30% (seed treater), 2g of Arasan 75% (wettable powder) and 12 ml of water per kilogram of seed. Seed can also be treated by vitavax-200@2.5g/kg seed.

Time of sowing

Sowing dates should be chosen to avoid risky environmental conditions such as excessively cool or hot temperatures and during heavy shower. In Bangladesh, optimum time of sowing in rabi season is from mid October to 1st week of December, in kharif I season from mid February to end of March.

Land Preparation

The variety can be cultivated with normal land preparation or with minimum or zero tillage. Under normal condition four to five ploughings followed by laddering are adequate for sowing.

Sowing method

Seeds should be sown in rows. Usually, sowing is done in furrows in light textured soils and in ridges in heavy soils. In flood prone areas sowing can be done by dibbling method under zero tillage conditions after receding of flood water. It is recommended row to row 75 cm apart with a plant to plant spacing of 20 cm with one plant per hill which gives 66,666 plants/ha.

Fertilizer application

Fertilizer application depends on fertility status of the soil where the crop could be grown as well as the nutrient requirement of the variety. However, for composite and hybrid varieties the dose of Urea, TSP, MP, Gypsum, Zinc sulphate and Boric acid, respectively, are: 260, 177, 133, 97, 13.89, 5 and 543, 266, 200, 208, 13.89, 5 kg per hectare. Time and method of fertilizer application influence maize yield. One third of urea and other fertilizers should be applied at the time of final land preparation. Remaining two third of urea should be applied in two installments: One-third at tassel initiation (8-10 leaf stage) and the rest at about one week before silking or grain filling stage. In case of dibbling method of sowing, initial dose of fertilizers can be applied in the hole, 10 cm apart from the plants. The second and third doses of urea can be applied at 8-10 leaf stage and one week before silking. For better yield, 5-7 ton of cowdung per hectare should be applied.

Irrigation

The total amount of water required for the development of the variety varies with local conditions. Generally, water requirement is higher in hot, dry and low rainfall areas, and lower in cooler and more humid areas.

In rabi (winter season), residual soil moisture stored from monsoon can support a good stand of maize seeds and dibbled during September and October in the flood-prone areas, once flood water recedes. Water stress at the time of germination, floral initiation, anthesis, and grain filling stage would reduce grains yield considerably. One irrigation at each of these growth stages i.e. within a day of seeding; at 8-10 leaf stage; a week before silking or grain filling stage, is necessary for high yield. Waterlogging at any stages of growth is harmful so, drainage is essential for summer crop.

In kharif1 (summer season), there is no need to irrigate except during prolonged drought period. However, if the crop is sown before rains, a pre-sowing irrigation is

required for germination and good subsequent growth. Under heavy rainfall conditions, drainage should be provided.

3.3 Intercultural Operation

For a good stand of maize, thinning at crop establishment stage may be required. In case of over-planting, thinning to a desired number should be done within two weeks of germination or when the seedlings are about 15 cm tall. Care should be taken not to disturb standing plants at the time of thinning operation.

Earthing up of plants is one of the most important operations in maize cultivation. Earthing up means placing of soil near the base of the plant collected from the space between the rows. This operation helps to provide anchorage of the lower whorls of adventitious roots above the soil which then begin to function as absorbing roots. This operation also prevents the plants from lodging. The furrows made out of this operation could be used as drainage or irrigation channels, depending on the requirements. This operation can be performed with the help of spade at the time of application of the second dose of urea at 8-10 leaf stage of the crop.

Weed control is essential to ensure good harvest. In Bangladesh, weeds are not a serious problem in the winter season but in the summer season weeding is necessary. When the seedlings are about 2 weeks old, first weeding should be done. Another 2-3 weedings may be required depending on the degree of weed infestations during different life cycle of the crop. Maize farmers of Bangladesh practice hand weeding when weed infestation is very high.

Pest Management

Although insects and diseases are not a serious problem in the country but the situation is changing with the increasing of area and intensity of maize cultivation. The important diseases appear during seedling, growing and maturity stages of maize are given below:

Major diseases and control measures:

Major diseases are: 1) Seed rot and seedling blights; 2) Leaf blight; 3) Yellow leaf blight; 4) Stalk rots; and 5) Ear rot and kernal rots.

Control measures:

- Application of proper fungicide should be done to control those diseases.
- Tilt 250 EC @ 0.05% should be applied to control leaf blight diseases, starting when lesions are first observed.

Major insects and control measures

Major insects are: 1) Maize aphid; 2) Corn earworm; 3) Cut-worms; 4) Stem borer; 5) Seedling maggot and 6) Hairy caterpillar

Control measures:

- For controlling cutworm, field irrigation, application of poison bait or application of granular insecticides @ 1.5 kg a.i/ha should be done.
- Dursban, Pyrifos 20 EC @ 5 ml/litre of water should be sprayed to control soil borne insects.
- Marshall 20 EC or Diazinon 60 EC @ 2ml/litre water could be sprayed properly to control stem borer insects.
- For ear worm, the larvae could be killed after collecting from the infested cobs. Cypermethrin (Ripcord 10 EC/ Cymbush 10 EC/ Fenom 10 EC) @ 2ml/litre water could be sprayed to a control this pest.

3.4 Harvesting and Seed preservation

Harvesting should be done when plants show distinct signs of drying, the husk cover is completely dry and the grains are fully mature. Grain maturity could be identified from the milk line of kernels or the formation of a black layer at the junction of grain and placenta. Premature harvesting reduces the yield and the germination ability of the seed. If possible, a prompt harvest of the seed crop after it reaches physiological maturity is recommended, as delays will unduly expose the seed to temperature, rainfall, diseases and insects, bird damage, and theft. It is commonly harvested with 15 to 25% moisture content. Harvesting fully mature grain would result in maximum yield, improved appearance and reduced susceptibility to injury from high drying temperatures. In Bangladesh, harvesting is done by hand. The cobs are separated from the stem and the plants are cut near the ground. Soon after harvesting, the cobs should be dehusked and sundried for about 2-3 days. Dried cobs are shelled either by corn sheller or by hand. Both power and manually operated sheller could be used. The shelled kernels should be dried again before storing at optimum moisture level of 12 to 13 percent.

Drying is important before storage to avoid deterioration, reduction of seed borne insect and diseases attack and to maintain viability of seed. If maize grains are used for seed purpose, it may be treated with a fungicide or a combination of fungicide and insecticide to protect it against attack by diseases and insect pests. The treatment should be done before logging and storage.

II. TUBER CROPS

1. Potato

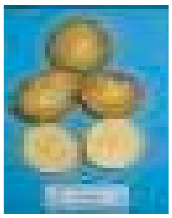
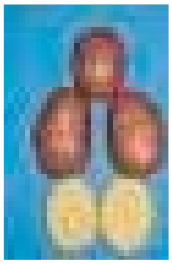
Potato is the third most important crop in Bangladesh. In respect of nutrient, potatoes are comparable with rice and wheat. It can easily be digestible. Although potato is a temperate crop, it can be grown in most parts of the country during the winter season. Well fertilized, sunny weather with sufficient soil moisture is appropriate for potato plantation. The optimum growth and development takes within 15-21^{O} C. It is being cultivated in Bangladesh since 1960 from exotic varieties. At present, potato is grown in about 4.61 lac hectares of land to produce 84 lac tons. The average yield of potato is 18.08 t/ha (BBS, 2011). Its production can be increased upto 30-40 t/ha using high yielding varieties and improved production technology. A brief description of these varieties, their important characteristics and production technology is given below.

1.1 Varieties

Tuber Crop research Centre (TCRC) of BARI has so far developed 44 varieties which were selected from exotic varieties, foreign germplasm and germplasm developed in Bangladesh through crossing programme. The most popular and suitable variety is selected as per producers and end users requirement. A brief description of 27 released varieties along with their important characteristics is given below.

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Alu-5 (Patrones) (1993)	It was introduced from the Netherlands. **Tuber:** Whitish skin, round to oblong shaped. Early maturing variety. **Tuber yield:** 25-30 t/ha. **Duration:** 85-90 days.	
BARI Alu-6 (Multa) (1993)	It was introduced from the Netherlands. **Tuber:** White skin, oval to oblong shaped. This is a popular variety. **Tuber yield:** 25-30 t/ha. **Duration:** 85-90 days.	
BARI Alu-7 (Diamant) (1993)	It was introduced from the Netherlands. **Tuber:** white skin, oval to oblong shaped, medium to large size, smooth skin, light yellow flesh, shallow eye. This is the most popular variety. **Tuber yield:** 25-35 t/ha. **Duration:** 90-95 days.	
BARI Alu-8 (Cardinal) (1993)	It was introduced from the Netherlands. **Tuber:** Red skin, oval shaped, medium to large size, smooth skin, and shallow eye. This is also a most popular variety. **Tuber yield:** 25-35 t/ha. **Duration:** 90-95 days.	
BARI Alu-10 (Kufri Sindhuri) (1993)	It was introduced from India. **Tuber:** Red skin, oval shaped. **Tuber yield:** 20-30 t/ha. **Duration:** 100-105 days.	

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Alu-13 (Granola) (1994)	It was introduced from the Netherlands. **Tuber:** Whitish skin, round to oval shaped, medium size, light yellow flesh, smooth skin**.** Suitable for export. It can be harvested at 60-65 days after planting for early market. **Tuber yield:** 20-30 t/ha. **Duration:** 85-95 days.	
BARI Alu-15 (Binella) (1994)	It was introduced from the Netherlands. **Tuber:** White skin, oval shaped, smooth skin. **Tuber yield:** 25-35 t/ha. **Duration:** 90-95 days.	
BARI Alu-16 (Arinda) (2000)	It was introduced from the Netherlands. **Tuber:** White skin, oval shaped, smooth skin. **Tuber yield:** 25-35 t/ha. **Duration:** 90-95 days.	
BARI Alu-17 (Raja) (2000)	It was introduced from the Netherlands. **Tuber:** Attractive red skin, oval shaped, yellow flesh, smooth skin, shallow eye. Substitute for local variety. Moderately resistant to late blight. **Tuber yield:** 25 -30 t/ha. **Duration:** 90-95 days.	
BARI Alu-19 (Bintje) (2003)	It was introduced from the Netherlands. **Tuber:** Pale yellow skin, oval to long oval, medium to large size, smooth skin, flesh pale yellow, shallow eye**.** Suitable for food processing. **Tuber yield:** 20-25 t/ha. **Duration:** 90-95 days.	
BARI Alu-21 (Provento) (2004)	It was introduced from the Netherlands. **Tuber:** White skin, oval to oblong shaped, medium to large size, smooth skin, pale yellow flesh. Long dormancy period in natural storage**.** **Tuber yield:** 25-35 t/ha. **Duration:** 90-95 days.	
BARI Alu-22 (Saikat) (2004)	It was introduced from CIP, Lima, Peru. **Tuber:** Red skin, round to oval shaped, medium size, smooth skin, pale yellow and flesh. Suitable for saline areas. **Tuber yield:** 25-30 t/ha. **Duration:** 85-95 days.	
BARI Alu-25 (Asterix) (2005)	It was introduced from the Netherlands. **Tuber:** Red skin, oval to oblong shaped, medium to large size, smooth skin and pale yellow flesh. Suitable for food processing. **Tuber yield:** 25-35 t/ha. **Duration:** 90-95 days.	
BARI Alu-26 (Felsina) (2006)	It was introduced from the Netherlands. **Tuber:** White skin, oval to oblong shaped, large size, smooth skin and pale yellow flesh. **Tuber yield:** 25-35 t/ha. **Duration:** 90-95 days.	
BARI Alu-27 (Esprit) (2008)	It was introduced from Germany. **Tuber:** White skin, oval to oblong shaped, large size, smooth skin and pale yellow flesh. Suitable for food processing. **Tuber yield:** 25-35 t/ha. **Duration:** 85-90 days.	

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Alu-28 (Lady Rosetta) (2008)	It was introduced from the Netherlands. **Tuber:** Red skin, Round to oval shaped, medium size, smooth skin, attractive yellow flesh and medium deep eye**.** Suitable for processing**. Tuber yield:** 25-30 t/ha. **Duration:** 85-90 days.	
BARI Alu-29 (Courage) (2008)	It was introduced from the Netherlands. **Tuber:** Red skin, round to oval shaped, medium to large size, medium deep eye and attractive yellow flesh. Suitable for processing. **Tuber yield:** 20-26 t/ha. **Duration:** 85-90 days.	
BARI Alu-30 (Meridian) (2009)	It was introduced from Germany. **Tuber:** White skin, oval shaped medium size, shallow eye and light yellow flesh. **Tuber yield:** 25-35 t/ha. **Duration:** 90-95 days.	
BARI Alu-31 (Sagitta) (2010)	It was introduced from the Netherlands. **Tuber:** White skin, oval shaped large size, light deep eye and light yellow flesh. **Tuber yield:** 30-40 t/ha. **Duration:** 90-95 days.	
BARI Alu-32 (Quincy) (2010)	It was introduced from the Netherlands. **Tuber:** Red skin, oval to long oval shaped, large size, shallow eye and light yellow flesh. **Tuber yield:** 30-40 t/ha. **Duration:** 90-95 days.	
BARI Alu-33 (Almera) (2011)	It was introduced from the Netherlands. **Tuber:** White skin, long oval shaped large size, shallow eye and pale yellow flesh. **Tuber yield:** 25-35 t/ha. **Duration:** 90-95 days.	
BARI Alu-34 (Laura) (2011)	It was introduced from Germany. **Tuber:** Red skin, long oval shaped large size, shallow eye and deep yellow flesh. **Tuber yield:** 25-35 t/ha. **Duration:** 90-95 days.	
BARI Alu-35 (2012)	It was developed in Bangladesh by crossing programme. **Plant:** Medium height, intermediate type of stem, stem green with weak extension of anthocyanine coloration. **Leaves:** Medium size of leaf with weak anthocyanine coloration on the mid rib, very weak waviness of margin of the leaflet, no anthocyanine coloration on the blade of young leaflets at apical rosette. **Tubers:** yellow skin, oval shaped medium deep eye and light cream flesh. **Tuber yield:** 38-45 t/ha. **Duration:** 90-95 days.	
BARI Alu-36 (2012)	It was developed in Bangladesh by crossing programme. **Plant:** Medium height, intermediate type of stem, Growth habit semi-erect to spreading, stem green with medium extension of anthocyanine coloration. **Leaves:** Medium size of leaf with strong anthocyanine coloration on mid rib. Weak waviness of margin of the leaflet. **Tuber:** Red skin, long oval shaped, medium to large size, shallow eye and light yellow flesh. **Tuber yield:** 34-42 t/ha. **Duration:** 90-95 days.	

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Alu-37 (2012)	It was developed in Bangladesh by Crossing programme. **Plant:** Medium height, intermediate type of stem, stem green with no anthocyanine coloration. **Leaves:** Medium size of leaf with no anthocyanine coloration on mid rib, very weak waviness of margin of the leaflet. **Tuber:** Yellow skin, oval to long oval shaped, medium size, shallow eye and light yellow flesh. **Tuber yield:** 38-44 t/ha. **Duration:** 90-95 days.	
BARI Alu-38 (2012)	It was introduced from Germany; **Plant:** Medium height, intermediate type of stem, growth habit semi-erect and stem green with very weak anthocyanine coloration on the base of the stem. **Leaves:** Medium green leaf, leaf with no anthocyanine coloration of mid rib, very weak waviness of margin of the leaflet. **Tubers:** Brownish skin, oval to long oval shaped, medium size, shallow eye and cream colour flesh. **Tuber yield:** 32-40 t/ha. **Duration:** 90-95 days.	
BARI Alu-39 (2012)	It was introduced from the Netherlands; **Plant:** Medium height, intermediate type of stem, growth habit semi-erect to spreading, stem green with no anthocyanine coloration. **Leaves:** Medium size of leaf with no anthocyanine coloration on mid rib, very weak waviness of margin of the leaflet. **Tubers :** Brounish skin, oval to long oval shaped, medium to large size, shallow eye and cream colour flesh. **Tuber yield:** 30-40 t/ha. **Duration:** 90-95 days.	

1.2 Production Technology

Land and soil

Medium high to high land with loamy to sandy loam soil is the best suitable for potato cultivation.

Seed rate

1.5- 2.0 t/ha (whole tuber); 1.2 -1.5 t/ha (cut tuber)

Seed treatment

Seed should be treated with 3% boric acid solution before sprouting for controlling the common scab disease. In this case, boric acid should be melted with light heat water. After cooling of the boric acid solution, it should be sprayed on potato tuber.

Time of sowing

15 to 30 November is the optimum time but sowing may be done in October to December.

Land preparation

Soil should be tilth properly by ploughing and laddering.

Sowing method
Ridge to Furrow method

Fertilizer application

Cowdung 10 t/ha (at final land preparation), (i) Urea 350 kg/ha (50% at the time of planting + 50% at 30-35 days after planting), (ii) TSP 100 kg/ha, (iii) MP 210 kg/ha, (iv) Zypsum 84 kg/ha, (v) Micronutrient deficient in soil like $ZnS0_4$ and Boric acid may be fertilized @ 12 and 5 kg/ha, respectively as basal dose. Zn fertilizer is not allowed to mix with Phosphatic fertilizer.

Irrigation

Irrigations need for potato cultivation depending on the soil type. Sometimes, pre-sowing irrigation may be required. Normally irrigation at 8-10, 40-45 and 60-65 days after sowing could be applied. Irrigation water should be maintained 2/3rd depth of the furrow.

1.3 Intercultural Operations

Weeding followed by top dressing and earthing up should be done at 30-35 days after sowing (DAS). In some cases, weeding may be required at 10-15 and 60-65 days after sowing (DAS).

Pest Management

Major diseases and control measures:

Fungal disease

A total of 57 diseases and disorders of potato have, so far, been recorded in Bangladesh. Among them, late blight (*Phytophthora infestans* (Mont de Bary), stem canker and Black scurf (*Rhizoctonia solani)* are the most important disease of potato in Bangladesh.

Late Blight

Late blight is the major limiting factor to increase potato production. In Bangladesh, the infection of late blight was first reported in 1922. It occurs every year under favourable condition (High humidity, low temperature and foggy weather) with varying intensities wherever potato is grown in the country. More than 25% yield is reduced due to late blight of potato every year. All the cultivated varieties in Bangladesh are more or less susceptible to late blight. Potato variety, Raja, Dheera and BARI TPS-1 and 2 showed tolerant reaction to late blight disease. In general TPS progenies are more tolerant compared to tuber varieties.


Late blight infected stem

Late blight appears on leaves, petiole and stem as pale green and turns into brown to black water soaked spots under favorable condition.White cottony mycelial growth appears under the surface of infected leaf in the morning during high humidity and leaf wetness condition. Under cool, foggy and wet conditions, whole plant of the field rot and die rapidly within 4-5 days and tubers also rot and spread in storage. Under severe condition, emits foul smell from rotted leaf in the field. The sections from infected tuber appeared brown with necrotic tissues.

Control measures:

- Use disease free certified seeds.
- Follow early planting and early harvesting (15 Novto 15 Feb).
- Weed management.
- Haulm pulling at 80 DAP.
- Under cool, foggy and wet conditions, spray should be continued with fungicides at 15 days interval. Any of the fungicides like Dithane M-45 or Indofil or Melody duo or Hamancozeb @ 0.2% at 15 days interval should be done.
- When symptoms appear, spraying with fungicides or mixture of fungicides at 7 days interval
- Secure @ 1 g/ L water or
- Melody duo 2 g + Secure 1 g in 1 litre water or
- Acrobat MZ 2 g + Secure 1 g in 1 litre water or
- Acrobat MZ 2 g + Melody duo 2 g in 1 litre water or
- Melody duo 2 g + Dithane M-45 2 g in 1 litre water
- High ridge during earthing up.
- Restricted irrigation in the infected field.
- Do not cover the harvested tuber lots by infected potato debris.
- Sorting of infected tubers during storage.

Stem canker and Black Scurf

Causal fungus of this disease is *Rhizoctonia solani*and now becoming a major disease of potato in Bangladesh.

Aerial green tubers produce in the axes of petioles and branches.Sunken shallow brown cankers affect stolons and stem at or below the soil line. Ultimately, infected plant died and tuber size reduced.

Stem canker and Black Scurf infected plant

Control measures:

- Use of disease free seed.
- Destruction of crop debris.
- Crop rotation with cereals or leguminous crop.
- Seed treatment with Boric acid (3%) before storage.
- Rogue out of diseased plant from the field.
- Spraying with Bavistin (0.1%) at the base of the plant.
- Avoid excessive irrigation.

Bacterial disease management

Bacterial wilt (*Ralstonia solanacearum*), Common scab (*Streptomyces scabies*) and Soft rot (*Erwinia spp*.) are the most important bacterial diseases of potato in Bangladesh.

Bacterial Wilt

Initial symptoms of wilt may affect one side of a leaf first, or one branch and not another. Later symptoms are severe wilt and death. Vascular strands darken and in cross section a gray to brown slime exudes, except in mild cases which may be confirmed by the flow of milky white strands from a stem section immersed in clear water.

Bacterial wilt infected plant

Control measures:

- Rresistant source of bacterial wilt was not detected in Bangladesh.
- Use of certified seeds.
- Use of whole tuber.
- High ridge during earthing up.
- Crop rotation with non-solanaceous crop.
- Soil application with stable bleaching powder (SBP)@ 25-30 kg/ha.
- Intercropping with maize or wheat.
- Minimum irrigation should be maintained and irrigation should be stopped at the moment of disease expression.
- Diseased plant should be removed including surrounding soil and apply SBP at the rate of 20-25 kg/ha into the affected area.

Blackleg and Soft Rot

Black and slimy lesions most often progress up the stem from the soft rotted mother tuber. Young plants are commonly stunted and erect. Yellowing and upward rolling of leaflets may occur, finally wilting and death. Soft rot in field or storage often follows any type of tuber injury. Tissues become wet, cream to tan colored and soft, and are easily separated from healthy tissue. Emit foul smell.

Black leg infected plant Soft rot infected tuber

Control measures:

- Use diseased free seed.
- Prohibit excess irrigation in the field.
- Early cultivation should be done to avoid high temperature.
- Maintain proper grading before storage.
- Soil amendment with SBP @ 20-25 kg/ha.
- Tuber should be treated with 3.0% Boric acid solution before storing as seed tuber.

- Crop rotation with cereals or leguminous crop.
- Harvest in dry weather and proper care during harvest, transit & storage.
- Potato should be storedin dry and well ventilated room.
- Destruction of crop debris.

Common Scab

Scab appears on tubers as circulate to irregular lesions as corky-appearing, raised and pitted. They are variable in size and shape.Periderm turns brown and rough. Under severe condition, the periderm depressed and rotted.


Common scab infected tuber

Control measures:

- Application of ammonium sulfate (equally in three installments) instead of urea as a nitrogen source proved most effective in reducing common scab disease of potato.
- It was also found that the incidence of common scab can be minimized effectively by maintaining proper soil moisture from 30 DAP to 60 DAP.
- Seed treatment with 3% boric acid before storage showed most effective in reducing scab disease of potato.
- Crop rotation with cereals or leguminous crop.
- Green manuring crop should be used.

Virus diseases

Viruses are the main problem in our country to reduce potato production. It decreased the production generation to generation of potato. There are several viruses remain in plant and tuber in latent condition. However, major viruses of potato are described below.

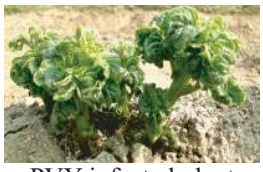
Potato Leaf Roll Virus Disease (PLRV)

Leaves become upward rolled which initiates from lower leaves. Rolled leaves are stiff and leathery and plant growth often stunted. PLRV is transmitted by aphid. Spots appear on leaves and defoliation occurred.


PLRV infected tuber

Potato Viruses Y (PVY)

Leaves became twisting and downward turning of leaflet margin. Plant growth severely stunted. Leaf and tuber size reduced markedly. Leaves look shiny.


PVY infected plant

Mosaics (Potato Viruses X, S and M) diseases

Mosaic symptoms may be caused in leaves of potatoes by several different viruses singly or in combination. Normally causes mosaic, crinkling, top necrosis, spotting or even leaf drop. Sometimes necrosis of petioles and leaf veins are occurred. Leaves are stiff and leathery and plant growth often stunted. Yield is reduced.


PLRV, PVY and PVS combinely infected plant

Control measures:

- Use disease free certified seed.
- Follow early planting and early harvesting (15 Nov to 15 Feb).
- Isolation distance maintains.
- Weed management.
- Virus eradication through tissue culture.
- Indexing viruses through ELISA.
- Production of breeder seed under net-house.
- Haulm pulling at 80 DAP.
- Grading, sorting and storing in cold storage maintaining proper temp.
- Rouging all virus infected plants.
- Spraying systemic insecticides as Admire (0.05%) to control vector.

Major insects and control measures:

Potato is an important crop world wide. The yield of potato is greatly reduced due to attack of several insect pest and diseases, including several viruses which contribute to the degeneration of seed stocks. For better tuber crop production, good quality of seed materials needs to be supplied to the farmers. So, emphasis should be given to produce disease and insect free seed. Major insect pests of potato are Cutworm, Potato tuber moth, Aphid, Whitefly and Leafhopper.

Potato cutworm (*Agrotis ipsilon*)

Cutworm is a polyphagous and the most devastating soil pest. Yield is reduced up to 35- 40%by cutworm.Young caterpillars feed on leaves and later on stems. Mature caterpillars cause the most damage. They are capable of eating or destroying the entire plant. Some times they cut-off young seedlings at ground level during night. Caterpillars feed on tubers and roots, boring a wide shallow hole.

Potato cutworm

Control measures:

- Hand picking of caterpillars at night by torch or very early morning.
- Flooding of the field for a few days before sowing can help to control cutworm caterpillars in the soil.
- Potato crops grown for seed should be monitored closely and good sanitation should be maintained.
- Use of poison bait by controlling cutworm.
- Use of insecticides Chlorpyrifos (Chlorpyrifos 48EC/Pyrifos 20EC @ 5ml/1L water at 15 days interval)/Carbofuran (Dursban 20EC and Furadan 5 G @ 20 kg/ha.)
- Pheromone traps are used to monitor and catch moths of cutworms.

Potato Tuber Moth (*Phthorimaea operculella)*

Damage in field Damage in storage

Potato tuber moths (PTM) attack potato in both field and storage.It causes 100% tuber damage in the farmers field and home storages. Small larvae usually enter the tuber at the eyes. Frequently, the larvae feed just below the surface of the potato leaving a dark tunnel. The tunnels are filled with larval excreta. Damage tuber attacked by bacterial infestation resulting potato tuber is rotted.

Control measures:

Pest incidence can be reduced through cultural practices such as –

- Controlling irrigation to prevent soil cracking that allows moths to reach the tubers.
- Hilling-up to properly cover the tubers.
- Harvested tubers are not left in the fields overnight; the heaps of tubers should be covered with polythene sheet / dried straw/ cloth to laying egg on the seed tubers.
- Using pheromone traps to capture adult moth and monitor field populations.
- Likewise, repellent plants such as *Minthostachys* spp., eucalyptus, or lantana help to protect stored tubers.
- The PTM damage can be reduced by dipping tubers in suspension of Phenthoat / Deltamethrin at 2 ml/L of water for 15 minutes and then drying after shade especially seed tubers.

Aphids

Green peach aphid: *Myzus persicae*

Potato aphid: *Macrosiphum euphorbiae***

Aphid colonies can be easily identified in plant terminal leaves and on the underside of leaves and plant root in the field. As a result black sooty mould fungus that grows on the honeydew produced by the nymphs will cover the plant. Due to severe infestation, leaf become curl and finally dried from upper portion of the plants.They also appear in tuber sprouts in stores. Finally they transmit viruses to seed potatoes.

Aphid affected laves Aphid Infected tubers

Control measures:

- Foliar sprays of Neem seed extract (1 kg, half broken neem seeds are dipped into 10 litres water for 12 hours).
- Foliar spray of soap water @ 2gm /L of water at 3 days interval.
- Sticky yellow traps can be used for population level evaluation and control.
- Different predatory and parasitoid insects also feed on aphids.Common predators are lady bird beetles and their larvae, green lacewing larvae, and syrphid fly larvae.
- Schedule spaying of insecticides such as-Melathion (Fyfanon 57EC, Malataf 57EC@ 2ml/1L of water)/Imidaclorpid (Admire 200 SL @ 0.5ml/1L of water) should be monitored regularly.

- Haulm pulling will be done for seed potato production.
- Rogue infected potato plants to reduce the incidence of viral disease infection within a field.

White flies

(*Aleurodicus disper, Bemisia tabaci)*

Besides the presence of nymphs and adults on the underside of leaves, white flies cause yellowing of infested leaves. Whitefly excretes honeydew covers the lower leaves and supports the growth of black sooty mould, which may coat the entire plant. Recently, potato apical leaf curl virus has been reported and up to 100% infection occurred in India. This virus transmitted through white flies.

White fly

Control measures:

- Unnecessary use of insecticides should be avoided.
- Sticky yellow traps can be used for population level evaluation and control.
- Foliar sprays of Neem seed extract (1 kg, half broken neem seeds is dipped into 10 litres water for 12 hours).
- Foliar spray of soap water @ 2gm /L of water at 3 days interval.
- Monitor on schedule spray of insecticides such as-Melathion(Fyfanon 57EC, Malataf 57 EC @ 5 ml/1L of water) or Imidaclorpid(Admire 200SL@ 0.5ml/1L of water)

Leafhopper (*Empoasca spp.* and *Amrasca spp*.)

Besides the presence of nymphs and adults on the underside of leaves, leafhoppers burn leaf edges with top leaf roll and foliar yellowing. Plants may die prematurely. Some species transmit mycoplasmal diseases such as aster yellows and witches'-broom disease.

Leafhopper

Control measures:

- Avoid alternate host from the seed potato production fields.
- Use light trap for preventing infestation.
- Resistant or tolerant varieties can be used for controlling leafhopper population.
- Foliar spray of Neem seed extract (1 kg, half broken neem seeds is dipped into 10 litres water for 12 hours).
- Schedule spray of insecticides such as- Quinalphos (Corolux 25EC, Debiqueen 25EC and Kinalux 25EC @ 2 ml/L of water) and monitored regularly.

1.4 Harvesting and Seed preservation

Harvesting should be done at 80 to 90 days after sowing (depending on the varieties). After curing, the potato tuber should be preserved in cold storage at 2.5^0- 4^0 C with 85-95 % Relative humidity (RH).

III. OIL SEED CROP

Oil seed is one of the most important crops in Bangladesh in terms of agricultural production. This edible oil plays an important role in human nutrition in our daily life. A good number of oil seed crop like mustard/rapeseed, groundnut, sesame, linseed, niger, safflower, sunflower and soybean are being cultivated in Bangladesh. The first three are considered the major oil crops. However, all oil seed crops are cultivated in about 3.8 lac hectares and 7.5 lac metric tons edible oil is produced in Bangladesh (BBS, 2011). From our internal production, one-third of the total requirement can be met up. The shortfall is met up by import at the cost of huge amount of money per year. Bangladesh Agricultural Research Institute (BARI) and other organization have developed a good number of high yielding varieties (HYV) of different oil crops including some improved production technologies. If farmers use these technologies, the internal oil seed production will be increased. Among them, the most important oil crops in Bangladesh are described below.

1. Mustard

It is the main edible oil crop in Bangladesh. It ranks top in respect of area and production among the oil crops grown in this country. Mustard oil has been using as cooking oil from the time immemorial. This crop is cultivated, at present,in about 2.54 lac hectares.The production is about 2.46 lac metric tons oil (BBS, 2011). The average yield of mustard is 974 Kg/ha. Total production and per hectare seed yield of this crop may be increased by using high yielding variety (HYV) and improved production technologies. The different varieties of mustard seed contain 40-44% oil and mustard oil cake contains 40% protein. Oil cake is a nutritious food items for cattle and fish. It is also a good organic fertilizer for crops. Dry mustard plants may be used as fuel.

1.1 Varieties

A brief discussion of important popular varieties of mustard and their important characteristics is given below**:**

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Sarisha-9 (2000)	BARI Sarisha-9 (*Brassica rapa*) is a short duration variety collected from India under seed exchange program of SAARC technical assistance. This line was improved through selection process and performed well in different yield trials for rabi (winter) season. **Plant height:** 85-95 cm; short plant stature. **Number of siliqua/plant:** 80-100; **Number of seeds/siliqua:** 15-20. **Brown seed and 1000-seed weight:** 2.5-3.0g. **Seed yield:** 1.45-1.65 t/ha. **Duration:** 80-85 days.	

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Sarisha-11 (2001)	BARI Sarisha-11 (*Brassica juncea*) variety was collected germplasm from home and abroad and was developed by BARI through selection process for rabi season. **Tall plant height**: 120-130 cm. **Number of siliqua/plant:** 75-150 and number of seeds/siliqua: 12-15. **Brown seed and 1000-seed weight:** 3.5-4.0g. Bold seed. Moderately resistant to *Alternaria* blight. Moderately heat and Saline tolerant (Salinity level: 6-8 dS/m). **Seed yield:** 2.0-2.5 t/ha and Stover yield: 2.5-3.0 t/ha. **Duration:** 95-100 days.	
BARI Sarisha-13 (2004)	BARI Sarisha-13 (*Brassica napus*) is an exotic variety named as NAP-198 line of Sweden was selected through selection procedure. **Plant height:** 80-100 cm. Waxy coating on leaf; erect type. Bold seed. Flower yellow. Moderately waterlogged tolerant. **Oil content:** 42-43% and 1000-**seed weight:** 3.8-4.0g. **Seed yield:** 1.77-2. 20 t/ha. **Duration:** 90-95 days.	
BARI Sarisha-14 (2006)	BARI Sarisha-14 (*Brassica rapa*) was developed through a cross variety in 1997 from Oil Seed Centre, BARI. This variety is almost self compatible tyre which helps to produce considerable yield at adverse weather condition like fussy weather, absence of pollinating agent and rainfall etc during flowering stage. Short duration variety; **Plant height:** 75-85 cm. **Number of siliqua/plant:** 45-60, number of seeds/siliqua: 15-20. Erect type. Suitable for cultivation in between T. aman and Boro rice**. Yellow seed and 1000-seed weight:** 3.5-3.8g. **Oil content:** 43%. **Seed yield:** 1.4-1.6 t/ha. **Duration:** 75-80 days.	
BARI Sarisha-15 (2006)	BARI Sarisha-15 (*Brassica rapa*) variety was collected germplasm from local area of kahalo, Bogra in 2002 and was selected after conducting research trial for years. Short duration variety; **Plant height:** 90-100 cm. **Number of siliqua/plant:** 70-80 and number of seeds/siliqua: 20-22. Erect type. White flower; yellow seed. **Oil content:** 42%. Suitable for cultivation in between T. aman and Boro rice. **1000-seed weight:** 3.25-3.50g. **Seed yield:** 1.64-1.65 t/ha. **Duration:** 80-85 days.	
BARI Sarisha-16 (2009)	BARI Sarisha-16 (*Brassica juncea*) is an exotic variety which was collected from the Netherland. This line performed very well in respect of yield both in research station as well as farmers field for rabi (winter) season. **Tall plant stature:** 175-190cm **Number of siliqua/plant:** 180-200 and number of seeds/siliqua: 9-11. Moderately resistant to *Alternaria* blight. Moderately heat and Saline tolerant (salinity level: 6-8 dS/m). **Brown seed and 1000-seed weight:** 4.7-4.9g. Bold seeded. **Seed yield:** 2.0-2.2 t/ha. **Stover yield:** 3.0-3.5 t/ha. **Duration:** 105-115 days.	

1.2 Production Technology

Land and Soil

Medium to medium high land is suitable for cultivation but loamy soil is the best for mustard cultivation. It can also be cultivated in clay loam and sandy loam soil.

Seed rate: 7 kg/ha

Seed treatment

Seed treatment before sowing with Captan or Vitavex-200 (2 g/kg of seeds) could be helpful to reduce the incidence of *Alternaria* blight.

Time of sowing

Mid-October to mid-November is the optimum time for mustard crop sowing in the northern part of the country but where winter comes early, mustard seeds could be sown earlier than the other areas.

Land preparation

Land should be well prepared by 4-5 times ploughings followed by laddering. Land should be well pulverized and free from big clods and weeds.

Sowing method

Seeding could be done both in line and broadcasting methods. In case of line sowing, row to row distance is 30 cm and in rows seeds should be sown continuously

Fertilizers dose

The fertilizer doses of different fertilizers (kg/ha) for different varieties are as follows:

Name of fertilizer	BARI Sarisha-9,11,13,14,15 and 16
Urea	250-300
TSP	170-180
MP	85-100
Gypsum	150-180
Zinc sulphate	5-7
Boric acid	10-15
Cowdung (ton)	8-10

The above fertilizer rate may be varied depending on AEZ and fertility condition of land.

Fertilizer application

Fifty percent urea and full amount of other fertilizer should be broadcasted during final ploughing. The rest amount of urea should be top dressed at 20-25 days after emergence (DAE) of seedling i.e. before flowering.

Irrigation

Adequate soil moisture is required before flowering, i.e. at 22-24 DAE and during siliqua formation i.e. 50-55 DAE. If soil moisture is not adequate during the said stages, irrigation should be applied. However, light flood irrigation or hose pipe irrigation could be applied during initial stages of crop.

1.3 Intercultural Operation

Excess seedling in the mustard field is not desirable. So, weeding cum thinning should be done in two installments during 10-12 DAE and 18-20 DAE, respectively. Plant population should be 50-60 per square meter. When optimum moisture condition exists in the field after irrigation, the soil should be loosened by using small spade or nirani.

Pest Management

Major insects and control measures:

Aphid

Control measures:

- Foliar insecticides namely Melathion 57 EC, Marshal 20 EC, Metasystox 25 EC, Maladan 57 EC at the rate of 2ml/litres of water is found most effective and controlled 100% aphid population.
- Spraying of insecticide should be done at afternoon when the pollinating bees are away from the mustard field.

1.4 Harvesting and Seed preservation

The plants are ready for harvest when 70-75% siliquae of rapeseed and mustard become straw colour. Plants should be harvested in the morning. Crop should be harvested at right time and carried it to the threshing floor and should be kept in heaps for 4-5 days. After that period, plants should be sun dried for 2 to 3 days and then threshing should be done by bullocks or by beating with a piece of wood or bamboo stick. After cleaning, seeds should be dried for 2-3 days in the sun. When moisture content of seed is at 8-9%, seeds can be stored in the bags or a tin container in a cool and dry place.

2. Groundnut

Groundnut is an important oil seed crop. It is also the best edible oil seed crop. In Bangladesh, it occupies third place in respect of area and production. At present, in rabi (winter) and kharif (summer) season, a total of 31.58 thousand hectares land is under groundnut cultivation and produce 54 thousand metric tons (BBS, 2011). Production can be increased by using high yielding variety (HYV) and improved production technology. The crop seed contains 48-50% oil and 22-29% protein. Although the quality of groundnut oil is superior to mustard oil but it is not popular in this country as cooking oil because of consumption habit. It is mainly consumed as roasted nut and as a confectionary item.

2.1 Varieties

A brief discussion of popular varieties of groundnut and some of their important features is as follows:

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI China badam-5 (1998)	This variety was developed from Dhaka-1 variety through mutation breeding in the Oil seed Research Centre, BARI. **Plant height:** 30-35 cm. Leaves light green. Hairy at lower surface and edge of leaf. Pod rough, wavy and veins prominent. Seeds light brown in colour and bigger in size. **100-seed weight:** 50-55g. Seed dormancy two weeks. **Nut yield:** 2.7-3.0 t/ha. **Duration:** 135-150 days for rabi (winter) and 115- 125 days for kharif (summer) season.	
BARI China badam-6 (1998)	This variety was selected through different exotic varieties. **Plant height:** 35-40 cm. Leaves green. Pod smooth, soft, whitish. Seeds brown in colour and bigger in size. **100-seed weight:** 50-55g. **Nut yield:** 2.8-3.0 t/ha. **Duration:** 140-150 days for rabi (winter) and 120-130 days for kharif (summer) season.	
BARI China badam-7 (2004)	It is an exotic germplasm collected from ICRISAT, Hyderabad, India. **Plant height:** 38-45 cm.Pod smooth, soft, whitish and **number of pods/plant:** 20-25. Leaves green. Seed size large, brown in colour. **100-seed weight:** 52-58g. Moderately tolerant to leaf spot andrust, less aphid infestation. **Oil content:** 49-51%. **Nut yield:** 2.8-3.4 t/ha. **Duration:** 140-155 days for rabi (winter) and 130-140 days for kharif (summer) season.	

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI China badam-8 (2006)	This variety was developed from collected germplasm of ICRISAT, India. **Plant height:** 35-42 cm. Leaves light green. Pod smooth, soft, whitish and **number of pods/plant:** 20-25. Cluster pod bearing. Seed size large and brown in colour. **100-seed weight:** 42-45g. **Shelling (%):** 70-75. **Oil content:** 49-50%. **Nut yield:** 2.5-2.7 t/ha. **Duration:** 140-150 days for rabi (winter) and 125-140 days for kharif (summer) season.	
BARI China badam-9 (2010)	It is a selection variety which was collected from germplasm of ICRISAT, Hyderabad, India. **Plant height:** 40-45 cm. Leaves light green. Pod soft, whitish and number of pods/**plant:** 20-25. Cluster pod bearing. Seed size medium. **100-seed weight:** 45-50g. **Oil content:** 48-50%. **Shelling (%):** 74. **Nut yield:** 2.5-2.8 t/ha. **Duration:** 140-150 days for rabi (winter) and 120-130 days for kharif (summer) season.	

2.2 Production Technology

Land and Soil

Sandy loam and sandy soil of char area (river bank) are suitable for groundnut cultivation. Soil should be soft and loose, so gynophores of groundnut flower can easily penetrate the soil and go down to form nuts.

Seed rate

Seed rate depends on germination percentage. However, 95-110 kg/ha is optimum.

Seed treatment

Pre-sowing seed treatment with Vitavax 200 (2-3 g/kg of seed) or Agrason (4 mg/kg of seed) could reduce the disease infestation.

Time of sowing

Groundnut could be cultivated both in rabi (winter) and kharif (summer) seasons in Bangladesh. In the rabi season, mid October to mid November is the optimum time of sowing while July-August is the best time for sowing groundnut during kharif-II (summer) season.

Land preparation

Soils of char area are very loose, so it requires 3-4 ploughings followed by ladderings are sufficient. Irrigation and drainage system could be developed by making canals after final ploughing and laddering.

Sowing method

Seeds should be planted in rows. In general, row to row distance is 30 cm and plant to plant distance is 15 cm for all the varieties except Tridana variety (DM-1) where row to row distance is 25 cm and plant to plant distance 10 cm. Seeds should be placed at 2-3 cm depth of soil.

Fertilizer dose and application method

Groundnut plant itself fixes atmospheric nitrogen. So, the requirement of urea for this crop is very low. However, the fertilizer dose is Urea: 25-30; TSP: 150-170; MP: 80-90; Gypsum: 160-180; Zinc sulphate: 4-5 and Boric acid: 9-11 kg/ha, respectively. All fertilizers should be applied before final land preparation.

Irrigation

There is no need of irrigation in the soil of char area but in the high land where soil becomes dry quickly are required one or two irrigations. In kharif-1 (summer; March-June) season, one irrigation should be required depending on the field condition but in kharif-11 (summer; July-November) season, there is no need of irrigation. Drainage may be needed to drain out excess water.

2.3 Intercultural Operation

Pest Management

Major insects and control measures

Major insects: Hairy caterpillar, Jassids and Thriphs

Control measures:

- In case of hairy caterpillar insect infestation, leaves of infested plant should be destroyed along with the eggs and larvae of insects.
- For adult insect control, Ripcord 10 EC or Nogos 100 EC should be sprayed @ one ml of insecticide with one litre of water.
- Diazinon 60 EC @ 2 ml per litres of water should be sprayed to control Jassids and thriphs.

2.4 Harvesting and Seed preservation

When plants become mature, the leaves of the lower parts of plants become yellow. Surface of pods become rough and hard, veins become prominent, inner surface of pods shell becomes blackish in colour. Cover of kernels become brown in colour. These are the ideal condition when the crop is ready for harvest.

Pods should be dried for 8 hours after harvesting. Moisture content of pods should be 8-9%. Seeds should be cooled and then stored after sun drying. For storing groundnut, different types of containers may be used. If seeds are stored in air tight condition whether polythene bags and synthetic bags, the quality of seeds and viability of seeds are restored for more than one year but during rainy season, seeds should be checked and dried and kept in the same container.

3. Sesame

Sesame is the second most important edible oil crop in Bangladesh. It contains 5.3% water, 5.2% minerals, 2.9% fibre, 43.3% fat and 25% carbohydrate per 100g edible portion. At present, this crop is cultivated in about 80 thousand hectares of land and produces about 49 thousand metric tons. It is grown both in kharif (summer) and rabi (winter) season. But in this country, sesame is mostly grown in kharif season. It is grown almost in all regions of Bangladesh. Generally, black and brown coloured sesame seeds are cultivated in this country. The sesame seeds contain 42-45% oil and 20% protein. At precent, it occupies 34.8 thosandhectares of land and produces 31 thousand metric tons with an average yield of this crop is 889 Kg/ha (BBS, 2011). But it could be possible to increase sesame production upto 1200 Kg/ha through improved management practices.

