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TECHNOLOGIES DEVELOPED IN THE MUJIB CENTENARY

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2021

Bangladesh Agricultural Research Institute

TECHNOLOGIES DEVELOPED IN THE MUJIB CENTENARY

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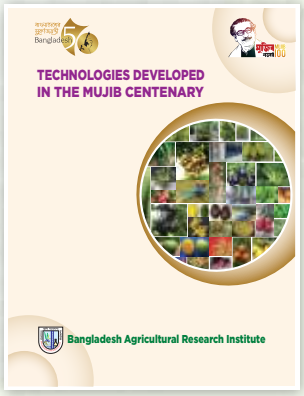

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Minister
Ministry of Agriculture
Government of the People's
Republic of Bangladesh

Message

I am very pleased to know that Bangladesh Agricultural Research Institute (BARI) is going to publish a technology-based book entitled, **'Technologies Developed in the Mujib Centenary'** to celebrate the birth centenary of the Father of the Nation Bangabandhu Sheikh Mujibur Rahman and the golden jubilee of Bangladesh's independence. Such credential effort of BARI is very much praiseworthy.

The greatest Bengali of all times, the Father of the Bengali Nation, Sheikh Mujibur Rahman cherished within him a friendly attitude to agriculture and the farmers. He dreamt of a prosperous, self-dependent and developed 'Sonar Bangla' by developing agriculture. So he took some groundbreaking steps in agriculture like call for the Green Revolution, waving tax, improvement and modernization of agricultural organizations to ensure innovations and use of scientific farming and modern production technologies. The result of such steps was the beginning of unprecedented progress in agriculture.

The present government, under the strong and dynamic leadership of his daughter, the Honorable Prime Minister Sheikh Hasina, is adopting agriculture-friendly policies and implementing them. Bangladesh has already made a bright example in agricultural growth throughout the world despite its increasing population and decreasing cultivable land, natural disasters and climate change. Meanwhile, self-sufficiency in staples has been attained in normal years. Furthermore, Bangladesh has achieved the status of developing country by meeting all development indicators. In-sha-Allah, under her scholastic guidance, we would be able to achieve the much cherished Vision 2041 to build Bangladesh as a developed country in the world.

I believe that, climate resilient varieties of fruits, vegetables, pulses, oilseeds and spices, and advanced production technologies as included in this book would be useful to the scientists, extension personnel, planners and relevant stakeholders involved in the agriculture sector. I wish that the scientists of BARI would continue their efforts in research for achieving nutrition security, and bringing production sustainability of high value crops and exploring the export potentials through preservation, packaging and value addition.

Joy Bangla, Joy Bangabandhu
Long live Bangladesh.

(Dr. Muhammad Abdur Razzaque, MP)

Senior Secretary
Ministry of Agriculture
Government of the People's
Republic of Bangladesh

Message

I would like to express my humble respect and deepest gratitude to the Father of the nation, Bangabandhu Sheikh Mujibur Rahman on his birth centenary and on the golden jubilee of independence, also to all those who snatched the red sun of independence by shedding their drops of blood and sacrificing their modesty in the liberation war of 1971 and painted the name of independent sovereign Bangladesh on the map of the world.

Although the country is self-sufficient in food (staple food rice), it lags far behind in achieving nutritional security. In order to achieve nutritional security, besides rice, the daily demand of vegetables, fruits, roots, pulses, oil seed and spice crops must be met for every person in the county. At present, the production deficit of these crops is about 35-65%, which is met by imports from abroad, resulting in expenditure of huge foreign exchange. The government has given special importance to achieving self-sufficiency by reducing the production deficit of all these crops, and the scientists of BARI are playing a key role in making this challenge a success. They have already developed 594 improved / modern varieties of different crops and 563 advanced production technologies which have greatly increased the production of these crops in response to the effects of climate change, and the significant achievement is that the country now has a surplus of potatoes. In recognition of such contributions, BARI won the country's highest honor, the "Independence Award" in 2014.

In the midst of stagnant world life, collapsed economy and frequent lockdown in the ongoing COVID-19 pandemic, agriculture in Bangladesh is a moving forward at an irresistible pace with the strong leadership and inspiration of the Hon'ble Prime Minister and Minister of Agriculture Dr. Md. Abdur Razzaque, MP. Scientists of BARI are also moving in unison, ignoring the dreads of the COVID-19 pandemic and they have released 42 varieties and 45 improved production technologies in this period of Mujib centenary. I am very happy to know that BARI is publishing a book entitled "Technologies developed in the Mujib centenary for improving Nutrition Security and Farmers Economic Condition" to honor and commemorate the birth centenary of the Father of the Nation and the 50th anniversary of independence. Wish that this commendable initiative of BARI be successful and that all these technologies be used in the farmers' field to achieve the nutritional security of the country, accelerate the commercialization of agriculture and improve the economic condition of the farmers.

(Md. Mesbahul Islam)

Director General
Bangladesh Aricultural Research Institute

Preface

Bangladesh Agricultural Research Institute (BARI) is delighted to publish the book "Technologies Developed in the Mujib Centenary". The book is being published at a very special moment when the entire nation is celebrating the golden jubilee of independence side by side the 100th birth anniversary of the Father of the Nation Bangabandhu Sheikh Mujibur Rahman. The book is dedicated with deepest respect and gratitude to all the freedom fighters and to those for whom we have achieved the independence in exchange of their blood, modesty and self-sacrifice.

I remember with innermost respect the eternal philosophy and direction of Bangabandhu Sheikh Mujibur Rahman in building an agriculture rich, hunger and poverty free 'Sonar Bangla'. Bangabandhu established the importance of agriculture by promoting the status of agriculturist to class-I on 13 February, 1973 as a primary step for transforming agri-food system in Bangladesh.

Agriculture is the main driving force of the economy of Bangladesh. Bangabandhu realized that, the development of agriculture was not possible without modernization of agricultural system. Today's Bangladesh Agricultural Research Institute is the result of that cherished agricultural thought of Bangabandhu. Following the ordinance issued by Bangabandhu in 1973, BARI was established as an autonomous institution in 1976 to feed a burgeoning population of the country.