3.1 Varieties

The popular varieties of sesame developed by BARI and their important features are described below:

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Til-3 (2001)	This variety was developed through selection procedure from collection of local different germplasms of sesame for kharif (summer) season**. Plant height:** 100-120 cm.Stem, leaves hairy. Brown seed colour; Flower white with violet shading. **Number of capsules/plant:** 60-65. **Number of seeds/capsules:** 50-55**. Seed yield:** 1.2-1.4t/ha. **Duration:** 90-100 days.	
BARI Til-4 (2009)	This variety was developed through selection process from local germplasms. It gave good performances during kharif (summer) season. **Plant height:** 90-120 cm. **Most of the pods:** 8-chambered. Brown seed colour. **Number of capsules/plant:** 85-90. **Number of seeds/capsules:** 75-77. **Seed yield:** 1.4-1.5 t/ha. **Duration:** 90-95 days.	

3.2 Production Technology

Land and Soil

Sandy loam along with high land is the best suitable for sesame cultivation but it could not survive in water logging condition.

Seed rate: 7 kg/ha

Seed treatment

Seeds should be treated with fungicide before sowing because seeds often bear diseases pathogens which hamper seedling growth and development. So, seed treatment is very important for maintaining normal plant growth and healthy seedling. Vitavex-200, Bavistin, Captan and Homai should be used as for seed treatment. A big container with lid could be used for seed treatment. Fungicide @ 2 g/kg of seeds or any other recommended rate should be used. Seeds should be sown on the following day after proper mixing.

Time of sowing

For kharif-1 season, the optimum sowing time is end of February to middle of April and for autumn crop the optimum sowing time is mid August to mid September. However fork harif-1 (summer) season, early sowing is advocated for sesame cultivation to achieve higher yield.

Land preparation

Land should be prepared by 4-5 times ploughing followed by laddering. Land should be free from big clods and weeds. Land should be levelled, and drains should be made for easy drainage of excess rain or irrigation water. In the raised bed system, drainage of excess water could easily be controlled.

Sowing method

In case of line sowing, line to line distance is 30 cm and seeds are sown continuously in line whileafter emergence, plant to plant distance should be kept at 5cm.

Fertilizer dose and application method

Fertilizer dose varies depending on soil fertility and also differs in different agro-ecological zones (AEZ). However, fertilizer dose for sesame crop is Urea: 100-125; TSP: 130-150; MP: 40-50; Gypsum: 100-110; Zinc sulphate: 0-5 and Boric acid: 8-10 kg/ha, respectively. Fifty percent urea and full dose of other fertilizers should be applied at the time of final ploughing. The rest amount of urea should be top dressed at 25-30 days after sowing i.e. before flowering. Adequate soil moisture is necessary during top dressing.

Irrigation

Generally, irrigation is not required for sesame cultivation. But for kharif-1 crop, irrigation may be required at initial stage of the crop because of late rain. So, one irrigation would be required before flowering at 25-30 days after sowing. Sesame crop could not tolerate water logging. So, irrigation water or rain water should be drained out by making drains in the field immediately after irrigation or rainfall.

3.3 Intercultural Operation

Excess plants should be thinned out at 10 days after germination keeping 50-60 plants per square meter. In case of line sowing, the excess weeds from the field should be removed at 10 -15 DAE and another at 20- 25 days after sowing.

Pest Management

Major insects and Control measures:

Hairy caterpillar

Control measures:

- Alsan 50EC 1 ml in 1 litre of water should be mixed and sprayed to control hairy caterpillar.
- Alsan 50EC, Cilicron 50EC, Desis 25EC may also be used at the rate of 1 ml in 1 litre of water for controlling eggs of the insect.

3.4 Harvesting and Seed preservation

Sesame plants mature within 85-90 days. All capsules do not mature at a time. Plants should be harvested before drying of capsules. Harvested plants should be kept in heaps for 3-4 days. The plants should be dried in the sun for few days and then threshing should be done. Seeds should be dried for 2-3 days in the sun. When moisture content of seed is at 8-9% then seeds should be stored in the bags or a tin container in a cool and dry place.

IV. PULSE CROPS

All the pulses belong to Papilionaceae group of botanical family *Leguminosae.* Pulses are the most common item in the daily diet of the people of Bangladesh. Being the cheapest source of protein, pulses are, in fact, poor men's meat and are eaten freely as a substitute for animal protein which is extremely expensive. Pulse not only contain lot of protein comparable with meat in terms of quantity, but have higher energy value than meat and contain much more of minerals, such as, calcium, phosphorus and iron. The production of pulse crops in Bangladesh is far below requirement. At present, pulses are grown on area of 2.54 lac hectares with total production of 2.33 lac metric tons (BBS, 2011). The average yield of pulses are 900 kg/ha. In order to meet pulse requirement of the present population, production must be increased through increase of areas, using of high yielding varieties and application of improved production technologies. The most important pulse crops are described below.

1. Lentil

Lentil is essentially a temperate crop but it is adapted to cooler regions of the sub-tropics. It is a very suitable for production as sole crop and intercrop. In Bangladesh, it is sown as rabi (winter) crop on residual soil moisture. Lentil is somewhat drought tolerant but susceptible to water logging. It is the most important pulse crop in Bangladesh. Generally, farmers cultivate locally popular variety of lentil in broadcast method. The yield level of this variety is very low. However, at present the area of lentil is 83 thousand hectare with total production of 80,000 metric tons (BBS, 2011).

1.1 Varieties

A brief discussion of popular BARI varieties and their important characteristics is given below.

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Masur-4 (1996)	This variety was introduced from ICARDA, Syria. **Plant height:** 40-45 cm. Resistant to stemphylium blight and rust. **Protein:** 25.80%, **CHO:** 59.80%. **Cooking Time:** 12 min. **Head Dhal yield**: 88.68%. **1000-seed weight:** 19.5-20g. **Seed yield:** 2.0 t/ha. **Duration:** 110-115 days.	
BARI Masur-5 (2006)	This variety was introduced from ICARDA, Syria. Medium plant stature. **Plant height:** 38-40 cm. Resistant to Stemphylium blight and rust. Tolerant to foot rot and modrerately resistant to aphid. **Protein:** 26%, **CHO:** 59.80%. **Cooking Time:** 12 min. Head **Dhal yield:** 78%. 1000-seed weight: 19g. **Seed yield:** 1.5- 2.2 t/ha. **Duration:** 98-110 days.	

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Masur-6 (2006)	This variety was introduced from ICARDA, Syria. **Plant height:** 40-45 cm. Resistant to Stemphylium blight and rust. **Protein:** 26%, **CHO:** 58.9%. **Head Dhal yield:** 78%. **CookingTime:** 12 min. **1000-seed weight:** 19.8g. **Seed yield:** 1.6-2.5t/ha. **Duration:** 110-115 days.	
BARI Masur-7 (2011)	This variety was introduced from ICARDA, Syria. **Plant height:** 32-38 cm. Tolerant to Stemphylium blight and rust. **Protein:** 26%, **CHO:** 58.9%. **Head Dhal yield:** 78%. **Cooking Time:** 12 min. **1000-seed weight:** 23-25g. **Seed yield:** 1.8-2.3 t/ha. **Duration:**115-120 days	

1.2 Production Technology

Land and Soil

It may be grown in all types of well drained soils. Lentil prefers full sunny environments, loose, organic matter rich well drained soil. It grows best in slightly acidic soil with pH 6.0-6.5. Loam and clay loam soils are suitable for lentil.

Seed rate

It requires 30-35 kg seeds for one hectare of land.

Seed treatment

Seed should be treated before sowing by provex @ 2 g/kg of seed for successful crop production.

Time of sowing

The optimum sowing time is last week of October to first week of November (10 November) but it could be sown upto end of November.

Land preparation

Land should be well prepared by 3-4 times ploughing followed by cross laddering. Land should well pulverized and free from big clods and weeds.

Sowing method

Seeding could be done both in broadcasting and line sowing method. In case of line sowing, row to row distance is 25 cm and in rows seed should be sown continuously.

Fertilizer application

Urea, TSP, MP and Boric acid should be applied @ 44, 100, 40 and 7.5 kg/ha, respectively during final land preparation.

Irrigation

The crop normally grows under rainfed condition but if necessary, one irrigation is to be given at vegetative stage.

1.3 Intercultural Operation

Weeding should be done at 25-30 days after emergence.

Pest Management

Major diseases and control measures:

Stemphylium blight

Stemphylium blight start with the appearance of small pin-headed light brown to tan coloured spots on leaflets. Under ideal conditions the small spots enlarge rapidly, covering the entire leaflet surface within a 2-3 day period. The infected tissue appears light cream in colour, often with angular patterns of lighter and darker areas that spread across, or long, the entire leaflet. The affected foliage and stems gradually turn dull yellow, giving a blighted appearance to the crop. The infected leaves can be abscised rapidly, leaving only the terminal leaflets on the stems. The stems bend down, dry and gradually turn ashy white, but pods remain green. White mycelial growth can sometimes be seen on the infected stems.

Stemphylium blight of lentil

Control measures:

- Being stubble-borne disease strategies such as destruction of old crop residues, and crop rotation would assist in decreasing potential inoculum sources.
- The most economical and sustainable strategies to control Stemphylium blight are through use of resistant/tolerant variety (BARIMasur-4, BARIMasur-5, BARIMasur-6 and BARIMasur-7).
- Delay sowing reduces the incidence of *Stemphylium* blight disease of lentil but it reduces the pod setting and lowering the seed yield significantly.
- Application of Rovral (Iprodion) 50 WP (0.2%) or Secure 600 WG (Fenamidone + Mancozeb), Companion(Mancogeb+Canendazim) performs better to control the disease effectively when sprayed 3 times at an interval of 10 days starting from the initiation of the disease.
- Integrated Disease Management include the use of healthy seed and Secure 600 WG spray with wider spacing (40 cm) performed higher yield through lower disease incidence.

Foot rot

Foot rot occurs in the field as patches of dead plants, most often at the seedling stage. The pathogen attacks the collar region of the plant causing slight yellows brown discoloration and rotting of the tissue. The young seedling shows damping

Foot rot disease of lentil

off symptom. The infected crop become chlorotic, quickly dies and dries up. The pathogens are soil borne and incidence of the disease has been observed to be higher in soil with initially high moisture content.

Control measures:

- Use of tolerant variety (BARIMasur-5, BARIMasur-6 and BARIMasur-7).
- Seed treatment with Provax-200 @ 0.25% w/w of dry seed.
- Changing the seeding date and tillage method was found effective to reduce the incidence of diseases. Optimum sowing at the beginning of November found better throughout the country.
- Soil treatment with *Trichoderma* spp. and/or *Rhizobium* spp. inoculum @ 210 g/ha showed better result against foot and root rot.

Rust

Rust disease of lentil

Rust starts with the formation of yellowish-white pycnidia and aecial cups on the lower surface of leaflets and on pods, singly or in small groups in a circular form. Later, brown uredial pustules emerge on either surface of leaflets, stem and pods. Pustules are oval to circular and up to 1 mm in diameter. They may coalesce to form larger pustules. The telia, which are formed late in the season, are dark brown to black, elongated and present mainly on branches and stems. In severe infections leaves are shed and plants dry prematurely, the affected plant dries without forming any seeds in pods or with small shriveled seeds. The plant has a dark brown to blackish appearance, visible in affected patches of the paddock or in the whole paddock if totally infected.

Control measures:

- Use of tolerant variety (BARI Masur-5, BARI Masur-6 and BARI Masur-7).
- In the northern districts of Bangladesh, the diseases occur at the end of February. The disease can be avoided by selecting early maturing varieties like BARI Masur-1 as well as by adjusting sowing date i.e. by the first week of November in the northern and last week of October in the southern parts of the country.
- Seed treatment with Provax-200 @ 0.25% w/w of dry seed as well as protective foliar spray with Tilt (Propiconazol) 250 EC (0.05%) performed well.
- Integrated Disease Management includes use of healthy seed + tolerant variety + Seed treatment + Tilt spray + wider spacing (40cm).

Major insects and control measures:

Aphid *(Aphis craccivora Koch)*

Aphid is the key pest of lentil in the field condition. It injures lentils mostly by direct feeding. Direct feeding by the insect includes sucking sap from leaves, stems,

blossoms and pods. Plants heavily fed upon are stunted and produce fewer and smaller pods and seeds. Smaller plants may die. Normally10-15% yield may be lost by aphid infestation.


Aphid of Lentil

Control measures:

- To control aphid infestation avoid late sowing, if late, completely avoid mixed crop with mustard. Yellow pan trap can control aphid, which is made by soap dust mixed with water in yellow pan.
- Conserve natural enemies (Lady beetle, syrphid fly etc.) in the crop field by minimum or no use of insecticides for the enhancement of biological control.
- Spraying of detergent (Jet powder @ 5 g/l water) or neem seed extract @ 50 g/l at 5-7 days interval.
- In case of severe infestation, Melathion 57 EC or Dimethoate 40 EC @ 2 ml/l can be sprayed twice at 7 days interval.

Pod Borer (*Helicoverpa armigera* Hubner)

The young larvae feed on the chlorophyll of young leaves and skeletinize it. During the podding stage the larvae bore inside the pod by making hole and then feed on the developing grain.

Control measures:

- Hand picking of young larvae should be killed and removed from the plot.
- Install Bird perches @ 50/ha would be required.
- Spray insecticides like Lambda-Cyhalothrin (Karate 2.5 EC or Reeva 2.5 EC) @ 1 ml/l of water.

1.4 Harvesting and Seed preservation

There are two ways to harvest the crop. One is, when almost all the pods turned brown, the plants may be pulled out and another one is to cut at the ground level with a sickle, then drying in the field or on the threshing floor. When the plants and pods dry then brittle with a stick. Often, cattle or power thresher are allowed to trample on the plants to thresh the pods. Seeds should be cleaned by winnowing, which is generally done by tossing the produce in the air with forks on a windy day.

Seed preservation

Lentil should be properly stored because seed is vulnerable to heavy insect damage. The seeds should be cleaned, dried thoroughly in sun and moisture content should be lowered down to 8-9 %. Then seeds should be cooled and kept either in sealed polythene bags along with naphthalene balls covered by jute bags, tin containers or air tight earthen pots in store rooms. Finally, seed should be stored in dry and above ground place.

2. Mungbean

Mungbean (*Vigna radiata* L. Wilczek) belongs to the family leguminosae. This is one of the important pulse crop in Bangladesh. It contributes only about 11.53% of the total pulse production. It ranks fifth among the pulse crops. It is a crop of the tropics and sub-tropics which requires a warm temperature regime. The optimum temperature ranges from 20°- 35°C depending upon season. It is a rich source of protein and several essential micronutrients. It contains 24.5% protein, and 59.9% carbohydrate. It also contains 75 mg calcium, 8.5 mg iron, and 49 mg B-Carotene per 100 g of split dual. The foliage and stem are also a good source of fodder for livestock as well as a green manure. Like other leguminous crop, the crop can fix atmospheric nitrogen and improves soil fertility and fits well in many cropping system because of its short maturity period. In Bangladesh, mungbean is grown in area of 27.6 thousand hectares with total production of 19.0 thousand tons with an average of 690 kg/ha (BBS, 2011). But the production is extremely insufficient compared to its requirement. To fulfill the demand of the country, the area and production of the crop needs to be expanded. The varieties and their important characteristics are presented below.

2.1 Varieties

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Mung-2 (1987)	This variety was introduced from Philippine (M-7715). **Plant height:** 45-52 cm. Tolerant to YMV and CLS. Photo Insensitive. **Protein:** 22.56%, **CHO:** 46.15%. **Head Dhal yield:** 76.1%. **Cooking Time:** 15 min. **1000-seedweight:** 25.33g. **Seed yield:** 1.1-1.35 t/ha. **Duration:** 65-70 days	
BARI Mung-3 (1996)	This variety was developed from crossing between Sona mung and BARI Mung-2. **Plant height:** 50-55cm. Tolerant to YMV and CLS Photo Insensitive. **Protein:** 20.81%, **CHO:** 49.53%. **Head dhal Yield:** 67.5%. **Cooking Time:** 15 min.**1000-seed weight:** 29.4g. **Seed yield:** 1.0-1.3 t/ha. **Duration:** 60-65 days	
BARI Mung-4 (1996)	This variety was developed from local cross (BMX 841121). **Plant height:** 52-57 cm. Resistant to YMV and CLS. Photo Insensitive. **Protein:** 23.1%, **CHO:** 51.32%. **Head dhal Yield:** 68%. **Cooking Time:** 17 min. **1000-seed weight:** 31.9g. **Seed Yield:** 1.1-1.3t/ha. **Duration:** 60-65 days	

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Mung-5 (1997)	This variety was introduced from AVRDC (NM- 92). **Plant height**: 41-46 cm. Resistant to YMV and CLS. Photo Insensitive. **Protein:** 20.93%, **CHO:** 49.46%. **Head dhal Yield:** 68%. **Cooking Time:** 18 min. Quite Synchrony in maturity. **1000-seed weight:** 41.9g. **Seedyield:** 1.40-1.45 t/ha. **Duration:** 58-60 days	
BARI Mung-6 (2003)	This variety was introduced from AVRDC (NM- 94). Medium plant stature. **Plant height:** 40-45 cm. Resistant to YMV and CLS. Photo Insensitive. Bold seed size with green seed coat. **Protein:** 21.2%; **CHO:** 46.8%. **Head dhal Yield:** 67.2%. **Cooking Time:** 18 min. Synchrony in maturity and late potentiality. Recommended for cultivationin in Jessore, Khulna, Faridpur, Pabna, Rajshahi and Dinajpur. **1000-seed weight:** 40.0g. **Seed yield:** 1.5 –1.6 t/ha. **Duration:** 55-60 days	

2.2 Production Technology

Land and Soil

It may be grown in all types of lands with well drained soils but it prefers medium high land and well drained loamy soil and does not tolerate water logged condition. It prefers slightly in acidic to neutral soil with P^H6.2-7.2.

Seed rate

20 kg for small seeded and 25 kg for bold seeded are required for one hectare of land.

Seed treatment

Seed should be treated before sowing by provex @ 2 g/kg of seed for successful crop production.

Time of sowing

The optimum sowing time for kharif-1 season is last February through mid March and for kharif-II season is first August through last September. But mungbean crop could be grown in late rabi (winter) from mid January through mid February, particularly in the areas of Southern region.

Land preparation

Land should be well prepared by 2-3 times ploughing followed by cross laddering. Land should be well pulverized and free from big clods and weeds.

Sowing method

Seeding could be done both in broadcasting and line sowing method. In case of line sowing, row to row distance is 30 cm and in rows seed to seed distance 8-10 cm.

Fertilizer application

Urea, TSP, MP and Boric acid should be applied @ 44, 100, 40 and 7.5 kg/ha, respectively during final land preparation.

Irrigation

In Kharif-I season, before sowing the soil is to be irrigated to ensure germination. If moisture is needed, water should be supplied during cropping season.

2.3 Intercultural Operation

Weeding should be done at 20-25 days after emergence**.**

Pest Management

Major diseases and control measures:

Out of 20 diseases recorded in Mungbean, 12 are caused by fungi, 2 by nematode, 5 by virus/mycoplasma and 1 by bacterial disease. So far, two diseases *viz.* MYMV, Cercospora leaf spot and powdery mildew are the major ones. Recently, Sclorotina blight is also appearing as a major disease. These are evenly distributed all over the growing zones.

Yellow Mosaic Virus (YMV)

YMV causes irregular yellow and green patches in older leaves and complete yellowing in young leaves of susceptible variety. Affected plants produces fewer flowers and pods. Pods often develop mottling, remain small and contain fewer and smaller seeds. In balckgram two symptom "yellow mottle" and "necrotic mottle" can be distinguished.

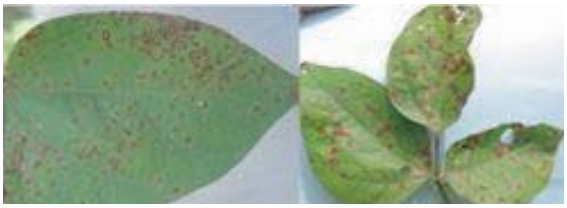
Yellow mosaic virus

Control measures:

- The most economic and sustainable method to control YMV are through use of resistant/tolerant variety (BARI Mung-5 and BARI Mung-6) along with cultural practices includes rouging of virus infected plant and alternate hosts. Adjustment of sowing date is an essential approach in reducing the incidence of YMV through escaping the disease.
- Foliar sprays with Admire 200 SL (Imidachlorpid) @ 0.25 ml/litre, 2 to 3 times 7-10 days interval at the first sign of disease.

Cercospora leaf spot

The disease is recognized by the appearance of leaf spots that are circular to irregular shape with grayish white centers and reddish brown to dark brown margins. The initial symptoms of the disease appear as



Cercospora leaf spot

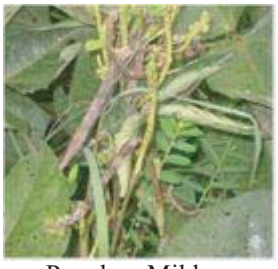
water soaked spots on leaves. As spots become older they turn reddish or brown around the circumference with grey or white ceners. Many spots may coalesce together causing an enlarged dead area on the infected leaves. Heavy infection of cerospora can cause mungbean plant prematurely dry and defoliated.

Control measurers:

- Use of tolerant variety (BARI Mung-6 and BARI Mash-2)
- Crop debris of virus infected plant and alternate hosts weed hosts should also be removed at the time of planting.
- Systemic fungicides Bavistin 70 WP (Carbendazim) at 2g/lis found effective to control the disease.

Powdery Mildew

The disease appears first on leaves as powdery masses, which later turn dirty white. Symptoms appear on pods, stems and branches. Powdery mildew occurs under cool temperature (20-26^{0}C) and is favoured by cloudy weather. It can cause up to 40% yield loss. In the early stage, the disease appears as light yellowish irregular spots on leaves which turn brown quickly. A powder mass grows over the spots covering the entire leaf surface.



Powdery Mildew

Control measurers:

- Planting of resistant/tolerant cultivars (BARI Mung-6 and BARI Mash-2 moderately resistant).
- Mid September sowing is suitable for avoiding the disease.
- Foliar spray (2-3 times) with tilt 250EC (0.1%) or Thiovit 80 WP (0.2%) at 12-15 days interval.

Major insect and control measurers:

Stem fly (*Ophiomyia phaseoli*)

The adult females puncture the leaves with the help of their ovipositors for feeding and oviposition. Soon after hatching the larvae enters the nearest vein, move into the petiole and down to the stems; feed inside it and finally tunnels the main stem even up to roots. The affected plants have stunted growth and poor yield. The stems both the above and below ground level shows cracking, browning and swelling. In cases of heavy infestation, many plants die.

Stemfly in mungbean stem

Control measurers:

- Clean cultivation like timely weeding cum thinning can suppress the pest.
- Intercropping of companion crops like maize, brinjal and groundnut in mungbean reduce 25 to 51% plant infestation over sole crop.

- Seed treatment with carbofuran (Furadan 5G) @ 40g/kg followed by foliar application of Dimethoate @ 2 ml/l at 30 days after sowing is found effective.

Flea Beetles

Two types of flea beetles viz. Crucifer flea beetle and stripped flea beetles attacks mungbean severely. The larvae live in the soil and fed upon the roots of the host plants. The adults feed on the cotyledons and leaves of young plants making innumerable round holes. The older damaged leaves dry up and the plant is rendered with few pods.

Flea beetles

Control measurers:

- Removal and destruction of weeds.
- Spraying should be done with Dimethoate (Tufgor 40 EC) or Carbosulfan (Marshal 20 EC) @ 2ml/litter of water from the 1st incidence of the pest.

Jassid *(Amrascabiguttula)*

Both nymphs and adults of jassids suck plant sap. As a result of their severe attack, the leaves curl, turn pale and become bronze. The leaves ultimately become dry.

Jassid with infested plant

Control measurers

- Conservation of natural enemies.
- In case of heavy infestation, Dimethoate (Tufgor 40 EC.) can be sprayed @ 2ml/l of water.

Whitefly *(Bemisiatabaci)*

Nymphs and adults suck sap from the leaves which lowers vitality of the plants. Sooty mould develops on affected leaves and the affected plants look sick. The growth of crop is stunted when the whitefly attack is severe.

Whitefly

Control measurers:

- Remove and destroy of heavily infested leaves to reduce insect population.
- This pest can be controlled by spraying Dimethoate (Tufgor 40 EC) @ 2 ml/l water.

Hairy caterpillar, *Spilosoma obliqua*

The caterpillars feed voraciously on the green portion of the leaves and make it net like in appearance. The infested leaves dry up. In case of heavy infestation plant may die.

Hairy caterpillar

Control measurers:

- Hand pick the infested leaves with aggregated young larvae and destroy the caterpillars.
- Spray insecticides like Lambda-Cyhalothrin (Karate 2.5 EC/ Reeva 2.5 EC) @ 1 ml/l of water.

Leaf folder


Leaf folder

Larvae fold the leaves and eat the green surface. Infested leaves dry up or even plant may die.

Control measurers

- Remove the folded leaves with larva and destroy.
- Spray Cypermethrin (Ripcord 10 EC) @ 1 ml/l of water.

Hawk moths (*Acherontia spp.*)

The caterpillars feed voraciously on leaves and defoliate the plants causing heavy damage.

Control measurers

- Install bird perches.
- Deep ploughing exposes the pupae for predation to insectivorous birds.
- Hand picking and destruction of caterpillars.
- Spray insecticides like Lambda-Cyhalothrin (Karate 2.5 EC/ Reeva 2.5 EC) @ 1 ml/l of water.

Aphid *(Aphis craccivora Koch)*


Aphid

Aphid injures mungbean mostly by direct feeding. Direct feeding by the insect includes sucking sap from leaves, stems, blossoms and pods. Plants heavily fed upon are stunted and produce no or fewer and smaller pods and seeds. Smaller plants may die.

Control measurers:

- Conserve natural enemies (Lady beetle, Syrphid fly etc.) in the crop field by minimum or no use of insecticides for the enhancement of biological control.
- Spraying of detergent (Jet powder @ 5g/l water) or neem seed extract @ 50g/l at 5-7 days interval.
- In case of severe infestation, Malathion 57 EC or Dimethoate 40 EC @ 2 ml/l can be sprayed twice at 7 days interval.

Thrips *(Megalurothrips distalis)*


Thrips affected

Thrips may attack mungbean in both seedling and flowering stages. In seedling stage it attacks when trifoliate leaves form. It is the major cause of yield loss in mungbean, particularly in the flowering and pod formation stages. Infested flower drops and damaged buds may also be shed before the flowers open. Pod production is low and pods are deformed.

Control measurers:

- Install white sticky trap**.**
- Spray of Imidachloprid (Admire 200 SL/ Imitaf 20 SL) @ 0.5 ml/litre of water at 100% flowering and 100% podding stage.

Pod Borer complex (*Maruca sp. / Helicoverpa sp /* Gram blue, *Euchrysops*)

The young larvae feed on the chlorophyll of young leaves and skeletinize it. During the podding stage, the larvae bore inside the pod by making hole and then feed on the developing grain.

Control measurers:

- Install bird perches @ 50/ha.
- Hand picking of larvae.
- Install pheromone traps at a distance of 10 m apart to kill moth population.
- Sequential release of eggs and larval parasitoids (*Trichogramma* and *Bracon*).
- Spray recommended insecticides at 100% podding stage and seed developing stage can effectively control pod borer.

Bruchids (*Callosobruchus spp.*)

The adult and grub feed on the grain by making a small hole. Infested stored seed can be recognized by the white eggs on the seed surface and the round exit holes with the 'flap' of seed coat.

Control measurers

- Before preservation, seeds should be well dried. Preservation should be done in an air tight container.
- Using 1 phostoxin tablets for every 50 kg seeds in an air tight container can keep the stored seed for about one year without infestation.

2.4 Harvesting and Seed preservation

Crop should be harvested at 55-70 DAE, depending upon growing season and variety. In Kharif-I and Late rabi season pod should be picked after it become blackish in colour. But in kharif-II season plants should be harvested as in lentil/chickpea.

Mungbean should be properly stored because seed is vulnerable to heavy insect damage. The seeds should be cleaned, dried thoroughly in sun and moisture content should be below 8–9 % then seeds should be cooled and kept either in sealed polythene bags along with naphthalene balls covered by jute bags, tin containers or air tight earthen pots in store rooms. Finally, seed should be stored in dry and above the ground place.

3. Chickpea

Chickpea (Gram) is a temperate crop and well adapted to sub-tropical condition. It is highly sensitive to excess moisture, high humidity and cloudy weather which affect its flowering and pod setting. Chickpea is a cool season annual crop and prefers diurnal cycle of cool (17.8°- 21° C) nights and warm (21°- 26.7° C) days. It can not withstand heavy rains and does not grow well in wet regions. They produce good yields in drier condition because of their tap root. High yield and quality seeds are obtained from areas having lighter and well distributed rainfall patterns. However, at present the area of Chickpea is 8,097 hectares with total production of 7000 metric tons (BBS, 2011).

3.1 Varieties

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Chhola-3 (1993)	**Plant type:** Medium erect. **Flower colour:** Pink. **Seed colour:** Brown. BGM tolerant. **Protein content (%):** 25.2. **1000-seed weight:** 180-190g. **Seed yield:** 1.8-1.9 t/ha. **Duration:** 115-125 days	
BARI Chhola-5 (1996)	**Plant type:** Spreading. **Flower colour:** Pink. **Seed colour:** Brown. BGM tolerant. **Protein content (%):** 21. **1000-seed weight:** 110-120g. **Seed yield:** 1.7-1.8 t/ha. **Duration:** 115-125 days.	
BARI Chhola-6 (1996)	**Plant type**: Semi spreading. **Flower colour:** Pink. **Seed colour:** Brown. BGM tolerant. **Protein content (%):** 19.42%. More suitable for late sowing **1000-seed weight:** 160-170g. **Seed yield:** 2.5-2.6 t/ha. **Duration:** 125-130 days.	
BARI Chhola-7 (1998)	**Plant type:** Medium erect. **Flower colour:** Pink. **Seed colour:** Brown. BGM tolerant. **Protein content (%):** 25.2. More suitable for Barind region **1000-seed weight:** 180-190g. **Seed yield:** 1.8-1.9 t/ha. **Duration:** 115-125 days.	
BARI Chhola-9 (2011)	**Plant type:** Erect. **Plant height:** 55-60 cm. **Flower colour:** Pink. **Seed colour:** Brown. BGM tolerant. **Pod per plant:** 55-60. **Protein content (%):** 19.4. **1000-seed weight:** 180-220g. **Seed yield:** 1.9-2.6t/ha. **Duration:** 125-130days	

3.2 Production Technology

Land andsoil

Loam and clay loam soils are suitable for chickpea cultivation. It can be grown on soils having P^Hrange of 6.0-9.0 although it is sensitive to salinity and alkalinity. Chickpea grows in fertile sandy loam and well drained soils.

Seed rate

40-45 kg seeds are required for one hectare of land.

Seed treatment

Seed should be treated before sowing by provex @ 2 g/kg of seed for good harvest.

Time of sowing

In most parts of the country, the optimum sowing time is November 20 to December 07 and for Barind region the optimum sowing time is last week of October to first week of November.

Land preparation

Chickpea does not require fine land preparation but it needs 2-3 ploughings with cross laddering for land preparation.

Sowing method

Seeding could be done in both broadcasting and line sowing method. In case of line sowing, row to row distance is 40-50 cm and in rows seed to seed distance 10-15 cm.

Fertilizer application

Urea, TSP, MP and Boric acid should be applied @ 20, 100, 40 and 7.5 kg/ha, respectively during final land preparation.

Irrigation

Chickpea normally grows in rainfed condition but in Barind region, one irrigation during vegetative stage is effective.

3.3 Intercultural Operation

Weed should be controlled at 30-35 days after emergence.

Pest Management

Diseases of chickpea:

Out of 17 diseases recorded in chickpea, 12 causes by fungi, 3 by virus/mycoplasma and 2 by nematode. So far, three diseases *viz. Botrytis grey Mold,* Collar rot and Fusarium Wilt are the major ones. These are evenly distributed all over the growing zones.

Major diseases and Control measures:

Botrytis Gray Mold (BGM) of chickpea

The fungus survives up to 5 years on the seed if stored at 18^0C. The viability of the fungus on seed is influenced by relative humidity. High relative humidity (95%) with temperature between 20-25^0C for several hours during the day and a dense canopy are the most favourable for infection and rapid spread of the disease. Excessive vegetative growth due to too much irrigation or rain, close spacing and varieties that have a dense canopy favour disease development.

BGM infested plant and seed

Initial symptom ofthe fungus forms grey or brown to light brown lesions on the leaflets, branches, and pods. The infected portion is covered with erect hairy sporophores giving a mouldy appearance. The growing twigs and flowers are particularly susceptible to infection. Lesions on stem are 10-30 mm long and stem are girdled completely. Tender

branches break off at the point where the grey mould has caused rotting. Affected leaves and flowers turn into a rotting mass. Lesions on the pod are water-soaked and irregular. On infected plants, the pods contain either small, shriveled seeds or no seeds. Grayish white mycelium might be seen on the infected seed. The dense canopy of plant leads to excess soil moisture conservation and association with high nitrogenous fertilizer aids disease development quicker and turns the plant grayish.

Control measures:

- Use of BGM tolerant cultivar (BARI Chola-5 and BARI Chola-9).
- Foliar application of a fungicide such as Bavistin 50WP (Carbendazim 50%), Secure 600 WG (Fenamidone + Mancozeb) can also effectively reduce BGM development.
- Seed treatment with Provax-200 @ 0.25% w/w of dry seed gives good protection against BGM disease in Bangladesh.

Foot rot

Foot rots disease caused by *Sclerotium rolfsii* could induce up to 84% yield loss. The disease is favoured by high soil moisture with high temperature (28-30^{0}C). The infected plants turn slightly yellow followed by death and drying. Affected young seedlings may collapse and older seedling may dry without collapsing.


Foot rot disease

The fungus attacks the host at the collar region at soil level and white fungal mycelia are visible with some ckickpea seed like sclerotia at the base of the infected plants adjacent to soil. Infected plants turn slightly yellow followed by death and drying. Affected young seedlings may collapse and older seedlings may dry without collapsing.

Control measures:

- Seed treatment with Provax-200 @ 2.5 g/ka seed.
- BAU Bio-fungicide alone or in combination with BINA bio-fertilizer reduces incidence of the disease.

Fusarium wilt

Initial symptoms prior to wilting were reported as sudden dropping of terminal leaves and twigs, chlorosis of leaflets, dropping of older leaves and overall drying of the plant.


Symtoms of Fusarium wilt

Control measures:

- Use resistant cultivar (deshi-type and wild *Cicer* species).
- Pre-sowing seed dressing with Provex/Bavistin.
- BAU Biofungicide alone or in combination with BINA biofertilizer reduces incidence of the disease.

Major insects and control measures:

Chickpea is damaged by a number of insect pests. The major insect pests of this crop are discussed.

Pod borer (*Helicoverpa armigera* Hubner)

Pod borer

The pod borer, *Helicoverpaarmigera* (Hubner) is a major and serious pest in most of the chickpea growing areas in Bangladesh. On an average of 30 to 40 per cent pods were found to be damaged by pod borer with 400 kg/ha grain loss. In favourable weather condition pod borer may cause 90-95 per cent pod damage. The females lays eggs singly or 2-6 eggs in a cluster at night on the lower surface of the leaves, flowers and pods of chickpea plant. The young caterpillar skeletonizes the leaves, while grown up caterpillar bores into the pods and feed the seeds inside. Larval period varies from 10 to 15 days and variable in colour. The general body colour is brownish or pale green with lateral non broken stripe along each side of the body and one distinct dorsal stripe.

Control measures:

- Sowing of chickpea should be done within November 10 to November 30 and optimum sowing time is November 15 for ensuring higher yield with less pod borer damage.
- Hand picking of larvae.
- Perching (60-70 sticks/ha) can be used for sitting insectivorous birds.
- Sequential release of eggs and larval parasitoids (*Trichogramma* and *Bracon*).
- Intercropping in chickpea with companion crops like coriander, linseed, mustard, wheat and safflower can reduce 45 to 60% pod damage by *H. armigera*.
- Chickpea sown on 15 November and first spraying with *Helicoverpa* Nuclear Polyhedrosis Virus @ 500 LE/ha at 100% podding stage and second spray after 7 days interval with Cypermethrin @ 1 ml/l of water could give the best protection and ensure higher yield.

3.4 Harvesting and Seed Preservation

There are two ways to harvest the crop. One is, when almost all the pods turned brown, the plants may be pulled out and another one is to cut at the ground level with a sickle. Then drying in the field or on the threshing floor. When the plants and pods would dry, then brittle with a stick. Often, cattle or power thresher are allowed to trample on the plants to thresh the pods. Seeds should be cleaned by winnowing, which is generally done by tossing the produce in the air with forks on a windy day.

Seed preservation

Chickpea should be properly stored because seed is vulnerable to heavy insect damage. The seeds should be cleaned, dried thoroughly in sun and moisture content should be lowered down to 8-9 %. Then seeds should be cooled and kept either in sealed polythene bags along with naphthalene balls covered by jute bags, tin containers or air tight earthen pots in storerooms. Finally, seed should be stored in dry and above ground place.

V. VEGETABLE CROPS

Vegetable forms a group of specialized crops. They are important economically and from a health point of view. They fit well in most farming systems as their maturity period from planting to harvest is short. With the ever-increasing human population, vegetables have played an important role in our national economy. Vegetables provide maximum output and more income per unit area of land to small-scale farmers, particularly when compared to cereals. A wide range of vegetables are grown in Bangladesh. The summer vegetables are mostly indigenous whereas most of winter vegetables are of European origin. Production of vegetables in the cool season is hazard free, and blessed with a favourable climate. During summer, vegetable production is affected by flood, cyclones, and other factors associated with high temperature, humidity and rainfall. At present, vegetables are grown in about 4.52 lac hectares of land with total production of 30.8 lac metric tones (BBS, 2011). Vegetable production in Bangladesh is far below requirement. BARI and other organization have developed a good number of HYV of different vegetable crops including improved production technology. If farmers use these technologies then internal requirement will be met up even we can export some vegetables abroad. The most important vegetables are described below.

1. Tomato

Tomato (Solanum lycopersicum) is one of the most important vegetable of Bangladesh. It is a good source of vitamin A and C as it provides antioxidant elements (such as Lycopene) which prevent cancer. At present, it occupies 25 thousand hectares of land and produces about 2.35 lac metric tons with an average yield of 9.39 t/ha (BBS, 2011) which is very low compared to other tomato growing countries. This poor yield could be increased through use of high yielding variety. However, now-a-days farmers of Bangladesh is very much interested to grow high yielding (OP and hybrid) variety for avoiding disease problem and to get early harvest (short duration), good quality fruit along with higher yield. But lacking of good OP/hybrid tomato varieties and improved production technology are the main constraints to increase national average yield.

1.1 Varieties

Bangladesh Agricultural Research Institute (BARI) has so far developed 21 tomato varieties (13 OP and 8 Hybrid) for both winter and summer season. Besides, many exotic and local OP and hybrid varieties are also grown in Bangladesh e.g. Mintoo Super, Mintoo F_1, Bahar, BINA Tomato, Pusa Ruby etc. The main features of the important BARI released winter and summer tomato varieties grown in Bangladesh are given below.

Tomato (Winter)

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Tomato-2 (Ratan) (1986)	High yielder, tolerant to Bacterial wilt (BW). Fruits are round and red in colour. **Optimum planting time:** mid October to mid November. **Average fruit weight:** 85-90g. **Fruit yield:** 85-90 t/ha. **Duration:** 120-130 days.	
BARI Tomato-14 (2007)	Large round fruit with attractive red flesh colour. **Each fruit weight:** 90-95g. Very good shelf life. Tolerant to bacterial wilt. Prolonged harvesting period (45-60 days). Recommended for early and late winter. **Fruit yield:** 85 t/ha. **Duration:** 140-150 days.	
BARI Tomato-15 (2009)	Thick skin and edible flesh having very good shelf life. Attractive red flesh colour. Less seeded fruits. Obovoid fruit shape. **Each fruit weight:** 65-70g. **Fruits per plant:** 30-35. Resistant to TYLCV (Yellow Leaf Curl Virus). TSS more than 4%. **Fruit yield:** 80-85 days. **Duration:** 130-140 days.	
BARI Hybrid Tomato-5 (2008)	Large flattened round fruit with attractive red flesh colour. Very good shelf life. **Average fruit weight:** 95-100g. **Fruit per plant:** 35-40 and **weight:** 3-4 kg. Resistant to bacterial wilt and Yellow Leaf Curl Virus. **Fruit yield:** 95- 100 t/ha. **Duration:** 170-180 days.	
BARI Hybrid Tomato-6 (2008)	Large round fruit with attractive red flesh colour. Very good shelf life. **Individual fruit weight:** 90-95g. Resistant to bacterial wilt and Yellow Leaf Curl Virus. **Fruit yield:** 90-95 t/ha. **Duration:** 170-180 days.	
BARI Hybrid Tomato-7 (2011)	Medium large round fruit with attractive colour. Thick pericarp with high shelf life. Very good shelf life. **Number of fruits per plant:** 40-45. **Average fruit weight:** 70-75g. Tolerance to TYLCV. **Fruit yield:** 90-95 t/ha. **Duration:** 120-130 days.	

Tomato (Summer)

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Hybrid Tomato-3 (2006)	Heat tolerant hybrid tomato variety developed by Horticulture Research Centre (HRC), BARI. **Number of fruits per plant:** 35-40. **Each fruit weight:** 40g. **Fruit yield:** 35-40 t/ha. **Duration:** 90-100 days.	
BARI Hybrid Tomato-4 (2006)	Heat tolerant hybrid tomato variety. **Number of fruits per plant:** 30-35. **Each fruit weight:** 50g. Good shelf life. It can produce economical yield without hormone application. **Fruit yield:** 40-45 t/ha. **Duration:** 100 days.	

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Hybrid Tomato-8 (2011)	Heat tolerant variety. Attractive red coloured fruit with thick flesh. Flattened round fruit shaped. Fruit size bigger than other summer hybrid tomato. **Number of fruit per plant:** 22-25. Raised bed, plolythene shed required protecting the crop from rain. **Average fruit weight:** 60-65g. **Fruit yield:** 35-40 t/ha. **Duration:** 90-100 days.	

1.2 Production Technology (winter tomato)

Climate, land and soil

The optimum temperature required for tomato is 20-25^{0}C for better production. High to medium high land is suitable for tomato cultivation. Tomato may be grown on a wide range of soil from sandy to clay. The optimum soil P^H required for tomato is 6.5-7.0. In acidic soil, liming is required.

Seed rate

200-220 g seed is required for one hectare of land.

Seed treatment

Provax 200 / Thiram 75% dust @ 3g mixed with 1 kg seed should be done and shake well before sowing.

Time of sowing

September- October is the optimum time for seed sowing of winter tomato.

Seed bed preparation

Tomato seedlings are raised in the nursery bed. Seed bed should be 3 m in length and 1 m in breadth. Seed beds are prepared with the mixture of sand, compost and soil. Tomato seeds are sown in the line on a well prepared seed bed and lightly covered with soil.

Transplanting method

After 7-10 days of sowing, the young seedlings are transplanted on the second bed at a distance of 4 cm in both ways. The bed should be irrigated immediately after transplanting. The seedling should be protected from strong sun and heavy rain. Thirty-five days old seedlings should be transplanted in the main field at a spacing of 60 cm × 40 cm (row × plant).

Land preparation

Tomato should be planted in well pulverized field with 4-5 times ploughing sfollowed by laddering. Farmyard manure/compost and recommended dose of chemical fertilizer are incorporated into soil during final ploughing.

Fertilizer dose and application methods

Cowdung: 10t/ha, Urea: 550 kg/ha, TSP: 450 kg/ha, MP: 250 kg/ha, Gypsum: 120 kg/ha, Boron: 2 kg/ha. Half of cowdung, half of TSP and entire amount of gypsum and boron should be applied during land preparation. The remaining half of cowdung and TSP should be applied during pit preparation before a week of planting. The entire urea and MP are to be applied in 3 equal installments of 21, 35 and 50 days after transplanting.

Irrigation

As and when necessary.

1.3 Intercultural Operation

Training of tomato plants with the help of ropes is claimed to have resulted in early ripening, higher yield of better quality fruits and seeds, lesser disease incidence, easier intercultural operation and harvesting. Pruning side shoots and staking have claimed to have higher yield, uniform and large fruit. Stacking with bamboo or dhaincha (Sesbania sps) sticks beside each plant is to be given after transplanting. Prunning of all side suckers except the sucker just below the first flower cluster are to be done. Stacking leads to higher yield of marketable fruits and facilitate management operations such as irrigation, intertillage, pest control and harvesting. Besides, weeding, loosening the soil and earthing up etc. should be done as and when necessary. Mulching should be done after irrigation to ensure aeration.

Pest management

Major diseases and control measures:

Virus

Control measures:

- Virus is the major problem for tomato production so net (60 mesh) protection during seedling stage is necessary.
- Spray with Admire 200 SL/Imitaf 20 SL @ 0.5 ml/litre of water at 7-10 days interval should be applied to control white fly after planting.

Late blight

Control measures:

- Spraying Ridomil gold or Mancozeb 2 g /litre water.
- Remove infested plant.

Early blight

Control measures:

- Spraying Rovral 2 g/litre water at 15 days interval.
- Use resistant variety.

Bacterial wilt

Control measures:

- Use resistant variety.
- The land should be kept clean and well drained.

Major insects and control measures:

Tomato fruit worm

Control measures:

- Sanitation with clean cultivation.
- Sex pheromone based control measure.
- During severe infestation, spraying of Cypermethrin 10 EC @ 1 ml/litre or Fenvalerate 20 EC @ 0.5 ml/litre of water at 15 days interval should be applied.

Common cutworm/Prodenia caterpillar

Control measures:

- Practice IPM (Picking egg mass and Prodenia caterpillar) two times during total cropping period.
- Use of sex pheromone trap.
- Spray Cypermethrin @ 1.5 ml/l or Spinosad (Tracer 45 SC @ 0.5 ml/l of water at 15 days interval.

Leaf miner

Control measures:

- Hand picking of infested leaves.
- Use of yellow trap.
- Apply Neem oil + trix 2-3 times @ 5 ml/l of water at 7-10 days interval.

1.4 Harvesting and Seed preservation

Seed harvesting: Seed fruits are allowed to ripen to maturity on the plant. Only complete coloured and matured seed fruits are harvested. The seed yield of tomato is 145 kg/ha.

Seed preservation: Slice the selected fruits and separate the seeds then keep it 20^0-21^0C temperature and fermented for 24-36 hours. Wash the seeds properly after fermentation. After washing, dry the seeds properly and reduce moisture below 8%. Seeds should be preserved in air tight containers with dry and cool temperature.

Production Technology (summer tomato)

Climate, land and Soil

The most important limiting factor of summer tomato cultivation during rainy-summer season (March-October) is the high rain and high temperature when the

temperature ranges from 25-35^{0}C even as high as 40^{0}C in Bangladesh. On an average 200 mm of rainfall per annum falls on 80% of the land during this period. The rainy-summer season is the most difficult season for cultivation, as it corresponds to a high temperature period and crops are often damaged by heavy rain, high temperature and pest. High to medium land is required for tomato cultivation. Tomato may be grown on a wide range of soil from sandy to clay. The optimum soil P^H of summer tomato should be 6.5-7.0.

Tunnel preparation

Preparation of raised beds and polyethylene tunnel

The raised bed planting is beneficial and commonly adopted in low land tropics and high rainfall areas or for rainy season cropping. Generally, wider beds in loamy and heavy soils while narrower beds in lighter soils are recommended.

Summer tomato production under tunnel

During summer particularly in rainy season transparent poly tunnel is to be built on the raised beds to protect the plants. The raised beds height is to be maintained at 30 cm and width of two beds should be 2.30 cm (including 30 cm wide drainage channel in the middle point) along with a convenient length for each are to be arranged for making one tunnel. In this case tunnel height should be 120 cm on both sides and 180 cm in the middle. Between two tunnels there must be about 75 cm wide drainage channel to facilitate irrigation or drainage of water and for other operations.

Inside the tunnel

The seed rate and other cultural operations, pest managements, and harvesting and Seed preservation are same as winter tomato cultivation.

2. Brinjal

Brinjal belongs to the family Solanaceae and as known under the botanical name *Solanum melongena.* Brinjal is one of the important winter and summer vegetables which is grown extensively in Bangladesh. In Brinjal, a large variation of plant types, fruit colour, shape and size are available. At present, it occupies 46.57 thousand hectares of land and produces about 3.40 lac metric tons (BBS, 2011).

2.1 Varieties

Bangladesh Agricultural Research Institute (BARI) has developed 12 brinjal varieties (8 OP and 4 Hybrid) for winter and summer season which produce seeds under local climatic condition. Some popular local varieties-Singhnath, Islampuri, Khatkhotia, Dohazari etc. are cultivated widely in Bangladesh. The main features of the important BARI released varieties are given below:

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Begun-3 (F1) (Shuktara) (1992)	This is the most popular and attractive brinjal variety. It is a winter vegetable crop. Fruit shape is oblong with shining blackish purple colour, has export potential. **Number of fruits per plant:** 70-80. **Average fruit weight:** 55-65g. **Fruit yield:** 65 t/ha. **Duration:** 150-180 days.	
BARI Begun-4 (Kazla) (1998)	Oblong shaped fruits with shiny blackish purple colour. **Average fruit number per plant:** 70-80. **Single fruit weight:** 55-65g. **Optimum planting time:** Mid August to November. **Fruit yield:** 60-70 t/ha. **Duration:** 140-170 days.	
BARI Begun-8 (2006)	Fruits are long cylindrical and bright shiny purple,. **Numbers of fruits per plant:** 20-25 **Each fruit weight:** 70-80g. Prolific bearer during summer rainy season. Errect plant with purplish light foliage coverage. Resistant to bacterial wilt and heat tolerant. Recommended for round the year. **Fruit yield**: 40-45 t/ha. **Duration:** 180 days	
BARI Begun-10 (2009)	Long cylinderical shaped fruit. Attractive shine deep purple fruits skin colour. Heat tolerant line suitable for growing round the year. **Average each fruit weight:** 100-110g. Moderately resistant to bacterial wilt, aphid, soil nematodes and Jassid. **Fruit yield:** 55 t/ha (winter) and 35 t/ha (summer). **Duration:** 125-130 days.	
BARI Hybrid Begun-3 (2011)	Intermediate growth habit. Long cylindrical deep purple fruits. **Average fruit number per plant:** 60-70 and **Each fruit weight:** 90-110g. Fruit can be harvested in 55-65 days. Suitable for cultivation in rabi season. **Fruit yield:** 65-70 t/ha. **Duration:** 140 -150 days.	

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Hybrid Begun-4 (2011)	Dwarf type plant. **Plant height:** 50 cm. Light green oval shaped fruit. Tolerant to bacterial wilt. **Each fruit weight:** 100-110g. **Average number of fruits per plant:** 30-35. Suitable for cultivation in rabi season. Fruit can be harvested in 55-65 days. **Fruit yield:** 55-60 t/ha. **Duration:** 140 -150 days.	

2.2 Production Technology

Climate, land and soil

Long and warm growing season is desirable for successful brinjal production. Cool night and short summers are unfavorable to its satisfactory growth and development. The optimum temperature for its better growth is 15^0-17^0C. It can be grown on all types of soils from light to heavy soil. Higher yield may be obtained when soil becomes clay loam or silt. It does not grow well on a highly acidic soil. The plants grow well when soil P^H ranges from 5.5 to 6.5.

Seed rate

About 120-150g seed is required for one hectare of land.

Seed treatment

Healthy seedling is the pre-condition of a good crop. To get healthy seedlings, the seeds should be treated before sowing with Provax 200 @ 2.5 g/kg of seed. Then the seeds should be sown densely in a primary seedbed.

Time of sowing

Mid August-September for winter and mid February-March for summer are the optimum times for seed sowing.

Seedbed preparation

Nursery bed is to be made 15-20 cm high with fine prepared soil mixed with 3-4 kg well rotted cow dung/bed ($3m^2$). Usually the soil mixture for the bed should have one part soil, one part sand and one part compost. The standard size of the bed should be 1.0m x 3.0 m chich facilitates watering, weeding, mulching and after care. Make narrow lines of 3-4 cm deep and 4 cm apart and sow the seeds continuously in lines and cover with fine soil and water lightly. Seeds will germinate within 3-4 days. Protect the seedbed from direct sun and rain. The nursery beds should be prepared in the same way as primary beds with an addition of 30g urea, 15g MP and 15g TSP/bed. Nursery bed should be prepared 3-5 days before transplanting of seedlings

from primary bed. After one week of emergence, uproot the seedlings and transplant immediately in the nursery beds at a spacing of 4 cm x 4 cm, and provide light irrigation, protect the seedlings from direct sun and rain. Weeding and irrigation should be given when necessary.

Transplanting method

Thirty to thirty five day old seedlings should be transplanted having 5-6 true leaves. Before uprooting the seedling from seedbed, water the seedbed lightly to minimize root damage. Transplanting in the late afternoon is suggested to allow the seedlings to recover overnight. Under large-scale cultivation, watering by hand and shading are laborious and costly. Thus immediate post-transplanting irrigation is the best method of crop establishment. Missing hill should be filled up with spare seedlings within 10 days after planting.

Land preparation

Land should be deeply ploughed, well pulverized and weed free. After final preparation of land, prepare 70-80 cm wide and 15 cm high bed. In between two beds 40-50 cm wide canal maintained which help in irrigating the crop as well as in draining of water. On the bed, one row should be made and transplant the seedlings on the rows at a spacing of 70-80 cm.

Fertilizer dose and application method

Brinjal being a long duration crop requires a good amount of manures and fertilizers. The land is fertilized with cowdung, Urea, TSP and MP @ 10 ton, 375 kg, 150 kg and 250 kg/ha, respectively. The entire amount of cowdung, TSP and half of MP should be applied during land preparation. The remaining half of MP and entire amount of urea are tobe applied in three equal installments at 20, 40 and 60 days after transplanting.

Irrigation

Irrigation is essential for brinjal cultivation in regions where there is little or no rain during the growing season. Brinjal being a shallow rooted crop needs irrigation at frequent intervals. Irrigation should be given according to local requirements. However, the field should be irrigated every 10-12 days during the winter followed by mulching to facilitate good aeration.

2.3 Intercultural Operation

Shallow hoeing should be done in order to remove the weeds and loose the soil for better aeration to facilitate better root growth.

Pest management

Major insects and control measures:

Brinjal shoot and fruit borer (BSFB) is the most destructive insects of brinjal.

Control measures:

- Sanitation and pheromone trap is effective.
- **S**equential release of Trichogramma @ 1g (25,000) and *Bracon hebetor* @ 1bunker (800-1200) or of spraying Cypermethrin @ 1.5 ml/l or Spinosad @ 0.5 ml/l of water at 15 days interval.
- Spray Tracer @ 0.5 ml/l water is effective to control cut worm or irrigation with kerosene oil (5-7 litres kerosene / ha) or Dursban / Pyriphos 20 EC @ at 5.0 ml / litre of water should be sprayed on the soil around the seedling during evening.

2.4 Harvesting and Seed preservation

Edible purpose: Brinjal can be harvested after 2-3 months of seedling transplanting. Frequent harvest can be done after 5-7 days intervals with sharp knife. The fruit yield may range from 30 to 70 t/ha depending on variety.

Quality Seed production: The fruits are usually hand picked at ripen stage. Seeds should be collected from first or second tier fruits as those have a higher seed weight and germination rate than seeds collected from fruits beyond the second tier.There are two basic methods used for the extraction of brinjal seeds: (i) wet extraction and (ii) dry extraction. The wet extraction is favoured for large scale seed production while the dry extraction is for small scale.

In wet extraction, the harvested fruits are stored for 5-7 days in room temperate until they become soft. This allows the seeds to mature fully. The fruits are crushed or cut into thin slices. These are then softened by soaking till the seeds are separated from the pulp. Since the brinjal fruit pulp is relatively dry, it requires extra water during and after crushing and would be allowed to stand overnight to facilitate seed separation from the flesh.

In dry extraction, the ripen fruits are harvested and dried in the sun until they shrivel. During drying of purple and purple black fruits the skin colour turns to coppery brown. The fruits are then hand beaten to extract the seed. This method is used for small- scale seed extraction.

Seed yield

The variation in seed yield is due to environmental factors, crop management practices and varieties. The average seed yield is 200-300 kg/ha.

3. Cabbage

Cabbage (*Brassica oleraeca* var. *capitata* L.) is one of the most important winter vegetables which is grown extensively in Bangladesh. It is an introduced vegetable crop, but it has adapted itself well and is grown all over the country. In Bangladesh, the total area and production of cabbage is 15.79 hectares of land and 2.07 lac metric tons, respectively (BBS, 2011). It is rich in vitamin A, B and C. It also contains phosphorus, potassium, calcium, sodium and iron.

3.1 Varieties

Most of the varieties under cultivation in Bangladesh are hybrids and are imported from Japan, China and Europe. However, Bangladesh Agricultural Research Institute (BARI) has developed two tropical open-pollinated cabbage varieties which produce seeds under local climatic condition. A brief discussion of BARI developed varieties and their important characteristics are given below:

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Bandha kopi-1 (Provati) (1988)	It is a tropical open-pollinated cabbage variety having ability to produce abundant seeds under local climatic condition. Head is compact and medium size (2.5kg/ha). Head become harvestable after 80 days of transplanting. This variety is recommended for winter season crop. **Head yield:** 50-60 t/ha. **Produces seed locally and seed yield:** 600-700 kg/ha. **Duration:** 110-120 days It is cultivated all over Bangladesh.	
BARI Bandha kopi-2 (Agradut) (1998)	Open-pollinated tropical cabbage variety. Head is compact and flat. It becomes harvestable from 70-80 days from transplanting. Produces seeds locally and seed yield is about 600-650 kg/ha. **Average head weight:** 2.0-2.5 kg. **Head yield:** 65-70 t/ha. **Duration:** 110-120 days. It is also cultivated all over Bangladesh.	

The cabbage varieties are categorized in three groups considering planting time.

Early planting - Topmost, K-K cross, K-Y cross, BARI Bandhakopi-1 (Provati), BARI Bandhakopi- 2 (Agrodut).

Mid-season planting – K-K cross, K-Y cross, Green Express, Topmost.

Late planting- Atlas-70, K-K cross, K-Y cross, Topmost.

3.2 Production Technology

Climate, land and soil

It is a cool season crop which thrives best in a relatively cool moist climate. It can

withstand extreme cold comparatively better than cauliflower. The optimum temperature for its better growth is 15^0-20^0C. It may be grown on all types of soils from light to heavy soil. However; higher yield may be obtained in clay loam or silt soils. It does not grow well on a highly acidic soil but plants grow well within P^H ranging from 5.5 to 6.5.

Seed rate

About 350-400 g seeds is required for one hectare of land. Twenty nursery beds (1 m x 3 m) are required to grow the seedlings for one hectare of land.

Seed treatment

To have healthy seedling, the seeds should be treated before sowing with Provax 200@ 2.5 g/kg of seed. Then the seeds should be sown densely in a primary seedbed.

Time of sowing

For early planting, seeds should be sown in August, for mid-season planting in September and for late planting in November.

Seedbed preparation

The primary seedbed should be well- pulverized and mixed with 3-4 kg well-rotted cowdung/bed ($3m^2$). Make narrow lines of 1-1.5 cm deep and 4 cm apart and sow the seeds continuously in lines and cover with fine soil and water lightly. Seeds are made to germinate within 3-4 days. Protect the seedbed from direct sun and rain. The nursery beds should be prepared in the same way as primary beds with an addition of 30g Urea, 15g MP and 15g TSP/bed. Nursery bed should be prepared 3-5 days before transplanting of seedlings from primary bed. After one week of emergence, uproot the seedlings and transplant immediately in the nursery bed at a spacing of 4 cm x 4 cm, and provide light irrigation, protect the seedlings from direct sun and rain. Weeding and irrigation should be done when necessary.

Land preparation

Land should be deeply ploughed, well pulverized and weed free. After final preparation of land, prepare 1 m wide and 15 cm high raised bed. In between two beds 30 cm wide canals which help in irrigation of crops and drain out of water.

Transplanting method

Thirty to 35 day old seedlings should be transplanted having 5-6 true leaves. Irrigate the seedbed lightly to minimize root damage before uprooting the seedling from seedbed. On the bed, two rows 60 cm apart should be made and transplant the seedlings on the rows at a spacing of 45 cm to 60 cm (depending on the variety). Transplanting in the late afternoon is suggested to allow the seedlings to recover during night. Then immediate post-transplanting irrigation is the best method of crop establishment. Missing hill should be filled up with spare good seedlings within 10 days after planting.

Fertilizer dose and application method

Cabbage being a heavy feeder, responds well to the fertilizer application. BARI recommended 5-10 tons cow-dung/compost, 300-350 kg Urea, 200-250 kg TSP and 250-300 kg MP, 100 kg Gypsum, 4 kg ZnO, 3 kg Sodium molybdate and 10-15 kg Borax per hectare. The entire quantity of cowdung/compost, TSP, Gypsum, ZnO, Sodium molybdate, Borax and half of the MP are to be applied during final land preparation. The entire quantity of urea and the rest of MP should be applied as top dressing in three equal installments. It is recommended that one additional dose of Urea and MP (100 kg/ha each) is applied during bolting stage for seed production.

Irrigation

Irrigation is given according to the crop requirements and climatic condition. A crop after transplanting may need irrigation twice a week and later once a week. Heavy irrigation is avoided at the time of marketable maturity of heads to save the heads from splitting. Adequate moisture supply during flowering and seed development are necessary to obtain high seed yield.

3.3 Intercultural Operation

Shallow hoeing should be done in order to remove the weeds and loose the soil for better aeration to facilitate better root growth.

Pest management

Major insects and control measures:

Diamond back moth

Control measures:

- Removal and destruction of all the remnants, stubbles debris etc after the harvest of crop and plough the fields.
- Application of IPM approach in field (Picking of the egg masses and larvae of diamond back moth and prodenia caterpillar).
- Sequential release of Trichogramma @ 1g (25,000) and Bracon hebetor @ 1bunker (800-1200).
- Spray Cypermethrin @ 1.5 ml/l or Spinosad @ 0.5ml/l of water at 15 days interval.

Butterfly

Control measures:

- Hand picking and mechanical destruction of caterpillars at early stage of attack might reduce population of pest.
- In case of severe infestation spraying with Quinalphos (Kinalux, Debiquine 25 EC @ 1.5 ml/l of water.

Common cutworm/ Prodenia caterpillar

Control measures:

- Practice IPM (Picking of the egg mass and Prodenia caterpillar) two times during total cropping period.
- Use of sex pheromone trap.
- Spray Cypermethrin @ 1.5 ml/l or Spinosad @ 0.5 ml/l of water at 15 days interval.

Aphids

Control measures:

- Hand picking at initial stage.
- Conservation of natural enemies like lady bird beetle and syrphid fly.
- Spray soap water @ 5 g/l of water 2-3 times at 7-10 days interval.
- Apply Neem oil + trix 2-3 times @ 5 ml/l of water at 7-10 days interval.

Major diseases and control measures:

Alternaria leaf spot

Control measures:

- Seed treatment with Provax 200 @ 3 g/kg of seed.
- Foliar spraying with Rubral (2 ml/1 litre of water).

Cercospora Leaf spot

Control measures:

- Seed treatment with Provax 200 @ 3 g/kg of seed.
- Foliar spray of Bavistin or Knowin @ 2 kg/litre of water

3.4 Harvesting and Seed preservation

Cabbage heads become harvestable within 90-120 days of seeding. Heads should be harvested when they attain the full size and compactness depending on the variety. The yield may range from 75 to 100 t/ha. The early varieties give lower yield than mid and late varieties. However, the yield differs with the season, variety and location.

Seed harvest and preservation:

Harvesting can be done when seed pods are brown. Too ripe pods dehisce. Seed should not crash or split when rubbed between the hands. The harvesting may be done in two ways. Generally, the early plants are harvested first, when the pod colour of about 60 to 70 percent of the pods turn brown and the rest of the crop changes to a yellowish brown. After harvesting it is piled up for curing. After 4 to 5 days it is turned up side down and allowed to cure for another four to five days in the same way. It is then threshed with sticks and sifted with hand sifters. After thorough drying of seed in partial sun (up to 7 percent moisture content) it is cleaned and stored.

4. Cauliflower

Cauliflower (*Brassica oleracea* var. botrytis L.) is one of the popular winter vegetables of our country. It is an introduced vegetable from cooler regions, but now-a-days, many of the tropical type varieties are well-adapted and producing good curds as well as seeds under our climatic conditions. At present, the total area and production of cauliflower is 16.56 thousand hectares of land and 1.68 lac metric tons, respectively (BBS, 2011). Cauliflower is rich in minerals like potassium, sodium, calcium, iron, phosphorus and magnesium. It also contains vitamin A and C.

4.1 Varieties

In Bangladesh condition only the Asian/Indian varieties are capable of seed production. Such varieties are marketed by the name of month they mature like Kartika (October-November), Agrahayani (November), Poushali (December) and Maghi (January). These are open-pollinated varieties and are highly heterozygous in respect of all the characters whether vegetative or curd. Bangladesh Agricultural Research Institute (BARI) has developed two tropical open-pollinated cauliflower varieties which produce seeds under local climatic condition. A brief discussion of these developed varieties from BARI and their important characteristics is given below:

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Phul kopi-1 (Rupa) (1998)	An open-pollinated early and mid winter season variety producing white compact curd. **Individual curd weight:** 800g. It is creamy white coloured compact curd. Produce seeds locally. **Seed yield:** 500-600 kg/ha. **Curd yield:** 28-30 t/ha. **Duration:** 65-75 days.	
BARI Phul kopi-2 (2006)	An open-pollinated early and mid winter season variety having yellowish white compact curd. It is an attractive creamy white compact colour. **Individual marketable curd weight**: 800-900g. Abundant seeds produced locally in winter season. **Seed yield:** 500-700 kg/ha. **Curd yield:** 26 t/ha. **Duration:** 60-65 days.	

The cauliflower varieties are categorized in three groups considering planting time:

Early planting – Patnai, Kartika, Agrahyani, Pusa dipali, Early snowball, Tropical 55 days, Tropical 45 days.

Medium planting – Poushali, Snowball X, Snowball Y, Snowball 16, Agrahyani, BARI, Fulcopi-1 (Rupa), BARI, Fulcopi-2.

Late planting – Unique snowball, Maghi Banarashi Poushali Main crop, Rakhushi late.

4.2 Production Technology

Climate, land and soil

The varieties of cauliflower are very much sensitive to temperature and photoperiodic requirements. It is, therefore, essential to select the proper variety to be sown at the proper time. Cauliflower generally requires a cool and moist growing season. It can not withstand too low or too high temperature. High temperatures produce poor quality curds like leafy, fuzzy, looze and yellow coloured ones. It may be grown on a wide range of well-drained soil. However, the early varieties prefer sandy loam, whereas for the late varieties, loam or clay loam is preferred. The optimum P^H for this crop is 5.5 to 6.6.

Seed rate

About 250-300g seeds are required for one hectare of land. Twenty nursery beds (1 m x 3 m) are required to grow the seedlings for one hectare of land.

Seed treatment

To get healthy seedling, the seeds should be treated before sowing with Provax @ 2.5 g/kg of seed. Then the seeds should be sown densely in a primary seedbed.

Time of sowing

For early planting, sowing of seeds should be done by 15th August, for medium planting by 15th September and for late planting by 15th of October.

Seedbed preparation

The primary seedbed should be well pulverized and mixed with 3-4 kg well rotted cowdung/bed (3m^2). Make narrow lines of 1-1.5 cm deep and 4 cm apart and sow the seeds continuously in lines and cover with fine soil and water lightly. Seeds are made to germinate within 3-4 days. Protect the seedbed from direct sun and rain. The nursery beds should be prepared in the same way as primary beds with an addition of 30g urea, 15g MP and 15g TSP/bed. Nursery bed should be prepared 3-5 days before transplanting of seedlings from primary bed. After one week of emergence, uproot the seedlings and transplant immediately in the nursery beds at a spacing of 4 cm x 4 cm, provide light irrigation and protect the seedlings from direct sun and rain. Weeding and irrigation should be given when necessary.

Land preparation

Land should be deeply ploughed, well pulverized and weed free. After final preparation of the land, prepare 1 m wide and 15-20 cm high bed will be done. In between two beds 30 cm wide canals which will help in irrigating the crop as well as in drainage.

Transplanting method

Transplanting age of the seedlings is 30-35 days having 5-6 true leaves. Irrigate the seedbed lightly to minimize root damage before uprooting the seedling from seedbed. On the bed, two rows 60 cm apart should be made and transplant the seedlings on the

rows at a spacing of 45 cm to 60 cm (depending on the variety). Transplanting in the late afternoon is suggested to allow the seedlings to recover during night. Immediate post-transplanting irrigation is the best method of crop establishment. Missing hills should be filled up with spare good seedlings within 10 days after planting**.**

Fertilizer dose and application method

The cauliflower requires heavy manuring as it removes large quantities of major nutrients from the soil. The recommended doses for cauliflower is cowdung: 5-10 tons/ha; urea: 250-300; TSP: 150-200; MP: 200-250; Borax: 10-15 kg/ha and Sodium molybdate: 2 kg/ha, respectively.

The entire amount of compost, TSP, Borax, Sodium molybdate and half of the MP should be applied during final land preparation. The entire urea and rest of the MP are to be applied in three equal installments. It is recommended that one additional dose of urea and MP (100 kg each per hectare) is to be applied during flowering for seed production.

Irrigation

Irrigation is given according to the crop requirements and climatic condition. A crop after transplanting may need irrigation twice a week and later once a week. Adequate moisture supply during flowering and seed development are necessary to obtain high seed yield.

4.3 Intercultural Operation

Shallow hoeing should be done in order to remove the weeds and loose the soil for better aeration to facilitate better root growth.

Pest Management

Major insects and control measures:

Diamond back moth

Control measures:

- Removal and destruction of all the remnants, stubbles debris etc. after the harvest of crop and plough the fields.
- Application of IPM approach in field (Picking of the egg masses and larvae of diamond back moth and prodenia caterpillar).
- Sequential release of Trichogramma @ 1g (25,000) and *Bracon hebetor* @ 1bunker (800-1200).
- Spray Cypermethrin @ 1.5 ml/l of water or Spinosad @ 0.5 ml/l of water at 15 days interval.

Butterfly

Control measures:

- Hand picking and mechanical destruction of caterpillars at early stage of attack would reduce population of pest.
- In case of severe infestation spraying with Quinalphos (Kinalux, Debiquine 25EC @ 1.5 ml/l of water).

Common cutworm/ Prodenia caterpillar

Control measures:

- Practice IPM (Picking of the egg mass and Prodenia caterpillar) two times during total cropping period.
- Use of sex pheromone trap.
- Spray Cypermethrin @ 1.5 ml/lof water or Spinosad (Tracer 45 SC @ 0.5 ml/l of water at 15 days interval.

Aphids

Control measures:

- Hand picking at initial stage.
- Conservation of natural enemies like lady bird beetle and syrphid fly.
- Spray soap water @ 5 g/l of water 2-3 times at 7-10 days interval.
- Apply Neem oil + trix 2-3 times @ 5 ml/l of water at 7-10 days interval.

Major diseases and control measures:

Alternaria leaf spot

Control measures:

- Seed treatment with Provax 200 @ 3g/kg of seed.
- Foliar spraying with Rubral (2 ml/1 litre of water).

Cercospora Leaf spot

Control measures:

- Seed treatment with Provax 200 @ 3 g/kg of seed.
- Foliar spray of Bavistin or Knowin @ 2 kg/litre of water.

4.4 Harvesting and Seed preservation

Cauliflower should be harvested when the curd has attained the proper size, bright colour and compactness. The plant is cut off well below the curd so that the stub thus left protects the curd during transport and marketing. Solid and compact curds of white colour are required for quality cauliflower. The yield may range from 15 to 25 t/ha depending on variety and maturity group. Like cabbage, the early group varieties give lower yield than the mid-and late-group varieties.

Seed harvest and preservation

Harvesting can be done when pods are brown. Too ripe pods dehisce. Seed should not crash or split when rubbed between the hands. The harvesting may be done in two lots. Generally, the early plants are harvested first, when the pod colour of about 60 to 70 percent of the pods turn brown and the rest of the crop changes to a yellowish brown. After harvesting it is piled up for curing. After 4 to 5 days it is turned up side down and allowed to cure for another four to five days in the same way. It is then threshed with sticks and sifted with hand sifters. After thorough drying of seed in partial sun light (up to 7 percent moisture content) than it should be cleaned and stored in cool room or air tight container.

5. Okra

Okra **(*Abelomoschus esculents*)** is one of the most important summer vegetables which is grown extensively in Bangladesh. At present, a total area of 10.35 thousand hectares of land is under okra cultivation which produces about 43.21 thousand metric tons (BBS, 2011). Okra is rich in vitamin A, B, C and different minerals specially iodine. It helps in digestion. Okra can be cooked as fry or curry.

5.1 Varieties

Most of the varieties are under cultivation from local and hybrid. Bangladesh Agricultural Research Institute has released BARI Dherosh-1 in 1996. The variety is grown mostly round the year (Except November–January). Plants are indeterminate; erect having 2-3 branches, fruits are green with 5 marked ridges and 14-18 cm long at edible stage. Each plant produces 24-28 fruits. Fresh edible yield: 14-17 t/ha. This variety is tolerant to Yellow Vein Mosaic Virus, downy and powdery mildew.

There are few more varieties like Pusa A-4 Arka Anamika, Parbhahi Kranti from India which is resistant to YVMV. Hybrids of several seed companies are also available in the market.

5.2 Production Technology

Climate and soil

It is a summer season crops. It requires high and humid condition for growth and development. Okra may be grown in all types of soil. In sandy loam and clay-loam soils are the best for okra cultivation to achieve higher yield. The optimum soil P^H range is between 6.0 and 6.8.

Seed rate

4-5 kg seed is required for one hectare of land.

Seed treatment

The seed should be treated with 3g of Captain or Thiram per kg seed before sowing for having good crop.

Time of sowing

Seed should be sown during (a) mid February-mid March and (b) mid June-July. Soil temperatures between 27-30^o C is required for quick and better seedling emergence. Seeds will not germinate below soil temperatures of 17^{o}C. Seeds should be soaked in clean water for 24 hours before sowing.

Seedbed preparation

Okra seeds should be sown directly in the field.

Seed sowing /planting

The seeds should be sown in 1.0 m wide and 20-25 cm raised bed. In between the two beds keep 30 cm space should be kept for irrigation and drainage. For early crop row to row space 50 cm and plant to plant space 40 cm, but in general 60 cm x 30 cm spacing needs to be maintained. Two to 3 seeds per hill should be sown.

Land preparation

Land should be thoroughly prepared by deep ploughing, harrowing and laddering for okra plantation.

Fertilizer dose and application method

The amount of fertilizers and manures required for this crop is: Cow dung 14 t/ha, Urea 150 kg/ha, TSP 100 kg/ha, MP 150 kg/ha. The entire amount of cow dung, TSP and 2/3rd MP should be applied at the time of final land preparation. The remaining MP is to be applied after 30 days of seed sowing. Urea should be applied in three equal installments at 30, 45 and 60 days after sowing.

Irrigation

First irrigation in case of bed sowing should be given immediately after sowing. Care should be taken not to allow over flow the beds. Subsequently irrigations should be given after every four to five days in the hot season or every 10-14 days in moderate season. Frequency of irrigation should be increased on loose sandy type of soils.

5.3 Intercultural Operation

For successful okra production weeding, thinning and earthing up is the most important intercultural operations. Earthing up in the rows should be done in rainy season.

Pest Management

Major insects and control measures:

Shoot borer

Control measures:

- Hand picking at early stage.
- Bidrin or Dimecron 100 EC @ 1 ml/litre of water or Diazinon 50 EC @ 2 ml/litre of water.

Shoot and fruit borer

Control measures:

- Hand picking at early stage.
- Spraying of Bidrin or Carbicron 100 EC@ 1 ml/litre of water should be applied.

Leaf hopper

Control measures:

- Hand picking at early stage.
- Diazinon or Melathion @ 2 ml/litres of water is to be sprayed.

Aphid

Control measures:

- Hand picking at early stage.
- Melathion @ 2 ml/litre of water should be sprayed.

Major diseases and control measures:

Yellow vein mosaic virus (YVMV)

Control measures:

- Roguing of the infected plants.
- Control white fly, the vector, by spraying Ripcord 50 EC @ 2 ml/litre of water should be applied.

Powdery mildew

Control measures:

- Spraying of Bavistin @ 2 g/litre of water should be applied.

Damping off

Control measures:

- Seed treatment with Thiram @ 3 g/kg of seed should be done before sowing.

5.4 Harvesting and Seed preservation

Crop harvest: Flowering begins from 35 to 40 days after sowing and fruits are ready for harvest four to five days after flowering. Okra pods may be harvested continuously at alternate days. The young fruits can be harvested in the morning. Delay in harvesting may make the fruits fibrous and they loose their tenderness and taste. Okra yield 14-17 t/ha with proper management.

Seed harvest and Preservation: Harvesting can be done when pods are brown. Pods from the middle part of the plants should be selected. After harvesting, pods it should be dried for 7 days to collect seeds. For seed production 100 metre isolation between two varieties should be maintained for varietal purity. The seeds should be dried in partial sun light to reduce moisture content to 7%. With proper management okra seed yield is 1.0-1.5 t/ha.

6. Bitter Gourd

Bitter gourd (*Momordica charantia*) is one of the high value vegetables of Bangladesh. It can be grown all over Bangladesh in both kharif (summer) and rabi (winter) season. Two types of bitter gourd are cultivated in the country. The large fruit is called 'Karala' which is more than 10 cm long. The small fruit (less than 10 cm long) is called 'Ucchaya' which is echo type of bitter gourd. Mature fruits of bitter gourd are used as vegetables, preparation of pickles and stored as a dry vegetable. It has medicinal properties which include laxative, and curing blood diseases, rheumatism, diabetics and asthma. Fruits are easily digestible, and have healing and wormicidal effect on the body. It is a good source of vitamins and minerals. Every 100 gram edible portion of fruits of Karala contains 1.6g protein, 1.6mg iron, 20mg calcium, 70mg phosphorus, 88g vitamin C, 126 micro gm beta carotene and Ucchaya contains 2.1g protein, 2mg iron, 23mg calcium, 38mg phosphorus, 96mg vitamin C, 126 micro gm beta carotene. In Bangladesh, it occupies about 9.23 thousand hectares of land and produces 45.1 thousand metric tons (BBS, 2011).

6.1 Varieties

Vegetable Division of BARI has developed one open pollinated variety of bitter gourd in 2006. This variety was developed through selection process from the local land races. It is well adapted throughout the country. The special features of this variety are stated below:

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Karala-1 (2006)	It is a kharif (summer) season variety. Its special features include dark green and medium sized fruit (18-20cm long), prolific bearer, number of fruits per plant: 30-35, **average fruit weight:** 105g, **fruit flesh:** 1.0-1.2cm thick. It is suitable for export. **Yield:** 22-25t/ha.	 

6.2 Production Technology

Land and soil

The land with well drainage, irrigation facilities and exposure to sufficient sunshine should be selected. The land should not be used in previous year for growing the same crop. Soil containing an abundant supply of organic matter is considered the

most desirable for the cultivation of bitter gourd. Loamy soil with a P^H value of 5.5-6.8 is the best for successful production of bitter gourd.

Seed rate

5-6 kg seeds are required for one hectare of land.

Seed treatment

Seeds are soaked in water for 15-20 hours or in 1% potassium nitrate (KNO_3) solution over night for easy germination. Seeds are treated with Vitavex at the rate of 2 g per kilogram seeds before sowing to avoid seed borne diseases and get vigorous seedlings.

Time of sowing

Seeds could be sown from February-May for regular (large type) size to grow in summer season. The small one (ucchaya type; echo type of bitter gourd) is sown in August to September for winter crop.

Seed bed preparation

Bitter gourd seedlings are produced in poly bag for planting in the field. The size of poly bag is 6 cm x 8 cm. The growth medium for seedling production is prepared by mixing well decomposed compost and soil in a 50:50 ratio. Two seeds are sown in each poly bag.

Transplanting method

Sixteen to 20 days old seedlings are transplanted in the prepared pit. Seedlings are watered immediately after transplanting and continued every afternoon till seedling establishment. Among the two seedlings in any pit, comparatively vigorous one is finally allowed to grow in the field for crop production.

Land preparation

Land is prepared by 4 to 5cm deep and cross ploughing and harrowing followed by laddering.

Bed and pit preparation

Fifteen to 20cm raised and 1.2 m x 9.6 m plots are prepared for bitter gourd production. Pits of 45 x 45 x 40 cm size are prepared with 1.5 m apart in a single row along the bed. Centre of the pits are kept 45 cm apart from the bottom side along the irrigation channel and 75 cm from the top/bottom side of the bed. Sixty centimeterirrigation channel and 30 cm drainage channel are kept alternativelybetween the plots.

Fertilizer dose and application method

Sufficient food supplies are essential for its successful production. The general

recommendation based on soil test proved beneficial in those areas where more specific information is not available.

Manures and fertilizers for bitter gourd are as follows:

Manure/ fertilizer	10 days prior to transplant/pit	At transplant (g/pit)	10-12 DAT* (g/pit)	24-25 DAT (g/pit)	38-40 DAT (g/pit)	54-56 DAT (g/pit)	68-72 DAT (g/pit)
Cow dung/ compost	10-12kg	-	-	-	-	-	-
TSP	40g	-	-	-	-	-	-
MP	35g	-	20	-	-	-	-
Urea	-	10-12	20	20	20	30	20
Gypsum	35g		-	-	-	-	-
Zinc sulphate	3g	-	-	-	-	-	-
Boric acid	3.5g	-	-	-	-	-	-

*Days after transplanting.

Irrigation

Sufficient water is necessary during vegetative, flowering and fruit setting stage of bitter gourd plant. In dry weather, bitter gourd should be irrigated at every 5-6 days interval.

6.3 Intercultural Operation

Mulching should be done to break the crust of the soil after each of the irrigations to provide sufficient aeration to the root zone of the plant.

The field should be kept free from weeds during the crop period. Hand hoeing is recommended for weed control. Early hoeing may be fairly close to the plants and at a shallow depth (5-10 cm). Subsequent hoeing should be relatively shallow and not immediately adjacent to the plants. After the vines cover the trellis hoeing is stopped, but it is necessary during that time to go through the field and pull out the weeds.

Side branches or leaves near the base of the plant up to 10-12 nodes should be removed. These are called parasitic branches or leaves.

Two bee colonies per hectare are required for maximum fruit set. Fruit set of bitter gourd can be increased up to 20-25% by hand pollination as compared to the natural pollination. Hand pollination should be completed within 10:00-10:30AM. Bitter gourd flowers are seen very early in the morning. Stigma remains receptive till 10 hours of anthesis. But maximum stigma receptivity remains at anthesis.

Pest management

Major diseases and control measures:

Major diseases: Powdery mildew and Downy mildew.

Control measures:

- Clean cultivation and applying of Theovit 80 WP @ 2 g per litre of water at an interval of 15 days to control Powdery mildew.
- Clean cultivation and applying of Bivomeal MZ @ 2 g per litre of water at an interval of 12 days to control Downy mildew.

Major insects and control measures:

Major insects: Red pumpkin beetle, Fruit fly, Epilachna beetle and Mite

Control measures:

- Hand picking or spraying Savin @ 2 g per litre of water at an interval of 10 days to control red pumpkin beetle.
- Fruit fly could be successfully controlled by combined application of sex pheromone and mashed sweet gourd poison trap.
- Epilachna beetle is controlled through destruction of infested leaves including beetle and spraying of 5 ml Neem oil plus 5 ml Trix in one litre of water at an interval of 8-10 days. Melathion 57EC @ 2 ml per litre of water at an interval of 10 days is suggested to spray at severe infestation of this beetle.
- Mite could be controlled by spraying Vertimac @ 1.5 ml per litre of water at an interval of 10 days.

6.4 Harvesting and Seed preservation

Harvesting: Bitter gourd fruits are harvested at green edible stage. The edible maturity indices include fruits looking shiny or bright, standard size, but not over matured and within 12-14 days after pollination.

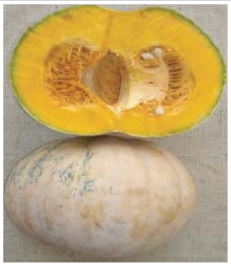
Seed preservation: Moisture content of the seeds should be 7% for safe storage. The well dried seeds are placed in containers and stored in a cool, well ventilated room, preferably provided with some means of dehumidification; and with protection from rats, mice and other pests. Tin-can with moisture resistant polyethylene can be used for this purpose.

7. Pumpkin

Pumpkin or sweet gourd (*Cucurbita moschata* Duch Ex Poir) is one of the most preferred vegetables of Bangladesh. It is grown widely from homestead to commercial field and marketed all over the country. It's tender stem and leaves, flowers, ripe and unripe fruits are used to prepare delicious vegetables. The total area and production of pumpkin in Bangladesh is about 24.8 thousand hectares land and 2.18 lac metric tons, respectively (BBS, 2011). Pumpkin is relatively high in energy and carbohydrates and good source of vitamins and minerals. Every 100 gram edible portion of matured fruits contain 1.4g protein, 100mg calcium, 30mg phosphorus, 50 micro gm beta carotene and 2g vitamin C. Matured fruits help control night blindness and diabetics. The well matured fruits have highest storability among all the cucurbits (4-6 months).

7.1 Varieties

Vegetable Division of BARI has developed two open pollinated varieties of pumpkin in 2007. These varieties were developed through selection process from the local land races. Both the varieties are well adapted throughout the country. They have highest storability among all the vegetables. The special features of these varieties are furnished below:

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Mistikumra-1 (2007)	It is an early winter variety released for consumption at ripe stage. Fruit skin colour brown and fruit shape flat. Its special features include deep orange flesh color, total soluble solid (TSS) 11.5%, uniform flesh thickness, storability of fully mature fruit 5-6 months, tolerant to *Papaya ring spot virus* (PRSV), **average marketable fruit weight:** 4.5-5.0 kg. **Fruit yield:** 32-35 t/ha. **Duration:** 135-160 days.	
BARI Mistikumra-2 (2007)	It is a year round variety released for consumption at both green and ripe stage. Yield of green harvest is 30-40% higher over the ripe stage. Its special features include dark orange flesh colour. Total soluble solid (TSS) 10.5%, storability of green harvested fruit one month and ripe fruit 5-6 months. Fruit skin colour is green with deep brown patches. **Average marketable fruit weight:** 2.4-2.8 kg. Tolerant to *Papaya ring spot virus* (PRSV), powdery mildew and cucumber mosaic virus. **Fruit yield:** 25-30 t/ha. **Duration:** 135-160 days.	

7.2 Production Technology

Land and soil

The land with well drainage, irrigation facilities and having exposure to sufficient sunshine should be selected. The land used in previous year for growing the same

crop should not be used. Soil containing an abundant supply of organic matter is most desirable for culture of pumpkin. Loamy soil with soil P^H value of 5.5-6.8 is best for successful production of pumpkin.

Seed rate

4-5 kg seeds per hectare (20-25g per decimal) are required for direct seeding. On the other hand, 2.5-3.0 kg seeds per hectare are required if seedlings are produced in poly bag in nursery.

Seed treatment

Seeds are soaked in water for 15-20 hours or 1% potassium nitrate (KNO_3) solution overnight for easy germination. Seeds are treated with Vitavex at the rate of 2 g per kilogram seeds before sowing to avoid seed borne diseases and get vigorous seedlings.

Time of sowing

Seeds may be sown from October to December for winter crop and February to May for summer crop. But for seed production November sowing is the best for pumpkin plantation.

Seed bed preparation

Pumpkin seedlings are produced in poly bag for planting in the field. The size of poly bag is 6 cm x 8 cm. The growth medium for seedling production is prepared by mixing well decomposed compost and soil in a 50:50 ratio. Two seeds are sown in each poly bag.

Seedlings are growing in poly bag

Compost: Soil=50:50 in poly bag

Transplanting method

Sixteen to 20 day old seedlings are transplanted in the prepared pit. Seedlings are watered immediately after transplanting and it continues every afternoon till seedling establishment. Two seedlings transplant per pit, vigorous one is finally allowed to grow in the field for crop production.

Land preparation

Land is prepared by 4 to 5 cm deep and cross ploughing and harrowing followed by laddering.

Bed and pit preparation

Fifteen to 20 cm raised and 2.5 m x 8 m sizedplots are prepared. Pits of 45x45x40 cm size are prepared 2 m apart in a single row along the bed. Centre of the pits are kept 50 cm apart from the bottom side along the irrigation channel and 1 m from the

top/bottom side of the bed. Sixty centimeter irrigation channel and 30cm drainage channel are kept alternatively between the plots.

Fertilizer dose and application method

Sufficient food supplies are essential for its successful production. The general recommendation based on soil test proved beneficial in those areas where more specific information is not available.

Manures and fertilizers recommendation for pumpkin are as follows:

Manure/ fertilizer	10 days prior to transplant/pit	At transplant (g/pit)	10-12 DAT* (g/pit)	24-27 DAT (g/pit)	38-42 DAT (g/pit)	54-58 DAT *(g/pit)	68-72 DAT (g/pit)
Cow dung/ compost	10-12kg	-	-	-	-	-	-
TSP	50g	-	-	-	-	-	-
MP	40g	-	20	-	-	-	-
Urea	-	10-12	20	20	25	30	25
Gypsum	40g		-	-	-	-	-
Zinc sulphate	3g	-	-	-	-	-	-
Boric acid	3g	-	-	-	-	-	-

* DAT=Days after transplantation,

Irrigation

Sufficient water is necessary during vegetative, flowering and fruit setting stage of pumpkin plant. In dry weather, pumpkin should be irrigated at every 5-6 days interval. The rainy season sown crop should also be irrigated, if necessary. After the fruit sets and bed covers with trailing vines, irrigation should be given once in every two weeks. When fruits start ripening watering should be reduced. Three weeks before fruit picking irrigation should be stopped.

7.3 Intercultural Operation

Mulching should be done to break the crust of the soil after each irrigations to provide sufficient aeration to the root zone of the plant.

The field should be kept free from weeds until harvesting. Hand hoeing is recommended for weed control. Early hoeing may be fairly close to the plants and at a shallow depth (2-4 inch or 5-10 cm). Subsequent hoeing should be relatively shallow and not immediately adjacent to the plants. After the vines cover the ground hoeing is stopped. But it is necessary during that time to go through the field and pull out the weeds.

Side branches or leaves up to 10-12 nodes should be removed. These are called parasitic branches or leaves.