Since inception, BARI is working relentlessly and contributing to achieve food and nutrition security of the country. It has strengthened and modernized research activities and immensely contributed to end poverty and hunger through increasing climate resilience in agricultural production systems.

Despite the outbreak of the COVID-19 pandemic since the beginning of Mujib Centenary, scientists of BARI have continued their research activities and has released 43 improved varieties of vegetables, fruits, pulses, oilseeds, spices, tuber crops and flowers. Besides, it has developed 45 improved crop production technologies which have been included in this special publication. I believe that technologies, developed during the period of Mujib Centenary, will be useful for the researchers, extension personnel, farmers and stakeholders involved in agriculture sectors.

My deepest gratitude and appreciation to heroic freedom fighter, renowned agricultural scientist, Hon'ble Minister, Ministry of Agriculture, Dr. Muhammad Abdur Razzaque, MP, for having a look at the manuscript and gave valuable advice on improving the quality of the book in spite of his tremendous busy schedule..

Thanks are extended to the scientists for their contribution in this publication. Sincere appreciations are also extended to those who are involved in compiling and editing the manuscript.

Dr. Md. Nazirul Islam

CONTENTS

B. Improved Technologies for Crop Production

A. Modern/Improved Varieties of Different Crops

Bangladesh Agricultural Research Institute (BARI) is working for ending hunger, achieving food security, improving nutrition and promoting sustainable agriculture. BARI is conducting research on 211 crops like tuber crops, cereals, pulses, oilseeds, fruits, vegetables, spices etc (excluding rice, wheat, maize, sugar, jute, cotton and tea). All these crops are important for food security as well as meeting nutritional requirements of human being. Scientists of Horticulture Research Center, Tuber Crops Research Center, Pulses Research Center, Oilseed Research Center, Spices Research Centre, and Plant Breeding Division of BARI have been working to develop improved varieties of crops by using germplasms from home and abroad. In addition, the institute has developed many improved varieties along with some salinity, draught, water-logged tolerent as well as vitamin, carotene, zinc and iron enriched varieties. Till now, 602 varieties of different crops have been developed of which 43 varieties have been released in the Mujib Centenary (2019-20 & 2020-21).

Technology #1 : Modern variety of mango "BARI Aam-12"

Salient features of the technology

- An extremely late season variety.
- Fruit elliptic in shape and average weight of individual fruit is 435 g.
- Pulp is orange in colour, firm in texture and has aroma like Langra variety.
- Edible portion of fruit is 82% and TSS 23%.

Suitable environment: Mango is mainly a tropical fruit, but it can also be commercially grown in sub-tropical region. Deep, well drained, fertile loamy soil is suitable for its cultivation, though it can be grown in any kind of soil. Soil pH 5.5 to 7.5 is suitable for mango cultivation.

Production/ utilization method

Planting: Suitable planting time is May-July, but it can also be planted in the month of August-October. It is better not to plant the mango sapling during intense rainy season. The pits of 1 m × 1 m × 1 m in size at a distance of 8 m × 8 m to 10 m × 10 m are to be prepared at least 15-20 days before transplanting. During pit preparation cowdung 20 kg, TSP 500 g, MoP 250 g, gypsum 300 g, zinc sulphate 50 g and boric acid 50 g should be mixed with the soil of pit and filled it up. If there is less moisture in soil then water should be applied in the pit. After 10-15 days of pit preparation, 1 year old selected sapling should be transplanted in the middle of the pit keeping it upright and strait without damaging the original soil bowl of the sapling. After transplanting stacking, fencing and irrigation facilities should be ensured.

Fertilizer dose and application method: Fertilizers are to be applied to individual plant considering age. Amount of fertilizers needed – i) for 1-4 years old plant: cowdung 15 kg, urea 250 g, TSP 250 g, MoP 100 g, gypsum 100 g, zinc sulphate 10 g and boric acid 20 g; ii) for 5-7 years old plant: cowdung 20 kg, urea 500 g, TSP 250 g, MoP 200 g, gypsum 200 g, zinc sulphate 10 g and boric acid 20 g; iii) for 8-10 years old plant: cowdung 25 kg, urea 750 g, TSP 500 g, MoP 250 g, gypsum 250 g, zinc sulphate 15 g and boric acid 30 g; and iv) for 11-15 years old plant: cowdung 30 kg, urea 1000 g, TSP 500 g, MoP 400 g, gypsum 350 g, zinc sulphate 15 g and boric acid 30 g; v) for 16-20 years old plant: cowdung 40 kg, urea 1500 g, TSP 750 g, MoP 500 g, gypsum 400 g, zinc sulphate 20 g and boric acid 40 g; and finally vi) for more than 20 years old plant: cowdung 50 kg, urea 2000 g, TSP 1000 g, MoP 800 g, gypsum 500 g, zinc sulphate 25 g and boric acid 50 g. The fertilizers should be applied in three splits. The first split (whole organic manure, TSP, gypsum, zinc sulphate and boric acid plus 50% urea and MoP fertilizer) has to be applied within 15-30 September. The rest of urea and MoP should be divided into two equal halves and one part (2nd split) of which has to be applied at the end of March at marble stage of fruit, and the rest urea and MoP are to be applied during the last week of April to

the 1st week of May or just one month before harvest. If necessary, light irrigation should be dispensed after fertilizer application.

Diseases and Insect-pest management: Anthracnose is a fungal disease of mango which is responsible for flower and fruit dropping as well as rotting of mature fruits of mango. For this reason, Indofil M 45 at the rate of 2.0 g/L or Tilt 250 EC 0.5 ml/L of water can be sprayed after panicle emergence but before flower opening stage wetting is required for the whole panicle. After one month, at the pea stage of the fruit, the above mentioned spray should be applied soaking the leaf, panicle and shoots well. To reduce mature fruit rotting, hot water treatment at 55^0 C for five minutes can be done at the postharvest stage. Sooty mold is another fungal disease in mango seen on the leaf, panicle and young shoots caused by the sucking pests like mango hopper and mealy bug because of honey dew secretion and growing black cover. For this reason, Thiovit @ 0.2% can be sprayed. Besides, mango hopper is the most damaging pest during flowering. Confidor 70 WG @ 0.2 g per litre of water can be sprayed once after panicle emergence but before flower opening stage and the other one at the pea stage of the fruit.