Earthen plate should be put turning upside down under each fruit of pumpkin to avoid rotting. Two bee colonies per hectare are required for maximum fruit set. Fruit set of pumpkin can be increased up to 30-35% by hand pollination as compared to the natural pollination. Hand pollination should be completed before 9:00 AM. Anthesis, stigma receptivity and pollen dehiscence in pumpkin at early morning and remain receptive till mid of the day. But maximum stigma receptivity remains at anthesis.

Pest management

Major diseases and control measures:

Major diseases: Powdery mildew (PM) and viruses.

Control measures:

- Clean cultivation and application of Theovit 80 WP @ 2 g per litre of water at an interval of 15 days.
- Virus is spreaded out by its vector aphid. Virus can not be controlled by spraying pesticides. Population of vector can be restricted by applying two table spoons soap powder in 10 litres of water and spraying at an interval of 7 day sduring cool season or insecticide of melathion group @ 1.5 ml per litre of water at an interval of 7 days regardless of season.

Major insects and control measures:

Major insects: Red pumpkin beetle, Fruit fly and Mite

Control measures:

- Spraying Savin @ 2 g per litres of water at an interval of 10 days should be done to control Red pumpkin beetle.
- Fruit fly could be successfully controlled by combined application of sex pheromone and mashed sweet gourd poison trap.
- Mite could be controlled by spraying Vertimac @ 2 ml per litres of water at an interval of 10-12 days.

7.4 Harvesting and Seed preservation

Harvesting

Pumpkin fruits are harvested at full maturity stage. The maturity indices of pumpkin fruit include: i) Fruit colour changes to yellow or yellow orange or straw colour; ii) Peduncle becomes straw colour and iii) Vines start drying

Seed preservation

Moisture content of the seeds should be 7% for safe storage. The well dried seeds are placed in containers and stored in a cool, well ventilated room, preferably provided with some means of dehumidification, and with protection from rats, mice and other pests. Tin can with moisture resistant polyethylene can be used for this purpose.

8. Carrot

Carrot belongs to the family Umbelliferae under the botanical name *Dancus carota.* Carrot is one of the important winter season root crops. At present, it occupies about 1.39 thousand hectares of land and produces 15.02 thousand metric tons (BBS, 2011). It is eaten as raw and cooked as curries. Pickles and sweet foods are also made from carrot. It is rich in carotene, Vitamin-A and contains appreciable quantities of thiamin and riboflavin.

8.1 Varieties

Carrot is a native of Europe. Bangladesh has not yet developed any variety. But some popular hybrid varieties introduced from Europe and Asia. Koruda, new koruda, koruda max are very popular variety which are extensively cultivated in Bangladesh. BARI developed some OP advanced line with seed production potentiality.

Seed production of advanced line

Advancedline

8.2 Production Technology

Climate, land and soil

Carrot is a cool season crop. The colour development, growth and development of roots are influenced by temperature. The optimum temperature for its better growth and colour development is 15-25^{0}C. The growth and development of carrot are hampered when the temperature is above 25^{0}C. Carrot grows well in well drained, deep, loose and loamy soil. Looseness of soil is important in the production of good round shaped roots. The yield is also high. The maximum yield is expected at soil P^H 5.5-6.5.

Seed rate

About 5 kg seeds per hectare or 20g seeds per decimal are required for its production.

Seed treatment

Healthy seedling is necessary for a good crop. To get healthy seedlings, the seeds should be treated before sowing with Vitavax 200 @ 2.5 g/kg of seed. Then the seeds should be sown densely in a primary seedbed.

Time of Sowing

Mid September- mid December is the optimum time for carrot seed sowing in this country.

Method of sowing

Carrot is grown from seed. The seeds are sown on ridges or in flat beds about 1.5 cm deep. Seeds are sown in small furrows, mixed with coarse sand or fine soil. The seeds of carrot are to be soaked in water overnight before sowing.

Land preparation

Land should be deeply ploughed, well pulverized and weed free. After final land preparation 60 cm wide and 15 cm high bed should be done. In between two beds 30 cm wide canals for irrigation and drainage is required. The line to line 30 cm and plant to plant 20 cm distance should be maintained.

Fertilizer dose and application method

Carrot is a deep rooted crop. A good amount of manures and fertilizers should be applied for higher yield. The lands are fertilized with cowdung, Urea, TSP, MP and gypsum @ 10 tons, 250 kg, 200kg, 200 kg and 100 kg, respectively per hectare. The entire amount of cowdung, TSP, gypsum and half of MP should be applied during land preparation. The remaining half of MP and entire amount of urea should be applied in three equal installments at 20, 40 and 60 days after sowing.

Irrigation

Carrot needs sufficient moisture in the soil throughout its life cycle. Carrot should be irrigated before any wilting of leaves. The carrot crop should not be irrigated too much. First irrigation requires after sowing of carrot and subsequent irrigation can be started four to six days later after germination. Sprinkler irrigation is found to greatly improve germination.

8.3 Intercultural Operation

Carrot grows slowly at the seedling stage. So, the removal of weed is a must especially at the early stage. The soil should be hoed from time to time to allow proper aeration. After 8-10 days of germination, one healthy seedling should be kept at a distance of 10 cm for its proper development.

Pest Management

Major insects and control measures

Major insects: Aphids, Leaf miner and Cutworm

Control measures:

- Hand picking of infested leaves and yellow sticky trap control aphids and leaf miner.
- To control cutworm, apply neem oil + trix 2-3 times @ 5ml/l of water at 7-10 days interval as foliar spray.

8.4 Harvesting and Seed preservation

Carrot can be harvested after 90 days of sowing. Early harvest can be done after 75 days of sowing. The average root yield of carrot is 20-25 t/ha. Carrot may remain fairly fresh for 3-4 days at ordinary temperature. Carrot can be stored at 12^0 C for a long period without deterioration of its quality.

9. Cucumber

Cucumber (*Cucumis sativus)* is one of the most popular vegetables in Bangladesh. A wide range of variability is seen in farmers' field with low yield potential. There is a bright scope of development of OP/F_1 variety utilizing the existing variability. Olericulture Division, HRC, BARI collected and evaluated a large number of germplasm including local and exotic (OP and F_1) for the last few years.There is no released variety of cucumber but research is going on at BARI. Some promising lines have been developed. Most of the varieties under cultivation in Bangladesh are OP and hybrids from different seed companies and some are imported from Japan, India, China, Thailand etc. BADC is producing seeds of two local cultivars namely Baromashi and Patia Giant. However, the total area and production of cucumber in Bangladesh is about 7.71 thousand hectares of land and 48.45 thousand metric tons, respectively (BBS, 2011).

9.1 Varieties

Some commercial cucumber varieties available in the market from local and exotic sources are Alavi F_1, Green King F_1, Ever Green F_1Shila, Shital, Beer Shrestha. Sufala, Devy F_1, Dynasty F_1, Heera F_1 etc. BARI has developed some promising lines which are yet to be released.

CS 0079 CS 0080
Promising lines

9.2 Production Technology

Land and Soil

High to medium high land is required for cucumber cultivation. Silty-loam and clay-loam soil with a P^H 6.5 or slightly above containing sufficient organic matter are the most suitable for production of cucumber. It can also be grown in sandy or sandy-loam soil.

Seed rate

2.5 to 3.5 kg seed is required for one hectare of land.

Seed treatment

Seed treatment with Provax or Captan 2 g for 1 kg seed.

Time of sowing

February to March is the optimum time for seed sowing.

Land preparation

Twenty cm raised and 1 m width beds are to be prepared depending upon the land size. Pits of 40 x 40 x 30 cm size are to be prepared depending upon the land size.

Pits are to be prepared 1 m apart for fresh fruit production and 1.5 m apart for seed production in a single line along the bed. The top of the pit is to be kept little bit above the bed level. Centre of pits are to be kept 40 cm apart from the bottom side along the irrigation/drainage channel and 50 cm and 75 cm from the top bottom side of the bed for fresh and seed production, respectively. Between beds 50 cm wide space is kept for irrigation and 30 cm for drainage alternately.

Sowing method

Seeds are to be sown in the polybag/plastic pots. After that 17 to 20 day sold seedlings should be planted in the pit.

Fertilizer dose and application method

Recommended fertilizer dose and methods of application are given below:

Manure/ fertilizer	10 days prior to transplant/pit	At transplant (g/pit)	10-12 DAT* (g/pit)	24-27 DAT (g/pit)	38-42 DAT (g/pit)	54-58 DAT *(g/pit)	68-72 DAT (g/pit)
Cow dung/ compost	10-12kg	-	-	-	-	-	-
TSP	50g	-	-	-	-	-	-
MP	40g	-	20	-	-	-	-
Urea	-	10-12	20	20	25	30	25
Gypsum	40g		-	-	-	-	-
Zinc sulphate	3g	-	-	-	-	-	-
Boric acid	3g	-	-	-	-	-	-

* DAT= Days after transplanting

Irrigation

As and when necessary

9.3 Intercultural Operation

Supporting: Support is necessary for fresh fruit production. For this, net–wire or thin rope of jute and bamboo may be used as trellis or macha.
Weed Control: As and when necessary

Pest Management

Major insects and control measures:

Red pumpkin beetle

Control measures:

- Cover seedlings with mosquito net for 30-35 days.
- Killing of adults by catching with hand or sweeping net.
- Spray Nitro 50 EC or Quinalfos @ 1.5 ml/l of water in case of severe infestation.

Cucurbit fruit fly

Control measures:

- Use of bait traps with synthetic pheromone and MSG (Mashed Sweet Gourd).
- Clean cultivation.
- Bagging of fruits just after fruit set for 10-15 days.

Mite

Control measures:

- Spraying with Neoron/Tork
- Spray Omyties etc. @ 1 ml/litre water at 15 days interval till control.
- Spraying of Neem oil @ 5 ml/l of water + 5 ml trix at 7 days interval.

Leaf miner

Control measures:

- Hand picking of infested leaves.
- Use of yellow sticky trap.
- Spraying of Neem oil @ 5 ml/L of water + 5 ml trix at 7-10 days interval.

Epilachna beetle

Control measures:

- Collection and destruction of eggs mass, larvae, pupae and adults at the initial stage of infestation is the best and very effective means for the management of epilachna beetle.
- Red bug and pentatomid bug are the predators of the larvae of epilachna beetle. Although their predatory rate is not very good but if they can be conserved would be helpful to kill the larvae of epilachna beetle.
- Spray with Neem oil 5 ml + 5 ml trix @ per litres of water at 7 days interval.
- If less than 20% leaves of the infested plants are damaged, no insecticidal spray is necessary. In case of severe infestation, Diazinon 60 EC or Sumithion or Folithion 50 EC or Melathion 57 EC @ 2 ml/litres water could be sprayed 2 times at an interval of 10 days.

Major diseases and control measures:

Powdery mildew

Control measures:

- Crop rotation and clean cultivation.
- Spray Thiovit @ 2 g/litre water at an interval of 7 days till control.

Downy mildew

Control measures:

- Seed treatment with Provax 200 @ 2 g/kg seed.
- Crop rotation and clean cultivation.
- Spray Ridomil @ 2 g/litre water at an interval of 7 days till control.

Anthracnose

Control measures:

- Seed treatment with Provax 200 @ 2 g/kg seed.
- Crop rotation and clean cultivation.
- Spraying with Tilt @ 2 g/litre water at an interval of 7 days.

Mosaic virus

Control measures:

- Infected plants should be removed and destroyed.
- Use of disease free seed.
- Spray Marathion @ 2 ml and Chess @ 1 ml/litre water for aphid control at 7 days interval and 15 days interval respectively.

Fruit rot

Control measures:

- Soil application with Tricho-compost @ 2.5 t/ha.

Fusarium wilt

Control measures:

- Grafting 12 days seedlings with 15 days Bottle gourd or Pumpkin seedlings.
- Can be controlled raising soil temperature up to 32-33^{o} C using plastic mulch.
- Can be checked to some extent by dranching with Captan @ 2 g/litre water.
- Seed treatment with Vitavax 200 @ 2 g/1 kg seed or Use of resistant varieties.

Root knot nematode

Control measures:

- Soil management with poultry liter @ 5 t/ha, mustard oilcake @ 600 kg/ha, Trico-compost @ 2.5 t/ha.
- Use of grafted seedlings

9.4 Harvesting and Seed preservation

Any malformed or deformed fruits should be removed earlier and only healthy fruits are selected for seeds. The fruits are allowed to ripen fully. The factors to judge full maturity in cucumber as follows:

- Yellow or brown or brownish –yellow or resetting skin colour of fruit.
- Carpel separation in transverse section of fruit.
- Fruit stalk adjacent to the fruit withers.
- Mature seeds separate easily from the interior flesh.

After full maturity fruits are harvested and allowed to keep 5-7 days for post-harvest maturity in a shade dry place under ordinary condition. Moisture content of the seeds should be 7% for safe storage. The well dried seeds are kept in containers and stored in a cool, well ventilated place.

VI. FRUIT CROPS

Among all kinds of food in the plant kingdom fruit is perhaps the most original one that the people of pre-historic ages depended almost entirely on it. Fruits are the most delicious natural or uncooked food. It is only the fruits whose food value has not been impaired by cooking before they reach the stomachs. Fruits have the least possibility of being contaminated or adulterated naturally which can be eaten almost anywhere, in any form and by anybody without being hesitant about their purity or cleanliness. Fruits are not only ready-made delicious food but they are also valued for their vitamins and mineral contents. Many fruits are extra-ordinary source of vitamin C and A. In addition, some fruits contain vitamin B, iron and some has high caloric value. Many fruits have high energy values too and so on. However, BARI has developed a good number of high yielding varieties of different fruits along with improved production technologies. Among them, the most important fruit crops in Bangladesh are described below.

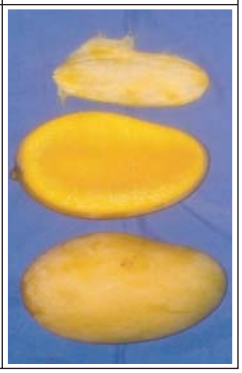
1. Mango

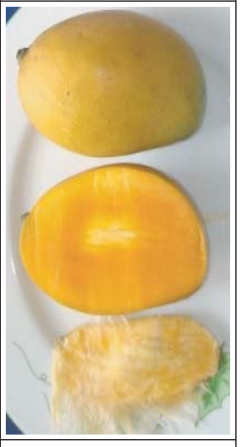
Mango is the most popular and tasty fruit in Bangladesh. It is called the king of fruits. It is a national tree of Bangladesh. Mango is cultivated in almost all districts of Bangladesh. But a good quality and high value mango is grown well in the districts of north-western and south-western region because of soil and weather condition. It is a main source of income of many people of those areas. But now-a-days, mango is cultivated commercially in all districts of Bangladesh in addition to those mentioned areas due to introduction of high yielding mango varieties. At present, the total area and production of mango is 27.5 thousand hectares and 8.89 lac metric tons, respectively (BBS, 2011). Different kinds of taste, scent, nutrient value and uses of mango are not comparable to any other fruits. Ripened mango contains adequate quantity of carotene or vitamin A and minerals. It ranks top of the list among all fruits of the world in respect of vitamin A content.

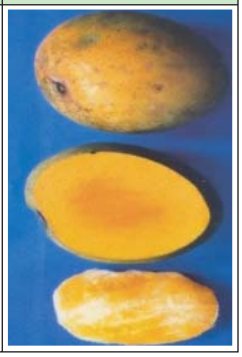
1.1 Varieties

BARI developed 10 (ten) mango varieties and their important features are given below:

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Aam-1 (1996)	High yielding, early and regular bearer variety. Plants are big tree, dome shaped, spreading and moderately vigorous. It flowers in mid-January; fruits are set in mid-February and harvested in late May. **Fruits are medium, individual fruit weight:** 200g, round shaped and coloured. The average length, breadth and thickness of fruit are 7.6, 6.7 and 5.9 cm respectively. **Flesh colour orange, texture firm, abundantly juicy; edible portion:** 71%. TSS 20%; fibre absent. **The number of fruits in each plant:** 1000-1100. Taste of fruit is excellent having good keeping quality. Tolerant to common insect pests and diseases of mango. The variety possesses export potentiality and country wide adaptability. **Fruit yield:** 20-22 t/ha.	

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Aam-2 (1996)	High yielding mid-season, regular bearing, coloured variety. Plants are medium sized tree, dome shaped, spreading and moderately vigorous. It flowers in mid to late January; fruits are set in mid-February and harvested in late June. **Fruits are medium and each fruit weight:** 250g and oblong in shape. The average length, breadth and thickness of fruit are 9.75, 7.25 and 6.10 cm respectively. Pulp is yellow in colour, medium juicy and medium sweet (17.5% TSS); **edible portion:** 69%. Fibre absent. Tolerant to common insect pests and diseases of mango. The variety possesses export potentiality and country wide adaptability. **Fruit yield:** 20-26 t/ha.	
BARI Aam-3 (1996)	High yielding, late and regular bearer exotic variety. Plants are medium, dome shaped, spreading and moderately vigorous. It flowers in mid to late January; fruits are set in mid-February and harvested in late June to early July. Fruits are big (600g) and **individual fruit weight:** 215g, ovate-oblong in shape. The average length, breadth and thickness of fruit is 8.3 cm, 6.0 cm and 5.8 cm, respectively. Pulp is soft, deep yellow in colour, fibreless, very juicy, pleasant flavour and very sweet (23.4% TSS). Tolerant to common insect pests and diseases of mango. **Edible portion:** 71% and country wide adaptability. **Fruit yield:** 18-22 t/ha.	
BARI Aam-4 (Hybrid) (2002)	High yielding, regular bearing and late hybrid variety (Ashwina x M-3896) of mango. Plants are medium sized tree, dome shaped, spreading and moderately vigorous. It flowers in mid to late January; fruits are set in mid-February and harvested in late July to early August. Fruits are big and each **fruit weight:** 600g; round shaped and greenish yellow in colour. Pulp is soft in texture, yellow in colour, medium juicy, fibreless and very sweet (24.5% TSS) having pleasant flavour. **Edible portion:** 80%. Tolerant to common insect pests and diseases of mango. The variety possesses country wide adaptability. **Fruit yield:** 15-16 t/ha.	
BARI Aam-5 (2009)	High yielding, regular bearing and early season variety. Plants are big tree, dome shaped, spreading and moderately vigorous. It flowers in mid-January; fruits are set in mid February and harvested in late May. **Fruits are medium and its weight**: 230g, elliptic in shape and bright yellow in colour. Pulp is firm, medium juicy, fibreless, and sweet (19.0% TSS) having pleasant flavour. **Edible portion:** 70%. Tolerant to common insect pests and diseases of mango. This variety is mainly suitable for south-western region. It possesses export potentiality. **Fruit yield:** 15-20 t/ha.	

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Aam-6 (2009)	This variety was identified by BARI through "National Mango Show 1993". Locally this variety is known as "Bou Bhulani". High yielding, mid-season, regular bearing variety. Plants are medium sized tree, dome shaped, spreading and moderately vigorous. It flowers in mid January; fruits are set in mid-February and harvested in the last week of June. **Fruits are medium and each fruit weight:** 280g, elliptic in shape and yellowish green in colour. The average length, breadth and thickness of fruit are 9.9, 9.5 and 11.3 cm respectively. Pulp is soft, medium juicy, fibreless, yellow in colour and sweet (21% TSS). **Edible portion:** 71%. Tolerant to common insect pests and diseases of mango. Good storage ability. This variety is mainly suitable for north-western region. **Fruit yield:** 8-10 t/ha.	
BARI Aam-7 (2009)	High yielding, mid to late season, regular bearing coloured variety. Plants are big trees, dome shaped, spreading and moderately vigorous. It flowers in mid to late January; fruits are set in mid-February and harvested in late June. The average length, breadth and thickness of fruits are 9.5, 8.1 and 6.2 cm, respectively. **Fruits are medium and individual fruit weight:** 285g, roundish in shape having attractive yellow skin colour with red tinge. Pulp is soft, medium juicy, fibreless, yellow in colour and medium sweet (18.0% TSS). Tolerant to common insect pests and diseases of mango. **Edible portion:** 77%. **Fruit yield:** 18-20 t/ha.	
BARI Aam-8 (2009)	High yielding, late season, regular bearing, poly-embryonic variety. Plants are medium sized tree, dome shaped, spreading and moderately vigorous. It flowers in mid to late January; fruits are set in mid-February and harvested in early July. **Fruits are medium and each fruit weight:** 270 g. Number of fruits per tree: 500-600 and their weight: 135-162 kg in different locations; oblong in shape and bright yellow in colour at ripen stage. The average length, breadth and thickness of fruit are 11.3 cm, 7.0 cm and 6.0 cm, respectively. Pulp is soft, juicy, fibreless, bright yellow in colour and very sweet (22% TSS). **Edible portion:** 70%. Tolerant to common insect pests and diseases of mango. Good storage ability. Adaptable in all areas of Bangladesh. Four to five true to type saplings can be obtained from one stone. **Fruit yield:** 13.5-16.2 t/ha in 8 years old trees.	
BARI Aam-9 (2011)	Moderately high yielding, regular bearer and early Kanchamitha (sweet in green stage) variety. Plants are big trees, dome shaped, spreading and vigorous. Flowering time is mid-January and harvesting time of fruit at green stage is early May. **Fruits are small sized and its weight:** 166g, elipsoid in shape and green in colour at edible unripe stage. Fruits are sweet in green stage (kancha mitha). **Seeds are small, edible portion:** 68% and medium sweet (TSS 11%) at green edible stage. It is suitable for north-western region particularly in greater Rajshahi. **Fruit yield:** 1.35 t/ha. in three years old tree.	

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Aam-10 (2012)	High yielding, early and regular bearer. Plants are big trees, dome shaped, spreading and moderately vigorous. It flowers in mid to late January; fruits are set in mid February and harvested in first fortnight of June. **Fruits are medium and individual fruit weight:** 200g. **Number of fruits per tree:** 800-1000 and **their weight:** 160-200 kg; roundish in shape and yellowish green in colour and sweet (TSS 18.0%). **Edible portion:** 65%. Tolerant to common insect pests and diseases of mango. It is recommended for cultivation in high rain prone areas of north-eastern and eastern region. **Fruit yield:** 15-20 t/ha.	

1.2 Production Technology

Land and soil

High and medium high land should be selected for planting mango trees. In hilly areas, the hill slopes should be below 45^0. Mango can be grown almost in all kinds of soil, but the most desirable soil is one which is of medium texture, that is deep and well drained and has a pH range of 5.5 to 7.5 and a water table below 180 cm round the year.

Time of transplanting

May to mid-July is the best period for transplanting mango sapling. If irrigation facilities are available and planting materials are in hand, transplanting in spring and early summer from March to April may be suitable.

Sapling collection

For planting, mango sapling should be the graft of an ideal variety. The graft should be healthy, strong and disease free. The grafts should be collected from a reliable nursery or from Government farm.

Transplanting method

Spacing: The planting distance varies with variety, fertility level of the soil and general growing conditions in the area. If the growth is vigorous, the distance should be 12m x 12m, but where the growth is less, it can be reduced to about 10m x 10m. For dwarf variety (like BARI Aam-3) 8m x 8m distance is sufficient.

Pit preparation: The pit should be of at least 1m x 1m x 1m in size. The pit should remain exposed for 10 to 15 days before it is filled with soil, manure and fertilizer. The pit needs to be filled with 20kg well rotten cowdung or compost, 500g TSP, 250g MP, 250g gypsum and 50g zinc sulphate. The soil of the pit needs to be watered if the soil is dry during pit filling.

Transplanting: Transplanting of healthy, strong and disease free mango sampling has to be done at 10 to 15 days after the pit filling with soil-fertilizer mixture. The sapling with its root ball of earth should be taken out of the soil, poly-bag or pot intact. The sapling is

then placed in the centre of the pit excavating as much soil as necessary to accommodate the root ball. After planting, the soil around the plant is firmly pressed and irrigated immediately after planting. A stake must be pegged at one side, and sapling is then tied to the stake with rope keeping some distance between stake and sapling.

Fertilizer dose and application method

The nutritional requirements vary with the region depending upon the type of soil and age of the tree. The year to year dosage of fertilizer is given below:

Manure and Fertilizers	Age of plant, (years)					
	2 - 4	5 - 7	8 - 10	11 - 15	16 - 20	> 20
Cowdung or compost (kg)	10 - 15	16 - 20	21 - 25	26 - 30	31 - 40	41 - 50
Urea (g)	250	500	750	1000	1500	2000
TSP (g)	250	250	500	500	750	1000
MP (g)	100	200	250	350	450	500
Gypsum (g)	100	200	250	350	400	500
Zinc sulfate (g)	10	10	15	15	20	25
Boric acid (g)	20	20	30	30	40	50

Fertilizers are to be applied in two split doses, one half immediately after harvesting of the fruits in June-July and the other half in September-October at the end of rainy season. The manure and fertilizer should be duly placed into the ground in trenches that may be 30 cm wide, 15-20 cm deep and 30 cm away from the base of a one year old plant. In this manner, the circular trench/canal around the tree may have to make 2-3 m away from the trunk in 10-12 years and 4 m away in about 30 years old trees. The manure and fertilizer should be applied evenly in the circular canal/trench which is then back filled in with soil.

The manure and fertilizer may also be applied by spading or ploughing the soil around the plant up to the area shaded by the plant at noon. The manure and fertilizers should be spread all over but 1 m away from the trunk and then mixed with soil by spading or ploughing up to a depth of 15 cm. There must be an irrigation of the soil after each application of fertilizer whether the same is spread over the surface or in the trenches.

Irrigation

Number and frequency of irrigations depend upon the type of soil, climatic conditions especially rainfall and its distribution and age of trees. The need for irrigation arises higher during drier part of the year from November to April and lesser in summer (May-June). The clay or heavier soils needs to be irrigated less frequently than the lighter soils (e.g. sandy loam). Depending on all these factors, plants up to the age of six months may need to be irrigated at an interval of 2-6 days, plants between 6 and 18 months may be irrigated after every 4-12 days, and those aged 1.5-5.0 years may need irrigation at an interval of 1-3 weeks. When the trees are in full bearing stage, generally two irrigations are needed in modified basin method-one at full bloom and another at pea stage of fruit. This is helpful in reducing fruit drop and improving fruit size. In modified basin method dike should be constructed around each tree to prevent water run-off during irrigation.

Irrigation may be applied in hole system also. In this system, dig four 20 cm deep and 15 cm wide holes 1.5 to 2 m away from the trunk and fill the holes first to capacity with water. After filling the last few holes, water poured earlier will be dried and the holes should be filled again. Beside these methods, orchard may be irrigated through flooding. However, for obtaining good flowering one must stop irrigation at least 2-3 months before the flowering period. Irrigation during this period is likely to promote vegetative growth, which will be detrimental to flowering.

1.3 Intercultural Operation

Ploughing: The orchard should be ploughed two times in a year-first operation should be done before the onset of rainy season. This helps checking run-off losses and facilitate maximum intake of water into the soil, and suppressing weed. Orchards may be ploughed again after the rainy season is over so as to suppress the weed growth and also to break capillaries.

Training and Pruning: Normally mango trees require very less or no pruning. However, the training of the plants in the initial stages (2-3 years) is very essential to give them a proper shape. At least 100 cm of the main trunk should be kept free from branching. Moreover, it is advisable to keep a watch on the development of shoots from the rootstock. Such a shoot or growth leads to a branch that bears the characteristics of the rootstock which is of seedling origin and is not desirable. This kind of shoot must be eliminated soon after its detection.

Removal of panicle: The grafted plants of mango often produce some flowers in the same year of planting or before attaining sufficient vegetative growth. These flowers should be pinched off for the first 3 years to provide proper vegetative growth as well as for developing a good framework of the plant.

Pest Management

Major insects and control measures:

Name of insect	Control measures	
	Name of pesticides /treatment	Rate per litre of water
Mango hopper	Cypermethrin (Cymbush/Basathrin /Fenom) 10 EC or Sumicidin 20 EC or Decis 2.5 EC	1.5 ml/l At panicle emergence (4-6") and at fruit set (pea) stage
Mango fruit fly	Or Bait trap	1 g Dipterex 80sp or Secufon 80 SP + 100 g mashed ripe mango pulp + 100 ml water (1 trap per tree)
	Or Decis 2.5 EC	1 m l/1
	Or Methyl eugenol sex pheromone trap	1 trap per tree
Mango fruit weevil	Fenitrothion (Sumithion /Lithion/Fenitox) 50 EC	2 m l/l
Mango defoliator	Dichlorovos (Vapona /Phosvit) 100 EC	2.5 ml/l
Mango leaf cutting weevil	Cypermethrin (Ripcord/Cymbush/ Basathrin /Fenom) 10 EC	1.5 ml/l

Major diseases and control measures:

Name of disease	Control measures	
	Name of pesticide /treatment	Rate per litre of water
Anthracnose	Indofil M-45	2 g/l . At panicle emergence (4-6") and at fruit set (pea) stage
	Or Tilt 250 EC	0.5 ml/l. At panicle emergence (4-6") and at fruit set (pea) stage
Die-back	Indofil M-45	2 g/1
	Or Bordeaux mixture (copper sulphate + lime)	1%
Powdery mildew	Thiovit or Wettable sulfur	2 g/1
	Or Tilt 250 EC	0.5 ml/l
	Or Bavistin	1 g/l . 2-3 spray-first one before flower opening and other two after fruit set
Sooty mould	Thiovit	2g/1
Red rust	Bordeaux mixture	1%
	Or Copper oxychloride	3 g/1
	Or Cupravit	1 g/1
Stem end rot/post harvest anthracnose	Indofil M-45	2 g/l
	Or Hot water treatment	Soaking of freshly harvested fruit in hot water (55^0C) for 5 minutes

1.4 Harvesting and Fruit preservation

The various criteria recommended for judging maturity are (i) slight colour development on the shoulders, (ii) when one or two ripe fruits fall from the plant naturally, and (iii) when the specific gravity of fruits ranges between 1.01 and 1.02. This method is more dependable. For this, fruit samples from various parts of the tree are taken and dropped in a bucket of water; if the fruits are mature they will submerge completely in the water. Number of days taken by the fruit to mature depends on the variety and the climatic conditions and, hence it cannot serve as a guide. However, in general, fruits mature between 90 to 130 days from the fruit-set stage.

Fruits should not be picked by shaking the branches and making them fall on the ground. There should be neither a bruise on the skin nor a shattering of the fruit. If possible, the fruits should be picked by hand. For most trees, therefore, a bamboo pole harvester has to be used. This harvester has an iron blade at its edge and a net-bag below it. When the fruit-stalk is snapped by the blade, the fruit fall into the bag. Harvested fruits are heaped under the tree on rice straw or on mango leaves for a while.

The harvested fruits should first be graded according to size and appearance before marketing and storage. Ripe fruits and damaged fruits of relatively poor quality are usually retained for local markets and better types which are still remaining green and hard are packed for distance places. Fruits of each grade are to be packed separately in a container that should indicate at its top the variety, size, number of fruits and consignee's address. Bamboo baskets are of common use in Bangladesh. Rice straw is a very suitable material for placing around the fruits inside the basket. In recent days, plastic crates are becoming popular for transporting mango.

2. Guava

Guava is a very popular fruit with enrichment of vitamin C. This crop is grown more or less everywhere in Bangladesh. At present, Guava is commercially cultivated in most of the regions of Bangladesh after developing high yielding guava varieties. Presently, its area and production, respectively is 4.88 thousand hectares and 2.71 lac metric tons in Bangladesh (BBS, 2011). Guava is, often called as Apple particularly in the region of Sub-tropical countries for its many roles. Fresh, green guava is eaten by the people. Besides this Jam, Jelly and juice are made from guava through different processing.

2.1 Varieties

BARI developed 3 (three) guava varieties and their important characteristics are given below:

Name of Varieties (Year of Release)	Important Characteristics	Crop
Kazi Peyara (1984)	High yielding variety produces fruit twice a year. The plants are dwarf, spreading and moderately dense. In the main season, it flowers during March-April and the fruit are harvested in July-August. The other season, it flowers in September and the fruits are harvested in February. **Average fruit weight:** 450g. Fruit are pear to roundish in shape, smooth and shiny, yellowish green at ripen, white fleshed, crispy in texture and sour-sweet in taste (8% TSS). It is less seeded variety contains 109 seeds per 100g fruit. Fruit contain 202 mg vitamin C/100g of flesh. It can be stored well for 10 days at room temperature. Country wide adaptability. **Fruit yield:** 28-30 t/ha.	
BARI Peyara-2 (1996)	High yielding variety produces fruit almost round the year. The plants are dwarf, spreading and moderately dense. In the main season, it flowers during March-April and the fruits are harvested in July-August. The other season, it flowers duruing September and the fruits are harvested during winter season (February) **Fruit are round, fruit weight:** 400g, rough and shiny surface, yellowish green at ripen, white fleshed, less seeded, crispy, juicy and sweet in taste (10% TSS). It can be stored upto 12 days at room temperature. Country wide adaptability. Suitable for homestead. Sensitive to anthracnose, wilt and fruit fly. **Fruit yield:** 30-35 t/ha.	
BARI Peyara-3 (2003)	High yielding, regular bearer and pink fleshed variety. The plants are medium in size, spreading and moderately dense. It flowers during March-April and the fruits are harvested in September. Fruit are medium (180g each) in size, globose in shape, red fleshed, soft, medium crispy and slightly sour (7% TSS) in taste. Seeds are small and medium hard. Attractive pink coloured tasty juice can be prepared from the fruit. Suitable for processing (making jelly). This variety is mostly preferred by hill people It is recommended for cultivation in hill region. **Fruit yield:** 20-22 t/ha. But yield potential 12.25 t/ha from 5 years old tree.	

2.2 Production Technology

Land and soil

Guava trees are very hardy and can thrive on all types of soil provided that the roots have access to a constant supply of water but they are sensitive to water logging. For best production, guava should be grown in deep, well drained soils, high in organic matter. The crop is fairly salt and drought resistant and the P^H may range from 4.5 to 8.2. High and medium high land should be selected for planting guava trees. In hilly areas, the hill slopes should be below 45^0.

Time of transplanting

The planting of guava should be done when the weather is neither too wet nor too dry. The best planting time is May-June which might help in the establishment of young plants. Planting may also be done after the rainy season i.e. August-September. Where there is a scope of irrigation, guava saplings can be planted round the year.

Sapling collection

Guava can be propagated through sexual and asexual means. Air layering (or marcottage) and seeds are commonly used for propagation of guava. Guava sapling should be of an ideal variety. The sapling should be healthy, strong and disease free, and should be collected from a reliable nursery or from Government farm.

Transplanting method

Spacing: The planting distance varies with variety, fertility level of the soil and general growing conditions in the area. For Kazi Peyara and BARI Peyara-2.5m x 5m spacing but for BARI Peyara-3 and some local cultivars, 6m x 6m distance is required. Before planting, the field should be deeply ploughed, harrowed and levelled.

Pit preparation: The pits of about 60 cm x 60 cm x 45 cm should be dug in hexagonal or square system of planting. The contour system is followed in hilly areas. The pit should be of at least 60cm x 60 cm x 45 cm in size. The pit should remain exposed for 10 to 15 days before it is filled with soil, manure and fertilizer. The pit needs to be filled with 15-20kg well rotten cowdung or compost, 250g TSP, 250g MP, 100g gypsum and 25g zinc sulphate. The soil of the pit needs to be watered if the soil is dry during pit filling.

Transplanting: At the planting time a small hole is made at the centre of the refilled pit and the desired air-layer/seedling is planted. Water should be applied immediately after planting. Staking and fencing are also necessary.

Fertilizer dose and application method

The nutritional requirements vary with region depending upon the type of soil and age of tree. The year to year dosage of fertilizer is indicated below.

Requirements of manures and fertilizers of guava (year to year fertilizer doses) are as follows:

Manure and Fertilizers	Age of plant, (year)				
	1-2	3-4	4-5	5-6	> 6
Cowdung (kg)	10 - 15	16 - 20	21 – 25	26 - 30	40
Urea (g)	100	200	300	400	500
TSP (g)	100	200	300	400	500
MP (g)	100	200	300	400	500
Gypsum (g)	50	100	150	200	200
Zinc sulphate (g)	5	10	10	15	20
Boric acid (g)	5	10	10	15	20

Fertilizers should be applied in three split doses, one third is immediately after harvesting of the fruits in September-October, other one third is in February at the end of winter season, and the last installment is at the time of fruit sett (April-May).

The manures and fertilizers should be duly placed into the ground in trenches that may be 30 cm wide, 10-15 cm deep and 30 cm away from the base of a one year old plant. In this manner, the circular trench/canal around the tree may have to be made 1-2m away from the trunk in 5-6 years. The manures and fertilizers should be applied evenly in the canal/trench which is then back filled in with soil.

The manures and fertilizers may also be applied by spading or ploughing the soil around the plant up to the area shaded by the plant at noon. The manure and fertilizers should be spread all over but 50 cm away from the trunk and then mixed with soil by spading or ploughing up to a depth of 10-15 cm. There must be an irrigation of the soil after each application of fertilizers whether the same is spread over the surface or in the trenches.

Irrigation

Irrigation is essential before flowering, during fruit setting and development since during this period the soil moisture and atmospheric humidity remains very low. At the time of flowering, the temperature in most of the region in Bangladesh remains within 30-35^{o} C causing high transpiration. Generally, no irrigation is given to bearing trees as a result of which moisture stress due to prolonged period of drought causes yield reduction through fruit drop. Young plants also suffer due to shortage of water resulting poor growth and even death. Irrigation of young trees should be done by basin system. The full grown trees are irrigated by flooding or by furrow system. Irrigation at fortnightly interval after fruit set gives good harvest. Irrigation is also essential after the application of fertilizers.

2.3 Intercultural Operation

Ploughing: The orchard should be ploughed two times in a year-first operation should be done before the onset of rainy season. This helps checking run-off losses and facilitating maximum intake of water into the soil, and suppressing weed. Orchards may be ploughed again after the rainy season is over so as to suppress the weed growth and also to break the capillaries.

Training and pruning: The main objective of training guava plants is to provide a strong framework and scaffold of branches suitable for bearing a heavy remunerative crop without damaging the branches. The system of training is open centre, in which the plants are headed back. Primary shoots are retained for the initial framework which is subsequently pruned by cutting one third to half of their length after 3 months. After making the initial

framework, the two side shoots are permitted to grow initially and after 3-4 years, doubling of selected branches is continued. As the flowers and fruits are borne on current season growth, thinning out, i.e. a light annual pruning is considered beneficial to encourage new shoots after the harvest. All dead, diseased, unproductive branches, crowded shoots and water sprouts should be pruned back annually.

Fruit bagging: Bagging of fruits at an early stage of development has been found most effective against insect and disease infestation. It also protects the fruits from bird and bat damage. Moreover, there is a good scope of getting more return with the production of good looking fruits of good shape and size from bagging. It is, therefore, advocated to practice regularly fruit bagging using brown paper bags. Spraying of fungicide (Tilt 250 EC @ 0.5 ml/L) is essential prior to bagging for controlling anthracnose.

Mulching: Mulching is generally practiced for conserving soil moisture and suppressing weed growth. Dried leaves, straw or water hyacinth are generally used as mulch. The use of mulch would encourage the development of better root system of young guava plants.

Fruit thinning: High yielding cultivars like Kazi Peyara and BARI Peyara-2 bear such heavy crops that many limbs are broken or badly bent. Hence, fruit thinning should be done in such a way that the tree will retain one fruit for every 50 leaves. Normally 2-3 fruits are borne in one cluster. Only one fruit should be allowed to develop per cluster. Fruit thinning in the main season promote fruit bearing in the off-season.

Pest Management

Major insects and diseases and their control:

Name of pest	Control measures	
	Name of pesticide /treatment	**Rate per litre of water**
Fruit fly	Bait trap (5g Mipsin 80sp + 100 g mashed banana pulp) or Methyl eugenol sex pheromone trap	1 trap per tree 1 trap per tree
White fly	Powder soap or Liquid soap or Imidachloprid (Admire 200SL/Imitaph 20SL)	5g/l 5 ml/l. At initial stage of infestation 0.5 ml/l. 2-3 spray at 15 days interval
Fruit borer	Clean cultivation Fruit bagging	-
Anthracnose	Knowin 50WP or Tilt 250 EC	2.0 g/l 0.5 ml/l 3-4 spray at 15 days interval starting from marble stage of fruit
Fusarium wilt	Quick drainage Grafting onto resistant rootstock like Poly peyara) Liming with Dolochun	- - 1000 kg/ha

2.4 Harvesting andSeed preservation

The green colour changes to yellowish green or yellow when the fruit ripens. The fruit is harvested in July/August and February/March of the following year. Guava is harvested individually by hand with proper care.

Endocarp with seed is separated from mesocarp and allowed to ferment for 24 hours. Then the mesocarp is mashed and the seeds are the extracted washing it in running water. The seeds are dried in room under fan for several days and preserved in air tight bottle.

3. Litchi

Litchi is very popular both in home and abroad for its appealing flavour and taste. Litchi is grown mainly in greater Rajshahi, Dinajpur, Kustia, Jessore, Pabna, Mymensingh and Chittagong districts and Chittagong Hill Tracts. At present, the total area and production of litchi is 1.86 thousand hectares and 66.5 thousand metric tons respectively in Bangladesh (BBS, 2011).

3.1 Varieties

BARI has so far developed 5 (five) high yielding varieties of litchi. A brief description of the varieties along with some important characteristics is given below.

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Lichu-1 (1996)	High yielding, regular bearing, early variety. Plants are big tree, dome shaped, spreading and vigorous. It flowers in mid January; fruit are set in mid February and harvested in mid May. **Fruit are oval shaped weighing:** 20g each. Its length and breadth are, respectively 3.5 cm and 3.1 cm. It is brick-red in colour, juicy and sweet (18-20% TSS). **Edible portion:** 65%. Suitable for northern districts particularly in Rajshahi and Pabna region. **Fruit yield:** 10-12 t/ha.	
BARI Lichu-2 (1996)	High yielding, late maturing, regular bearer variety. Plants are medium tree, dome shaped, spreading and less vigorous. It flowers in late January; fruit are set in mid to late February and harvested in early June. The average length and breadth of fruit is, respectively 3.4 and 3.0 cm. **Fruits are roundish weighing:** 18g each, pink coloured, juicy and sweet (18% TSS). **Edible portion:** 68%. **The number of fruits in each mature plant:** 2300-2700. Tolerant to common insect pests and diseases of litchi. Suitable for eastern region of the country and also performing well in mid and western region. **Fruit yield:** 8-10 t/ha.	
BARI Lichu-3 (1996)	Mid-season regularly shy bearing, small seeded, good quality and high value variety. Plants are medium tree, dome shaped, spreading and less vigorous. It flowers in late January; fruits are set in mid to late February and harvested in late May. **Fruit are heart shaped, weighing:** 20-22g, juicy, rose scented and sweet (20% TSS). The average length and breadth of each fruit is 3.0cm and 3.3cm respectively. **Edible portion:** 76%. **The number of fruits in each plant:** 1600-2000. Tolerant to common insect pests and diseases of litchi. This variety is suitable for cultivation all over Bangladesh. **Fruit yield:** 5.0-5.5 t/ha.	

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Lichu-4 (2008)	Mid season high yielding, regular bearing, small seeded, good quality and high value variety. Plants are big trees, dome shaped, spreading and moderately vigorous. **It flowers in late January; fruit are set in mid to late February and peak harvesting period:** 2nd week of June. **Fruit are big weighing:** 26g each, globose in juicy. Attractive deep red in colour and white flesh. Pulp is soft, very juicy and very sweet (22% TSS) and pleasant in flavour. The number of fruit in each plant: 5000 and weighing: 130 kg. **Very high edible portion:** 75%. Tolerant to common insect pests and diseases of litchi. Possess export potentiality. This variety is commercially suitable for cultivation in Dinajpur and Rangpur region. **Fruit yield:** 10-13 t/ha.	
BARI Lichu-5 (2012)	Late season high yielding, regular bearing variety. Plants are medium tree, dome shaped, spreading and less vigorous. It flowers in late January to early February; fruits are set in mid to late February and harvested in early June. **Fruits are medium weighing:** 21.8g each. **Number of fruit per tree:** 3500 and their weight: 73.5 kg. Heart shaped, deep red in colour, very juicy and sweet (17.5% TSS). **Edible portion:** 73%. Tolerant to common insect pests and diseases of litchi. Possess export potentiality. Suitable for eastern hilly region. **Fruit yield:** 11.5 t/ha in 15 years old trees.	

3.2 Production Technology

Land and soil

High and medium high land should be selected for planting litchi trees. In hilly areas, the hill slopes should be below 45^0. The litchi can be grown in almost all kinds of soil, but performs better in deep well drained loamy soil having pH 6.5-6.8.

Time of transplanting

The planting of litchi should be done when the weather is neither too wet nor too dry. The best planting time is May-June which might help in the establishment of young plants. Planting may also be done after the rainy season i.e. August-September where there is a scope of irrigation.

Sapling collection

Litchi can be propagated through sexual and asexual means. However, air layering (or marcottage) is the most economic and popular method of vegetative propagation. Litchi sapling should be of an ideal variety adaptive to the location. The sapling should be healthy, strong and disease free, and should be collected from a reliable nursery or from Government farm.

Transplanting method

Spacing: The planting distance varies with variety, fertility level of the soil and growing conditions in the area. Where the growth is vigorous, the distance should be 10m x 10m, but where the growth is less, it can be reduced to about 8m x 8m. For dwarf varieties (like BARI Lichu-3) 7m x 7m distance is sufficient.