Irrigation: Frequent light irrigation should be provided in the early stages of growth of the sapling. Irrigation must be stopped 3 months before panicle emergence. Four irrigations at 15 days interval starting from full bloom stage are suggested.

Intercultural operations: Weeds have to be controlled through ploughing before and after the rainy season. In the hilly areas, weed should be controlled regularly by cutting the weeds. For maintaining a proper shape and structure of the plant, training should be done after 2-3 years of planting maintaining a height of 1-1.5 meter from the base. Pruning of dead, diseased, dry and weak branches should be done every year after the rainy season. Moreover, if the plant becomes bushier, the additional branches should be cut for proper sunlight and aeration.

Harvesting time: August-September.

Yield/Output: Per hectare yield (with three years old palnts): 2.5 – 3.0 tons

Technology #2: Hybrid variety of mango "BARI Aam-13"

Salient features of the technology

- It is a late season, high yielding and coloured hybrid mango variety.
- Rich in carotene.
- Individual fruit weight is 220 g, TSS: 21% and edible portion of fruit is 74.6%.

Suitable environment: Same as described for BARI Aam-12 (Technology #1**)**

Production/ utilization method: Same as described for BARI Aam-12 (Technology #1**)**

Yield/Output: Per hectare yield (with 14 years old trees): 5-6 tons.

Technology #3: Modern variety of mango "BARI Aam-14"

Salient features of the technology

- It is a late season, high yielding and coloured hybrid mango variety.
- Skin colour is attractive maroon at ripe stage.
- Individual fruit weight is 569 g, TSS 22.83% and edible portion of fruit is 75.35%.
- Export potential variety

Suitable environment: Same as described for BARI Aam-12 (Technology #1)

Production/ utilization method: Same as described for BARI Aam-12 (Technology #1)

Yield/Output: Per hectare yield (with 8-9 years old trees): 13-14 tons

Technology #4: Modern variety of mango "BARI Aam-15"

Salient features of the technology

- It is a high yielding, regular bearing and late season mango variety.
- Individual fruit weight is 680 g and TSS is 24%.
- Edible portion of the fruit is 82.35%.

Suitable environment: Same as described for BARI Aam-12 (Technology #1)

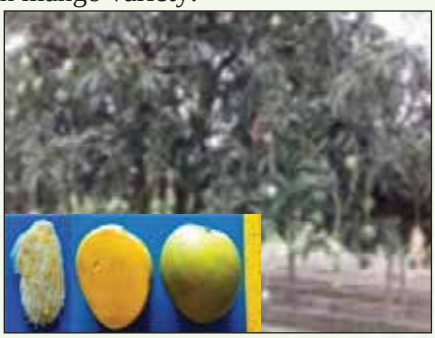
Production/ utilization method: Same as described for BARI Aam-12 (Technology #1)

Yield/Output: Per hectare yield (with 8 years old trees): 20-22 tons.

Technology #5: Modern variety of mango "BARI Aam-16"

Salient features of the technology

- It is a high yielding, regular bearing and late season mango variety.
- Individual fruit weight is 571 g, TSS is 25% and edible portion of the fruit is 80.2%.



Suitable environment: Same as described for BARI Aam-12 (Technology #1)

Production/ utilization method: Same as described for BARI Aam-12 (Technology #1)

Yield/Output: Per hectare yield (with 15 years old trees): 22-24 tons.

Technology #6: Hybrid variety of mango "BARI Aam-17"

Salient features of the technology

- It is a high yielding, regular bearing and late season hybrid mango variety.
- Individual fruit weight is 650 g, and TSS is 25.50%.

Suitable environment: Same as described for BARI Aam-12 (Technology #1)

Production/ utilization method: Same as described for BARI Aam-12 (Technology #1)

Yield/Output: Per hectare yield (with 7 years old trees): 12-15 tons

Technology #7: Improved variety of falsa "BARI Falsa-1"

Salient features of the technology

- Regular bearer and high yielding variety.
- Individual fruit weight is 0.66 g.
- Edible portion of the fruit is 88% and soury-sweet in taste (TSS 24%).
- Storage period is 2-3 days in normal room temperature.
- This variety is suitable to cultivation in almost all agro-ecological zones of the country.

Suitable environment: Falsa is mainly an Equatorial fruit, but it can also be grown in the sub-equatorial region. Warm and humid air interferes with fruit set during flowering. Falsa can be cultivated in almost all types of soils, but the soil with good drainage quality must be ensured.

Production/ utilization method

Planting: Suitable planting time is June-August, but it can also be planted round the year if irrigation water is available. In the homestead, it is planted in separate pits. The pits of 1 m × 1 m × 1 m in size at a distance of 8 m × 8 m are to be prepared at least 10-15 days before transplanting. During pit preparation cowdung 10-15 kg, TSP 150-200 g, MoP 100-150 g and gypsum 50-100 g should be mixed with soil of pit and filled it up. If there is less moisture in soil then water should be applied in the pit. At the scheduled time, the selected sapling should be placed directly in the middle of the pit, the soil should be pressed around the sapling by hand and tied with a stand.

Fertilizer dose and application method: The amount of fertilizer vary with age of the plant such as, i) for 1-4 years plant: cowdung 12 kg, urea 250 g, TSP 200 g, MoP 150 g, gypsum 100

g, zinc sulphate 10 g and boric acid 10 g; ii) for a 5-10 years old plant, cowdung 18 kg, urea 350 g, TSP 300 g, MoP 300 g, gypsum 200 g, zinc sulphate 20 g and boric acid 15 g; iii) for a 11-15 years old plant cowdung 24 kg, urea 500 g, TSP 450 g, MoP 450 g, gypsum 250 g, zinc sulphate 30 g and boric acid 20 g; and iv) for a 15 years or more old plant, cowdung 30 kg, urea 650 g, TSP 600 g, MoP 600 g, gypsum 300 g, zinc sulphate 40 g and boric acid 25 g. The above fertilizers should be divided into two equal splits, the first split in the month of Jyasthai-Ashar (May-July) and the second split in the month of Ashwin (September-October) in the shaded area at noon and has to be mixed thoroughly by spading. Upto three years of age, use of urea and MoP fertilizers evenly in 4-6 splits, i.e. every 2-3 months interval accelerates the primary growth of the plant. If there is lack of moisture in the soil, it is necessary to irrigate immediately after applying fertilizer.

Disease and insect-pest management: Usually, no insect infestation and disease infection noticed in this variety. But sometimes mealy bug infestation on fruit, stem and leaf is observed. Hence, Sumithion 50 EC @ 2 ml/litre water can be sprayed 2-3 times at an interval of 15 days.

Irrigation: Irrigation is essential in the dry season. Irrigation should be applied for 2-3 times at 15 days interval after fruit set.

Intercultural operations: The surroundings of the plant base should be kept weed free. Dried, dead, diseased and weak branches and sycophants and parasitic herbs should be cut off after fruit harvest every year. Bordeaux paste (100 g $CuSO_4$, 100 g CaO and 1 litre of water) or any copper fungicide should be applied at the cut end.

Harvesting time: Fruits are harvested in May-June.

Yield/Output: Per hectare yield (with 12 years old trees): 3-4 tons.

Technology #8: Improved variety of bullock's heart "BARI Ata-1"

Salient features of the technology

- Regular bearer and high yielding variety.
- Fruits are comparatively bigger and individual average fruit weight is 261 g.
- Edible portion is 72% and very sweet in taste (TSS 26%).

Suitable environment: Bullock's heart is mainly a tropical fruit crop. But the crop is spread upto calm weathered sub-tropical region. It can be grown in almost all kinds of soil but the soil must be deep, fertile and well drained. It can't tolerate waterlogging. Soil pH is 5-8 is better for growing bullock's heart.

Production/ utilization method

Planting: June to August is the best time for planting. But planting can be practiced round the year provided that irrigation facility is ensured. In the homesteads, it is generallty planted in separate

mounds. The pit of 1 m x 1 m x 1 m in size at a distance of 6 m x 6 m are to be prepared 15-20 days before transplanting of saplings. Cowdung 10-15 kg, TSP 250 g, MoP 250 g and gypsum 100 g should be mixed with the top soil of each pit and filled it up and kept after applying water in the pit. At the scheduled time, the saplingy should be placed directly in the middle of the hole.

Fertilizer dose and application method: Depending on the age of the plant fertilizer dose may vary. In case of 1-4 years old plant: 12 kg cowdung, 300 g urea, 200 g TSP, 150 g MoP, 100 g gypsum, 20 g zinc sulphate and 10 g boron; for 5-10 years old plant: 18 kg cowdung, 450 g urea, 300 g TSP, 300 g MoP, 200 g gypsum, 30 g zinc sulphate and 15 g boron; for 11-15 years old plant: 24 kg cowdung, 600 g urea, 450 g TSP, 450 g MoP, 250 g gypsum, 40 g zinc sulphate and 20 g boron; and in case of plant with more than 15 years of age: 30 kg cowdung, 750 g urea, 600 g TSP, 600 g MoP, 300 g gypsum, 50 g zinc sulphate and 30 g boron should be applied. The above fertilizers should be divided into two equal halves, the 1st half to be applied in the month of Jyasthai-Ashar (May-July) and the 2nd half in the month of Ashwin (September-October). Fertilizers to be applied at noon. Gypsum and zinc sulphate may be applied every alternate year. Upto three years of age, applying urea and MoP fertilizer in 4-6 splits at an interval of 2-3 months accelerates the vegetative growth.

Disease and insect-pest management: Dieback disease is one of the major problems of bullock's heart. The twig and branches die from the top because of this fungus. This drying process slowly moves downward. To control the disease, infected shoots should be cut and Bordeaux paste (100 g $CuSO_4$, 100 g CaO and 1 litre of water) should be applied. Indofil M-45 or other fungicides of mancozeb group at 2 g per litre of water or Bordeaux mixture (10 g $CuSO_4$, 10 g CaO and 1 litre of water) should be sprayed at 15 days interval for 2-3 times. Besides, mealy bug attack on leaf and fruit is noticed sometimes. Cottony layers develop on the leaf, fruit and stem because of the infestation of this insect. The insect under the layer sucks the leaf sap. As a result, the plant becomes weak. Use of slippery plastic band of 8-10 inch width at 1 m above the ground can prevent the nymph climbing up from the ground, if infestation occurs. Spraying of Sumithion 50 EC at the rate of 2 ml per litre of water at 10-15 days interval for 2-3 times perform effectively in order to control the insect.

Irrigation: Frequent irrigation is required for faster growth of the young plants. It usually flowers from July to September. Therefore, in the dry season, at fruit growth stage, i.e. during the month of December-January, irrigation should be done at 15-day intervals considering soil moisture.

Intercultural operations: Weed to be controlled by ploughing the land just before and after the rain. Weeding should be done in the hilly region on a regular basis. All the side branches leaving 1.0-1.5 m of 2-3 years old plant should be removed to give a proper frame to the plant. Every year, the dried, dead, diseased and weak branches and sycophants and parasitic herbs should be cut off after fruit harvest. Bordeaux paste (100 g $CuSO_4$, 100 g CaO and 1 litre of water) or copper fungicide should be applied at the cut end after prunning. Besides, if the tree becomes very bushy, additional branches should be pruned in order to facilitate light penetration and aeration.

Harvesting time: Early March to mid May. Fruits should be collected only when they are fully mutured. Collected mature fruits ripen well within 2-3 days.

Yield/Output: Yield per hectare (with 8 years trees): 22-24 tons.

Technology #9: Improved variety of jamun "BARI Jam-1"

Salient features of the technology

- Regular bearer and high yielding variety.
- Fruits are bigger and individual fruit weight is 9.8 g.
- Very sweet (TSS 12.4%) and edible portion is more than 83%.