Pit preparation: The pit should be at least 1m x1m x 1m in size. The pit should remain exposed for 10 to 15 days before it is filled with soil, manures and fertilizers. The pit needs to be filled with 15-20 kg well rotten cowdung or compost, 500g TSP, 400g MP, 250g gypsum and 50g zinc sulphate. A basket of soil from an old litchi orchard, which contains mycorrhizal fungi, should be added. The soil of the pit needs to be watered if the soil is dry during pit filling.

Transplanting: At the planting time a small hole is made at the centre of the refilled pit and the desired air-layer is planted. Pot plants have a very brittle root system and should be handled carefully to minimize the damage of roots. Water should be applied immediately after planting. Staking and fencing are also necessary. The young litchi plant is very delicate and the mortality rate after planting is high. This is due to non-hardened planting material and lack of proper care at the time of planting and afterwards**.**

Fertilizer dose and application method

The nutritional requirements vary with region depending upon the type of soil and age of tree. The year to year dosage of fertilizers is indicated below.

Requirement of manures and fertilizers (year to year nutrient doses) are as follows:

Manures and Fertilizers	Age of plant, (year)					
	2 - 4	5 - 7	8 - 10	11 - 15	16 - 20	> 20
Cowdung (kg)	10 - 15	16 - 20	21 - 25	26 - 30	31 - 40	41 - 50
Urea (g)	250	500	750	1000	1500	2000
TSP (g)	500	1000	1500	2000	2500	3000
MP (g)	200	400	750	1000	1250	1500
Gypsum (g)	100	150	200	250	300	400
Zinc sulphate (g)	10	15	20	30	40	50
Boric acid (g)	10	15	20	30	40	50

Fertilizers should be applied in three split doses, one third should be done immediately after harvesting of the fruits in May-June, other one third should be in September- October at the end of rainy season, and the last installment should be at the time of fruit set (February).

The manures and fertilizers should be duly placed into the ground in trenches that may be 30cm wide, 10-15cm deep and 30cm away from the base of a one year old

plant. In this manner, the circular trench/canal around the tree may have to be made 2-3m away from the trunk in 10-12 years and 4m away in about 30 years. The manures and fertilizers should be applied evenly in the canal/trench which is then back filled in with soil.

The manures and fertilizers may also be applied by spading or ploughing the soil around the plant up to the area shaded by the plant at noon. The manures and fertilizers should be spread all over but 1 m away from the trunk and then mixed with soil by spading or ploughing up to a depth of 10-15 cm. There must be an irrigation of the soil after each application of fertilizer whether the same is spread over the surface or in the trenches.

Irrigation

Irrigation is essential during flowering, fruit setting and development since during this period the soil moisture and atmospheric humidity remains very low. At the time of flowering, the temperature in most of the region in Bangladesh remains within 27-28^{0}C, but it increase afterwards and transpiration rises considerably. Generally, no irrigation is given to bearing trees as a result of which moisture stress due to prolonged period of drought causes yield reduction through fruit drop. The fruits which remain do not develop fully and they often split and become unfit for consumption. Young plants also suffer due to shortage of water resulting poor growth and sometimes death. Irrigation of young trees should be done by basin system. The full grown trees are irrigated by flooding or by furrow system. Irrigation atfortnightly interval after fruit set gives good harvest. Irrigation should not be provided before flowering of litchi trees. Irrigation is also essential after the application of fertilizers.

3.3 Intercultural Operation

The orchard should be ploughed two times in a year-first operation should be done before the onset of rainy season. This helps checking run-off losses and facilitate maximum intake of water into the soil, and suppressing weed. Orchards may be ploughed again after the rainy season is over so as to suppress the weed growth and also to break capillaries.

Training of litchi plants during the early years is necessary to provide a good framework. Once the desirable shape and strong framework is achieved, no pruning is usually necessary, except the removal of dead or diseased branches and damaged shoots or cross limbs. Since litchi flowers are borne mostly on terminal shoots of current year's growth, and old shoots rarely produce flowers, some pruning to promote new growth, by snipping of old branches appears to be justified. This is done indirectly when a part of the shoot bearing the cluster of fruits is removed during harvesting. Heavy pruning of the tree causes profuse vegetative growth resulting in poor fruiting. In case, the tree is making too much vegetative growth both shoot and root pruning is necessary.

Mulching is generally practiced for conserving soil moisture and suppressing weed growth. Dried leaves, straw or water hyacinth are generally used as mulch. The use of mulch will encourage the development of better root system of young litchi plants.

Pest management

Major pests and diseases and their control:

Name of pest	Control measures	
	Name of pesticide /treatment	Rate per litre of water
Litchi mite	Vertimec Or O'mite 57 EC	1.5 ml/l 1.8 ml/l 2 spray-at 15 days interval starting from emergence of new leaf
Litchi fruit borer	Cypermethrin (Cymbush/Basathrin /Fenom or other) 10 EC or Sumicidin 20 EC or Decis 2.5 EC	1.5 ml/l 2 spray-one at pea stage and another one 15-20 days before harvesting
Powdery mildew	Thiovit/Cumolax/Sulfolac Or Tilt 250 EC	2.0 g/l 0.5 ml/l 2 spray-one at flower bud emergence and another one at fruit set (pea) stage
Bat	Drive away of the pest making sound or focusing torch light	-

3.4 Harvesting and Fruit preservation

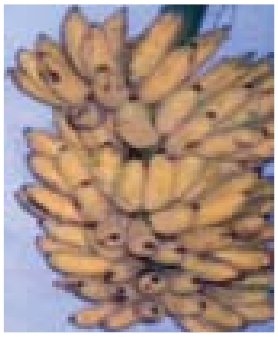
Quality of litchi fruits depends on the stage of harvest; because litchi is a non-climacteric fruit and does not improve in quality after harvest. Maturity of fruit is judged by colour development, flatness of tubercles and comparative smoothness of the epicarp. The fruit colour changes from greenish to pinkish red colour. The development of red pigmentation was found to be associated with anthocyanin pigment. Generally, fruit are harvested at about 55-60 days after fruit set. Fruit are harvested in May-June in bunches with few leaves. This is said to prolong the storage life of the fruit and at the same time the tree receives mild pruning. If the individual fruit is harvested, the skin at the stem end is ruptured causing the fruit to rot quickly. The fruits should not be harvested immediately after rains when the trees are wet as the spoilage of the fruit in storage would be high. Harvesting should be done in the cool part of the day preferably in late afternoon. Harvested fruit must not be kept under direct sun.

4. Banana

Banana is very nutritious among all other fruit particularly in the tropical region. It is one of the fruit which is available throughout the year. This crop is widely cultivated in Bogra, Jessore, Barisal, Rangpur, Mymensingh districts etc. In Bangladesh, its area is 53 thousand hectares and production is 8.08 lac metric tons in a year (BBS, 2011). The average yield of banana is 15.60 tons/ha. Its nutrient value such as calorie, vitamin and minerals is very high. The average yield of banana is higher than any other fruit and crops.

4.1 Varieties

A lot of varieties of banana are available in Bangladesh. Banana can be classified into two types based on use i.e. table banana and plantain. Amritsagar, Sabri, Kabri, Champa, Nepali and Rangin sagar are grown commercially in different parts of Bangladesh. BARI has developed four HYV of banana. Some salient features of these varieties are described below:

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Kola-1 (2000)	**Individual bunch weight**: 25 kg and contains 8-11 hands with 150-200 fingers. **Individual fruit weight:** 125g, fruit colour bright yellow and good in taste (TSS 24%). It is grown throughout the country. Generally, its growing season is September –January. **Fruit yield:** 50-60 t/ha and **Duration:** 11-12 months.	
BARI Kola-2 (2000)	High yielding introduced hybrid plantain variety. This variety is resistant to Panama and Sigatoka leaf spot disease. The plants are semi dwarf, strong and robust. **Bunch weight:** 15-20 kg, **individual fruit weight:** 100g and deep green in colour, **number of fruit/bunch:** 100-110. It is suitable for cultivation all over Bangladesh. **Fruit yield:** 35-40 t/ha and **Duration:** 11-12 months.	
BARI Kola-3 (2005)	It is popularly known as Bangla kola. It is high yielding variety of Kabri banana, Fruit are cylinder in shape, medium long (12-13 cm); **number of fruits/bunch:** 140-150, **bunch weight:** 23-25 kg, **individual fruit weight:** 144g. It is yellow in colour when ripened, seedless, very sweet (TSS 25.5 %) and tasty. It is tolerant to common insect pests and diseases and especially suitable for greater Sylhet, Chittagong and hilly areas. **Fruit yield:** 50 t/ha and **Duration:** 11-12 months.	

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Kola-4 (2006)	High yielding variety of Champa banana. **Medium statured plant having height:** 294 cm. Fruits are medium in size. **Number of fruit /bunch:** 178, **bunch weight:** 19 kg; **individual fruit weight:** 97g, ripe fruit yellow in colour, seedless and sour sweet in taste (TSS-20%). It is tolerant to common insect pests and diseases. Possesses export potentiality. This variety is cultivated throughout the country. **Fruit yield:** 47 t/ha and **Duration:** 11-12 months.	

4.2 Production Technology

Land and soil

Medium high land to high land with proper drainage facilities should be selected. For successful cultivation of banana, soil should be at least 60-80 cm depth, fertile loam and sandy loam soil with adequate sunlight. It can also be grown in different types of soil. The optimum soil pH 6.0-7.5 is suitable for banana growth.

Time of transplanting

Planting of banana should be done before or after monsoon i.e. May-June and September-October. Planting can also be done successfully in February-March if irrigation facilities are available.

Sapling collection

Sword sucker having narrow, slender leaf like sword with big rhizome, vigorous growth, about 50 to 60 cm height and 1.5-2.0 kg in weight should be selected for planting. Nowadays, heading back of tall sucker is beneficial. Suckers are produced commercially through tissue culture. The tissue cultured saplings establish quickly with low mortality rate and uniform growth. Besides, banana can be harvested within a short period compared to normal sucker. Moreover, tissue culture saplings are virus disease free. Sapling should be collected from the reliable nursery or from Government farm.

Transplanting method

Square or Hexagonal system is suitable for plain land and contour or terrace system for hilly region.

Spacing: For dwarf varieties 1.5 x 1.5 m (row x plant)

For tall and semi tall varieties 2.0 X 2.0 m (row x plant)

Pit Size: 45 x 45 x 45 cm^3

Transplanting: After land preparation with desirable tilth, clods should be broken and weeds are removed. Then pits are dug maintaining a distance of 1.5 to 2 m. The pits are filled with well mixed soil and 10 kg well rotten cowdung or manure, 400g TSP, 300g MP, 200g gypsum, 5g zinc sulphate and 5g boric acid per pit at 10-15 days before

transplanting. Then, selected suckers/tissue cultured plantlets should be transplanted into the pit. Irrigation should be done immediately after transplanting of sucker.

Fertilizer application

Banana responds to both manures and fertilizers. The dosages of fertilizers depend on the variety and initial soil fertility. For split application 500g urea and 300g MP per plant should be applied in four equal installments at two months interval commencing from two months up to six months after planting and one installment of urea and MP should be applied after flowering. Both urea and MP are mixed thoroughly and spread around the plant and incorporate into the soil with spade. Fertilizer should be applied 30 cm away from the base of the stem and up to area shaded by the plant. Adequate moisture should be maintained at least for 15 days after application of fertilizers.

Irrigation

Banana is a moisture loving plant. During dry season, the plants are to be irrigated at 10-15 days interval to maintain satisfactory moisture level in the soil. In fact, it requires irrigation throughout the year except during heavy rain. Proper drainage should be maintained during rainy season to avoid water logging.

4.3 Intercultural Operation

Desuckering: Desuckering is done after 4-5 months of transplanting. Depending on the variety it is continued up to flowering at certain interval. One selected sucker is allowed to grow as ratoon crop after flowering.

Weeding and mulching: Weeding is accomplished as and when required to keep the crop free from weeds and to keep the soil loose for proper aeration. Mulching should be done after irrigation at appropriate time to break the soil crust and to make the soil loose as well. In the banana field, it is essential to remove undesirable materials such as dried, diseased and decayed leaves, pseudostem after harvest, male bud, last end of inflorescence and withered floral parts etc.

Propping: All plants are supported by bamboo immediately after emergence of inflorescence for protecting them from bending or falling down due to heavy bunch load and damage by storm.

Earthing up: Earthing up is important particularly during rainy season which provides support to the base of the plant and also encourages development of new root system.

Intercropping: Planting of banana may be followed by planting of intercrops like brinjal, chilli, okra, radish, onion, potato, carrot, coriander, lentil, cabbage, cauliflower, spinach etc. during the initial growth stage depending on climatic condition. During intercropping additional fertilizer should be applied so that banana plant does not suffer from nutrient deficiency.

Ratoon crop: The yield of first ratoon is higher than the main crop. Besides the cost of production of ratoon crop is less than the main crop and the crop can be harvested earlier than the main crop. Continuous three ratoon crop is recommended. After that, yield becomes lower with increased insect pest and disease attack. At the time of main crop harvesting the plant should be cut down one meter above the ground level. Then all the suckers including the rhizome of mother plant should be removed except the selected sucker and exposed place should be filled up with soil mixed with manure and fertilizer. Immediately after this operation irrigation should be given. Other cultural practices should also be adopted as like as main crop.

Crop rotation: Banana should not be cultivated more than four times including ratoon crop in the same field, because of highly exhaustive in nature. As a result of banana cultivation the soil loses its fertility and yield becomes lower. Other crops like vegetables or fruits (except banana) are recommended in banana field to improve the soil health and good yield.

Pest Management

Major insects and control measures:

Banana leaf and fruit beetle

Adult beetle feeds the green parts of young leaves and skin of young fruit. As a result, small patches appear on the young leaf and fruits. With the increasing size of fruits, the spots become larger and turn blackish brown in colour. The skin of banana looks like pox spot which reduces the market price.

Blackish brown like pox spot disease

Control measures:

- Clean cultivation. The inflorescence should be covered with perforated polythene bag (transparent/ blue) immediately after shooting.
- Spray with Diazinon 60 EC @ 2 ml/l of water or Fenfen 20 EC @ 1.5 ml/l of water three times starting from emergence of inflorescence, after opening of first hand and after complete opening of banana bunches.

Covered with perforated polythene bag to protect banana

Major diseases and control measures:

Panama disease or Banana wilts

This is the most harmful disease of banana. It causes due to fungus (*Fusarium oxysporum*) which is soil borne and gets entry into the plant body through roots. It is most serious in poorly drained soil. Affected plants show sudden yellowing of lower

leaves, including leaf blade, petiole and later they hung around the pseudostem and wither. Black streaks appear on rhizomes and pseudostems. Sometimes, pseudostem splits longitudinally. Acidic alluvial soils favour the spread of disease. Sabri banana is very susceptible to this disease.

Panama disease

Control measures:

- Uproot all affected plants and destroy them.
- Use disease free planting material.
- Avoid banana planting on infested soil at least 3-4 years.
- Use disease resistant cultivar/variety.
- Apply lime by mixing with soil (1:3) in the pit and near the base of the plant.

Leaf spot or Sigatoka disease

Symptom: It is a fungal disease. The first symptom of infestation is the presence of light yellowish spots on the young leaves. After that the spots enlarge, become oval and the colour also changes to dark brown. In severe cases, the numerous spots coalesce and covering large parts of the leaf. The yield may reduce up to 10-15%.

Leaf spot disease

Control measures:

- Use disease resistant cultivar/variety.
- Remove severely infected leaves or parts of leaves and destroy them.
- Proper spacing should be maintained so that all the plants can get sufficient air and sunlight.
- Spray with Score or Tilt @ 0.5 ml/litre of water or Nowin or Bavistin @ 2 g/l of water or Aconazol/Folicor @ 0.1 ml/l of water 2-3 times at 10-15 days interval immediately after disease symptom appear on leaves.

Bunchy Top

It is a virus disease and is spreaded by aphid. Infected plants show short, narrow and upright leaves at the top of the pseudostem, bunched together into a rosette form.The margin of the leaves become wavy and slightly rolled upward. There is an extreme reduction in size of the leaves and leaf petiole. The results are stunted growth of whole plant, which does not produce bunch of any commercial value.

Bunchy Top virus disease affected plant parts

Control measures:

- Remove all affected plants along with complete rhizome and destroy.
- Use any resistant variety/cultivar (BARI Kola-3) or virus free planting material.
- Spray with Emidacloprid (Admire 200 SL) @ 0.25 ml/l of water or Ripcord 1 ml/l of water at 15 days interval to control banana aphid.
- Avoid using sucker from affected plant.

Heart rot:

It is a minor bacterial disease. The flag leaf of the plant show blackish and decays.

Control measure:

- Remove all affected plants and destroy.
- Use disease free suckers.
- Ensure good drainage facilities, proper spacing and sufficient air and sunlight.

Nematode

The burrowing nematode lay eggs in the root tissue, after hatching out, larvae also feed on root. Small dark black spots appear on the roots and decays. Fungus and bacteria easily enter into root and affect the plant. Affected banana plants are unable to uptake nutrients and water from the soil. Plant growth and yields are affected adversely.

Nematode disease

Control measures:

- Follow crop rotation for 2-3 years.
- Use nematode resistant variety.
- Adopt phytosanitary measures.
- Apply Furadan 5G or Bistaben 5G @ 45-60kg/ha or Ragby 10G @ 30 kg/ha 3-4 times per year.

4.4 Harvesting and Fruit preservation

Fruits are harvested when they are green but fully mature. Maturity symptoms are: the colour of the fruit changes from deep green to a lighter green; shedding of floral ends of the fruits with slightest touch i.e. when it dry; the angle or ridges of the fruits become less prominent or round i.e. after the attainment of 3/4th full stage. Depending on season generally all seedless or less seeded banana varieties mature within 11 to 15 months after planting. But seeded variety requires 20-24 months for maturity. Harvesting is performed by cutting the bunch, retaining 15-20 cm stalk, this will help in handling. Bunch should not put in hard place or soil after harvest to avoid black spots on banana because the spotted banana is rotten quickly during ripening and consequently the market value is reduced.

5. Jujube (Ber)

Jujube (Ber) is one of the most nutritious fruit in Bangladesh. It has its taste and nutrient value. This crop is cultivated in all districts but good quality crop is grown mainly in Rajshahi, Comilla, Khulna, Barisal and Mymensingh. The total area and production of ber is respectively 1.12 thousand hectares and 78.2 thousand metric tons (BBS, 2011). It is a good source of minerals, vitamin A and vitamin C. This crop can be eaten both in green and ripened stage. Scented ketchup, different types of sauces are made from ber and these are very tasty.

5.1 Varieties

Comilla kul, Narikeli kul, Rajshahi kul and Apple kul are cultivated in different parts of the country. Bangladesh Agricultural Research Institute (BARI) has developed three improved varieties of ber whose salient features are given below:

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Kul-1 (2003)	High yielding regular bearing variety. Trees are medium in height and medium spreading. Flowering appears in September and harvesting starts at 2nd week of February. **Fruit are medium, fruit weight:** 23g, oblong but pointed at the lower end, yellowish green. Pulp is white, crispy, very sweet (12-13% TSS) and delicious, devoid of astringency. **Seed is small and edible portion:** 92%. The variety is suitable for growing at Rajshahi and Khulna region and possesses export potentiality. **Fruit yield:** 10-12 t/ha.	
BARI Kul-2 (2003)	High yielding regular bearing variety. Trees are medium in height and medium spreading. Flowering appears in September and harvesting starts at last week of January. **Fruit are medium, fruit weight:** 34g, oval in shape, sweet (11.5% TSS) and tasty. **Seed is small and edible portion:** 91%. This variety is suitable for cultivation all over Bangladesh and possesses export potentiality. **Fruit yield:** 18-20 t/ha.	
BARI kul-3 (2009)	High yielding mid-season variety. Trees are dwarf and more or less straight. Flowering appears in September and harvesting starts at 2nd week of January. **Fruits are big and average weight of each fruit:** 75g, shape is ovate oblong. Pulp is white, very juicy, crispy, very sweet (14% TSS), devoid of astringency. **Seed is small, edible portion:** 96%. It is suitable for cultivation all over Bangladesh and possesses export potentiality. **Fruit yield:** 22-25 t/ha	

5.2 Production Technology

Land and soil

High land with proper drainage is suitable for ber cultivation. Ber can be grown in a wide range of soil including a porous and infertile soil which is unsuitable for other fruits crops. It can successfully be grown in saline and alkaline soil as well. It can tolerate drought as well as water logged condition. However, loamy to sandy loam soil with pH 6.5 to 7.5 is the best.

Time of planting

The best time for ber planting is June-July (beginning of monsoon) and September-October. Besides, planting can be done in any time of the year except winter with assured irrigation.

Sapling collection

During selecting of planting materials the following points should be considered: i) improve variety from the authentic source of scion. ii) Sapling should be 1-2 years old, good vigour, uniform growth with 2-3 branches. iii) Good compatibility between scion and rootstock and free from pest and diseases. The sapling should be collected from the reliable nursery or Government farm.

Transplanting method: Square or Hexagonal system.

Spacing: Spacing depends upon soil types, pruning operation, varieties and climatic conditions. But in general, it is followed: (4-6 m x 4-6 m (plant x row).

Pit size: 1x1x 1m^3

Transplanting

On well prepared land, the spots are marked and pits are dug in April-May for monsoon planting and August-September for post monsoon planting. The pits are filled up with uniformly mixed top soil and 25kg well rotten cowdung, 250 g TSP, 250g MP and 250g Gypsum per pit.

Fertilizer application

Fertilizer and manure should be applied regularly to have proper growth and higher yield. The doses of fertilizer depend on age of tree and soil fertility status. Fertilizer doses for different ages of tree are given below.

Requirement of manures and fertilizers per tree (year to year doses of nutrients) are as follows:

Plant age (year)	Quantity of manures and fertilizer per tree			
	Cowdung (kg)	Urea (g)	TSP (g)	MP (g)
1-2	10	300	250	250
3-4	15	500	400	400
5-6	20	750	700	700
7-8	25	1000	850	850
9 and above	30	1250	1000	1000

Besides these, fertilizer and manure which are deficit in regional basis should be applied. The aforesaid manure and fertilizers should be applied in two equal installments in May-June and September-October (after fruit set), respectively. Fertilizers should be mixed uniformly with the soil followed by irrigation. Generally in adult tree, application of fertilizer should be done starting from 1-1.5 m away from the base of the tree up to the area shaded by the plant and confined with 3.5 m of the canopy of the tree. Dibbling method may be followed where fertilizer application is difficult.

Irrigation

Ber is grown successfully on dry climate. However, for better survival and establishment of newly planted ber plants, light irrigation should be given. During dry season especially at the fruit development stage, it needs irrigation for better fruit development and quality improvement. Irrigation should be given at one month interval from October to February depending on the moisture status of the soil.

5.3 Intercultural Operation

Training and pruning

Training of ber tree is essential during first 2-3 years to build up a strong framework. New shoot develop from the rootstock should be removed regularly. Bamboo sticks are fixed for support and straight growth of the tree. While pruning, care should be taken so that there is no branch below one metre height of main stem. Above one metre, the 4-5 branches spreading in all directions should be allowed to ensure the tree to grow in good and balanced shape.

The fruits of ber are born on the axil of leaves on the young shoots of current season. Therefore, annual pruning is necessary immediately after fruit harvest to induce healthy shoots which provide maximum fruit bearing area on the tree. Medium pruning is recommended up to 3-4 years old tree i.e. heading back 50-60 cm from the top of the branches and branchlets. After the tree attains the desirable size and shape, one year old branches should be heading back (pruned) leaving 20-30 cm from the base of the branch. Besides, weak, thin, diseased, broken and intercrossing/criss-cross branches should be removed with a sharp secateurs or pruning shear during pruning.

Intercropping

After planting ber, 4-5 years are required to cover the interspaces between the trees. Generally, leguminous crops are preferred as intercrop as they enrich soil in addition to some income. Under irrigated conditions vegetables and chillies can be grown. In suitable climatic condition, papaya can be grown as intercrop in the first three years.

Weeding

In order to keep the ber plantation free from weeds, regular hoeing is advised. Always shallow cultivations are done. Whenever root-suckers are found, they should be removed because they reduce the yield potential of ber tree.

Pest Management

Major insects and control measures:

Leaf chafer


Leaf chafer

Beetles feed on leaves mainly during night. The leaves become just like a sieve. The severe attack is found during rainy season when new flush is produced.

Control measures:

- Spray with Sumialpha/Sumithion @ 2 ml/l of water two times at an interval of 10 days.
- Besides, weeds should be removed around the tree and apply Chloropyriphos (Pyrifos 20EC/ Dursban 20EC) in the soil @ 5 g/l of water.

Ber nut weevil


Ber nut weevil

Nut weevil is a new pest and has become a serious threat to ber cultivation. About 50% fruits are found to be infested by the pest. The weevil feed only on the seed portion of developing fruit and arrest further development of fruit.

Control measure:

- Clean cultivation. Destruction of bushes from the orchard, collection and destruction of infested fruit before emerging adults from the fruit.
- Spray of cypermethrin @ 1.5 ml/l of water at initial stage of setting at 10 days interval.

Fruit fly


Fruit fly

It is the most serious pest of ber. The adult female lay eggs by inserting its ovipositor in developing mature fruit. After 2-5 days, larvae feed on pulp. Infested fruit becomes unfit for eating and drop down.

Control measures:

- Collect the infested fruit and destroy them completely.
- Ploughing orchard should be done during summer to expose the hibernating pupae to the sun and birds.
- Spraying of the trees with Ripcord/Cymbush 10EC @ 1 ml/l of water or Desis @ 0.5 ml/l of water 2-3 times should be applied at an interval of 10-15 days.

Tube spittle bug


Tube spittle bug

This is a new threat to ber farmers. In 2010, it was recorded first time at Bogra Zila in northern region of Bangladesh. 100% crop may be damaged by this pest if it is not noticed at early stage of flowering. Nymphs of the bug suck sap from flower. Affected flowers are dried completely and unable to bear fruit Heavy infestations can cause complete failure of the crop. Nymphs construct calcareous tubes in which they live and feed.

Control measures:

- Clean cultivation.
- Hand picking and destruction of tube with bug.
- Spray with Fenitrothion (Sumithion/Folithion/Fenitox 50EC @ 1.5 ml/l of water at 10 days interval.

Major diseases and control measures:

Powdery mildew

Generally the disease appears in September-October. Affected fruits show white powdery spots which later cover whole area of fruit. The white powdery mass also spread on flowers and leaves. Later white spots turn to brown and flowers and fruit drop down. Fruits crack if the fungus attacks at the mature stage.

Powdery mildew

Control measure:

- The orchards should be clean.
- Spray the tree at the time of flowering with Thiovit/Salfolac/Kumolux @ 2 g/l of water 2-3 times at an interval of 10-15 days.

Fruit rot

Infection starts with light brown spots on the apical end of the fruit and later whole area of the fruit is covered and they turn dark brown in colour. The amount of vitamin C is decreased and harmful alpha toxin develops due to attack of this pathogen.

Fruit rot

Control measure:

- Collect the affected fruit and destroy them.
- Spray 2-3 times with Indofil M-45 @ 2 g/l of water at an interval of 10-15 days.

Sooty mould

Appearance of black spots on the lower surface of the leaves and in advanced stages the entire lower surface may be covered by sooty mould and the leaves may drop down.

Sooty mould

Control measures:

- Clean cultivation, collection and burning of shaded leaves should be done.
- Insecticide Bavistin @ 1g per litre of water 2-3 times should be sprayed at 10-15 days interval.

5.4 Harvesting and Fruit preservation

The fruits are plucked up at right stage of maturity i.e. when the colour of the fruits changes from green to yellowish or golden. Care should be taken so that any injury or cracking of fruits does not occur during fruit harvest. Cool weather of morning or late afternoon is more suitable for fruit plucking. This practices enhances shelf life of Ber to some extent.

6. Papaya

Papaya is one of the most important fruit in the world. It is also a very important and popular in Bangladesh. Some salient features of papaya crop are: (1) it is a short duration crop; (2) it is widely used not only as fruit but also as vegetables and (3) this crop is very tasty, nutritious and used for medicinal purpose. The good quality of papaya crop is mainly grown in greater Rajshahi, Pabna and Jessore. At present in our country, its area and production are about 1.24 thousand hectares and 1.25 lac metric tons, respectively (BBS, 2011). The average yield of papaya is 7 ton/ha. Ripe papaya is a good source of vitamin A which is next to mango.

6.1 Varieties

A lot of variability of papaya is available in Bangladesh. BARI has developed only one improved papaya variety whose salient features are described below:

Shahi pape

It is a high yielding dioecious variety. The plant is medium in height (1.6 to 2.0 m), fruit born low on the stem. Fruits are medium size, **fruit weight:** 800-1000g, oblong in shape, **seeds per fruit:** 500-550. **The flesh thickness:** 2.5 to3.0cm. Colour is deep orange-red. **Fruit/plant:** 40-60 and very sweet in taste (TSS 12%). It is suitable for cultivation all over Bangladesh. **Fruit yield:** 40-60 t/ha and **Duration:** 10-11 months.

Shahi Pape

6.2 Production Technology

Land and soil

Medium to high land with proper drainage facilities is suitable for papaya cultivation. Deep soil enrich in organic matter having good drainage facilities is good for papaya production. However, loamy to sandy loam soil with rich in plant nutrients and well drained are the best. The crop is very suitable for cultivation when soil pH ranges from 6.0 to 7.0. It does not survive in water logging condition.

Time of transplanting

September-October and December-January is the best time for seed sowing of papaya. The seedlings are suitable for transplanting at 40-50 days after seed germination.

Seedling raising

Healthy seedlings are the pre-requisite for good crop. Papaya seedlings should be grown in pots or in the seed beds.

In pots: Polythene or plastic pots are used for raising seedlings. 12 x 8 cm size pot with 3-4 holes at the bottom is filled with prepared potting media. The potting media is prepared with the mixture of river silt and well decomposed cowdung in equal proportion. Two to three seeds are sown per pot at 1cm depth in the media of the pot at least 55-65 days before transplanting in the main field. The pots are watered regularly to keep the media moist for higher germination. The pots are used to keep in the warm place of the net house. Scorch sunlight is not advocated for seed germination. The moisture of the potting media should be maintained and excess water should be drained out from the pot. Seedlings raised in pot are suitable to transfer in the distant places.

In seed beds: The seeds are sown in seed bed maintaining 10-15 cm row to row distance, 3-4 cm from seed to seed in a depth of 1.0-1.5 cm. The seedlings are uprooted with minimum damage of roots just before planting. Even 2nd transplanting should be done from seed bed to pot just 7-10 days after germination.

Sapling collection

Sapling or seed should be collected from a reliable nursery, Government farm or seed company.

Transplanting method: Square system

Spacing: 2 m x 2 m (plant x row)

Pit size: 60 x 60 x 45 cm^3

Transplanting: First of all, field is well ploughed and harrowed, after then; pits are dug maintaining 2 x 2 m distance. The pits are filled with well mixed soil and 15 kg well rotten cowdung or compost, 500 g TSP, 250 g gypsum; 20 g zinc sulphate and 20 g boric acid at 10-15 days before transplanting and kept moist by watering. Then, transplanting of 40-50 days old seedling is done in the evening hours. Just after planting, seedling are provided with support and watered soon. In case of dioecious varieties like Shahi usually three seedlings should be planted per pit.

Fertilizer application

Fertilizers should be applied in time to achieve good yield. The dosages of fertilizers should be applied depending on the variety and initial soil fertility. 450-500 g urea and 450-500 g MP per plant should be applied as split application. 50g urea and 50g MP should be applied per plant one month interval commencing from one month after planting. The fertilizer dose should be double after flowering. Both urea and MP are mixed thoroughly and spread around the plant and incorporating into the soil with spade. Fertilizer should be applied 30 cm away from the base of the stem and up to the area shaded by the plant at noon. Each application should be followed by light irrigation.

Irrigation

Light and frequent irrigation is needed during dry season. Generally, papaya crop is irrigated at 10-15 days intervals in winter and 5-7 days in drought condition

depending upon the moisture status of soil. Satisfactory drainage facilities should be maintained to drain out excess water during irrigation and rainy season.

6.3 Intercultural Operation

Removal of excess plants: When flowering starts after 3-4 months of planting, it becomes very easy to uproot male plants from dioecious papaya varieties. About 5-10% male plants are allowed for pollination. In the row one male plant should be left against 10 to 20 female plants. Generally single robust plant is left per pit.

Weeding: The land should be free from weeds all the time. At the time of weeding, care should be taken to ensure that soils are not made too loose during rainy season.

Earthing up: Earthing up of the papaya plant should be done especially during rainy season. This provides support to the plant to remain in erect position.

Fruit thinning: More than one flower and fruit come out from the leaf axil of most of the papaya varieties. Fruit should be thinned out retaining one healthy fruit per axil to allow adequate space for attaining good size of the fruit.

Propping: All plants should be stacked by bamboo immediately after flowering starts for protecting them from falling down due to heavy weight of fruit per axil and from any damage by wind.

Pest Management

Major insect and control measures:

Mealy bug

Mealy bug has recently emerged as a major threat to different crops especially papaya in many regions of Bangladesh causing serious economic loss. The pest is small in size, oval shape; their body is covered with white waxy materials. They suck sap from young leaves, twigs, flower and fruit. They inject a toxic substance into the leaves. The result is chlorosis, stunted plant growth, leaf deformation, early leaf and fruit drop and sooty mould.

Affected by Mealy bug

Control measures

- The affected leaves including insect should be destroyed at the initial stage of attack or the insect should be rubbed with tooth brush and destroyed.
- In case of severe infestation, spraying 2-3 times at 10-15 days interval with soap water @ 5 g/l or Admire 200SL @ 0.25 ml/l of water.

Major diseases and control measures:

Damping off and Collar rot


Damping off and Collar rot

This disease is common in nursery bed. Water soaked patches are found on the stem which gradually enlarge and girdle the base of the stem. The affected area turns black and rots. Then seedlings are topple down on the ground with the constriction at the ground level. This disease is more serious during rainy season.

Control measures

- Remove and burn affected plants and provide good drainage facilities.
- Soil of seed bed should be sun dried properly before seed sowing.
- Treat the seed before sowing with Secure 2-3 g/kg of seed.
- Half rotten poultry refuse should be applied for soil amendment @ 5 ton/ha before 15-21 days of seed sowing.
- Disease severity can also be reduced by applying Secure @ 2 g/l of water in the soil through drenching.

Anthracnose

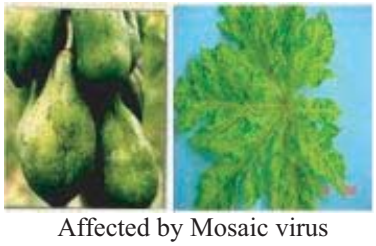

Anthracnose disease

Brown colour rot is seen on the surface of the fruit and the fruit become unfit to eat.

Control measures

- Spray Nowin/Bavistin/Kadazim @ 2 g/l of water two to three times at an interval of 10-15 days.

Papaya Mosaic virus


Affected by Mosaic virus

It is very wide in occurrence. The affected plants become stunted, leaves become yellow and petioles show bending downward. Different types of aphids act as vector.

Control measures

- Uproot affected plants and burn them immediately.
- Insecticide Admire 200SL @ 0.25 ml/l of water at 15 days interval should be applied to control aphid.

Papaya leaf curl virus


Leaf curl virus

Affected leaves show curling, crinkling and distortion. The size of the leaf is reduced considerably. The disease is transmitted through white fly.

Control measures

- Uproot affected plants and burn them.
- Admire 200 SL @ 0.25 ml/litre of water at 15 days interval should be applied to control white fly.

Rootknot nematode

The nematode lay eggs in the root tissue, after hatching out, larva also feed on the root. Affected root swollen and form knot. Plants become weak; growth is stunted and leaves show yellowish colour and then dry off.

Affected by Root knot nematode

Control measures

- Follow crop rotation for 2-3 years.
- Apply Furadan 5 G @ 5 g/plant 3-4 times per year.
- Apply half rotten poultry refuge or mustard oilcake @ 3 t/ha or 300 kg/ha and mixed with the soil uniformly three weeks before planting.

Nutrient deficiency problem

Boron deficiency

Papaya is very sensitive to boron. Affected leaves show curling, sometimes develop only midrib without lamina, Latex exudates from the fruit and fruit are irregular and bumpy in shape.

Affected by Boron deficiency

Control measures:

- 20 g boric acid or 50 g borax should be applied at the time of pit preparation. All the leaves should be sprayed with boric acid or borax @ 2 g or 5 g/liter of water two to three times at 10-15 days interval, if the deficiency symptom appears even adding boron in the pit.

6.4 Harvesting and Seed preservation

When the latex become thin and watery papaya is suitable for harvest for vegetable purpose. On the other hand, mature fruit showing a tinge or 5-10% yellow colour appear on the fruit surface are ready for harvest. If the fruit are allowed to ripe, they are often damaged by birds. The individual fruit is harvested with hand. Fruit are not allowed to fall on the ground or come in contact with the soil while plucking. Seeds are collected from the well ripen fruits. The seeds are rubbed with hand to remove seed coat and washed with clean water. Seeds are dried in shade to reduce moisture. Then seeds are stored in air tight container or desiccators.

VII. SPICES CROP

Spices crop are very popular in Bangladesh. The main spices are: onion, garlic, chilli, turmeric, ginger, coriander, round chilli etc. These spices are cultivated in an area of about 3.19 lac hectares and their production is 16.52 lac metric tons (BBS, 2011). The production of spices is not sufficient to meet up the demand. So a lot of spices is imported from abroad. Total production and per hectare yield of spices crop may be increased through high yielding variety (HYV) and improve production technology.

1. Onion

Onion is one of the most important spices crop for the people of Bangladesh. It is also used as a vegetable. The shortfall of onion is met up by import. Its production and per hectare yield can be increased through using BARI developed HYV and improved production technology. It is mainly grown in rabi (winter) season but BARI developed 3 high yielding varieties which could be cultivated during kharif (summer) season. The leaves of onion and its stem are full of vitamin C and Calcium. At present, it covers about 1.28 lac hectares and produces about 10.55 lac metric tons with average yield of 8.25 t/ha (BBS, 2011).

1.1 Varieties

BARI has so far developed five varieties of onion. Among of them, two varieties (viz. BARI Piaz-1 and BARI Piaz-4) are for rabi (winter) season and three (viz. BARI Piaz-2, BARI Piaz-3 and BARI Piaz-5) for kharif (summer) season. Some of their important characteristics are stated below.

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Piaz-1 (1996)	This crop is grown only in rabi season. **Plant height:** 50-55 cm, 10-12 leaves in each plant, round and flat in shape of bulb, thin in neck, reddish-pink in bulb colour. **Bulb weight:** 20-25g and more pungent test with good shelf life. The picking of matured umbels can be made within 140-150 days. **Seed yield:** 550-650 kg /ha. **Bulb yield:** 12-16 t/ha. **Duration:** 130-140 days.	
BARI Piaz-2 (2000)	This crop is suitable for only summer (kharif) season with short duration crop. Bulbs are round in shape and red in colour. **Plant height:** 25-30 and 50-60 cm, respectively during early and late kharif season. **Weight of bulb:** 22-25 and 55-65g in early and late kharif season, respectively. The bulb is moderately pungent. The shelf life of bulbs depends on prevailing rains. The bulbs can be stored maximum two months. **Seed yield:** 300-400 kg/ha. **Bulb yield:** 10-13 t/ha (early; kharif-1) and 18-22 t/ha (late; kharif-11). **Duration:** 95-110 days (kharif-1) and 140-150 days (kharif-11).	

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Piaz-3 (2000)	It is also a summer season corp. Bulbs is round in shape and red in colour. **Plant height:** 30-40 and 55-65 cm during early and late kharif season, respectively. **Weight of bulb:** 18-22 and 50-55g in early and late kharif season. The bulb is moderately pungent. The shelf life of bulbs depends on prevailing rains. However, the bulbs can be stored maximum two months. **Seed yield:** 400-500 kg/ha. **Bulb yield:** 10-12 t/ha for kharif-1 and 17-20 t/ha for kharif -11. **Duration:** 90-105 days (kharif-1) and 130-140 days (kharif-11).	
BARI Piaz-4 (2008)	It is a high yielding variety grown for rabi season. **Plant height:** 50-60 cm, 10-12 leaves in each plant, globular and pitcher-shaped bulb, 60-75g per bulb and dark red in colour. The bulb is pungent in taste. Comparatively less infestation of pest and diseases. **Bulb yield:** 17-22 t/ha. **Duration:** 160-170 days.	
BARI Piaz-5 (2008)	This variety is mainly grown in kharif season but it may also be grown throughout the year. Suitable for early and late kharif cultivation. Short duration. **Plant height:** 35-45 and 65-75 cm in plant height for early and late kharif season, respectively. Globular shape bulb, 30-40g and 70-80g per bulb in early and late kharif season and dark red in colour. The bulb is moderately pungent in taste. **Bulb yield:** 12-16 t/ha (kharif-1) and 18-20 t/ha (kharif-11). **Duration:** 60-80 days (kharif-1) and 115-125 days (kharif-11).	

1.2 Production Technology

Land and soil

Onion may be grown on various soils. But it grows well in friable and well-drained sandy-loam to clay-loam soil along with optimum P^H range between 5.8 and 6.5. The crop is sensitive to high acidity, alkalinity and salinity. Onions do not thrive well in the soil below P^H 5.8 because of trace element deficiencies and sometimes aluminum/manganese toxicity. The water-holding capacity of the soil should be high as onion is a shallow rooted crop. Good drainage is essential. Waterlogging may cause failure of the crop. Sandy soil needs more and frequent irrigations but favour early maturity, whereas heavy soil gives rise to misshapen bulbs.

Seed rate

Seed rate of onion depends on its quality, planting system, planting time, spacing etc. 4-5 kg seeds for transplanting system whereas 7-8 kg true seeds and 1200-1500 kg onion sets are required for cultivation of one hectare land in direct seeding and set planting method, respectively.

Seed treatment

Seed should be treated with Dithane M-45 @ 2 g/kg of seeds to avoid damage from diseases before sowing and protect seedlings from damping off *(Pythium* spp).

Time of sowing

In transplanting and direct seeding method, the best time for sowing rabi (winter) crop is late October to November. In case of early and late kharif (summer) onion, it is sown in February to March and July to August, respectively. In set planting method, the optimum time is September to October. In case of seed production, late October to November is the optimum time to plant seed bulb.

Sowing method

Direct seeding: In this method, seed rate is high. Intercultural operation is difficult for improper plant population. The plants can not use natural resources properly. The bulb yield is poor. Shelf life of the bulbs is comparatively very poor but labour cost is low.

Onion sets planting: The bulbs produced in this method are entirely fresh (green onion) and these bulbs are immediately consumed. Premature bolting occurs in this crop planting. Seed rate of the sets are high.

Seedlings transplanting: This is conventional seedling transplanting method, widely practiced by farmers. This method shows better results for longer shelf life of onion bulbs although the labour involvement and cost is high. The seedlings are usually transplanted on flat beds at a spacing of 15 cm from line to line and 8-10 cm from plant to plant.

Seedbed preparation

Onion seeds are sown in nursery beds to raise seedlings. The raised beds of 3 m long x 1 m wide and 20-30 cm high are preferred. The length of seed bed may also be formed in a convenient length depending upon type of soil, level of land, irrigation method etc. Raised bed is necessary to avoid problem of waterlogging in heavy soil. About 50 cm distance should be provided between 2 beds for easy operation of watering, weeding, spraying of pesticides etc. The surface of the beds should be smooth and well-levelled. Insecticide like Furadan should be incorporated in the seed bed to kill the soil insect-pests. The bed may be covered with polythene for solarization.

Land preparation

Prior to planting sets or direct seeding or transplanting seedlings, land is to be ploughed sufficiently to eliminate debris and soil clods. The onion land should be ploughed to a fine tilth by 4-5 times with a sufficient interval between two ploughings. The land may be ploughed by tractor or power tiller or country plough. But for well pulverization of the field, ploughing by tractor-driven implements is suitable. After ploughing, laddering is done for proper leveling. The field is then divided into beds of 1 m wide along with convenient length and channels of 50 cm wide**.**

Fertilizer dose and application methods

The requirement of nutrients depends on soil type, topography, AEZs, varieties, soil nutrient status etc. Onion responds very well to organic manures. About 5-10 tons of cowdung per hectare is adequate. Onion requires higher levels of fertilizers for maximum yields than most other vegetable crops. Green manuring with Dhaincha (*Sesbania aculeata*) and Sunnhemp (*Crotalaria juncea*) may be done to enrich soil health. Fertilizer dose and application methods are furnished below:

Manures and fertilizer	Total amount /ha	At the time of last ploughing	1st installment	2nd installment
Well decomposed Cowdung	5.0-10.0 ton	All	-	-
Urea	240 Kg	80	80	80
TSP	220 Kg	All	-	-
MP	150 Kg	75	38	37
Gypsum	110 Kg	All	-	-

For seed production

Manures and fertilizers are to be applied in land with well decomposed cowdung: 10 tons, urea: 260, TSP: 300MP: 150, Gypsum:100 and Boric acid:10 kg/ha, respectively. The entire quantities of well-decomposed cowdung are to be applied just after opening of the land. The total amounts of phosphorus, Gypsum, Boric acid and two-third of Potassium should be added during final land preparation. The entire urea is to be incorporated in three equal splits 20, 40 and 60 days after seed bulb planting. The rest amount of Potassium should be applied 60 days after seed bulb planting.