Suitable environment: Jamun is a tropical and sub-tropical fruit crop. It can be cultivated in both of the equatorial and sub equatorial regions. Though it can be grown in all types of soils, deep loam or sandy loam soil is more suitable. It can tolerate water logging to some extent. Dry weather at flowering stage is good, but light rain at the fruit growth and maturity stage helps to develop fruits well.

Production/ utilization method

Planting: June to August month is the best time for planting. But planting can be done round the year provided that irrigation facility is ensured. The pits of 1 m × 1 m × 1 m in size at a distance of 8-10 m at both sides have to be prepared 15-20 days before planting. During pit preparation 15-20 kg well rotten cow dung, 500 g TSP, 250 g MoP and 200 g gypsum should be mixed with the top soil of the pit and filled it up and kept after applying water in the pit. The sapling should be planted in the middle of the pit at the scheduled time.

Fertilizer dose and application method: Fertlizers to be applied considering age of the tree. Fertilizer recommendation – i) for 1-3 years old tree, 20 kg cowdung, 200 g urea, 200 g TSP, 200 g MoP and 50 g gypsum; ii) for 4-6 years old tree, 25 kg cowdung, 400 g urea, 300 g of TSP, 300 g of MoP and 100 g of gypsum; iii) for 7-10 years old tree, 30 kg cowdung, 600 g urea, 500 g TSP, 500 g MoP and 200 g gypsum; iv) for 11-15 years old tree, 40 kg cowdung, 800 g of Urea, 700 g TSP, 700 g MoP and 200 g gypsum; and v) for plant having more than 15 years of age, 45 kg cowdung, 1000 g urea, 800 g TSP, 800 g MoP and 300 g gypsum. The above fertilizer should

be divided into two equal halves, the 1st half in the month of Jyasthai-Ashar (May-July) and the 2nd half in the month of Ashwin (September-October) need to be applied. Gypsum and zinc sulphate are advised to apply every alternate year. Upto 3 years of age, applying of urea and MoP fertilizer in 4-6 splits accelerates the vegetative growth.

Disease and insect-pest management: Generally, no major disease infection is observed in jamun. In case of ripe fruits, light wound is noticed because of a kind of fungal infection. Hence, infected fruits should be collected and destroyed. Indofil M-45 or other fungicides of mancozeb group at 2 g per litre of water or Bordeaux mixture (100 g $CuSO_4$, 100 g CaO and 1 litre of water) should be sprayed at 15 days interval for 2-3 times starting from fruit set. Trunk/stem borer is one of the major enemies of Jamun. The caterpillars of this insect enter into the stem and start to climb upward eating through the central core. The infected branch or the whole plant dies if the control measure is not taken at appropriate time. At the initial stage of infestation, the insecticide of cypermethrin group at the rate of 2.0 ml per litre of water has to be sprayed at an interval of 15-20 days for 2-3 times. If the pore and insect excreted dirt are seen on the stem, the infested part should be scooped with knife to open the holes. The dirt inside the pores should be cleaned with the help of sickle or knife and required amount of Diazinon 60 EC should be poured into the pores. Then, the pores should be closed with coaltar or Bordeaux paste (100 g $CuSO_4$, 100 g CaO and 1 litre of water).

Irrigation and drainage: Frequent irrigation is essential for faster growth of the young plants. Irrigation in winter and summer can save the plants from the winter and drought, respectively. Irrigation for 2-3 times every 15 days interval is required after fruit set in March.

Intercultural operations: Weeds to be controlled by ploughing the land just before and after the rain. In the hilly region, weeding should be done on a regular basis. The side branches leaving 1.0-1.5 m of 2-3 years old plant should be removed to give a proper shape to the plant. Every year, the dried, dead, diseased and weak branches and sycophants and parasitic herbs should be cut off after fruit harvest. After pruning, Bordeaux paste (100 g $CuSO_4$, 100 g CaO and 1 litre of water) or copper fungicide should be applied at the cut end. In addition, if the plant becomes bushy, excessive branches should be pruned to facilitate penetration of light and air.

Harvesting time: Mid June to mid July. Since all the fruits do not ripe at a time, fruits have to be collected every 2/1 days interval.

Yield/Output: Yield per hectare (with 6 years trees): 5 - 6 tons.

Technology #10: Improved variety of wood apple "BARI Kodbael-2"

Salient features of the technology

- Regular bearer and high yielding variety.
- Availability of fruits in the off season (February to May), which is a unique character.
- Fruits are bigger in size; average individual fruit weight is 455 g.
- Pulp of a ripe fruit is attractive deep brown, soft and sour-sweet in taste.

Suitable environment: Wood apple is a tropical fruit crop and can withstand dry weather. It can be cultivated in all types of soils. But, the fruit trees grow well in the organic matter enriched loam to heavy clay soil which is well-drained. Besides, it also grows well in slightly saline soils.

Production/ utilization method

Planting: June-August is the best period for planting of wood apple. But planting can be preformed round the year provided that irrigation facility is available. Pits of 1m × 1 m × 1 m in size with 6 m × 6 m in distance should be prepared 15-20 days before planting. The upper soils of each pit should be mixed thoroughly with 10-15 kg of well rotten cowdung, 250 g TSP, 250 g MoP, and 100 g gypsum and filled up the pit well and kept after applying water in the pit. Healthy and disease free grafted sapling should be planted in the middle of the pit at the scheduled time.

Fertilizer dose and application method: Depending on the age, fertilizers to be applied such as: 8 kg cowdung, 250 g urea, 400 g TSP, 250 g MoP and 65 g gypsum to 1-4 years old tree; 12 kg cowdung, 500 g urea, 500 g TSP, 500 g MoP and 100 g gypsum to 5-10 years old tree; 16 kg cowdung, 800 g urea, 800 g TSP, 500 g MoP and 200 g gypsum to 11-15 years old tree; and 20 kg cowdung, 1100 g urea, 1000 g TSP, 600 g MoP and 250 g gypsum to a tree more than 15 years of age. The above fertilizer should be divided into two equal halves, the 1st half to be applied in the month of Jyasthai-Ashar (May-July) and the 2nd half in the month of Ashwin (September-October). Gypsum and zinc sulphate is advised to apply every alternate year. Upto 3 years of age, applying urea and MoP fertilizer in 4-6 splits may accelerate the vegetative growth.

Disease and insect-pest management: No major disease infection was observed in this variety of wood apple. However, woodapple fruit borer (*Deudorix isocrates*) enters into the fruit, eats the fruit flesh and leaves away. When the fruit is small, spraying with Proclame 5 SG at 1 g per liter of water for 2-3 times at 7-10 days interval effective to control this pest.

Irrigation and drainage: Frequent irrigation is essential for faster growth of the young plants. The dry period exists during the fruit development of this variety. Hence, considering the soil moisture level, irrigation for 2-3 times at 15 days interval during December-February is essential.

Intercultural operations: Weeds to be controlled by ploughing the land just before and after the rainy season. In the hilly areas, weeds should be controlled through cutting regularly. For attaining proper shape of canopy all the side branches of 2-3 years old plant should be removed leaving 1.0-1.5 m height of stem from base of the plant. The dried, dead, diseased and weak branches and sycophants and parasitic herbs should be cut off after fruit harvest every year. Bordeaux paste (100 g $CuSO_4$, 100 g CaO and 1 litre of water) should be applied at the cut end after pruning. Besides, if the tree becomes bushy, excessive branches should be pruned in order to facilitate light penetration and aeration.

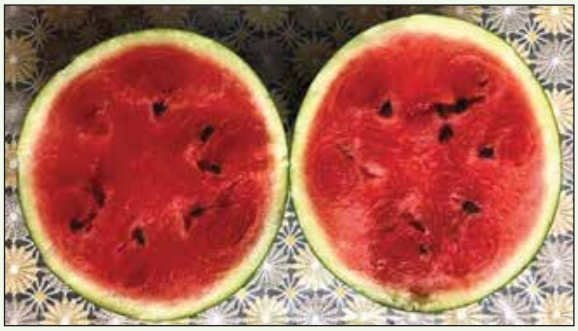
Harvesting time: February to May.

Yield/Output: Per hectare yield (with 10 years trees): 18-20 tons.

Technology #11: Improved variety of watermelon "BARI Tormuj-1"

Salient features of the technology

- High round shaped fruit.
- Skin deep green in colour.
- Flesh colour deep red.
- Sweetness 17% (TSS).
- Individual fruit weight: 4.0-5.0 kg.
- Number of fruits/plant: 5-6.
- Suitable for growing year round.
- Average yield 38 t/ha.



Suitable environment: Cultivable for growing all over Bangladesh- most suitable for northern, hill districts and southern region of the country. Flood free high land, sandy-loam soil having pH 5.0-6.5 is suitable for cultivation.

Production/ Utilization method

Sowing/planting: March-April is suitable sowing time. Seed rate is 200-250 g/ha. Usually 15-21 days aged seedlings are transplanted. Planting spacing: plant to plant 1.5 meter and line to line 2 meter.

Fertilizer dose and application method: Cowdung 10 ton, urea 250 kg, TSP 250 kg, MoP 200 kg, gypsum 100 kg, zinc sulphate 10 kg and boric acid 14 kg to be applied per hectare. Entire cowdung, TSP, gypsum, zinc, and boric Acid and half of the total MoP to be applied during final land preparation. Rest of the MoP and entire urea are to be applied in 4 equal splits at 15 days interval.

Diseases and incest-pest management: This variety is tolerant to pest and diseases as it is inbred variety. Integrated use of sex pheromone and bait trap should be used to control fruit fly infestation successfully. This variety is also tolerant to root rot disease.

Irrigation and drainage: Irrigation to be provided based on soil moisture condition and requirement of plants. Usually, 3-4 irrigations are required.

Intercultural operations: Weeding need to be done regularly. Suckers an vine should be removed allowing 4 stems only for fruit retention. The soil crusts required to break after irrigation. Appropriate pesticide should be applied to protect the plants from diseases and insects as and when needed.

Harvesting time: After 43-45 days of pollination the fruits attain maturity.

Yield/Output: Per hectare yield: 35-40 tons

Technology #12: Modern variety of watermelon "BARI Tormuj-2"

Salient features of the technology

- Oblong shaped fruit, skin light green colour having deep green narrow stripes.
- Yellow coloured flesh.
- Sweetness 16% (TSS).
- Individual fruit weight: 3.0-3.5 kg.
- Number of fruits/plant: 3-4.
- Suitable for growing round the year.
- Average yield 28 t/ha.

Suitable environment: Same as described for BARI Tarmuj-1 (Technology #11)

Production/ utilization method: Same as described for BARI Tarmuj-1 (Technology #11)

Yield/Output: Per hectare yield: 27 - 30 tons

Technology #13: Improved variety of brinjal “BARI Begun 11”

Salient features of the technology

- High yielding variety.
- Can be grown round the year.
- Medium size fruit, long egg shaped, green, fleshy, 100% edible.
- Heat tolerant and virus resistant.
- Tolerant to bacterial wilt and little leaf diseases.
- Average yield: 48 t/ha (winter); 33 t/ha (summer).

Suitable environment: Suitable for cultivation all over Bangladesh, but more suitable for Barishal and Patuakhali region. Flood free high land, sandy-loam soil having pH 5.5-7.5 is suitable for cultivation.

Production/ Utilization method

Sowing/planting: Mid September (winter) and mid February (summer) is proper time for sowing. About 250-300 g seed is required for 1 ha of land (1.5 g seed per decimal). Generally 35-40 days old seedlings are planted at a row to row distance of 70 cm and plant to plant distance of 50 cm.

Fertilizer dose (per hectare) and application method: Cowdung/compost 10 tons, urea 350 kg, TSP 300 kg, MoP 250 kg, gypsum 100 kg, boric acid 10 kg, zinc sulphate 10 kg, magnesium sulphate 10 kg. The entire amount of manure/compost, TSP, gypsum, boric acid, zinc sulphate, magnesium sulphate and half of MoP to be applied and mixed adequately within the final land preparation. The entire amount of urea and remaining MoP are splited into 5 and applied 15 days after planting, flower initiations, fruit settings, 2 times during harvesting, respectively.