Irrigation

Onion is a shallow rooted crop. Its root system is normally restricted to top 3 cm and roots penetrate seldom deeper (15 cm). The water requirement in onion crops depend upon crop growth, soil type, planting season etc. The water requirement at initial growth stage is less. At bulb formation, irrigation is necessary and moisture stress at this stage may lower the yield. The field should not be kept dry for long spell which otherwise results in splitting and allow to crop early maturity resulting lower yield. Frequent and light irrigation at weekly intervals have shown good results in bulb development, increase in yield and quality of the produces. Depending upon rain and soil type, 5-6 irrigations are enough. As the onion begins to mature and the tops begin to fall down, irrigation has to be terminated to stop root growth and allow the outer scale of the bulb to become dry and firm. Thus, irrigation should be stopped at least 15-20 days before harvesting for improving the keeping quality of bulbs.

1.3 Intercultural Operation

Cultural operation keeps the field absolutely free from weeds to produce a good crop of onion. Onions are one of the vegetable/spice crops most prone to weed infestation.

The crops are poor competitors against weeds due to its slow establishment and a canopy of short upright leaves. Henceforth, weeding is the most important activity for this crop.

Special operation for seed production

Earthing up

Soils around the plants should be done to protect seed crops from fall down.

Staking

Staking is one of the most important activities for intercultural operation in onion seed crop. Without this activity the program of onion seed production may be failed due to breaking of flower stalks by strong wind. Staking should be provided around the unit plots at 65 days after planting of seed bulbs with bamboo sticks and jute cord to keep the flower stalk erect and to protect them from strong wind. Breaking the flower stalks leads to produce higher percentage of chaffy seeds resulting in lower quality and low yield of onion seed.

Pest management

Major insects and control measures:

Onion Thrips (*Thrips tabaci*): The most common and serious pests are found in onion production. During dry and warm weather thrips feed on leaf surfaces and leaves become white. The insect has many host plants and adults and nymphs over winter on plants or plant debris or in weeds bordering the field.

Control measures:

- Preventive measures should be taken including destruction of weeds as they are alternate hosts.
- Badly infested leaves should be removed.
- The crop should be sprayed with insecticides like Admire/Score @ 2 ml/l of water at 15 days interval to keep the seed crops free from insect-pests.

Cutworm (*Agrotis* spp): It is a nocturnal insect. At night, after cutting the plants at collar region, the insect escapes itself in the soil near the plant.

Control measures:

- The insect should be controlled by hands after digging the soil near the infected plants.
- Flood irrigation should be done.

Bolting and sprouting in storage:

Application of Maleic hydrazide (MH) checks premature bolting and sprouting in storage. Spraying MH @ 2000-2500 ppm just before neck fall in rabi onion are recommended.

1.4 Harvesting and Seed preservation

In onion, neckfall is the indication of maturity for bulb. Time of harvest depends on several factors such as planting season, cultivar, market price, conditions of the crop etc. The duration of the crop is usually 5.5 and 3.5 months for rabi and kharif season, respectively. If onions are grown by direct seeding method, the crop is ready for about 20-25 days earlier than the transplanted ones. When the bulbs mature, the green tops become weaken and fall down that is called neckfall. When neckfall begins, irrigarion is to be stopped. In general, when more than 50% neckfall is found, the bulbs are harvested along with leaves by hand-pulling. The harvested plants with bulbs are allowed to cure for about 7 days. After complete curing, the roots and tops are clipped. The leaves are cut leaving about 2.25 cm tops above the bulbs. Curing is the drying of neck, root and outer scale tissue to remove excess moisture from them. It is essential to prevent disease infection, shrinkage and development of bad colour in bulb.

Bulb storage

The harvested bulbs are usually stored both for human consumption throughout the year and for growing seeds in the next year. Storage techniques and storage conditions have great impact on the shelf life of onion. Proper storage is crucial for retaining bulb quality. Factors influencing storage bulbs are variety, growing season, harvesting stage, curing, fertilizer and irrigation application, storage techniques, storage conditions, temperature and humidity etc. Early harvesting results in sprouting of bulbs while late harvesting results in formation of secondary roots during storage. Thick-neck bulbs resulting from premature harvesting also do not store well. The bulbs should be graded according to size and quality. Cool, dry and well ventilated store room will keep onion bulbs in good conditions for many months. On average, the storage loss of onion bulb may be 45-60% due to respiration weight loss, rotting of bulb and sprouting. This storage loss can be minimized by selection of suitable varieties with long shelf life, efficient irrigation management, balanced fertilization, optimum time of planting, proper harvesting time and improved storage. In cold storage, onion can be stored nearly for 10-12 months with temperature 0-5ºC and relative humidity 60%. The rabi (winter) onion store well than the kharif ones.

2. Garlic

Garlic is a very important spice crop under the family Alliaceae. It plays an important role for enhancing taste, scent during cooking. It is used also for medicinal purpose. Different types of diseases of human can be cured by using this medicinal plant. It contains 62% water, 29.8% carbohydrate, 6.3% protein, 0.1% mineral, 0.4% fibre and vitamin C. At present, its area and production is 42 thousand hectares and 2.09 lac metric tons, respectively (BBS, 2011). But its production is very low in comparison to our requirement and this is due to lack of high yielding variety.

2.1 Varieties

BARI has so far released 2 varieties of garlic. A brief description of the varieties and some important characteristics are stated below.

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Roshun-1 (2004)	This is a high yielding variety developed through selection procedure. **Plant height:** 60-62 cm and 7-8 leaves per plant. **Number of cloves per bulb varied from 20-22 and weight of bulb:** 19-20g. Very good keeping quality. This variety is more tolerant to virus and soft-rot disease. Disease and pest infestation is comparatively less. It is a rabi (winter) season crop. **Bulb yield:** 6-7 t/ha. **Duration:** 140-150 days.	
BARI Roshun-2 (2006)	High yielding variety. **Plant height:** 56-58 cm and 9-10 leaves per plant. **Number of cloves per bulb: 23-24 and weight of bulb:** 22-23g. Very good keeping quality. It takes more time to maturity depending on the weather condition. Resistance to viral disease. This variety has less infestation of pest and disease. It is a winter season crop. This variety is cultivated in all areas of Bangladesh. **Bulb yield:** 8-9 t/ha. **Duration:** 145-155 days.	

2.2 Production Technology

Land andsoil

Garlic can be cultivated in various types of soils but well drained fertile loamy soil is suitable for this crop.

Seed rate

The amount of planting material required varies from 700-1000 kg/ha, depending upon the weight of individual cloves planted and the spacing used.

Seed treatment

- Soak the selected cloves for 5 minutes in a solution of Ipridione (3 g/l) and Tufgor (2 ml/l).

- The treated cloves are then dried in shade till these are free from moisture by spreading on the floor. Then the cloves are ready for planting for the next day.

Time of sowing

Last week of October to 1st week of November is the suitable time for planting of garlic.

Sowing method

Garlic can be planted by following ways**:**

- Dibbling- Fields are divided into small plots convenient for irrigation.
- Furrow planting- Furrows are prepared at appropriate spacing (15 cm x10 cm) with hand hoe.
- Broadcasting-Cloves are scattered evenly in well leveled field/seed beds by hand.

Land preparation

Land should be brought to fine tilth by shallow ploughing 4-5 times, giving sufficient interval between two ploughings. Land should be levelled and divided into small plots and channels to facilitate proper irrigation and intercultural operations.

Fertilizer dose and application method

Manures and Fertilizers	Total amount /ha	At the time of last ploughing	1st installment (60 DAP)*	2nd installment (90 DAP)	3rd installment (110 DAP)
Well decomposed Cowdung	5 ton	All	-	-	-
Urea	217 Kg	109 kg	54 kg	54 kg	-
TSP	267 Kg	all	-	-	-
MP	333 Kg	167 kg	83 kg	83 kg	-
Gypsum	110 Kg	All	-	-	

* DAP= Days after planting

Full dose of cowdung should be incorporated in the soil at the time of land preparation. Full dose of TSP and gypsum should be applied as basal dose at the time of planting. Half amount of urea and MP should be applied at the time of final land preparation and the rest amount of urea and MP should be applied as top dress after 60 and 90 days of planting. If necessary, urea should be given at 110 DAP.

Irrigation

During land preparation, if soil moisture is not sufficient, it is necessary to irrigate the field a day or two days earlier. In case the soil becomes too wet after irrigation, the field should be allowed to dry until the desired moisture level is attained. Enough moisture is essential within the root zone during the vegetative growth. The frequency of irrigation depends on the soil type and occurrence of rainfall during the growing period. Clay loam soils are required three times irrigation but sandy soil requires frequent irrigation. Flash irrigation can be applied when crevices or cracks

on clay loam soils appear. Water should never be allowed to stay in the field beyond six hours. Irrigation starts just after planting and ends 20 days before harvesting.

2.3 Intercultural Operation

Generally 2 to 3 weedings are needed. First weeding should be done one month after planting, second one month after first weeding and third at later stage of crop. Hoeing at the time of bulb formation (75 DAT) helps in setting of bigger well filled bulbs.

Pest Management

Major insects and control measures:

Thrips *(Thrips sp.)*: Both nymphs and adults feed on the plant. They suck the sap of the plant from younger leaves to the growing points. The older leaves become withered or blasted in appearance.

Control measures:

- Thrips population is at its peak usually from late January to March, so early planting (October) is desirable.
- Burning of infested leaves.
- Spraying of chemicals (Imidacloprid/Fipronil) @ 1ml/l of water.

Mites *(Aceria tulipae)*: The pest is either seed-borne or mulch-borne. The affected plants become twisted and distorted with yellowish or pale-green streaks on the leaves. The leaf blade may not emerge readily from the cloves and the leaves separate poorly after emergence. The damage is called "tangle top."

Controlmeasures:

- Treat seeds with recommended chemicals.
- For field infestation, apply the Virtimec @ 2 ml/l water as early as the sign of infestation appears and repeat at 7 to 10 days interval until the pest is controlled.

2.4 Harvesting and Seed preservation

Garlic matures 140 to 160 days after planting. Indices are the softening of the main stem above the bulb and the yellowing of 75% of the leaves. Harvesting is usually done by pulling the individual plants by hand. The harvested bulb can be sun or air-dried for 3 to 4 days. After that 50 to 100 pieces bulbs aretied together.

Seed preservation:

- The farmers store their produce under ambient storage conditions by hanging the bundles in rows with bamboo stick or lumber in a well ventilated place.
- To minimize pest infestation during storage, clean and dry the area.
- Before the stocks are stored, spray the area with Melathion or other insecticides recommended for the control of storage pest.
- Regularly spray the surrounding with the recommended insecticides to prevent the occurrence of insect pests.

3. Chilli

Chilli is an important income generating crop and is well known mainly as a spices crop. Its demand is very high both in green and mature stages. Green chilli contains more Vitamin C than ripened chilli. About 60% yields could be losing due to improper time of weeding and management. At present, it occupies 1.05 lac hectares and produces about 1.76 lac metric tons (BBS, 2011).

3.1 Varieties

One high yielding variety of chilli has been developed by BARI named as BARI Morich-1 (Bangla lanka). A brief description of this variety with some important characteristics is furnished below.

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Morich-1 (Bangla Lanka) (2001)	**Plant height:** 30-35 cm with spreading 50-60 cm. **Number of fruits per plant:** 400-500 and **weight:** 700-750g, respectively. **Number of seeds per fruit:** 70-75. Thick pericarp. **Hotness:** Hot. Pest and disease infestation is comparatively less. Suitable for round the year cultivation. **Fruit yield:** 10-12 t/ha for green and 2.5-3.0 t/ha for dry chilli. **Duration:** 180-200 days.	

3.2 Production Technology

Land andsoil

Chilli crop grows on a wide range of soil but well drained sandy-loam soils with good fertility and moderate P^H (6.0-7.0) is the best for chilli cultivation.

Seed rate

About 0.8 to 1 kg of good quality seed sown in 100 sq.m. of area would give sufficient seedlings to transplant in one hectare of land with minimum germination of 75%.

Seed treatment

Seed treatment with Bavistin (Carbendazim) or any other systemic Fungicide @ 3 g/kg seed, as a plant protection measure against seed-borne diseases is desirable.

Time of sowing

In Bangladesh, September-October for the rabi (winter) seasonand the other February to March for the kharif (summer) season.

Seedbed preparation

Well drained, fertile and elevated areas in partial shade is preferred for raising seedbed and the selected area is to be cultivated, pulverized and levelled to bring the soil to a fine tilth. Seedbed measuring 1 m wide and 20-30cm high and of convenient length (3-5m) is required. In seedbeds well-decomposed cowdung @ 5-10 kg/bed is to be incorporated. Seedbeds should be provided by 30 cm width drainage channels.

After the completion of sowing (soaked seeds) the seedbeds are covered with gunny bagsor rice straw for about 72 hours and watered immediately for enhancing/accelerating germination.

Land preparation

Land should be brought to fine tilth by shallow ploughing 4-5 times, giving sufficient interval between two ploughings. Land should be levelled and divided into small plots and channels to facilitate proper irrigation and intercultural operations.

Sowing method

4-6 weeks old (10-15 cm tall) seedlings are transplanted, preferably during evening time and watered immediately to avoid transplanting shock.

Usual spacing for rabi season (40 cm x 40 cm) with population of 62,500 per hectare is required. But in summer transplanting at a spacing of 50 cm x 50 cm with population of 40,000 per hectare is required. Transplanting is a better method than direct seeding.

Fertilizer dose and application method

Chilli crops have a long growing season, so judicious use of manures and fertilizers is needed. Fertilizer dose and application methods are given below:

Manures and Fertilizers	Total amount /ha	At the time of last ploughing	1st installment (60 DAP)*	2nd installment (90 DAP)	3rd installment (110 DAP)
Well decomposed Cowdung	5-10 ton	All	-	-	-
Urea	210 Kg	-	70	70	70
TSP	300 Kg	All	-	-	-
MP	200 Kg	100	33	34	33
Gypsum	110 Kg	All	-	-	
Borax	3 Kg	All	-	-	-

* DAP= Days after planting

Irrigation

Maintenance of uniform soil moisture is essential to prevent blossom and fruit drop. The crop should be irrigated frequently depending upon the moisture retention capacity of the soil, amount and frequency of rainfall and evapo-transpiration. Generally, in Bangladesh 5-6 irrigations are needed. Two most critical stages of moisture stress in chillies are the initial establishmentof transplanted plants and the stage prior to blossoming. Water stress during the reproductive stage results in lower yield compared to stress imposed during the vegetative phase. So, it is needed to maintain the soil moisture regime at field capacity right after transplanting till harvest. Water should never be allowed to stay in the field beyond six hours. Excess water or water logging is harmful to plants and make scongenial environment for phytopthora wilt disease to explode and completely destroy the crop.

3.3 Intercultural Operation

Two to 3 hand weddings and 3 hoeing are necessary. Bunds, earthing up twice are also desirable.

Pest Management

Major insects and control measures:

There are a number of species of insects and pests, causing damage to chillies in Bangladesh. Amongthese pests: Thrips, mites, aphids and fruit borers are of serious in nature.

Thrips: Thrips and mites cause leaf complex of chilli. Both nymphs and adults damage the crop. They lacerate the leaf tissue and suck the sap. The infested leaves develop crinkles and curl upwards. The severely infested plants develop bronze colour.

Control measures:

- Regent/ascend granules (16 kg/ha) as soil application at the time of transplanting followed by 3-4 sprays of 0.06 per cent Imidacloprid / Fipronil at 10-12 days interval is found effective.

Mites: Mites occur throughout the year under field condition. However, two peak periods of infestation are October-November and March-April. The favourable temperature and humidity requirements for the mites are 18^0-25^0C and 80-90% respectively.

Both nymphs and adults suck the cell sap. They feed exclusively on the lower surface of the leaves. The affected leaves curl downward along the margins of the leaf and appear like inverted boat shape.

Control measures:

- The chemicals recommended for effective control of mites are Vertimec (2 ml/l water) and Movento (1ml/l water).
- Alternate use (at an interval of 10-15 days) of these two chemicals is found very effective.

Aphids

Control measures:

- Aphids are controlled by spraying Movento (1 ml/l water),Imidacloprid (0.06 ml/l) and Quinalphos (2.5 ml/l water).
- Alternate use (at an interval of 7-10 days) of these insecticides are found very much effective.

Pod borers: Pod borers are polyphagaous and appear both in vegetative and reproductive phase. Borers enter Chilli pods by second and third instars by making a hole near calyx and feeds on chilli seed. The affected pods drop off or develop white colour on drying.

Control measures:

- Quinalphos (2.5 ml/l water), Cypermethrin (2 ml/l water) and Chloropyriphos (2.5 ml/l water) are used for controlling pod borers of chilli.
- Set up pheromone traps for Spodoptera litura at 12 number/ha.

3.4 Harvesting and Seed preservation

The stage of maturity at which chililes are picked depends on the type and purpose for which they are grown. Chillies used for drying are picked at full ripe stage. For vegetable purpose, at green but full grown and for pickle at either green or ripe stage. Chilli seeds are stored either in polyethylene or glass/ plastic containers in cool and dry place.

4. Turmeric

Turmeric is very popular in Bangladesh as a spice crop. It is also widely used for medicinal purpose. At present, its production is very low in comparison to requirement. It is possible to increase production by using HYV and improve production technology. In Bangladesh, about 23.1 thousand hectares is cultivated and produces about 1.25 lac metric tons (BBS, 2011).

4.1 Varieties

A brief description of BARI developed varieties and their important characteristics are given below:

Name of Varieties (Year of Release)	Important Characteristics	Crop
BARI Halud-1 (Dimla) (1988)	**Plant height:** 105-120 cm with 9-10 leaves per plant. **Number of finger:** 7-8 and weight of "Motha" (Primary rhizome): 125-130g per plant. Rhizome weight per hill or clump: 400-420g, core color is yellow. Suitable for all over Bangladesh. **Rhizome yield:** 28-32 t/ha. **Duration:** 270-300 days.	
BARI Halud-2 (Sinduri) (1988)	**Plant height**: 60-70cm. **Tiller number per plant:** 2-3 and **number of finger per plant:** 7-8.**Weight of motha (primary rhizome):** 85-90g, **Rhizome weight per clump:** 375-380g. Core color is deep yellow. Suitable for all over Bangladesh. **Rhizome yield:** 20-25 t/ha. **Duration:** 240-270 days.	
BARI Halud-3 (2000)	**Plant height:** 110-125 cm. **Rhizome weight per plant:** 150-180g and **Rhizome per clump:** 700-800g. Core color is deep yellow. **The moisture percentage of dry matter:** 14-15%. Suitable for all over Bangladesh. **Rhizome yield:** 25-30 t/ha. **Duration:** 270-300 days.	

4.2 Production Technology

Land and soil

Turmeric can be grown in different types of soil, but it thrives best in well-drained, fertile, sandy loam to silty loam soil, rich in humus. It should be grown on medium to high land situation. It cannot stand water stagnation or alkalinity.

Seed rate

Seed (rhizome) rate 2000-2500 kg/hectare. Seed (rhizome) weight of 20-25g is preferable as planting material.

Seed treatment

Rhizomes are to be treated with Bavistin or Dithane M-45 @ lg/l water. Seeds are to be soaked in fungicides for about 30-45 minutes and dried in shade.

Time of sowing

Turmeric is generally planted between mid-March to April with the receipt of pre-monsoon rainfall.

Land preparation

The land is deeply ploughed 4-5 times to bring them to a fine tilth. Manure is incorporated during land preparation. Weeds, stubbles, roots are removed. Beds of 1.0-1.5 m width, 25 cm height and of convenient length are prepared with spacing of 50 cm between beds.

Sowingmethod

Two planting systems/ methods are followed:

- Raised Flat bed
- Furrow and ridge

Seeds are planted in 50-60 cm row and 25 cm between plants in row**.**

Fertilizer dose and application method

Whole amount of Cowdung, TSP, Gypsum and half of MP is applied during land preparation. Half amount of urea is to be applied at 50 days after planting as top dressing. Rest amount of urea and MP are to be applied at 80 and 110 days after planting as top dress. Total amount of manures and fertilizers are furnished in the following table.

Manures and Fertilizer	Total amount (/ha)	Last ploughing time	1st installment (50 DAP)*	2nd installment (80 DAP)	3rd Installment (110 DAP)
Cowdung(decomposed)	5.0 ton	All	-	-	-
Urea	304 Kg	-	152	76	76
TSP	267 Kg	All	-	-	-
MP	233 Kg	116	-	59	58
Gypsum	110 Kg	All	-	-	

*DAP= Days after planting

Irrigation

Mainly rain fed. Depending on the soil types and weather conditions, 6-8 irrigations may be required.

4.3 Intercultural Operation

Earthing up: After each top dress operation, the plants are to be earthed up.

Mulching: The crop is to be mulched immediately after planting with green leaves, rice straw, or banana pseudo stem or sugarcane trash etc. @ 12-15 t/ha.

Weeding: Weeding should be done thrice at 60, 120 and 150 days after planting depending upon weed intensity.

Pest Management

Major diseases and control measures:

Turmeric leaf spot *(Colletotrichum capsici)*

Control measures:

- Use disease free seed (rhizome).
- Treat the rhizome by steeping in a mixture of Dithane M-45 @ 2.5 g/l water and Bavistin @ 1 g/l water for about 60 minutes before storage as well as before emergence.
- Leaf spot can be controlled by spraying Bavistin@ 1-2 g/l water or Mencozeb @ 2 g/l water at 10-15 days interval for 2-3 times. The first spray must be at 30 days after emergence.

Turmeric leaf blotch (*Taphrina maculens)*

Control measures:

- Use of disease tolerant/resistant variety.
- Use disease free seed (rhizome).
- Rhizomes should be treated by steeping in a mixture of Dithane M-45 @ 2.5g/l water and Bavistin @1g/l for 60 minutes before storage as well as before emergence.
- Leaf blotch can be controlled by spraying Bavistin@1-2g/lor Mencozeb @ 2g/l water at10-15 days interval for 2-3 times. The first spray must be at 30 days after emergence.
- In severe infection spraying of Score or Foliqur @ 1ml/l of water at 7-10 days interval for 2-3 times.

Major insects and control measures:

Rhizome fly (*Mimegralla coeruleifrons)* Macq.

Shoot borer (*Conogethes punctiferalis)*

Control measures:

- Affected shoots should be destroyed.
- Spraying Melathion 2 ml/l of water at 30 day intervals or Carbosulfan 2 ml/l of water or Imidacloprid 0.5 ml/lofwater or Lambda-cyhalothrin 1 ml/l of water during July to October at 21 days interval.
- The spraying has to be initiated when the first symptom of pest attack is seen on the inner most leaves on the pseudo stem.

Leaf roller *(Udaspes folus)*

Control measures:

- Hand picking of caterpillers helps in reduction of insect population.
- Spraying with carbaryl 2 g/l water or dimethoate 2 ml /l water is effective for insect control.

Thrips *(Panchaetothrips indicus)*

Control measures:

- Spray water with detergent powder should be done.
- Spraying Dimethoate1 ml/l or Lambda-cyhalothrin1 ml/l water or Metasystox are effective for the control of this pest.

4.4 Harvesting and Seed preservation

Harvesting: The maturity of the crops is indicated by complete drying up of the plant including the base of stems. Depending upon the variety, the crop becomes ready for harvest in 7-10 months after planting. Early varieties mature in 7-8 months, medium varieties in 8-9 months and late varieties in 9-10 months.

The land is ploughed and rhizomes are gathered by hand picking or the clumps are carefully lifted with the spade. The land may be irrigated (if needed) 6-7 days before harvest. The harvested rhizomes are cleaned and other extraneous materials adhering to them are removed.

Preservation: Rhizomes for seed production are generally stored by heaping in well ventilated rooms and covered with turmeric leaves. The seed rhizomes can also be stored in pits and covered with soil or sand or saw dust.

VIII. FIBRE CROPS

1. Jute and Allied Fibres

Jute is an important industrial crop in Bangladesh. The sector creates employment in jute agriculture, trade, industries and helps in food security by getting foreign currency (6%) from the export of raw jute and jute products. Bangladesh ranks second among the jute growing countries. The crop is a versatile and environmental friendly bio-degradable natural fibre. During 1971-72 more than 6.78 lac hectares land were under jute cultivation but currently the area has dropped to 4.2 lac hectares. The present production is 5.09 lac bales or 9.16 lac tons (1 bales= 180 kg). Bangladesh Jute Research Institute has developed a number of jute varieties. The important characteristics of these varieties and their production technology are stated below.

1.1 Varieties

Jute is an annual and short day plant of the genus *Corchrous* of the family Tiliaceae. It is grown primarily for its fibre which has large commercial importance in the world. Two cultivated species, namely White *(Corchorus capsularis* L.*),* Tossa *(Corchorus olitorius* L.*)* and other allied fibres Kenaf (*Hibiscus cannabinus* L.) and Mesta (*Hibiscus sabdariffa* L.) are grown in Bangladesh.

Bangladesh Jute Research Institute (BJRI) has so far (upto 2011) released a total of 41 varieties of white jute, tossa jute, kenaf and mesta. Although white jute varieties produce finer fibre as compared to tossa jute varieties, the low yield of the former has led to the preference for the later among the resource-poor jute farmers. The most popular varieties of white jute, tossa jute, kenaf and mesta along with their important characteristics arestated below:

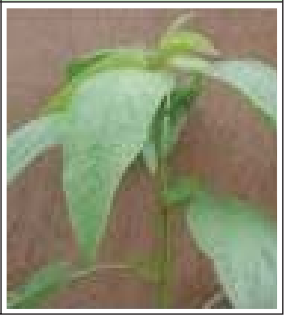
A. Brief discussion of popular white jute varieties *(Corchorus capsularis* L.*)* and their important characteristics.

Name of Varieties (Year of Release)	Important Characteristics	Crop
CVL-1 (1977)	Full green, stipule green, petiole green, leaf ovate lanceolate. **Leaf length breadth ratio:** 2.1:1. Fruit green, single or cluster of 2-4, seeds chocolate brown. **Plant height:** 3.0- 3.25 m. **Fibre recovery:** 6.51%. Most tolerant to mosaic virus. Fine and strong fibre, less cutting, suitable for late sown areas. Late aman can be transplanted after Jute harvest. **Fibre yield:** 5.16 t/ha. **Duration:**120-130 days for fibre.	

Name of Varieties (Year of Release)	Important Characteristics	Crop
CVE- 3 (1977)	Stem green, bright coppery red on older branches, upper portion of the petiole and stipule bright coppery red. Leaf ovate lanceolate, length breadth ratio of lamina: 2.1:1. Fruit bright red, single or in cluster of 2-5, seeds chocolate brown. **Plant height:** 3.0-3.5 m. **Fibre recovery:** 5.91%. Fibre fine and lustrous. Suitable for early sown area. Quick growing variety. Early maturing. Early aman can be transplanted after Jute harvest. **Fibre yield:** 4.52 t/ha. **Duration:** 110-120 days for fibre.	
BJRI Deshi Pat-5 (1995)	Stem tall, cylindrical, and unbranched, leaves serrated, upper surface of the petiole coppery red, fruit round capsule and light coppery red at young stage. **Plant height:** 3.00 to 3.50 m. **Fibre yield:** 2.75-3.25 t/ha. **Duration:** 110-120 days for fibre.	

B. Some popular tossa jute varieties (C. *Olitorius* L) and their important characteristics:

Name of Varieties (Year of Release)	Important Characteristics	Crop
O-9897 (1987)	Fully deep green, unbranched, leaves ovate deep green, succulent, fruit indehiscent, leaves ovate lanceolate. Length breadth ratio of lamina 2.7:1. Fruit green, cylindrical indehiscence, single or in cluster of 2-5, seeds brown with green tinge on seed coat. **Plant height:** 4.0-5.5 m. **Fibre recovery:** 6.70%. Fibre fine, strong and less cutting. Short day insensitive, free from premature flowering, wide time of sowing, suitable for 3-crop pattern. Early aman rice can be transplanted after early jute harvest. **Fibre yield:** 4.67 t/ha. **Duration:** 120-130 days for fibre.	
BJRI Tossa Pat-4 (2001)	Stem tall, unbranched, cylindrical and green, length breadth ratio of leaves: 1.2:2. Flower regular, sepal-5, normal green, petals-5, deep yellow, fruit cylindrical, long pod green, indehiscent, seeds brownish grey, 120-125 seeds per capsule, **1000-seed weight:** 2.21g. **Plant height:** 4.0-4.5 m. **Fibre recovery:** 6.70%. Less photosensitive, fibre fine, strong and least cutting than the existing varieties. **Fibre yield:** 4.81 t/ha. **Duration:** 120-130 days for fibre.	

Name of Varieties (Year of Release)	Important Characteristics	Crop
BJRI Tossa Pat-5 (2008)	Stem reddish in colour depends on sunlight, unbranched, stem cylindrical, stipule red. Length breadth ratio of leaves 1.2:1. Flower regular, petal-5, sepal-5. Fruit cylindrical, long pod, indehiscent. Seed bluish, 120-125 seeds per fruit. **1000-seed weight:** 2.2g. **Plant height:** 3.0-4.0m. **Fibre recovery:** 6.70%. Less photosensitive, fibre bright golden, strong and less cutting. **Fibre yield:** 5.0 t/ha. **Duration:** 120-130 days for fibre.	

C. Popular kenaf varieties *(Hibiscus canabinus* L.*)*and their important characteristics:

Name of Varieties (Year of Release)	Important Characteristics	Crop
HC- 95 (1995)	Stem tall cylindrical, unbranched, whole plant deep green, leaves lobed, the petal is light cream colour with very pink tinge on the inner basal part of the petals. Fruit capsule ovoid, indehiscent, seeds subreniform grayish brown. **Plant height:** 3.5-4.0m and fibre recovery: 6.23%. Fibre is bright and shiny. Suitable for medium low, less fertile and flood affected land. Green plants are excellent raw materials for paper pulp. Seeds contain about 20% edible oil. **Fibre yield:** 5.45 t/ha. **Duration:** 130-140 days for fibre and 180 days for seed.	
BJRI Kenaf-3 (2011)	Stem tall cylindrical, unbranched, whole plant green, the stem may become purple at maturity subject of exposure to light. Leaves simple cordate stipule folicious serrated, wavy. Petals light cream colour with a very light pink tinge on the inner basal part of the petals. Fruit capsule ovoid, indehiscent, seeds subreniform grayish brown. **Plant height:** 5.2-6.0 m and fibre recovery: 7.30%. Fibre is bright and shiny. Suitable for medium low, less fertile and flood affected land. High biomass and fewer prickles. Green plants are excellent raw materials for paper pulp. Seeds contain about 20% edible oil. **Fibre yield:** 6.65 t/ha and **Duration:** 130-140 days for fibre.	

D. Popular Mesta varieties and their important characteristics:

Name of Varieties (Year of Release)	Important Characteristics	Crop
HS-24 (1977)	Stem green with nodes purple, pigmented leaves fine lobed, petiole is smaller than lamina. Leaves 5 lobed with lanceolate segments which are serrated, central lobe longest, leaf lobed dark green with veins and margins purple, rough sepals light green with purple spots at maturity. Petals yellow with crimson red at the inner basal portion, fruits capsule ovoid hairy, dehiscent seeds dull brown reniform. **Plant height:** 4.0-6.0 m and fibre recovery: 6.23%. Suitable for high, less fertile and drought affected land. Transplanted aman can be grown after jute harvest. Resistant to root-knot nematodes. Seeds contain about 20% edible oil. **Fibre yield:** 4.70 t/ha and **Duration:** 150-160 days for fibre.	
BJRI Mesta-2 VM-1 (2010)	Dwarf, bushy, greenish purple red, prickles and bristles absent in the stem and leaves branched, stem green with nodes purple, pigmented leaves fine lobed, leaves sour taste, 3-5 lobed with lanceolate segments which are serrated, central lobe longest, leaf lobed dark green with veins and margins purple, flower petals light yellow colour, fleshy calyces on their flower buds. These calyces are used for many culinary purposes and preparation of Jam, Jelly, Tea and juice. **Plant height:** 3.0-3.5 m. Suitable for high, less fertile and drought affected land. Seeds contain about 20% edible oil. **Yield:** 2.0-2.5 t/ha and **Duration:** 100 days for vegetables.	

1.2 Production Technology

Soil and climate

Jute is widely grown in sandy loams, clay loams with varying soil management practices. Sandy soils and heavy clay soil are unsuitable for jute production. Soil with a low pH give a poor crop. The optimum pH is around 6.4. High and medium high land where rain and flood water does not stand is suitable for tossa jute cultivation. In the seedling stage water logging is not tolerated by both species. Jute requires a warm and humid climate with temperature fluctuating between 24^0C and 37^0C. The permissible relative humidity favorable to growth ranges between 70 and 90 percent. Rainfall is one of the most important factors for growing jute and the ranges from 250-270mm are essential requisite for good growth and yield of jute.

Seed rate

Proper seed rate is the main factor for plant population, growth of jute plant and for obtaining maximum yield. Quality seeds of an improved variety itself provide 20% additional yield of the crop. However, seed rate varies depending on crop establishment method provided germination percentage of seed being 80% or above.

A. Broadcast method	**Seed rate (kg/ha)**
C. capsularis (white)	7-8
C. *olitorius* (tossa)	5-6
H. cannabinus (kenaf)	13-14
H. sabdariffa (mesta)	12-13

B. Line sowing method	**Seed rate (kg/ha)**
C. capsularis (white)	5-6
C. *olitorius* (tossa)	3-4
H. cannabinus (kenaf)	11-12
H. sabdariffa (mesta)	10-11

Seed treatment

Jute, Mesta and Kenaf suffer from a number of diseases and pest. Among the seed borne diseases, only leaf mosaic is caused by virus, while the rests are caused by fungal diseases, viz. stem rot, black band, seed rot, seedling wilt, foot rot etc. which are frequently transmitted through seeds. These diseases can cause up to 30-70% yield loss. So seed treatment with Vitavax-200 (0.4%) i.e. for one kg of seed with 4gm Vitavax-200 or Provax-200 (0.4%) before sowing of seeds or preservation of seed is very useful to control all fungal seed borne diseases of jute and allied fibre crops.

Time of sowing

Different varieties have their respective time for sowing. If sown untimely the growth is retarded and yield is reduced. When sown earlier, premature flowering occurs and yield is drastically reduced with deterioration in quality. Generally the sowing of *capsularis* varieties starts from late February to April in low lying areas that retain moisture of the previous flood or monsoon. On the other hand *olitorius* jute seeds are sown from 15 March to April. For seed production, the suitable time of seed sowing/cutting is mid July to last week of August. Sowing time varies 15-30 days from North to South.

Land preparation

Jute land should be well tiled right after the first pre-monsoon shower. Depending on the previous crops and its soil texture, it requires a clean, clod-free field with fine tilth. The land therefore, needs two ploughings and two cross ploughings and harrowings for a sufficient preparation to a depth 10-15cm followed by laddering. Jute seed being a very small requires fine tilth for better emergence and establishment of seedlings. Clay soil needs more ploughing than sandy or sandy-loam. Kenaf and Mesta seeds being large in size which do not require fine soil tilth as in jute.

Sowing methods

The traditional method of sowing of jute is by broadcasting and line/row sowing. Line/row cropping has proved advantageous and a single or double row seed drill used for the *capsularis* and *olitorius* varieties are 30 and 20 cm apart respectively. The plant to plant distance is manually adjusted between 5 cm and 7 cm. Sowing is always done in shallow depth (3-4 cm). Adjustment in spacing is permissible on the basis of fertility of the soil. Row planted jute is more uniform, easier to cultivate, thin out, harvest and ret easily. Besides, the yield is substantially higher and fibre is more uniform. Row sowing requires additional labour and better soil preparation. Plant spacing 3cm by 8cm gave 9.7% more fibre and reduce weeding labor by 29% and harvest labour 10% as compared with broadcast seeding. Besides, line sowing (30 cm x 5 cm) increased the fibre yield by 12-25% and reduced the cost of cultivation by about 30% over broadcasting sowing method.

Fertilizer application

The yield of jute may be increased by the application of right kinds, quantities, methods and time of application of fertilizers. Fertilizers are organic materials of concentrated nature, they are applied mainly to increase the supply of one or more of the essential nutrients, i.e. nitrogen, phosphorus and potash. The use of manures (organic matter) and fertilizer is complimentary and not as substitute for each other. It was observed that among the nutrients, nitrogen is mainly responsible for increasing yield. Phosphorus or potassium alone does not increase yield which improves the fineness of fibre and potassium controls the disease of jute. The combinations of nitrogen, phosphorus and potassium interact together to give an extra fibre yield of 1000 Kg/ha. If cowdung used 5 t/ha then fertilizer urea dose could be reduced and TSP and Zinc sulphate would not be required. The variety wise required recommended fertilizer doses are given in the following Table.

Time and amount of fertilizer application (kg/ha) of Jute, Kenaf and Mesta fibre production

Variety	Urea		TSP	MP	Gypsum	Zinc Sulphate
	At basal	45 DAS	At basal	At basal	At basal	At basal
Deshi:						
CVL-1	83	83	25	30	45	11
CVE-3						
Tossa:						
O-9897	100	100	50	60	95	11
BJRI Tossa pat-4	88	88	50	40	95	11
BJRI Tossa pat-5	83	83	50	40	95	11
Kenaf:						
HC-95	66	66	25	30	-	-
Mesta:						
HS-24	55	55	25	-	-	-

* DAS= Days after seeding

Irrigation

Jute is a rainy season crop. There is no need for irrigation. If moisture is not sufficient enough in the field after sowing of seeds or before sowing of seeds, light irrigation is given for proper germination. Later on this crop is irrigated when the plants are 10 to 12 cm tall and 3-4 leaves are formed. Supplemental irrigation may be given to the crop according to requirement of the crop. The field should not be irrigated too much, but care should be taken that the field does not become dry and compact and the root development is hampered.

1.3 Intercultural Operation

Weeding is one operation which can increase crop yield. Efficient weeding saves moisture, crop nutrients and to some extent air and light required for the cultivated crop. Intercultural operations are as follows:

- First weeding, mulching and simultaneous thinning should be done after 10-15 days of sowing (DAS).
- Second weeding, mulching and simultaneous thinning may be operated after 25-30 DAS.
- Third weeding, mulching and simultaneous final thinning and topdressing of urea fertilizer followed by hoeing may be operated after 40-50 DAS.
- The jute field should be kept clean to avoid infestation from insects and pests. So pest management care should be necessary.
- Excess water should not be allowed to stand in the plot at growing stages.

Pest Management

The intensive cultivation of high yielding varieties and fertilizer responsive cultivars of jute create problems of insect, pests and mites. So all stages of growth of the crop from seedlings to seed pod formation are subjected to attack by pests. Hairy caterpillar, *Spilosoma oblique* (walker), which is considered as a sporadic pest on jute has become a major threat to jute crop. Semilooper, *Anomis sabulifera* (guen), stem weevil, *Apion corchori* (Marshall), Yellow mite, *Polyphagtarsonemus latus* (Banks) and the indigo caterpillar, *Spodoptera exigua* (Hubner) are the major pest of jute. Tossa (*Corchorus olitorius*) jute occupies 80% of the jute growing areas as agonist 20% by the white jute (C. *capsularis*), but unfortunately the incidence of major pests is more on tossa than white jute.

Major insects and control measure:

Field Cricket (*Brachytrypes portentosus*)

The adult insect is blackish-brown in colour, measure about 5 cm in length and the hind legs are enlarged. It occurs in the field from the time of sowing to late May and causes damage to seedling of jute plants. As a result, the plants are lost in

Field Cricket

patches or the entire crop of the field is badly damaged. In such a situation re-sowing becomes necessary. Damage increases when drought conditions prevail early in the season but decreases after heavy rainfall. Seedling jute plants above 18 cm escape the cricket attack.

Control measures:

- In localities where infestation occurs every year, higher seed rate may be used thereby increasing the initial plant population to offset losses due to field cricket attack. Thinning should be done when the plants attain about 20-25 cm tall.
- As and when field cricket burrows appear in the jute field, 'hole treatment' with recommended insecticide (Dursban 20 EC 3ml/l or 3.5 lit/ha 40 WP 2g/l. Vitanon 60 EC 1.60 lit/ha) is advised.
- Wherever possible infested fields should be flooded with water.
- Late sowing is preferred where field infestation occurs every year.

Jute Hairy Caterpillar *(Spilosoma obliqua)*


June Hairy caterpillar

It is a major pest of jute in Bangladesh. The adult insect is a pale buff colored, medium sized with black spots on the wings. The infestation starts from the middle of May and continues up to the end of August. Eggs are laid in clusters on the lower surface of the mature jute leaf. The young caterpillars remain gregarious for about 6 days on the lower surface of the leaves. Afterwards, they gradually disperse all over the field and defoliate the plants. In case of serious infestations the top shoots are also eaten up. Once the caterpillars have swarmed the field, nothing but bare stems will remain. As a result of infestation, the plants become stunted growth and yield reduced. The loss in fibre yield may vary from 75 to 200kg per acre depending on the intensity of infestation.

Control measures:

- Hand picking of egg masses and early instar larvae when they remain in a gregarious state and killing them by burning or in kerosinized water is considered to be the easiest method of control.
- After harvest the land should be ploughed well so that the pupae which remain in the soil or crevices are exposed to natural enemies.
- When the caterpillars are spread in the entire field, chemical control measures are necessary using recommended insecticide Hayzinon 60% EC or karate 2.5 EC, Riva 2.5 EC 1ml/L.

Jute Semilooper (*Anomis sabulifera*)

It is a serious pest of jute in Bangladesh. The adult moth is of dull brown colour having darker spots and wavy lines on the forewings. Field infestation begins from

middle of May when the plants are 60-90 cm tall and continues up to the end of July. A full grown larva is a typical semilooper and about 4 cm long. The female moth lays eggs singly on the ventral surface of the young leaves. Soon after hatching the larva becomes active and feeds on young leaves. There are 2-3 generations of jute semilooper during the jute season.

Semilooper

As they grow the larvae feed on leaf buds and top shoots. As a result of infestation growth is inhibited and side branches develop. The loss of fibre is about 75 to 100kg/acrc and the quality of fibre reduced. Control measures should be adopted when the infestation reaches 20 per cent.

Control measures:

- If perches are provided for insectivorous birds, they will eat up large number of semiloopers and help in controlling the pest considerably.
- A. Telinid fly (*Tricholyga sorbilans*) parasitizes jute semilooper larvae during June and July. The larvae of the parasite feed on the internal tissue of the host. The parasite is effective in reducing semilooper population.
- Spraying with any one of the recommended insecticides (Hayzinon 60 EC or Nokon 60 EC or Ekalux 25% EC) can give satisfactory control.

Stem Weevil *(Apion corchori)*

It attacks jute plants at all stages of growth from seedling to harvest. The adult insect is a small dull black weevil measuring about 2 mm in length. The rostrum is short cylindrical and gently curved. The female weevil bores on the stem and deposits eggs singly. After hatching, the grub feeds on the bark internal tissues of the stem. As a result of injury, mucilaginous and gummy substances accumulate around the wound cementing the larval excreta with the adjoining tissues. On retting it does not dissolve and forms a 'knot' with black stain on the fibre which causes lower fibre quality.

Stem weevil

In the early growing period the weevil attacks the top shoot for laying eggs. The activity of the grub damages the top shoot and causes development of side branches and deterioration of fibre quality.

Control measures:

- Removal and destruction of infested plants during early season could give effective control of the pest.
- Removal of Bon-okra (*Triumfetia rhomboidea*) and other shrubs and bushes during winter offers a possible reduction of Apion population.

- *C. olitorius* L. jute is less susceptible to Apion. An increase of this jute cultivation will minimize jute weevil damage.
- A high percentage of jute weevil grubs are attacked by two important parasites (Entedon sp. and *Bracon greeni*). The parasites are very useful in controlling the pest as they cause a high mortality of the grubs.
- It is desirable not to stack the harvested jute for more than 3 days. Quick steeping of harvested jute will destroy the immature stages.
- Infested *C. capsularis* L. plants should be sprayed with any of the recommended insecticides (Metasystox 25 EC or Hayzinon 60% EC or Dimecron 60 EC). Mixing of 18 ml pesticide with 12 litre water is recommended for spraying.

Jute Yellow Mite *(Palyhagotarsonemus latus)*


Jute yellow mite

It is very small in size and cannot be seen by naked eye but the symptom of its attack can easily be recognized. Generally, mite infestation begins in mid May and continues till the end of July. However, late infestation may occur up to August. It attacks the apical leaves and cause damage by sucking the plant sap. As a result of infestation, the young leaves crinkle, dry up and fall down. The vertical growth of the internodes gets suppressed and side branches develop. In case of heavy infestation the top shoot dies and apical branches appear resulting in great loss in yield and deterioration of fibre quality.

Control measures:

- Population of jute yellow mite is greatly reduced after heavy rainfall.
- Spraying with lime-sulphur in the ratio of 1:20 has been found to give satisfactory control. A second spray within 40 hours after the first spray is recommended for adequate control.
- Green neem leaf extract of *Azadirachta indica* in the ratio of 2:5 has been found to give effective control against jute yellow mite. Dry leaf extract using boiling water (100 gr + 1 litre water) for 15 minutes and spraying would inhibit mite activities. However, a second spraying within 40 hour is recommended for a satisfactory control.
- Spray the infested fields using recommended miticide (Kelthan 42% EC or Torque 55% WSC or Nerot 50% EC) when the infestation become serious.

Mealy Bug (*Pseudococcus virgatatus*)


Mealy bug

The infestation appears in mesta and kenaf field in July. The adult is elongate to oval in shape and pink in colour. They form colony and remain covered by waxy filaments. Both adults and nymphs feed on plant sap causing swelling of the terminal shoot. Such infestation reduces the plant height and induces side branches. The injury causes formation of "Witches broom".