Disease and insect-pest mamagement

Damping off: Dithane M 45 (1-2 g/ litre water) should be applied at seed bed wetting soil adequately. Seeds to be sown after a few days.

Stem rot and fruit rot/ phomophsis: Mixture of Bavistin/Nowwin (@ 2g/1 litre of water) to be sprayed over whole plants.

Wilting: Bacterial wilt disease can be controlled by grafting seedlings with either BARI Begun-8 or wild throwned species Symbrifollium.

Brinjal fruits and shoot borer: Insecticide TRACER to be sprayed following instructions on the label. Pheromone traps also to be placed in the field.

Leaf hopper/white fly: Yellow traps to be used in the field. Insecticide Success 2.5 S C (Spinosad) Pagasus, Confidor @1 ml/litre water to be sprayed over infested leaves to manage effectively.

Red mite: Vertimec 1.8 EC or Omite 1.8 EC at the rate 2 ml/ litre of water should be sprayed downward the leaves.

Irrigation: Irrigation to be provided based on soil moisture condition and requirement of plants.

Intercultural operations: Weeding needs to be done regularly. All suckers should be removed before first flower appeared. The soil crusts required to break after irrigation.

Harvesting time: Harvesting can be done after 2-3 month of planting. Morning and afternoon is the best time to harvest. Knife can be used for safe harvesting.

Yield/Output: Per hectare yield: 30-35 t (in summer) and 45-50 t (in winter).

Technology #14: Improved variety of brinjal "BARI Begun-12"

Salient features of the technology

- Winter variety.
- Tolerant to bacterial wilt disease.
- Number of fruits per plant 9-10.
- Average individual fruit wt. 600-700g.
- Average yield: 58 t/ha
- Suitable for southern part of Bangladesh.

Suitable environment: Suitable for cultivation all over the country, but more suitable for southern region. However, flood free high land, fertile sandy-loam soil having pH 5.5-7.5 is suitable for cultivation.

Production/ Utilization method

Sowing/planting: September (winter). Spacing, Fertilizer dose and application method, disease and insect-pest management, irrigation and intercultural operations are almost same as described for BARI Begun-11 (Technology #13).

Yield/Output : Per hectare yield **:** 55-60 tons (in winter).

Technology #15: Hybrid variety of brinjal "BARI Hybrid Begun-5"

Salient features of the technology

- Can be grown year round.
- Tolerant to bacterial wilt and little leaf diseases.
- Number of fruits per plant 20-24.
- Average individual fruit wt. 160-180g.
- Average yield: 32 t/ha (summer); 50 t/ha (winter)

Suitable environment: Same as described for BARI Begun-12 (Technology #14)

Production/ Utilization method

Sowing/planting in September (winter) and mid February (summer).

Spacing, Fertilizer dose and application method, disease and insect-pest management, irrigation and intercultural operations are almost same as described for BARI Begun-11 (Technology #13).

Yield/Output: Per hectare yield: 30-35 t (summer) and 50-55 t (winter).

Technology #16: Hybbrid variety of brinjal "BARI Hybrid Begun-6"

Salient features of the technology

- Year round, high yielding variety.
- Tolerant to bacterial wilt and little leaf diseases.
- Number of fruits per plant 40-50.
- Average individual fruit wt. 120-130g.
- Average yield: 38 t/ha (summer); 52 t/ha (winter)

Suitable environment: Same as described for BARI Begun-12 (Technology #14)

Production/ Utilization method: Sowing/planting in September (winter) and mid February (summer).

Spacing, Fertilizer dose and application method, disease and insect-pest management, irrigation and intercultural operations are almost same as described for BARI Begun-11 (Technology #13).

Yield/Output: Per hectare yield: 35-40 t (in summer) and 50-55 t (in winter).

Technology #17: Modern variety of summer cauliflower “BARI Fulkopi-3”

Salient features of the technology

- Individual average curd weight 400 g.
- Seed can be produced under local climatic condition.
- Average yield: 16 t/ha.

Suitable environment: Suitable for cultivation in allover Bangladesh, but more suitable for Cumilla, Gazipur, Narsingdi and Jessore districts. Flood free high land, fertile sandy-loam soil having pH 5.5-7.5 is suitable for its cultivation.

Production/ Utilization method

Time of sowing: Early to mid May is proper time of sowing for summer season cultivation. Some 150-200g seed is required for one hectare. Usually, 25-30 days seedling is transplanted maintaining spacing of plant to plant 40 cm and line to line 60 cm.

Fertilizer dose and application method: Cowdung 10 ton, urea 200 kg, TSP 175 kg, MoP 150 kg, gypsum 100 kg, boric acid 3 kg and amonium molibdate 1 kg to be applied per hectare. The entire amount of cowdung, TSP, boric acid and amonium molibdate to be applied during final land preparation. One third of urea and MoP to be applied during pit preparation. The remaining urea and MoP to be applied in 3 equal installments at 15, 30 and 45 days after transplanting.

Diseases and insect-pest management: Diamond back moth, aphid and cut worm can infest the crop. Diamond back moth can be controlled by spraying soap water @ 1g/1litre. Aphid can be controlled by spraying “Imitaf” @1.5 ml/lit. Cut worm can be controlled by using poison trap. Sometimes in later stage, cercospora leaf spot and rust diseases may appear. Rust can be controlled by spraying of Rovral @ 2 g/lit with water.

Irrigation and drainage: Generally 3-4 irrigations are required.

Intercultural operations: Successive 3-4 days regular irrigation is needed just seedling transplanting for crop survivality. Weeding is to be done as and when necessary. After irrigation, loosening of soil and earthing up is needed for better plant growth.

Harvesting time: Harvesting may be done after 80-90 days of sowing.