Control measures:

- At the beginning of attacks the tops of infested plants should be removed and destroyed.
- Infested fields should be sprayed with any of the recommended insecticides.

Spiral Borer (*Agrillus acutus*)


Spiral borer

It is a key pest of kenaf (*Hibiscus cannabinus L.*) in Bangladesh. It has recently been causing considerable concern in the production of kenaf. In a normal season field infestation of spiral borer starts in mid-July or more precisely 70-80 days after planting. At the time of initial infestation, the plants are about 120-130 cm tall and continue till harvest. The larval stage causes the damage. It burrows upward around the stem in a spiral fashion leading to the reed becoming wiry, brittle or remains attached to the stick during extraction of fibre, thus causing deterioration of fibre quality. It has been observed that nearly 65 per cent of borer attacks occur within the lower 1 meter and 92 per cent within 2 meters above soil level. This information may conveniently be utilized for its economic control.

Control measures:

- The incidence of the pest can be reduced by varying the time of sowing. Its infestation tends to decrease gradually with the shifting of sowing time beyond the month of April.
- Spraying of any one of the recommended insecticides Hayzinon 60% EC or vitanon 60 EC or Eka 25% EC can be sprayed. Covering the lower portion of the plant upto 2 cm above soil level will give effective and economic control.

Major diseases of jute, kenaf and mesta and control measures:

On the other hand jute suffers from a number of diseases; most are seed-borne. Among the seed-borne diseases, only virus causes the leaf mosaic, while rests were caused by fungal pathogens. Among the seed-borne fungal diseases, stem rot, black-band and anthracnose are caused by *Macrophomina phaseolina*, *Botryodiplodia theobromae* and *Collectotrichum corchori,* respectively and frequently transmitted from seed to plant to seeds. Even 60% to 70% jute plant may die in the field due to stem rot if no control measure is taken. The fungal jute pathogens, viz. *M. phaseolina*, *B. theobromae, Corchori*, *Fusrium rolfsi*, *Rhizoctonia solanii* are responsible for seed rot, post and pre emergence damping off, seedlings blight and transmission of the diseases to standing crops causing considerable yield loss and deterioration of fibre quality.The diseases and control measures are described below:

Stem rot

Leaf turns pale gray colour in the mid rib and turns black. The spot gradually grows lengthwise, encircles the stem, which internally rots and breaks the plant. As a result the plants die. The major disease of jute, stem rot, initiates at the seedling stage, when the plant height become 6 to 8 inches and it take place till adult stage of jute plant.

Brownish spot is noticeable on the leaves. These spots may be seen from the lower level to the apex of the plant. Black dots are present at the brownish pretentious place. Eventually the precious consign break down resulting in death of plant. Disease is disseminated by seed, soil and air. Deshi and Tossa jute are infected by this disease.


Stem rot diseases

Control measures

- Burn the crop debris.
- Spray Dithane M-45 @ 18.56g/10 litres water.
- Spray Dithane M-45, Manner M-45 @ 2g/1litre H_2O 2-3 times at the plant base soil.

Die back

Jute and kenaf plants usually the *Olitorius* varieties begin to dry from the tip downwards at almost full-grown stage. This fungus is seed and air borne. The affected part becomes brownish and the affected part drying from top to the lower part of the plant. The whole plant died off ultimately. Disease disseminated by seed, soil and air. Generally Tossa jute and Kenaf infected by this disease.


Die back diseases

Control measures:

- Two times spray of Dithane M-45 @ 18.56g/10 litres water at the interval of 2-3 days.
- Crop rotation with deshi jute instead of tossa, ii) Spraying of dithane M-45, Manner M-45 @ 2g/I litre water 2-3 times.

Wilting

Root system of affected plant becomes infested with a soil borne fungi. All the leaves become flaccid at a time and after few days dropping occurs. At the flowering stage, wilting occurs severely on jute plants. *Rhizoctonia solani* silted the whole plant and it becomes dried off which show the way to death of the plant. The *Olitorius* varieties are affected by this disease more than the Capsularis. Disease disseminated by seed and soil. Tossa jute is infected by this disease.


Wilting diseases

Control measures:

- The crop debris will be destroyed or burned.
- Crop rotaion will be maintained with Capsularis varieties
- Dithane M-45, Manner M-45 @ 18.56g/10 litres water.

Seedling blight

At seedling stage the basal portion of the plant showed brownish to blackish lesion & plant dies. Seed and soil borne pathogenwas responsible for this disease. Disease

disseminated by seed and soil. Seedling of Deshi, Tossa, Kenaf and Mesta are infected by this disease.


Seedling blight diseases

Control measures:

- Seed treatment with clove bata @ 125g/1 kg seed, Or Vitavex-200/provex-200 @ 4g/1 kg seed,
- Spraying of Dithane M-45 @ 2g/litre water 2-3 times at base of the seedling**.**

Black band

The lesion first appears as small black blackish brown patch, which gradually enlarges and encircles the stem making a black band around. This disease is seed, soil and air borne.

Disease disseminated by seed, soil and air. Deshi and Tossa jute infected by this disease.


Black band diseases

Control measures:

- Spraying of Dithane M-45, Manner M-45 @ 2g/I litre water 2-3 times.

Anthracnose

This disease is confined only to *C. capsularis* variety. Lesions coalesce to form a big canker, sometimes girdling the stem and shredding the fibre.
Disease is disseminated by seed, soil and air. Deshi and Tossa jute is infected by this disease.


Anthracnose diseases

Control measures:

- Seed treament with Vitavex-200/Provax-200 @ 4g/1 kg seed
- Crop rotation with rice, wheat etc.

Soft rot

The disease appears first near the ground level. Profuse white cottony mycelia growth occurs at the collar region of jute crop.

Disease disseminated by seed and soil. Deshi and Tossa jute infected by this disease.


Soft rot diseases

Control measures:

- Spraying of Dithane M-45, Manner M-45 @ 2g/1litre water 2-3 times at the base of the plant.

Root knot

Attack at early stage cause stunted and poor growth of plants with abnormal swollen tip and also produce severe gall formation in root systems. Disease disseminated by seed and soil. Deshi and Tossa jute infected by this disease.


Root knot diseases

Control measures:

- Crop rotation will be practiced.
- Soil treatment with Furadan-5G @ 16 kg/acre or 40 kg/ha of land.

Powdery mildew

At the end of the jute season fine white powdery mass appears to be accumulated on leaf-surface resulting fall of leaves, flower and fruits. Foggy weather is favorable for the growth. Disease disseminated by seed, soil and air. Deshi and Tossa jute infected by this disease.

Control measures:

- Spraying of Thiovit @ 32g/10 litres water just to see the symptoms.

Leaf mosaic

Yellow mosaic spots regular or irregular appear usually on *Capsularis* plants at any stage of growth affecting formation of chlorophyll. Disease disseminated by seed, soil and air. Deshi and Tossa jute infected by this disease.


Leaf mosaic diseases

Control measures:

- Uprooting of infected plants
- Spraying of Heyzine/Hemithrin @ 15ml/10 litre swater 2-3 times with 7 days interval.

Leaf curling

Due to leaf curling, the plants become pale, leaves turn into thick and rough. Due to leaf yellowing the top leaves of the plants become yellowish, mosaic pattern of green and yellow in which either the colour remain predominant.Disease disseminated by seed, soil and air. Deshi and Tossa jute infected by this disease.


Leaf curling diseases

Control measures:

- This disease can also be controlled by seed treatment using garlic paste. Before sowing seed should be treated with 125gms garlic paste per kg seed. After seed treatment with garlic paste seed should be dried in the sun for three days.

1.4 Harvesting and Seed preservation


Jute harvesting

Quality of jute fibre has direct relationship with stage of harvest. It could be harvested between 110-120 days. Early harvesting gives finer fibre of a good quality where late harvesting gives a large yield but a coarser fibre. But plants should be harvested at the early flowering stage. On an average, tossa jute varieties could be harvested 10 days before than deshi jute for good quality as well as yield. Harvesting is done by cutting the plants at or close to the ground level. Next the plants are tide in bundle loosely. Retting takes longer time if the bundles are tightly held. The retting microbes and water can not enter easily in tight bundle. The bundled jute plants should be kept stacked for 3-4 days in the field for defoliation. After defoliation it becomes ready for next operation of retting.

Retting

Anumber of methods have been developed and recommended for the improvement of fibre quality through retting. For retting gently flowing, fairly deep, clear and soft water is ideal. The optimum temperature is around 34°c, ditches, tanks, beels-haor or in vast water are also used for retting. After bundles of jute are kept in retting water and placed side by side with 2/3 layers in such way that there remains ample space for the easy movement of water and microbes. Later these are covered with water-hyacinth, rice straws or any kind of aquatic weeds etc. The float/jack is then weighed down with concrete blocks or are kept submerged (at least 10 cm below the surface water) with bamboo crating. Earth chunk, logs of banana, mango tree or any other green logs as covering or weighing materials should be avoided as they convert the fibre colour dark (shamla). In that case polythene-wrapped earth chunks can be used safely as it protects the plants to come in contact with clay. For accelerating the retting speed and improving the fibre colour, about one kg of urea may be applied in 1000kg of green jute plants. The urea may be added either in a water solution or sprinkled directly in the layers of the jute bundle in jute jaks. Retting is a microbiological process and, therefore, the end-point is determined by inspecting a few plants each day from the tenth day onward. If fibre slips out easily from the wood on pressure from the thumb and fingers, retting is considered complete.


Retting process

Fibre Extraction

The fibres can be extracted from the retted plants in two ways: (1) by taking one or two plants at a time sitting on the dry land or (2) by standing in knee-deep water and using a bamboo frame, a bunch of plants is taken out of the jak and the fibres are extracted from the whole bunch at a time by breaking the jute sticks at about 45cm from the bottom. In either of the two ways, if the bottom parts of the


Fibre Extraction

retted plants are scraped off by hand prior to extraction or beaten with a wooden beater the amount of cuttings are reduced significantly. Better fibres are obtained if extraction of fibres is done on the ground taking single or two plants at a time.After extraction, the fibres are washed thoroughly in clean water so that broken jute sticks, cuticular layer of barks, clay or any other dirts get free from fibres.

Removal of Shamla Colour (Dark Colour)

The shamla fibre (if produced due to improper practices) could be converted to bright and normal fibre if they are immersed in 2.5% Tamarind water solution or Acid mixture (0.25% sulphuric acid, 0.25%. hydrochloric acid and 0.6% oxalic acid). But the treated fibres should be well washed in clean water so that no trace of Tamarind or acid solution is left in the fibres. Otherwise fibre quality deteriorates at storage.

Drying of Fibres

After washing, the fibre should be dried well in a bamboo frame or by hanging in any way, so that it does not come in contact with mud or dust. Fibers should not be dried spreading on the ground. Mud or dust not only lowers the quality of the fibre but also creates health hazards to jute mill workers.

Drying of Fibres

Ribboning and Ribbon Retting

In Bangladesh, jute grows very well and sufficient water needs to be retted for quality fibre. But insufficient retting water produces poor quality fibre. It is also observed that due to environmental changes rainfall does not occur in season time for retting. As a result unavailable rainfall during the rainy season in jute growing areas of Bangladesh, often forces the farmers to keep the jute plants in low volume of muddy water ponds, cannels leading to improper retting and inferior quality fibre. In some cases, jute plants are getting dried in the field itself giving no monetary benefit to the resource poor jute farmers. To solve this retting water problem BJRI has developed a number of ribbon retting methods, which are hand rebboning with bamboo hook, roller ribboner and recently developed power ribboner. Through this technique ribbons (bark of plants) can be very easily separated out from the woody core in green stage (just after harvest).

Ribbon retting method

Before retting**,** ribbons should be arranged into ring form. If retting water is not available in the nearby places, ribbons may be retted in big earthen vats, filled with clear water. One may ret 30kg of ribbons in one of such big earthen vats.

If shallow small pond/ditches or canals are available in the nearby places, the ribbons may be retted by putting the ring of ribbon in a bamboo pole and steeping under water tying

with two bamboo poles fixed in the bottom of the pool. Retting may be conducted in artificially made small ditches dug around homestead of the farmers or in jute field covering the ditches with polythene sheets. The ditches may be filled with clear water from tube well or from any other water sources.

Advantages of Ribbon Retting:

- Lesser amount of water is required for retting.
- The quality of fibre improves.
- The jute sticks remain stronger since it is not retted.
- Minimum transportation cost is involved.
- Cutting free better quality fibre fetches better price.

Seed crop harvesting and post harvest processing

The seed crop becomes ready to harvest between mid October to mid December when 60-70% capsules/fruits become brown in colour in sunny dry. The harvested tops should be dried in sun for 4-5 days to bring it into threshing condition. Drying in the oven at 56ºC for 24 hours has found suitable for jute seed to bring its moisture content below 10%. However, it is not applicable to farmers' level. Jute seed should be dried 3-6 (for 8 hours a day) days in sun. This could help retain seed moisture content between 7-9% which is the most safe moisture level for storage of jute seed.

Seed preservation

Seeds preservation is influenced by the moisture content of seed, temperature and relative humidity which are related to the seed viability and germination for sowing. Jute seeds are delicate to lose their viability sharply if they are not stored properly. Jute seeds are harvested in October to November and Novemberto December for *Corchorus capsularis* and *Corchorus olitorius* respectively. Freshly harvested jute seeds have a high moisture content which is estimated about 20-25 percent. This content of moisture of seeds is harmful for preservation. So, that after threshing of jute, seeds moisture needs to be reduced to 7-9 percent by 4-6 sunning (6 hrs. a day). Even jute seed having moisture below 7 percent may be stored for about two years. It is noted that after each days sunning the seed should be cooled and stored. Beside, storage temperature also plays a vital role for seed viability and vigour. Sobhan and Khatun (1986) reported the effect of moisture content on jute (*Corchorus* spp.) kenaf and mesta seeds at storage temperature $+20^0$ C, $+4^0$ C and -20^0 C respectively upon viability and vigour. Storage at room temperature jute seeds with 4.0% to 7.75 moisture maintained above 80% viability up to 12 months of storage, the mesta seed maintained 80% viability up to 6 months of storage with 5.3 % to 7.5% moisture.

Storage condition plays a significant role in seed preservation. Storage containers having semipermeable to non-permeable status may be noted worthy for short term as well as long term seed preservation. Seed grower at farm level use different types of containers. The farmers of Bangladesh use four types of containers which are metal, clay pot, polythene bag, jute sacks. The storage efficiency of clay pot and jute sacks is permeable to relative humidity. Therefore, the tin container and non-permeable plastic container are suitable for long time preservation with cool and dry storage condition.

IX. SUGAR CROPS

1. Sugarcane

Sugarcane is the second major cash crop in Bangladesh. It is the basic raw materials for sugar industry and it supplies raw materials for paper and chemical plants. Sugar and gur are produced from the juice of the sugarcane. Around 55 lac tons sugarcane are produced from 1.20 lac hectares land (BBS, 2011). The temperature 30-40^{0}C and rainfall 1100 mm is better for growth and yield of sugarcane. Adequate sunlight and soil moisture are also essential. The average yield of sugarcane is 48 tones per hectare but upto 100 tones yield can be easily achieved through proper management.

1.1 Varieties

Bangladesh Sugarcane Research Institute (BSRI) has so far developed 41 sugarcane varieties. Of them the following varieties are now in commercial cultivation in Bangladesh. A brief description of these popular varieties, their important characteristics and production technology is given below:

Name of Varieties (Year of Release)	Important Characteristics	Crop
Isd 2/54 (1967)	Cylindrical internodes, ovate shape bud, outer auricle transitional-2 and inner auricle transitional-1. Resistant to red rot, slightly susceptible to borer and tolerant to water logged condition. It is mid maturing variety. Sugar in canes 12.97%. **Cane yield:** 79 t/ha. **Duration**: 360-400 days.	
Isd 16 (1981)	Cylindrical internodes, eye bud rectangular. Bud groove clear. Outer auricle deltoid and inner auricle long lanceolate. Moderately resistant to red rot and borers. It is early maturing variety. Sugar in canes14.48%. Popular for sugar and gur (jaggery) production. **Cane yield:** 92 t/ha. **Duration:** 350-390 days.	
Isd 20 (1990)	Conoidal shape internodes, eye bud triangular and overlap on growth ring. Outer auricle dentoid and inner auricle deltoid. It is mid maturing variety. Resistant to red rot, moderately susceptible to borer and tolerant to water logging condition. It can be grown in the low lying areas. Sugar in canes 13.48%. **Cane yield:** 72 t/ha. **Duration:** 360-390 days.	

Name of Varieties (Year of Release)	Important Characteristics	Crop
Isd 32 (2002)	Conoidal shaped internodes, bud oval shaped and touch growth ring. It is high tonnage variety. Outer and inner auricle dentoid. Moderately resistant to red rot, highly tolerant to flood, tolerant to drought and moderately tolerant to water logging condition. Mid maturing variety. Sugar in canes 12.60%. **Cane yield:** 104 t/ha. **Duration:** 370-410 days.	
Isd 33 (2002)	Moderately susceptible to red rot. Tolerant to flood and drought. Moderately tolerant to water logging condition. Inter node cylindrical, bud round. Early maturing variety. Sugar in canes 14.95%. **Cane yield:** 99 t/ha. Good ratooner and suitable for gur production. **Duration:** 360-390 days.	
Isd 34 (2002)	Internodes bobbin shaped, bud triangular. Moderately resistant to red rot. Tolerant to flood, water logging and drought. Suitable for low lands and ratoon crop. Sugar in canes 12.83%. **Cane yield:** 93 t/ha. **Duration:** 360-390 days.	
Isd 36 (2003)	Internodes bobbin shaped. Bud oval, outer auricle short lanceolate and inner auricle deltoid. It is non-flowering variety and popular for gur production. Moderately resistant to red rot. Tolerant to flood and suitable for char land. Early maturing variety. Sugar in canes 14.60%. **Cane yield:** 89 t/ha. **Duration:** 360-390 days.	
Isd 37 (2006)	Internodes cylindrical and bud roundish. It is quick growing variety. Moderately resistant to red rot and borer. Highly tolerant to flood, water logging and drought. Early maturing and suitable for gur production. Sugar in canes 14.42%. **Cane yield:** 101 t/ha. **Duration:** 360-390 days.	
Isd 38 (2007)	Moderately resistant to red rot and borer. Highly tolerant to flood and moderately tolerant to drought and water logging condition. Sparsely flower, early maturing and suitable for gur production. Sugar in canes 14.68%. **Cane yield:** 113 t/ha. **Duration:** 360-395 days.	
Isd 39 (2009)	Stress tolerant, internodes bobbin and bud oval. It is especially salinity tolerant, erect and non lodging variety. Resistant to red rot. Moderately resistant to borer. Highly tolerant to flood, water logging and drought. Sugar in canes 14.23%. **Cane yield:** 101 t/ha. **Duration:** 360-420 days.	

Name of Varieties (Year of Release)	Important Characteristics	Crop
Isd 40 (2009)	Stress tolerant, internodes bobbin, bud oval. Outer auricle transitional-3, inner auricle deltoid. It is especially salinity tolerant variety. Resistant to red rot. Moderately resistant to borer. Highly tolerant to flood, water logging and drought. It is early maturing and high sugar variety. Sugar in canes 14.86%. **Cane yield:** 103 t/ha. **Duration:** 360-420 days.	

1.2 Production Technology

Land and soil

High and medium high lands with no water-logging condition are suitable for sugarcane cultivation. It is grown well in loam, sandy loam and clay loam soils. As it is a long duration and deep rooted crop hence it needs 4 to 5 times ploughing and laddering to make land suitable for its growth successfully.

Fertilizer application

Fertilizer application plays the most effective role to increase the yield of sugarcane and sugar content. Correct doses of fertilizers, correct time and methods of fertilizer application increase the yield of sugarcane. Considering the fertility and productivity of soils under different agro-ecological zones (AEZs), the appropriate doses of fertilizer for sugarcane have been recommended as shown in Table 1.

Table1: Fertilizer Recommendation for Sugarcane under different AEZs (FRG, BARC 2005)

Sl.	Name of AEZ with location	Cane yield goal (t/ha)	Fertilizer Recommendation (kg/ha)						
			Urea	TSP	MP	Gypsum	Mg0	Zn So_4	Boric acid
1.	**AEZ 1.** Old Himalayan Piedmont Plain (*Panchagarh, Thakurgaon, Dinajpur)*	82.0±8.2	271	177	260	139	50	7	10
2.	**AEZ 3.** Tista Meander Floodplain (*Rangpur, Bogra, Joypurhat, Naogaon, Rajshahi)*	82.0±8.2	271	177	200	139	50	7	10
3.	**AEZ 8.** Young Brahmaputra & Jamuna Floodplain *(Sherpur, Jamalpul, Tangail, Manikgonj, Dhaka, Gazipur*)	100.0±10.0	326	202	200	167	-	7	-
4.	**AEZ 9.** Old Brahmaputra Floodplain *(Sherpur, Jamalpur, Tangail, Mymensingh, Netrakona, Narsingdi, Kishoregonj)*	60.0±6.0	217	127	110	83	-	6	-

Sl.	Name of AEZ with location	Cane yield goal (t/ha)	Fertilizer Recommendation (kg/ha)						
			Urea	TSP	MP	Gypsum	Mg0	Zn So_4	Boric acid
5.	**AEZ 11.** High Ganges River Floodplain *(Nawabganj, Rajshahi, Pabna, Kushtia, Jessore, Meherpur, Chuadanga, Magura, Satkhira)*	100.0±10.0	326	253	180	189	-	10	-
6.	**AEZ 12.** Low Ganges River Floodplain *(Natore, Pabna, Goalando, Faridpur, Madaripur, Sariotpur, Gopalgonj*)	100.0±10.0	304	182	130	194	-	10	-
7.	**AEZ 25.** Level Barind Tract *(Dinajpur, Gaibandha, Jaipurhat, Bogra, Naogaon, Sirajgonj)*	80.0±8.0	260	182	200	111	25	6	-
8.	**AEZ 26.** High Barind Tract *(Rajshahi, Nawabganj, Naogaon)*	80.0±8.0	260	182	150	139	25	6	-
9.	**AEZ 27.** North Eastern Barind Tract *(Dinajpur, Jaipurhat, Rangpur, Gaibandha, Bogra)*	80.0±8.0	260	127	200	139	25	6	-
10.	**AEZ 28.** Madhupur Tract *(Dhaka, Gazipur, Narsingdi, Tangail, Narayanganj, Mymensingh)*	80.0±8.0	260	152	250	139	25	6	
11.	**AEZ 29.** Northern and Eastern Hills (*Khagrachhari, Chittagong Hill Tract)*	65.0±6.5	206	127	160	83	20	4	-
12.	**AEZ 30.** Akhaura Terrace *(Brahmanbaria, Habigonj)*	65.0±6.5	206	127	200	111	25	4	-

Fertilizer application for ratoon sugarcane

Ratooning of sugarcane is advised as it matures early, reduces production cost and earns more profit.

For getting high yield of sugarcane in High Ganges River Floodplain areas, 15 tons Farm Yard manure (FYM) or press mud per hectare with 25% less recommended doses of fertilizers is required. For ratoon cane only 50% additional dose of Urea is required compared to plant cane (Table 2).

Table 2: Recommended doses of fertilizers (kg/ha) for plant and ratoon cane

Crop	Organic manure (ton/ha)	Urea	TSP	MP	Gypsum	Zinc sulphate
Plant cane	15	245	190	135	142	7.5
Ratoon cane	15	364	190	135	142	7.5

Seed rate

Normally sugarcane planting is done by two methods - Conventional method and Spaced transplanting (STP) method. For conventional method direct sett planting is done while for STP method setts are planted first in seed bed or in polythene bag and then after germination, the setts are transplanted in the main field. For conventional method high seed rate is required compared to STP method. For raising 22000 to 24000 seedlings or mother plants per hectare, seed rate is required as below:

For conventional planting: 6.0 - 7.0 t/ha
For spaced transplanting: 3.0 - 5.0 t/ha

Conventional method

STP method

Sett treatment

Sett treatment of sugarcane is done to control seed borne diseases (Red rot, Smut, White leaf, Ratoon stunting disease etc.) and to protect the seed from soil borne pathogens (Pineapple disease, Wilt etc.). To produce disease free clean seed (Breeder/Nucleus Seed and Foundation Seed), seed treatment is a mandatory. It is normally done in two ways viz. heat therapy and chemotherapy.

Heat therapy of sugarcane setts

- Before plantation the setts are treated by moist hot air treatment (MHAT) plant at 54°C for 4 hours with above 95% RH. It is effective in controlling the seed borne diseases like red rot, smut, white leaf etc. To control ratoon stunting disease setts are treated by hot water at 50°C for 3 hours .

Moist hot air treatment plant

Hot water treatment plant

Chemotherapy of sugarcane setts

- To protect sugarcane setts from the attack of soil borne sett rotting fungi like *Ceratocystis paradoxa*, *Fusarium* sp. setts are treated by dipping in Bavistin 50 WP/Knowin 50 WP/Corozim 50 WP etc. solution (0.1%) for 30 minutes.

Setts treatment by fungicide solution

Seed bed preparation

Seed bed is prepared for settling raising from setts of sugarcane. It is normally practiced for planting of sugarcane through spaced transplanting method (STP). The land is to be ploughed properly for seed bed preparation. The size of seed bed is 24×4 sq. ft.

Procedure: Eighty kg cowdung/compost/ press mud, 500g Urea, 500g TSP and 250g MP are mixed thoroughly with the soil. The seed bed should be 7.5-10 cm high from the ground. The treated setts are placed side by side on the seed bed and covered with

slight soil and straw. The seed bed is regularly watered for proper germination. For one hectare of land ten (10) seed bed of 24×4 sq. ft.size are enough to accommodate the required quantity of setts.

Time of sowing/planting

Sugarcane planting has been recommended as i) Early planting (September to October), ii) Mid planting (November to December) and iii) Late planting (February to March). In the early planted cane higher germination, higher number of tillers and higher yield of cane is obtained. In case of mid and late planting, spaced transplanting (STP) method is recommended. In the late planting, higher number of settlings is required compared to early planting. For mid and late planting irrigation is necessary for germination of setts or survival of settings. In the early planted cane at least 30 to 50% higher yield is obtained compared to late planted cane. Besides, early plantation provides opportunity for growing two intercrops with sugarcane.

Sowing method

Spaced transplantation (STP) method


STP method in the field

At present, sugarcane is planted in medium high and low land in the country. In many cases it is planted after T. aman harvest i.e. in the month of December and January. At that time temperature falls below 18^{o}C which is not at all congenial for sugarcane germination. To overcome the situation spaced transplantation (STP) technique has been developed. In this method sugarcane setts are placed in polybag or in soil bed in October/November. When land is ready, settlings are transplanted maintaining a particular distance and irrigation is applied. Through this technique only healthy settlings can be planted and its advantages are given below:

- Equal spacing between plant to plant can be maintained.
- No risk of gap in the sugarcane line.
- Cane yield could be increased to desired level with optimum plants in the field.
- Pest and disease infestation is less.
- STP method is more suitable than conventional method for production of Foundation and Certified seed.
- Intercrop can be grown with STP sugarcane.
- It requires about 50% less setts.

Different kinds of planting materials used as seed

Sugarcane can be planted using different kinds of planting materials. They are:

- Three bud sett
- Two bud sett

- Bag settling
- Single bud soil bed settling
- Double bud soil bed settling
- Ryungun settling
- Lateral shoot
- Stalk less settling
- Budchip settling


Different kinds of planting materials

Three bud and two bud setts are used for conventional method of planting while other kinds of settings are used for spaced transplantation (STP) method.

Irrigation

Development of pedal pump for irrigation

Agricultural Engineering Division of Bangladesh Sugarcane Research Institute has developed a pedal pump for irrigation. It is improved version of pedal operated treadle pump. A person can operate this pump in a manner like riding bicycle.


BSRI pedal pump

Advantages

- Woman, man or young person, everybody can operate this pump.
- Water lifting capacity : 60-100 L/min
- Irrigation capacity : 0.50 acre/day
- Cost of production : Tk. 4500.00

By using this pump farmers can lift huge quantity of water easily in a short time, which is suitable for small scale irrigation in small area of sugarcane, seedbed and garden.

1.3 Intercultural Operation

Development of Power operated Weeder

A power operated weeder for sugarcane has been developed from BSRI. The important characteristics of the weeder are as follows:


BSRI power operated weeder

- Those who have power tiller they can use this weeder by setting it with power tiller.
- It needs no extra parts of engine.
- Wideness of the weeder can be changed according to need.
- It needs one litre diesel per hour.
- It saves at least 2/3rdlabour cost and money.

Intercropping with Sugarcane

Different packages of intercropping, that is sowing of crops between two rows of sugarcane, have been developed. The technologies are given below:

- Potato/Onion/Garlic/Cabbage/ Cauliflower/Broccoli/Carrot/ Spinach/Radish/Lentil/Chickpea/ Mustard/Black gram etc. can be grown well as intercrop with single row sugarcane.

Intercropping Potato with Sugarcane

Intercropping Onion (bulb) with Sugarcane

- In the paired rows cane double intercrops can be grown. In that case first intercrops are Potato/Onion/ Garlic/Cabbage/Cauliflower/ Broccoli/Carrot/Spinach/Radish/ Lentil/Chickpea/Mustard/Blackram/ Cumin/Wheat etc. followed by Mungbean/Sesame/Amaranth or Green manuring crops like Dhaincha/ Cowpea.

Intercropping Wheat in Paired row Sugarcane

2nd Intercrop-Mungbean in Paired Row Sugarcane

Pest Management

Sugarcane is affected by a good number of diseases in Bangladesh. Forty (40) sugarcane diseases have so far been identified in the country. Of them seed piece transmissible diseases like red rot, smut, white leaf, ratoon stunting etc. causes maximum damage to crops in terms of yield and juice quality. Overall 20% losses of cane are caused by different diseases.

Major diseases and control measures:

Red Rot disease

Red rot is the most serious diseases of sugarcane in Bangladesh. It is a fungal disorder and has worldwide distribution. The pathogen attacks the stalk as a result the infected plant initially display a yellowing of 3rd and 4th leaf and gradually the whole crown become yellow and ultimately dries up. Splitting open of the infected stalk display a red discolouration intercepted by white patches symptoms. Due to infection of red rot, sugarcane plant dries up causing drastic reduction of weight of cane and sugar. In case of severe infection losses of sugarcane may go as high as 100%.

Infected field

Stalk red rot

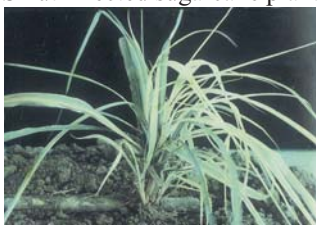
Control measures:

- Use of red rot resistant varieties like Isd 2/54, Isd 16, Isd 19, Isd 20, Isd 34, Isd 37, Isd 38, Isd 39, Isd 40.
- Avoid water logging condition in the field.
- Avoid ratooning of diseased crop.
- Follow crop rotation with green manure crops.
- Use heat treated seed materials or their successive generation. Sugarcane seed (sett) treatment by moist hot air at 54ºC with above 95% relative humidity (RH) for 4 hours is effective in eradicating red rot pathogen in the sett.
- Controlling sugarcane stem borer becauseit is a carrier of red rot pathogen.

Seed Transmissible Diseases

Major seed transmissible diseases are smut (C.O. *Ustilago scitaminea*), white leaf (C.O. Phytoplasma), Grassy shoot (C.O. Phytoplasma) and ratoon stunting (C.O. *Clavibacter xyli*). Smut infected plant display of producing whip like structure from the crown with narrow and erect leaf. White leaf infected plant shows dwarf growth with albino leaves. Grassy shoot infected plant display grassy appearance with numerous tillers. The ratoon stunting disease affected plant display stunting growth with pinkish/orange spots at the internal nodal tissues. All these disease are very much destructive. Due to these diseases in severe cases the yield of cane could be reduced up to 75%.

Smut infected sugarcane plant



White leaf infected clump

Control measures:

- Smut, white leaf and grassy shoot diseases could be controlled successfully by treating seed materials in moist hot air at 54ºC with above 95% RH for 4 hours and rouging of infected plants.
- Ratoon stunting disease can be controlled by treating seed materials in hot water at 50ºC for 3 hours.

Soil borne diseases

Some soil borne fungi such as *Ceratocystis paradoxa, Fusarium* sp. etc. causes sett rot and induces germination failure.

Control measures:

- To protect setts from the attack of these fungi some fungicides have been recommended. They are: Bavistin-50WP, Knowin 50WP, Genuine 50WP, Headazim 50WP, Seadazim 50WP, Corogim-50WP, Edvistin-50WP, Forastin-50WP, Agridazim-50WP, Aimcozim-50WP and Avistin-50WP. Sugarcane setts are to be treated in 0.01% (1 gm in 1 litre water) of any of the above fungicide for 30 minutes before planting.

Pineapple disease (Sett rot) infected sugarcane sett

Sugarcane nematodes


Root knot disease

Nematodes occurring in the sugarcane root environment are under the genera of *Meloidogyne* spp, *Hoplolaimus* spp, *Helicotylenchus* spp, *Tylenchorhynchus* spp and *Pratylenchus* spp. In sugarcane, the symptoms developed by nematodes resemble those caused by nutrient deficiency, drought or other root disorders. Unthrifty appearances, reduced rate of plant growth, stunting of growth etc. They also act as predisposing agents, cooperators and infection initiators of root infecting fungi.

Control measures:

- Nematicides (Furadan 5G, Rugby 10G, Alphafuran 5G) and Press mud were found effective in controlling sugarcane nematodes. Furadan 5G @ 2kg a.i./ha, Rugby 10G @ 2 kg a.i./ha, Alpataran 5G @ 2kg a.i./ha and press mud @ 20 tons per hectare have been recommended to control sugarcane nematodes.

Root parasite


Striga infested sugarcane field

Striga densiflora is a serious root parasite of sugarcane. The yield loss of sugarcane in the heavily striga infested field may go as high as 100%. Due to striga infestation, sugarcane plants die and disappear.

Control measures:

- Striga can be controlled successfully by applying urea @ 395 kg/ha in 3 (three) installments- 1/3rd during planting, 1/3rd during the month of April and the rest 1/3rd during May. Striga plants can be controlled within 24 hrs by spraying 5% urea solution (5 kg urea in 100 litre water) during sunny day.

Integrated Disease Management (IDM)

Actually no single method is effective in controlling different diseases. Most of the important diseases of sugarcane can be effectively controlled by integration of various control approaches. The integrated control approaches are:

- Selection of medium high and high lands for sugarcane cultivation.
- Selection of disease resistant varieties.
- Selection of disease free healthy seed materials.
- Heat therapy of seed materials (sett treatment in moist hot air at 54^{o}C with above 95% RH for 4 hours or in hot water at 50^{o}C for 3 hours).
- Chemical treatment of seed pieces with Bavistin 50WP (0.1%) or with similar fungicides, and
- Rouging of diseased clumps as and when detected.

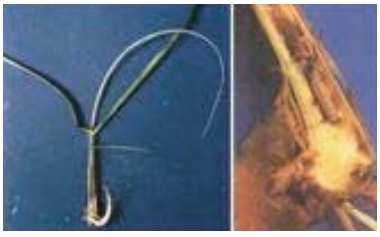
Major insects and their control measures:

Sugarcane Insects

About 70 insects and pests have so far been identified in the country and of them 7-8 insects are very much destructive.It is observed that about 20% yield loss of sugarcane occurred every year due to insect infestation.

Early shoot borer

The borer larvae enter the plants laterally by one or more holes in the stalk and bore downwards as well as upwards killing the growing point, thereby cutting off the central leaf spindle which dries up forming a dead heart that can be pulled out easily. The cut off portion inside the bored plant rots and the dead heart emits an offensive odour on being pulled out.



Early shoot borer affected plant

Control measures:

- Use of resistant variety.
- Early planting.
- Early shoot borer infested plant is to be cut down at the bottom level and larvae inside plant are to be the destroyed.
- Application of insecticides under Carbofuran group like Furadan 5G, Furafuran 5G, Curatar 5G etc. @ 40 kg/ha at the root zone of sugarcane and to be covered with soil. After application of insecticide light irrigation is to be applied.

Top Shoot Borer

Female moth of top shoot borer lays egg under side of sugarcane leaf. It looks like yellowish cotton mass. Within 6-15 days larvae comes out from egg and enter into the top of the cane through mid rib and destroy the top portion of cane. The larva bores its way to the central core of the spindle through the unfolded leaves, and as a result rows of shot-holes become visible when the leaves unfold. Burnt dead heart occur when the larvae cuts the growing point. In the grown up canes, the infestation results in dead heart which induces sprouting of the lateral buds giving bunchy top appearance.

Top shoot borer affected plant

Control measures:

- Collection of moth and egg mass of top shoot borer by hand and their destruction (January to June). It is easy, protective and environment friendly.
- Top shoot borer affected sugarcane plants are to be cut just below the attacking point and the larva inside the plants (January to June) destroyed. It is easy, curative and environment friendly. It should be done in a body in all sugarcane plots.

- Granular insecticides like Furadan 5G, Curatar 5G, Sunfuran 5G, Furataf 5G etc. (Carbofuran insecticides) are to be applied @ 40 kg/ha on both sides of sugarcane line in the shallow furrow made by plough and covered with soil. After application of insecticides, light irrigation is to be applied. If sufficient moisture remains in the soil, no need of irrigation. The insecticides must be applied in of March to May if infestation levels cross above 5%. It is an effective (above 80%) and phytotonic insecticides which helps in the growth of sugarcane.

Stem borer


Stem borer affected plant

Stem borer is the most serious pest of sugarcane. Due to its attack 8-70% yield loss of cane may occur. As the larva feed inside the internodes, excreta of insects are pushed to the exterior through the bore holes in the top internodes. Top leaves of infested cane dry completely. Tunneling of internodes is so severe that the dried top portion of the cane easily breaks off at the attacking point. Sett roots are formed in the infested internodes and envelope the stalk in a network of root hairs. The lateral buds also sprout.

Control measures:

- Primary infested cane should be cut down just below the affected point and destroying the larvae.
- Remove the older leaves of sugarcane. It reduces the infestation level of stem borer.
- Application of insecticides under Cartaf 4G group like Padan 4G, Sidan 4G, Rajex 4G, Sundan 4G @ 75 kg/ha on both sides of sugarcane line near the root zone are to be made and covered with soil. It is effective in controlling stem borers at least by 80%.

Root stock borer


Root stock borer affected plant

Rootstock borer is a serious pest of sugarcane which causes yield loss of cane by 2-73%. It attacks during May-October. Rootstock borer generally infests the young shoots. When its infestation occurs during the early stage of crop growth, dead hearts are formed. But in the grown up canes, no external symptoms is discernible except yellowing of leaves.The canes have to be dug out to detect its attack. The dead heart can not be pulled out easily and often, in the process the plant gets pulled out, with the larva either hanging out at the broken end of the shoot or remaining partly inside the underground portion and partly protruding outside.

Control measures:

- Root stock borer affected plants should be uprooted and the larvae of insects in the tunnel of root stock should be destroyed.

- Stubble burning after harvest of cane: After harvest of cane the stubble should be uprooted, dried and burnt in the field. It is very much effective in controlling root borer.
- If the infestation level cross above 5% then insecticides under Chloropyriphos 15G group like Lorseban 15G, Pyriban 15G, Nocoban 15G etc. @ 15 kg/ha or Rugby 10G @ 20 ka/ha should be applied in the root zone on both sides of sugarcane line and covered with soil.
- During application of insecticides, there should be sufficient moisture in the soil or after insecticide application irrigation should be applied in the field. It is effective in controlling rootstock borer and it has phytotonic effects.

White grubs

The grubs feed on the roots while the adults feed on foliage of tree and shrubs.Uneven growth in the field is observed. It also shows drying of crown, preceded by yellowing and wilting of leaves; roots are eaten away. Ultimately, the affected shoot/cane dries up.High incidence is observed in February-July.

White grub infested plant and adult of white grub

Control measures:

- Beetle of white grub living on jackfruit, mango, guava trees etc. should be controlled by light trap or by hand net and destroyed.
- Land should be deep ploughed and open in the sun for 3-4 days to kill the grubs.
- Early planting of sugarcane is recommended.
- Affected land should be made stagnant with water for 5-7 days.
- Insecticides under Carbofuran group like Furadan 5G, Curatar 5G, Sunfaran 5G, Furasan 5G etc. @ 40 ka/ha should be applied on both side of sugarcane line in the shallow furrow made by plough and covered with soil. After insecticide application, irrigation should be applied. It is very effective in controlling white grub and it has phytotonic effect on plant.
- Insecticide should be applied in March-April.

Termites

Termite is also a serious pest of sugarcane. It attacks sugarcane right from planting to harvest. After planting of sett, termite attack on it and eat the whole sett as a result gappy stand occur in the field. In the later stage it attacks the root system and stem of the sugarcane. Sometimes cane filled with moist soil inside the papery rind is displayed. Sugarcane plant dries up due to attack of termite.

Control measures:

- The termiterium should be destroyed and the queen of termite should be killed.
- Sugarcane sett should be planted in the deep trenches.

- Setts should be placed in zig-zag method.
- Planting sugarcane through spaced transplantation method.
- Using food trap (jute stick or Dhaincha inside the earthen pot and killing the termites).
- Sett treatment with insecticides like Gauchu 70 WS (0.2%) or with 0.1% of Cruser 70 WS before planting.
- Application of insecticides under Fipronil group like Regent 3 GR, Guly 3 GR @ 16.66 kg/ha on the setts after placement in the furrow.

1.4 Harvesting and production

Sugarcane should be harvested after attaining proper maturity because both yield and sugar percentage depends on maturity. Maturity symptoms of sugarcane may be determined by *Refractometer*. With this machine, % Brix (solid portion) is determined. The % Brix of mature cane is about 20-22 % and out of it 80-95% is sucrose.

Maturity symptoms may be determined by the following ways:

- Upper leaves start drying and become droopy.
- On the basis of time- plants become ready for harvest after 12 months of planting.
- Growth of the plants is stopped and top internodes become shorter.
- Stripping with knife, it produces metallic sound.
- Leaves become shorter and yellowish.
- Stem becomes slightly yellow.
- Plants become ready for harvest at the time of formation of inflorescence.
- Adventitious roots develop from the lower nodes.
- Buds will be prominent.

BSRI Developed Modern Sugarcane Crusher

An improved crusher has been developed for crushing and extraction of sugarcane juice for *gur* (jaggery) production. The key characteristics of the crusher are stated below:


BSRI modern sugarcane crusher

- The crusher is composed of three rollers.
- Its juice extraction capacity is about 55-62%, whereas the juice extraction capacity of the country power crusher is only 45-50%.
- Crushing capacity: 5.5-6.0 ton per day (8 hours).
- To operate the crusher 12 horse power engine is sufficient.
- As the crusher is provided with 4 (four) wheels it can be moved from one place to another.
- Cost of production of crusher is about Tk. 1,00,000 (one lac)

The *gur* maker can extract 10-15% more juice by using this crusher compared to country power crusher. By using this crusher extraction of sugarcane juice may be

increased by 10% and thereby the country can earn at least Tk. 250 corers more annually.

Clarification of Gur/Jaggery by using Ulat Kambal and Wild Okra


Using ulat kambal plant extract


Using wild okra plant extract

In our country, gur maker use health hazardous chemicals. Hydrose (Sodium hydro-sulfide) isused for clarification of gur and making its colour attractive to buyers. But instead of hydrose, the extract of wild okra (*Hibiscus* sp.) and ulat kambal (*Abroma agusta* L) could be used as clarificant for gur making. During boiling the juice extract of wild okra and ulat kambal have to be added with the juice @ 2 litres (500 g wild okra and ulat kambal smashed with 2 litres water)/200 litres juice. All dirt materials in the juice will be trapped with the mucilaginous extract and float on the juice. These floating materials could be removed so long it floats. Through this way cane juice could be make free from different dirt materials mixed with the juice. Now the juice is boiled for making gur. The gur produced through this process is healthy and bright golden colour. Wild okra and ulat kambal is found everywhere surrounding the land and household.

Production and Packaging of Granular Gur (Jaggery)

In hot humid weather condition, preservation of gur or jaggery is difficult for long time. During rainy season, reducing sugars present in gur absorb moisture and become fermented as a result gur become useless. The moisture percentage in gur should not be more than 7-8%. For long time preservation a technology has been developed to produce granular gur and its preservation. To do that at the time of gur preparation, prepared gur have to be stirred to prevent solidification and then dried in the sun for 1-2 days. These granular gur can be preserved in sealed polythene packet for long time without deterioration of its quality.


Concentrated gur


Sun drying of Granular gur


Storing of Granular gur in sealed polythene bag

X. FISHERIES

1. Monosex Tilapia

Bangladesh have hundreds and thousands of seasonal water bodies in the form of ditches, shallow ponds, road side canals, barrow pits. These water bodies have tremendous potential for aquaculture. These are especially suitable for the culture of fish species with short life cycle and characteristics of faster growth rate and require low input support. In such cases, tilapia can be a promising candidate for aquaculture in the suitable seasonal water bodies.

Selection of pond

For raising monosex tilapia ponds are to be selected where water remains for 4-6 months in a year. It would be better if the pond is 0.15-0.50 acre (15-50 decimal) in size and 1-1.25 m in depth.

Pond preparation

Dike repairing: Before stocking, broken dikes should be repaired properly to prevent entering of undesirable animals flood water in pond.

Cleaning of aquatic weeds: Aquatic weeds have harmful and beneficial effects on aquaculture. Free floating aquatic higher plants are very harmful if luxuriant growth prevails in the ponds. Submerged aquatic plants are also harmful if they grow excessively and extensively. Rooted emergent hydrophytes become helpful to increase aquatic biological productivity if they remain in small quantity under control condition.

Removal of undesirable fish species: Eradication of predators and other undesirable animals is the prerequisite for profitable fish culture. The methods such as repeated netting, pond drying and application of pesticide (Rotenone @30-50 g/40 m^2) are useful for removal of undesirable fish species.

Liming: Liming is one of the most important activity in preparation of pond. It should be used @ 250 kg/ha. It plays various roles in the pond fish culture.

Fertilization: Fertilization is an important part of fish culture. Pond should be fertilized with Urea + TSP (1:2) @ 37.50 kg/ha after three days of liming. It increases the primary productivity of pond water.

Stocking of fingerlings

Pure quality and standard size fingerling is of prime importance for maximum fish production from a unit water area. Monosex tilapia fingerlings each weighing 8-10 g should be stocked @ 62,500/ha on the 5th day after the application of fertilizer.

Supplementary feeding

To get maximum fish production from ponds, supplementary feeding is essential in addition to natural food materials. Generally, supplementary feed containing 25-28% crude protein is used @ 3-10% of estimated body weight of fish.

Fertilization

Along with the supplementary feeding, fertilizer such as Urea + TSP should be applied @37.50 kg/ha/15 days which accelerate the production of natural food organisms (Plankton) in water.

Intercultural operation

Sampling: In order to observe the growth rate, health status and feed adjustment, sampling should be done at an interval of 15 days (fortnightly).

Monitoring of water quality parameters: For better management, water quality parameters such as pH, dissolved Oxygen,transparency and ammonia should be determined at weekly intervals. To keep suitable water quality, Zeolite can be applied at the rate of 25-37.50 kg/ha at monthly interval.

Disease control: Prevention is better than cure is the basic principle should be followed to keep the fishes in better health. Tilapia is a hardy fish species and can survive in any harsh environmental condition. So, this species is less susceptible to various health hazards ranging from minor injuries to very fatal inspection. Though, sometimes tilapia fry is affected by protozoan parasite during winter season.

Harvest and selling

At the end of culture period i.e. after 5-6 months, when monosex tilapia could attain 200-250 g size, pond should be drained to harvest all fish. Without draining the pond, it is very difficult to catch all fish. A production of 13-15 tones/ha could be obtained from this type of culture system.

Selling: Minimum sale price of harvested fish at farm gate will be Tk. 90-95/kg. A net profit Tk. 3.50-3.75 lacs/ ha/6 months could be obtained.

2. Climbing perch (Koi Culture)

Air breathing climbing perch is a commercially important high value fish in Bangladesh. This hardy fish is very suitable for cultivation in ponds, reservoirs and rice fields.

Selection of pond

Climbing perch, koi can be cultured in any type of ponds either small or big. For better management, the pond size should be 0.20 to 1.0 acre (20-100 decimal) with an average water depth 1.0-1.25 meter along with fresh water supply facility.

Preparation of pond

- Broken pond dikes should be repaired properly.
- Aquatic weeds should be cleaned and free from water surface.
- Predatory fish and undesirable fish species should be eradicated by repeated netting followed by pond drying.
- Lime should be applied in the pond bottom at the rate of 250 kg/ha. The rate of dose of lime depends on pond soil pH.
- After three days of liming, pond should be filled up with fresh water (1.0 meter).
- Nylon net fence should be set up around the pond dykes.

Stocking of fry

Good quality and healthy koi fry having an average weight of 1.0 g size can be stocked in the prepared pond at the rate of 1.0-1.50 lac/ha.

Feed management

Balanced supplementary feed is essential for koi rearing in pond. For getting higher production, supplementary feed containing 35% crude protein enriched should be supplied at the rate of 4-20% estimated body weight in two times in a day at 6 days in a week.

Intercultural operation

- Fish should be sampled at 10 days interval.
- Food ration should re-adjust on the basis of sampling weight of fish.
- Each and every months, lime and salt should be applied in the pond at the rate of 50.0 kg and 125.00 kg/ha at fortnightly interval.
- When plankton density increased in the pond, in that case again monosex tilapia and catla (*Catla catla*) can be stocked at the rate of 5,000 and 1,250/ha, respectively.

- If stocking of monosex tilapia and Catla not possible, then water exchange (30%) should be done.
- As and when required, fresh water can be added through low lift pump or deep tube well to maintain average water depth of 1.0 meter.
- Water quality parameters such as Transparency (cmd.), pH, dissolve Oxygen (mg/l) and total Ammonia (mg/l) should be monitored at 3 days interval.

Control of disease

- Koi is susceptible to disease in winter season when water temperature is below 20°C.
- If water quality is unsuitable in this situation koi may be affected by disease and parasites.
- In this case, water exchange as well as liming (50 kg/ha) is needed to purify the pond water.
- Recommended antibiotics may be applied for treatment of fishes.

Harvesting

When koi fish will attain marketable size, then it can be harvested by repeated seine netting followed by pond drying. Through above mentioned management technique, after four months rearing, the average weight and production of koi would be 90-100 g and 8.0-9.0 tones/ha, respectively.

The farm gate sale price of koi Tk.130-150/kg where a farmer could achieve net profit Tk. 2.50-3.00 lacks /ha within 5.0 months by rearing koi in pond.

3. Stinging Catfish (Shing)

Among the endemic catfishes Shing (*Heteropneustes fossilis*) is very important fish for culture for its high market price and demand. Success in artificial breeding, availability of fingerling, and high rate of return made it a suitable species for aquaculture. Farmers interest for culture of catfish are also growing day by day.

Selection of Pond

Pond must be selected in a flood free area. Perennial pond preferably with an area of 0.12 to 0.16 ha and average depth of 1-15 m water should be maintained.

Preparation of Pond

- Draining and drying of pond is essential until pond bottom cracked or harden sufficiently. Predatory and unwanted fish and insects should be eradicated before stocking by applying Aquanone/Rotenone @ 40-60 g/40 m^2 (water depth 0.85-1.0 meter).
- Liming of pond is necessary to correct soil acidity and to promote release of soil nutrients. Agricultural lime $CaCO_3$ is normally used @200-250 kg/ha depending on soil quality.
- After 2-3 days of liming, cow dung @ 1500-2500 kg/ha, 25 kg urea and 12.5 kg TSP/ha should be applied for natural food production.

Stocking of fingerling

- Four to five days after application of fertilizer when water colour become greenish or brownish pond is ready for stocking.
- Good quality, disease free fingerlings of 0.1-2 g size each is better for stocking. Over wintered fingerling is preferable if available.
- Stocking density of fingerlings 187,500-250,000/ha

Use of fertilizer

- During culture period if water colour remains green no fertilizer is needed.
- If pond water is transparent, 25 kg urea and 12.5 kg TSP/ha should be applied.

Feed management

- Commercial Catfish feed or feed prepared from locally available feed ingredients may be used. Protein level of feed should not be below 30%.

- Feed must be given by calculating the total body weight of fishes at the rate of 10% at the beginning and down to 4-5% at the end of culture period.
- Feed should be applied twice daily.

Two different formulations for feed preparation are given below:

Feed ingredients	Formula 1(%)	Formula 2 (%)
Fish meal (A-grade)	40	25
Meat and bone meal	0	15
Mustard oil cake	20	20
Rice bran	20	20
Wheat bran	15	15
Molasses	4	4
Vitamin and Minerals mix	1	1
	100.00	100.00

Intercultural operations

- Optimum water level should be maintained.
- Regular observation of pond wall, leakage of pond must be monitored.
- Regular sampling should be done and feed should be adjusted accordingly.
- To maintain better water quality water should be exchanged periodically, 125 kg salt and 125 kg lime/ha should be applied alternatively per month.

Harvesting and selling

- After 8-10 months culture period when fish attain marketable size should be harvested.
- Most of the fish should be harvested by netting and then pond should be dried fully to catch all the fish.
- Fish production of 8.0-9.0 ton/ha could be obtained if proper management is applied.

4. Carp Polyculture

Endemic and exotic species of carps have significant importance for aquaculture and particularly for improving the livelihoods of the poorer sectors of society in several Asian countries. The management of exotic species of fish for aquaculture raises a number of important issues for stakeholders, particularly those involved in low input aquaculture. Carp polyculture means culture of various foods and feeding habit fish species together at the same pond. The purpose of this system is to raise fish production by utilizing food web of pond ecosystem, to utilize locally available agricultural by-products and residues as fish feed and to obtain higher fish production.

Selection of pond

Pond site must be selected in the flood and industrial effluent free area. Perennial pond preferably with an area of 0.4 to 0.8 ha and average depth of 2 to 3 m water will be selected.

Preparation of pond

- Dewatering and drying of pond is essential, if not possible, predatory and unwanted fish and insects should be eradicated before stocking by applying Aquanone/Rotenone @ 40-60 g/40m^2 (water depth: 0.85-1.0 m).
- Normally lime ($CaCO_3$) should be applied @ 200-300 kg/ha but the doses of lime depend on the pH of the soil. After determination of the pH of soil, lime could be applied as per dose 5-7, 2-4 and 0.5-1 kg/40 m^2 of P^H value 3-5, 5-6 and 6-7, respectively.
- After 2-3 days of liming, cowdung @ 2000-2500 kg/ha should be applied and 3-4 days prior stocking of fingerlings, urea and TSP (Triple Super Phosphate) should be applied @ of 40-50 kg/ha in the ratio of 1:1.

Stocking of fingerling

Selection of species: Selection and combination of species in carp polyculture system is essential for good aquaculture management and higher production (Table 1).

Table 1. Selection and combination of species in carp polyculture

Local name	Scientific name
Rohu/ Rui	*Labeo rohita*
Catla/Katal	*Catla catla*
Mrigal	*Cirrhinus mrigala*
Silver carp	*Hypophthalmichthys molitrix*
Bighead carp	*Aristichthys nobilis*
Common carp/Carpio	*Cyprinus spp*
Kalbasu/Kalbaush	*Labeo calbasu*
Grass carp	*Ctenopharyngodon idella*
Black carp	*Mylopharyngodon piceus*
Sharpunti/Raj punti	*Barbodes gonionotus*

Stocking density and rate: Stocking of pond should be done within March. For higher growth rate and as per market demand for good quality, over wintering advanced fingerlings must be preferred for carp polycuture system. Stocking density, size, rates and ratios are shown in following Table 2.

Table 2. Stocking density, species, size and stocking rate

Stocking density (ha)	Species (Local name)	Size (cm)	Stocking rate (%)
12500 fingerling/ha	Silver/Bighead carp	15-20	15
	Catla	15-20	10
	Rui	15-20	30
	Mrigal	15-20	25
	Carpio	12-15	8
	Grass carp	15-20	8
	Kalbasu	15-20	2
	Balck carp (good species to control snail from the pond)	15-20	2
In addition BFRI improved Raj punti 2500/ha (10-12 cm) could be stocked and harvested after 3-4 months.			

Feed management

- Natural food is not enough for better growth of fishes for commercial aquaculture. Supplementary (homemade or commercial pelleted feed maintaining 24-25% protein (Standard feed formula are shown in Table 3) should be fed everyday (2 hours after sun rise).
- Feed must be given by calculating the total body weight of fishes at the rate of 10% in the beginning and down to 2% at the end of culture period (Table 4).
- Netting must be done once in every month for checking fish health and for calculating the amount of feed to be given for the next month.
- Growth of grass carp depends on availability of green vegetations in the ponds. Green grass, small water hyacinth, banana leaves must be supplied for grass carp (10-15% body weight/day) in the bamboo made rectangular basket.

Table 3. A standard feed formula for carp polyculture feed management

Feed ingredients	Amount in the feed (%)	Protein in the feed (%)
Fish meal (A-grade)	15	9.00
Meat and bone meal	5	2.20
Mustard oil cake	20	7.00
Rice bran/Wheat bran	44.5	5.00
Maize/Wheat	15.00	1.80
Vitamin and Minerals	0.5	-
	100.00	25.00
Feed conversion ration (FCR) = 1.00 : 2.00		

Table 4. Monthly feeding schedule for carp polyculture system

Month	Feeding rate (% body weight of the fish)	Comments
1st	8.0	Feed may be withdrawn two days (beginning and middle of the week) in every week for minimization of the cost of feed but fertilization could be done regularly.
2nd	6.0	
3rd	5.0	
4th	3.0	
5th	3.0	
6th	3.0	
7th	2.5	
8th onwards	2.0	

Use of fertilizer: Both organic and inorganic fertilizer should be used four times in every month for raising natural food production. Inorganic fertilizer, Urea and TSP (1: 1) @ 50 kg/ha/month and organic manure, cowdung @ 500 kg/ha/month should be applied in every month. Each fertilizer should be used in every alternate week. Cowdung always should be used in pond in a diluted form. Application of fertilizer should be avoided when excessive plankton bloom occur in the pond.

Intercultural operations

- Ponds should be neat and clean and weed free.
- Optimum water level should be maintained.
- Regular observation of pond wall, leakage of pond must be monitored.
- Protection against flood.
- If transparency of water decreases below 8 cm then fertilization and feeding will remain stopped for the time being.
- Removal of toxic gas by pulling horra in daily basis in the 1 hour after sun rise and 2 hours before sun set.
- Protection against theft of fish
- Partial harvesting may be done sometimes which depends on the size of fish and condition of the water quality.
- Maintain effective record (cost return) keeping system.

Harvesting and selling

Actual carp polyculture period in Bangladesh is only 8 months (March-November). If improved carp polyculture technique used, all species would attain marketable size within 8 months culture period (Table 5).

5. Riverine Catfish (Pangus)

Pangasius hypophthalmus (*P. sutchi*), a freshwater riverine catfish, inhabits in the rivers of Thailand, Laos, Cambodia, Vietnam, Malaysia and Indonesia, was first introduced in Bangladesh on 28 August 1990. On 8 May 1993, *Pangasius hypophthalmus* was first induced to breed in Bangladesh at Riverine Station, BFRI, Chandpur. It is an omnivorous fish and breeds in rivers. Currently, most hatchery operators are producing fry of *P. hypophthalmus* and producing table fish intensively. *Pangasius hypophthalmus* can reach up to 15 kg but mature for the first time at 3 kg.

Selection of pond

Any size (small or large) and kind (seasonal or perennial) of ponds can be selected for mono- or polyculture of *P. hypophthalmus*. Pond size may range from 30 decimal to several acres. However, ponds having a size of 30 to 100 decimal are preferable for raising *Pangasius* species. Pond site should be free of flooding during rainy season. Depth of a pond should be 2.0 to 3.0 m, which can receive sufficient sunlight. Rectangular shape of pond is suitable for *Pangasius* culture, although it can be cultured in any shape of pond. Dyke should be cleared off branched trees. Clay soil is better than sandy soil for its culture.

Preparation of pond

Initially, the pond bottom soil should be sun-dried to eliminate undesirable species and organic deposition. Some undrainable ponds are treated with inorganic pesticides for disinfection purposes. Submerged and floating weeds are to be removed as these compete for nutrients in the soil and water, occupy space intended for fish, and tend to reduce fish harvesting efficiency.

Stone lime is to be used at the rate of 1 kg/40 m^2. After three days of liming, cowdung is to be applied at the rate of 7-10 kg/40 m^2. Pond is to be filled up with freshwater after 2-3 days of manuring. Use of chemical fertilizer depends on necessity. If it is required, then urea and TSP could be used at the rate of 50-100 g and 150-200 g/40 m^2, respectively. Chemical fertilizer and manure should not be applied if water colour is greenish. Pond should be sun-dried after two years.

Water quality management

Good water quality is a prerequisite for the culture of Pangasius species. In the pond, it enhances higher survival, better growth, and increased reproduction. Important parameters to be considered to maintain good water quality are as follows:

Dissolved oxygen (DO): It is probably the most critical water quality variable in fish culture. The DO level in the pond or any fish-rearing unit affects the appetite of the fish or its food intake, and consequently its growth. The primary sources of DO under a fish culture system are through photosynthesis and from atmospheric oxygen diffusion. Loss of oxygen is caused by plant (micro and macro) and fish respiration and oxygen diffusion back into the air. Concentrations of DO are lowest in the early morning just before sunrise, increasing to its maximum level in late afternoon, then decreases during the night. Fish cease feed or grow well if DO level remains at 3-4 ppm.

Oxygen depletion in the pond is caused by (i) excessive water fertility due to fertilisation and/ or feeding, resulting in high plant respiration and phytoplankton die-offs and (ii) high stocking density. Consumption of DO by fish and other organisms for respiration accounts for the greatest loss of DO. Low DO level in the pond can be corrected by (i) emergency aeration technique and mechanical aeration. The former is done by flushing high DO water into low DO pond. It is effective and inexpensive where adequate supply of high DO water is available as in adjacent streams or ponds. Mechanical aeration makes use of paddle wheel that splashes water into the air and the air blower, which injects air either at one side of the pond or through a perforated pipe.

P^H: It indicates whether the water is acidic or basic (alkaline) in reaction. To determine a typical pattern, water pH is usually measured early in the morning (6 am) and in the afternoon (6 pm). P^H values of about 6.5-9.0 at daybreak are considered best for fish production. The acidic and alkaline death points for fish are approximately 4-P^H and 11-pH, respectively.

Ammonia (NH_3): In freshwater ponds, ammonia occurs as a product of fish metabolism and decomposition of organic matter by bacteria. There are two types of ammonia in water: un-ionised ammonia and the ammonium ion. The un-ionised form of ammonia is toxic to fish while the ammonium ion is not, except at extremely high concentrations. For pond fishes, the toxic levels of un-ionised ammonia range from 0.6 to 2 mg l^{-1}. H_2 ion concentrations of total ammonia-nitrogen usually occur after phytoplankton die-off at which the CO_2 is also high and pH is low (acidic).

Clay turbidity: Suspended materials brought about by turbidity reduce light penetration required for photosynthesis, thereby reducing oxygen generation and phytoplankton production. When resulting from plankton organisms, such turbidity is desirable in the pond. However, water turbidity is due to suspended clay particles, it becomes undesirable. A persistent clay turbidity of 30 cm or less may prevent development of plankton blooms. Clay turbidity can be avoided by applying organic materials such as cut hay or grasses manure in the pond at 0.05 kg m^{-3} of pond water for a turbidity of 25 ppm and 0.4 kg m^{-3} for turbidity of 200 ppm. Another technique

is to apply alum [aluminium sulphate, Al $(SO_4)_3 14H_2O$] which causes suspended clay particles to coagulate and precipitate from the water column within a hour. The rate of application is from 25 to 30 mg l^{-1}. Lime can also be used to prevent persistent turbidity; however, continuous application of lime causes an increase in water pH.

Stocking of fingerling

Pangasius species are suitable for both mono and poly-culture. It responds to supplemental feeding and it adapts well to high stocking densities. *Pangasius* species are somewhat hardy and can grow well in any environment where few other species can survive. *Pangasius* species are bottom feeders and easy to culture with surface and column feeders.

Genetically pure/improved, healthy and strong fingerlings are to be stocked. In mono culture system, stocking density of *Pangasius* species fry ranges between 200 to 500 numbers/40 m^2. Size of fry at stocking should be 10 to 12 cm each and should be free from disease. Stocking density can be increased if water exchange system is available. Nearly uniform size fry should be stocked. In polyculture system preferable stocking density is 70-80, 10-20 and 30-40 numbers/40 m^2 for *Pangasius*, *Catla catla* and *Labeo rohita*, respectively. Culture period should be at least 9 months from March to November.

Use of fertilizer

Fertilizers are used to increase natural food for fishes. So, application of fertilizers depends on soil quality and water colour of the pond. If it is required, then urea and TSP are to be used monthly at the rate of 50-100 g and 150-200 g, respectively. If water has no colour then the dose is to be repeated. Chemical fertilizer and manure should not apply if water colour is greenish. Poultry droppings and raw cowdung should not be applied in the ponds of *Pangasius* species.

Feeding management

Pangasius is an omnivorous fish and non-predacious in feeding habit. It takes both of plants and animals as food and known as foul feeder. It is a voracious feeders and takes crustaceans, insects, small fish, shrimps, molluscs, snails, offal's, putrefying animal flesh, blood, crabs, rice, wheat, rice bran, wheat bran, mustard oilcake, sesame oilcake, fruits, roots, leaves, pulses, potatoes, stems, chilly, seeds etc. as food.

In ponds, *Pangasius* can be cultured with rice bran, mustard oil cake, wheat bran and fishmeal. Ration should be 4-5% of total body-weight daily. Fishes are to be reared with a locally prepared non-pelleted feed containing fish meal 30%, mustard oil cake 30%, rice polish 10%, wheat bran 28%, crushed mollusc shell 1.5% and salt 0.5% and fed at 4-5% of their body weight (bw) twice daily. Total ration should be split into two portions and applied at 09:00 and 16:00 hours. It is important to supply food in a particular place of a pond daily. Commercial floating and sinking feed can also

be supplied to culture *Pangasius* species. Percentage of protein in *Pangasius* feed should be 28 to 32%. Excessive feed should not be applied in ponds as it could deteriorate water quality and develop off-odour in fish.

Intercultural operation

After stocking of fingerlings, it is important to check fish periodically for health management and disease control. Monthly netting is advisable for sampling fish and feeding rate is to be adjusted accordingly. Bottom gas is to be removed weekly by applying *Horra* or *Moi*. Precaution should be taken during applying any aqua-drugs or chemicals for removing gas or maintaining water quality. Care should be taken during summer days especially in early morning as fish may be hanged to the surface water due to shortage of oxygen. To minimise this problem, water can be sprayed by low-lift pumps or potassium per manganate can be applied at the rate of 3-5 mg/40m^2. Other commercial drugs/chemicals for oxygen enhancer can also be applied according to the dose mentioned on the pack. Monthly water exchange of fish pond is preferable when high stocking density of fish is adopted.

Disease and health management

Being a hardy fish, *P. hypophthalmus* is less susceptible to diseases than other fish species. However, at high stocking density, fish may be affected by tail and fin rot disease. Bathing in @ 0.25 ppm (1 mg in 4l of water) solution of Acriflavin is effective against tail and fin rot disease. Besides, Argulosis can effectively be controlled by applying Secufon 80EC @ 1.0 g/40m^2 of pond area of 20-30 cm mean water depth, once in a week. It is advisable to apply stone lime @ 1.0 kg/40m^2 once, during early winter season.

Harvesting and selling

Harvesting of fish should be based on market price and demand. *Pangasius* species can be harvested after 9-12 months of stocking when attain an average weight of 0.9 to 1.2 kg. Large size fish should be harvested earlier than the smaller one. Harvesting of fish should start at midnight to attend the wholesale market in towns. After harvesting, fish should be graded according to size and weight. Live fish should be marketed due to higher price than the dead one. If odd-odour developed in fish then harvested fish should be placed in concrete tanks under continuous water flow for two days for removing odd-odour. Current whole-sale market price ranges between Tk. 80 and 90/kg of live fishes while retail price ranges from Tk. 120 to 150/kg.

XI. LIVESTOCK

1. Native Chicken

Native chicken is reared in almost every house in rural Bangladesh. Bangladesh Livestock Research Institute (BLRI) has innovated this technology. The main characteristics of the technology is to reduce mortality in family (native) chicken specially mortality of chicks through supplementary feeding and vaccination and to increase egg and meat production rate of native chicken. The technology may be adapted in all the farm families in rural areas who produce crop year-around. The farmers of Bangladesh would be able to produce more eggs and meat for fulfilling their family nutrition and income generation through this technology. This technology may be adapted in all areas of Bangladesh.

Main characteristics:

- The mortality of the chicks is reduced by supplementary feed, control of parasite, Newcastle and Fowl pox diseases.
- Improve the body weight and egg production of native chicken.
- Size of the rural farm with male-female ratio should be 1 cock: 3 hens or 1 cock: 6 hens with an area of 50 or more than 50 decimal in small, medium and large size farm.

Management

Night shelter and Creep feeder

Night shelter and Creep feeder

Creep feeder

- Each farmer should have a separate feeding pen (Creep feeder) for feeding supplementary feed to his or her chicken along with night shelter. This feeding pen can be made of bamboo and wire net or only bamboo consisting of two parts, one for adult chicken feeding and another for chicks.
- The size of the creep feeder should be 4 x 2.5 sq. feet for small farmers and 5x3 sq. ft. for large and medium farmers. The mesh size of the fence of the creep feeder should be 1.50 to 1.75 inches so that growing or adult chicken cannot enter into the feeding space of chicken to share the supplementary feed given to the chicks.

Feed management

- Thirty five (35) gm of supplementary chicken diet should be given to each growing and adult chicken divided in the morning and in the evening along with their scavenging feeding.
- Young chicks should be fed *ad libitum* upto 6 weeks of age. The amount of supplementation will be reduced gradually after 6 weeks. In the initial period, 4/5 days the mother hen should be allowed inside the creep feeder with the chicks. The

chicks don`t pick feed unless their mother do so. At the age of 10 weeks and onward the amount of supplementary feed per chicken will be 35 gm. During the period of 6-10 weeks the chicks will be habituated to scavenge feed in the homestead with their mother.

Egg production of the hens

- Small farmers should allow one of their 3 hens for chick hatching round the year; rest 2 hens would produce eggs throughout. On the contrary medium and large farmers should allow 2 of their 6 hens for chicks hatching and rest 4 hens should be allowed to lay eggs throughout the year.

Vaccination and Disease control

- The chicken house will be kept neat and clean for keeping the birds in hygienic condition as well as disease free. Moreover, the birds should be vaccinated as per following schedule.

Name of vaccine	Age at vaccination	Dose and Route
BCRDV	5-7 days	1 drop in each eye
BCRDV (Booster)	14 days	1 drop in each eye
Fowl Pox	30-35 days	Sub cutanious dose by needle
RDV	60 days	

Precaution measures

- It is necessary to follow the methods, route and dose of vaccine as per schedule.
- The supplementary feeds should not be consumed by the neighboring poultry.
- The chicken should be protected from predators (fox, jackle, kite etc.) in the respective areas.

Dissemination area and Method

- All areas of Bangladesh where agricultural products and bi-products are grown.
- The technology can be successfully disseminated to the farmers/users through Department of Livestock Services (DLS) and Non-Government Organizations (NGO) and their offices at the district and Upazilla levels.

Advantages of the Technology

- There is no harmful effect observed for this technology. The farmers should generate family income and reduce family nutritional gap. Moreover, chicken rearing at the homestead maintain the biodiversity and ecosystem of the environment.
- The mortality of the chicken especially chick mortality have been reduced from 55-60 to 25-30%. Traditionally, a farm family can earn Tk. 2000 by rearing 6/7 chickens if followed this technology. He/she could earn Tk. 6000 annually because the growth rate of the family chicken increased by 65% and egg production by 70%. If a total of five crore farm families of the country adopt the technology to produce at least 5 more chicken in each of their family, 25 crores of chicken may be added to present production to bridge the nutritional deficiency of the nation.

2. Cattle, Calf and Goat

2.1 Cattle Fattening

Cattle fattening package is a four steps rearing programme of male and/or infertile female emaciated cattle for harvesting their compensatory growth within a period of 60 to 120 days. The four steps programme include (1) Collection of animals considering their body characteristics, (2) Deworming, (3) Cost-effective feeding upto a profitable rate of life weight rain (LWG) and marketing. It is an easy and profitable system of cattle rearing to alleviate poverty, unemployment and generate income both for the rural women and youth. The cattle fattening system has been developed matching with the smallholder livestock production system in the country.

Selection and Rearing

Selection of animals is very important to harvest better benefit from the technology. Animals with correct skeletal structure, short and squarely placed legs, short necks, broad heads, wide back and breast, loose skin and rectangular or square in shape should be collected. After collection of animals from the market it should be kept separated from the other to observe the health of the animals and later on it should be dewormed after examination of feces. Market demands on the size and live weight of animals, fatty health, age and colour are the few factors for consideration to achieve a good market.

Making shed

The object of housing is to provide shelter to the calves against sun, rain, and other inclement weather. The type of housing depends on number of cattle to be fattened. For fattening one or two cattle farmers can rear with the existing cattle house but incase of 5-10 cattle complete stall feeding system is necessary. Depending on the arrangement of animals in the house, the housing systems can be classified into two types. i) Face out and ii) Face in systems.

i) Face out system: In this system, animals are standing in two rows and face of the animal in each row should be outward. The arrangement of the stall; a) Manger (M), b) Stall (S), c) Gutter/Drain (D) d) Central alley (C), the similar arrangement could be in other row. The formula for this arrangement: M 2'-8", S5'-0", D1'-4" C5'-0" D1'-4" S5'-0" M-2'-8". For one cattle the width of the stall is 4'-6" and length of the stall is 5'-0", then the floor

space of single animal is about 22.6 sq.ft. Therefore, the length of house depends on number cattle.

ii) Face in system: In face to face system, the face of the animals in the rows are inward direction inside the house. The formula of arrangement in this system is: D1-4" S5-0" M2-8" C5-0" M2-8" S5-0" D1-4".

General Management

After collection of the animal from market, animals should be kept separated from other animals of the herd to observe the disease status or animal carrying any disease in his body. The duration of quarantine period should be maintained at least 14 days. Then, the animals should be dewormed through identification of parasites. Depending on the season of rearing and duration of fattening period vaccination should be done against FMD, H.S, BQ and Anthrax. Fattening animals should be washed every day and the house should be kept clean and dry throughout the fattening period.

Feeding Management

Collection and preservation of feeds during production seasons, using locally available feed ingredients for formulation of diets and feeding a higher quality diet initially and minimization of feed cost at the later stage of rearing are the factors for formulation of cost effective diets. Any of the following feeding practices may be followed as feeding management;

(i) Ad lib Urea-molasses-straw (UMS) + a concentrate mixture (a kilo dry matter of which contains 10.0 to 11.0 MJ ME and 150 to 170g CP) @ 0.8 to 1.0% of LW

(ii) Ad lib green grass impregnantwith 5.0 to 10.0% molasses + concentrate mixture @ 0.8 to 1.0% of LW.

(iii) Ad lib UMS+ supplementary green grass + concentrate mixture @ 0.8 to 1.0% LW

(iv) Ad lib straw (preserved in fresh and wet condition) with 2% urea impregnant with 5.0 to 10% molasses + concentrate mixture @ 0.8 to 1.0% LW.

Vaccination and disease control

No risk but helps quality beef production for human consumption. Care should be taken about metabolic diseases such as acidosis, bloat etc. Fattening animals should not be fed excess grain in their ration.

Income

Depending on feed price, marketing facilities, and types of animals net benefit per animal in a period of 90 days may vary from TK. 6000 to TK. 8000 and sometimes even more than 10,000/ animal.

2.2 Calf rearing

Description

- Proper care immediately after birth and feeding of colostrum.
- Hygienic environment in and around the house.
- Prevention and control measures against infectious and parasitic diseases.

Rearing

Pregnant cow should be kept in a dry and hygienic place during parturition. Any abnormal situation should be informed to a veterinarian.

- Newborn calf should be kept on dry and clean place.
- Colostrum should be fed as early as possible. Colostrum is recommended to feed within 12 hours after birth.
- After parturition face and nose of a calf should be cleaned which would help start breathing. Help mother to lick away the ammonic sac and tissues. Use tin, Iodine on navel cord.
- Calf should be reared separately to avoid food sharing.
- Feed should be balanced depending on their age, sex and breed.
- Disease affected calf should be treated as early as possible and separated from the healthy calves
- Routine vaccination and deworming should be done.

Making shed

The object of housing is to provide shelter to the calves against sun, rain, and other inclement weather. In rearing young calves, it is desirable that an open exercise paddock directly communicating with their shelter and feeding house should be provided. Calf pens should be located close to the cow sheds, and clean drinking water should always be accessible to them. One calf should be provided 4 to 6 sq.ft floor space for better management and care.

General Management

The raising of a dairy calf begins even before it is born. Cows are not fed properly will give birth to under-nourished calves. Since the unborn calf makes most of its growth during the last 3 or 5 months before birth, special care must be taken to feed the cows liberally at that time. After giving birth, calf should be allowed to lick so as to make dry and for calf's comfortable breathing. The sooner the calf is dry the less chance there is of its being chilled specially in winter months. The calf should be reared carefully and in a hygienic management to avoid any illness and calves should be ear tagged for proper identification. If possible dehorning of calves may be carried out for better management in future.

Feeding Management



The feeding rations of calves can be divided into three types.

The Colostrum Feeding

It will vary with the system followed, but whatever system may be practiced, the calf must receive the first milk which the cow gives after calving and is called colostrums. Be sure to feed the calf enough of colostrums between 2 to 2.5 litres daily for the first 3 days following its birth. Any excess colostrum may be fed to other calves in the herd in amounts equal to the amount of whole milk normally fed. If possible where a cow is milked before calving, freeze some of the colostrums for later feeding to the calf. None of it should be wasted. The digestibility of colostrums increases when it is given at a temperature between 99°F and 102°F.

Whole milk feeding

In feeding whole milk, calves may be fed as per feeding schedule given below upto 3 months of age. After 3 months calves should be fed calf starter and good quality legumes or green grass available (Table 1).

Table 1. Feeding schedule for calves up to 6 months

Age of calf	Approx. body weight (kg)	Quantity of milk (kg)	Quantity of calf starter (g)	Green grass (kg)
4 days to 4 weeks	25	2.5	Small quantity	Small quantity
4-6 weeks	30	3.0	50-100	Small qty.
6-8 weeks	35	2.5	100-250	Small qty.
8-10 weeks	40	2.0	250-350	Small qty.
10-12 weeks	45	1.5	350-500	1-0
12-16 weeks	55	-	500-750	1-2
16-20 weeks	65	-	750-1000	2-3
20-24 weeks	75	-	1000-1500	3-5

Feeding, instead of whole milk, BLRI developed shoti based milk replacer may be fed to the calf as per schedule (Table 2).

Table 2. Feed ingredients and cost for the preparation of milk replacer (MR)

Ingredients	Ingredients used (%)	Cost involved for MR preparation (Tk./kg)
Shoti powder (cost included collection, processing and grinding etc.)	25	35.00
Soybean meal	64	26.88
Soybean oil	9	9.90
Dicalcium phosphate (DCP)	1	0.65
Vit-min-premix	0.5	1.00
Common salt	0.5	0.10
Total cost/kg		**73.53**

MR = Milk Replacer,

Feeding calf starter

After 3 months or 12 weeks calf should be given calf starter and good green grass or hay. The following formula may be used for the preparation of calf starter (Table 3). An ideal calf starter should contain 16-18% crude protein, 7-10% CF, 0.6-0.7% Ca, 0 .4-0.5% P, 0.15-.20% Mg and 0.07-0.08% Na.

Table 3. Ingredients of Calf Starter

SL. No.	Name of ingredients	Per cent in total mix (%)
1.	Wheat crushed	25
2.	Wheat bran	25
3.	Khesari bran	25
4.	Soybean meal	20
5.	DCP	3
6.	Vitamins minerals Premix	0.5
7.	Common salt	1.5
	Total	100

In addition to calf starter, 1-2 kg good quality green grass should be supplied to the calves. After 6 six months, the growing calves should be fed concentrate mixture @ 1% of the body weight and good quality green grass ad lib. basis. A concentrate mixture may be produced by using the following ingredients (Table 4).

Table 4. Ingredients of 1.0 kg concentrate mixture

SL. No.	Name of ingredients	Per cent in total mix (g)
1.	Wheat crushed	-
2.	Wheat bran	540
3.	Keshari bran	300
4.	Soybean meal	150
5.	DCP	05
6.	Vitamins minerals Premix	-
7.	Common salt	05
	Total	1.0 kg

Vaccination and disease control

Health management: "prevention is better than cure" this should the health management strategy. Most deadly diseases of calf are calfscour, pneumonia, diarrhoea and FMD. External and internal parasites are also important. The application of anthelmintic should be done at regular basis. Anthelmintic should be given twice a year; once at the start of rainy season (April-May) and again at the end of rainy season (October-November). Broad-spectrum anthelmintic should be used for deworming. For liver fluke; Facinex; Dovine etc. could be used. If calves are affected with skin diseases; it should be separated from the farm. Nuguvan, Gamaxin may be used for external parasites and liver fluke, Tapeworm and Round worms A-mectin,, Bennazol, Levavet may be used. Preventive measures against anthrax, calf diphtheria, and Black quarter and other contagious diseases should be taken. In addition, the following measures should be taken to keep the calf free from diseases.

- Feeding colostrums immediately after birth of calves.
- House should be kept clean and dry.
- Calf should be kept separated from dam.
- Keep the body of the calf clean from dirty materials.
- Supply sufficient amount of milk and other materials
- Feeder and water should be kept everyday.
- Sick calf should be separated from healthy calf.
- Regular vaccination and deworming should be carried out when necessary.

Income

The package would improve calf health and reduce calf mortality. As a result healthy calf would be produced with increased meat and milk production.

2.3 Goat Rearing

Description

A large number of people in the country are landless and lie below the poverty line. Among them a large proportion is destitute women and unemployed youth. They have no financial capacity to invest. This model provides an opportunity for their poverty alleviation. This model describes small-scale goat production through ensuring appropriate housing, feeding, breeding, health management and marketing of goat. Although commercial production of poultry and fishes in Bangladesh has increased rapidly but the progress in the production of ruminant especially goat is not visible yet. Of the 15 million of goats in Bangladesh, small and medium farmers rear 93%. Black Bengal (BB) goat is famous for its high birth rate, delicious low fat meat and super quality skin. Black Bengal is a dwarf meat type breed having average body weight of 15-20 kg and has an average growth rate of 30-50 g daily, which, are far lower than the other recognized meat type breeds of the world (Boer, Sudanese Desert, Barbari etc.). However, when we consider meat production from a doe in a year, BB probably yields greater amount of meat than the mentioned breeds as the former produces more kids in a year than the later. The milk production of BB is not sufficient that required for kid as milk producing breed. But, health and breeding management along with sufficient nutrients supply to pregnant doe may solve this problem. The model is prepared how a landless or small farmer can earn money by goat rearing.

Rearing

Necessary concentrate feed and medicine/vaccine have to be supplied to the farmer. Three BB bucks should be supplied to the area having 10-15 model farmers with 20-30 goats, where a farmer could be responsible for day to day management of the goat. The flock size with doe keeper would be between 10-12 goats. Under proper management, castrated male could be marketed within 12 months and the growing does within 6 months. Given the high birth rate of Black Bengal goat, a farmer can market 4 castrated goats and 3 does per year. However, this model is not possible to implement without institutional support. Management of the model could be easier if area-wise implementation is done.

Selection of the farmers and training

Ten to 15 beneficiary farmers may be selected according to following criteria:

- Farmer should be poor/landless/marginal.
- Destitute women/unemployed youth (should have priority)
- The beneficiary must have the willingness and eagerness for goat rearing and it is always better to have past experience in goat rearing.
- The farmers must be ready to provide necessary information.
- An initial three days training will be given to the selected farmers on housing, feeds and fodder nutrition, health, production of grasses, reproduction and marketing management. Once the beneficiaries start rearing goat, refresher training has to be arranged on specific issues.

Production management

Making shed

Goats usually prefer place where it is clean, dry, odorless, warm, sufficient light and good ventilation. Poor housing with dirty, wet, closed, dark and bad odorous, leads to origin and transmission of diseases like pneumonia, diarrhoea, ecthma, skin disease, etc. Besides, productivity in terms of weight gain, milk production and reproduction efficiency decreases. Average floor space requirement for a doe and growing goat is 7-10 and 3-7 sq. ft. respectively. As the flock size should be between 10-12 goats for a farm started with 2 goats, a farmer could built a raised floor (or macha) of 3 ft height and about (6x10) 60 sq.ft floor space. Macha could be made of bamboo or wood and can be built within farmer's house or can be built separately. For easier passage of faeces and urine from macha, slits of bamboo or wood should be set at 1.24 cm inch apart. From the middle of the house it should be sloped to both sides for easy removal of faeces and urine. Sufficient sand/ash should be given on the floor underneath macha to absorb urine and hold droppings. During the winter straw bedding of about 10-12 cm thick should be placed on macha and the goats should be covered with jute sacks at night to protect the kids from cold.

General Management

Breeding management of doe

A growing doe becomes sexually matured at 4-5 months of age, but it should not be used for breeding before reaching at least 12 kg live weight. A doe should be bred after 12-24 hours of signs of heat, i.e, if a goat showing heat in the morning it should be bred at afternoon and if the signs of heat are apparent in the afternoon, it should be bred in next morning. It is better to breed a breeding doe twice, once at 12 and 24 hour interval. A disease free, good quality and healthy Black Bengal buck should always be selected for the breeding purpose. To avoid inbreeding, buck should never be met with its full sister, mother, grandmother, daughter and granddaughter. Pregnancy period of Black Bengal goats ranges between 142-150 days.

Breeding management of Buck

A growing buckling shows signs of libido within 3-4 months, but they should not be used for breeding before 8-9 months of their age. A buck should not be used for breeding for more than 7-10 times in a week. In an area having 30-50 does, it requires about 3-5 bucks for breeding.

Feeding Management

- Feeding management according to age and production of goats.
- Feeding young goats: Milk obtained first 3 days after kidding is called colostrums, generally rich in energy and protein which act as an antibody for the newborn (Table1).

Table 1: Ingredients (%) present in normal milk and colostrums

	Fat	Protein	Lactose	Minerals	Total dry matter
Normal milk	5.09	3.33	6.01	1.60	10.03
Colostrum	5.6	8.10	4.80	0.85	20.30

Immediately after birth kid should be cleaned, dried and should have colostrums within half an hour. Birth weight of BB kids is usually 0.8-1.5 kg (average 1.00 kg). They should receive 150-200 g of colostrums for each kg body weight. These amounts of milk should be fed for 8-10 times in a day. Colostrum may not digest properly if it is fed to the kid after 12 hours of birth. Kid from 0-3 months of age should receive following amounts of milk and other solid feeds (Table 2). Usually BB kids weaned within 2-3 months of age

Table 2. Age-wise feed supply to the kids

Age (week)	Milk (g/kg body wt)	Rice gruel (g) (if necessary)	Green grass
0-2	200	Little amount	Small amount
3-4	150	Little amount	Small amount
5-6	150	150	Small amount
7-8	130	250	Sufficient amount
9-10	110	300	Sufficient amount
11-12	100	350	Sufficient amount

N.B Goats should be supplied sufficient amount of clean drinking water all the time.

Kid should have access to tree leaves and green grass from 1st week of their life, which helps them develop functional rumen within 4-5 weeks. If properly accustomed, a kid could start taking considerable amount (50-150 g) of green grass/tree leaves within one month. Good quality succulent grass like Rousi, Plicatulum, Centrosoma, Endropogon along with Durba, Sechi, Araila, Mashkalai, Khesari etc. Besides, leaves from Ipil-ipil, Jakfruit, Dhaincha etc. should also be offered.

Feeding adult goats

For a growing castrated male or non-pregnant female it requires about 2 to 3 kg of green grass and 200-250 g of concentrate mixture daily. A pregnant doe of 25 kg body weight may be given 2.5 to 3.5 kg of green grass and 350-450 g of concentrate mixture. Similarly, an adult buck may be given 2.5 to 3.5 kg of green grass and 200-300 g of concentrate. Feed management of breeding buck is same as that of growing goats. But 10

grams of germinated gram should be given to breeding buck to ensure proper breeding.

Vaccination and disease control

Health management:"prevention is better than cure" this should be the health management strategy. Timely vaccination and application of anthelmintic should be done at regular basis. Most deadly diseases of goat are PPR and Goat pox' vaccines against these should be given at 4th and 5th month of age respectively. Anthelmintic should be given twice a year; once at the start of rainy season (April-May) and again at the end of rainy season (October-November).Broad-spectrum anthelmintic should be used for deworming. For liver fluke; Facinex; Dovine etc. could be used. If goats affected with skin diseases; it should be separated from the farm. Dipping of all the goats in 0.5% Melathion solution at 15-30 days interval could be a good control strategy for skin diseases. Preventive measures against mastitis and other contagious diseases should be taken.

Income

The Cost-benefits in a farm are given in Table 3. Estimated net profit for a goat flock started with 2 does ranges Tk. 2050 (2nd year), Tk. 4000 (3rd year), Tk. 6200 (4th year) and Tk. 6200 (5th year) (Table 3).

Categories	**Year**				
	1	2	3	4	5
At the start of year					
Doe	2	2	2	4	4
Growing	-	1	3	2	1
Kid	-	4	4	6	6
Total	**2**	**7**	**11**	**12**	**11**
Death:Doe					
Growing					
Kid	1	2	3	3	3
At the end of year					
Doe	2	4	4	5	
Growing	3	7	9	8	8
Kid	4	4	6	6	8
Total	**9**	**15**	**19**	**18**	**21**
Sell					
Castrated goat	-	2	3	4	4
Growing doe	2	2	4	3	4
Earn from goat selling	2x800= 1600	2x800=1600 2x2200=4400	4x1000=4000 3x2200=6600	3x1000=3000 4x2200=8800	4x1000=4000 4x2200=8800
Total	**1,600**	**6,000**	**10,600**	**11,800**	**12,800**
Expenditure (yearly)	4000				
Feed	2500	3500	5000	5000	5000
Medicine	300	300	400	400	400
Others	100	150	200	200	200
Total	**6900**	**3950**	**5600**	**5600**	**5600**
Net profit/ Loss		2050	4000	6200	6200

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Appendix 2: Calendar of Selected Crops