Yield/Output: Per hectare yield: 16-17 tons

Technology #18: Improved variety of spinach "BARI Palongshak-2"

Salient features of the technology

- High yielding variety.
- Number of leaf per plant is 18-20.
- Leaf can be harvested within 50-55 days after sowing.
- At harvest stage leaf becomes broad shape and green colour.
- Edible leaf weight per plant is 125-130g.
- Average yield: 35 t/ha.

Suitable environment: Suitable for cultivation around the country, and also suitable for saline area.

Production/ Utilization method

Sowing: Can be sown from last of August to mid-January.

Fertilizer dose and application method: Cowdung 5 ton, urea 100 kg, TSP 120 kg, MoP 100 kg, gypsum 60 kg and boric acid 10 kg should be applied per hectare. Entire cowdung, TSP, gypsum, and half of the total MoP should be applied at final land preparation. Entire amount of urea and rest of MoP should be applied at two equal splits at 15, 30 days after sowing. In case of seed production, amount of last two instalments need to be applied at 45 and 60 days after germination.

Diseases and insect-pest management: This variety is tolerant to diseases and insects. Sometime leaf spot disease may appear in this variety. Spraying of Diathen M-45 @ 2g/litre can be effective to control the disease. For controlling aphid "Imitaf" @ 1.5 ml/ litre should be sprayed.

Irrigation and drainage: Irrigation to be done as per requirement considering field moisture condition.

Intecultural operation: Spinach is short duration crop with quick flowering. Thinning is required and 10 cm plant-to-plant spacing to be maintained. Intensive intercultural operation is needed for higher production of spinach as well as for seed production.

Harvesting time: Harvesting can be started from 50-55 days of sowing.

Yield/Output: Per hectare yield: 34-36 tons

Technology #19: Improved variety of yardlong bean "BARI Barboti-2"

Salient features of the technology

- Plant height 50-75 cm.
- Number of fruits per plant 30-32.
- Average individual fruit wt. 15g.
- Average yield 17 t/ha.
- Life cycle is only 60-70 days.

Suitable environment: Suitable for cultivation around the country, but more suitable for northern, hilly and southern districts. However, flood free high land, fertile sandy-loam soil having pH 5.0-7.5 is suitable for yardlong bean cultivation.

Production/ Utilization method

Sowing/planting: March-April (summer) is the suitable time for sowing. Per hectare seed rate 7-8 kg. Seeds are to be sown at a row to row distance of 60 cm and plant to plant distance of 25 cm.

Fertilizer dose and application method: Cowdung/compost 5 ton, urea 60 kg, TSP 120 kg, MoP 80 kg, gypsum 60 kg, and boric acid 10 kg to be applied per hectare. The entire amount of cowdung/compost, TSP, gypsum, boric acid, zinc sulphate and half of MoP are to be applied and mixed with soil during the final land preparation. The entire amount of urea is to be applied in 2 equal installments at 15 and 45 days after sowing.

Disease and insect-pest mamagement: The variety is tolerant to leaf mosic virus. Sometimes the crop is attacked by fruitfly. Fruitfly can be contorled by sex pheramon and poison bite trap.

Irrigation and drainage: Irrigation should be done depending on field moisture condition.

Intercultural operations: Weeding need to be done regularly. The crust formed after irrigation needs to be broken by weeder.

Harvesting time: Harvesting can be done after 40-45 days of sowing and continues upto 60-65 days.

Yield/Output : Per hectare yield: 17-18 tons

Technology #20: Improved variety of spongegourd “BARI Dhundul-2”

Salient features of the technology

- Deep green color at immature stage.
- Average individual fruit weight: 185 g.
- Number of fruits/plant: 110-115.
- Fruit length : 18 - 25 cm
- Average yield: 52 t/ha
- Less vegetative growth and suitable to grow at rooftop garden.

Suitable environment: Suitable for cultivation around the country, but more suitable for Cumilla, Gazipur, Narsingdi and Jashore districts. However, flood free high land, fertile sandy-loam soil having pH 5.5-7.5 is suitable for sponge gourd cultivation.

Production/ Utilization method

Sowing/planting: March-April.

Fertilizer dose and application Method: Cowdung 20 ton, urea 175 kg, TSP 175 kg, MoP 150 kg, gypsum 150 kg, zinc sulphate 12 kg, boric Acid 12 kg and magnesium sulphate 50 kg per hectare. Entire cowdung, TSP, gypsum, zinc sulphate, megnisium sulphate, boric acid and half of MoP should be applied at final land preparation. Rest of the MoP and entire urea should be applied at 15-20 days after sowing around the root zone of the plants.

Disease and insect-pest Management: This variety is tolerant to diseases and insects. Very less downy mildew infection was recorded in this variety and virus infection was nil. The combined use of sex pheromone and bite trap, the fruit fly infestation can be controlled successfully.

Irrigation and drainage: Irrigation to be provided 4/5 days after transplanting. After that, irrigation can be done 8-10 days interval as per requirement.

Intecultural operations: The beds and/or base of the plants should be kept weed free and clean always for irrigation and drainage of excess water.

Harvesting time: 8-10 days after pollination the fruits will be in edible stage.

Yield/Output: Per hectare yield: 50-55 tons

Technology #21: Modern variety of potato “BARI Alu-82”

Salient features of the technology

- Suitable for table purpose.
- Plant height medium; intermediate type; canopy habit semi-determinate; growth habit semi-erect; few branching; thickness of main stem medium; spreading of anthocyanin colouration in stem is very high.
- Tuber shape oval to long oval; size medium; depth of eyes very shallow; tuber skin smooth and purple; the colour of the base of eye purple; the colour of flesh yellow; eye distribution even; uniformity of tuber medium.
- D**ry matter: 20.07% (**18-25%)
- Average yield: 43 t/ha.

Suitable environment: In general, sandy loam soil is good for producing higher tuber yield than clay textured soils. The irrigation and drainage facilities, as well as fertility status of soil, are also important factors for potato production. There should be a uniform soil moisture supply throughout the growing period, especially 30 to 65 days after planting. For seed production of potato, it is preferable to select the field that was not planted with solanaceous crops for the last three years. If possible, the chosen field could be isolated 30 meters from either potato or similar crops. If the field has any history of potato diseases particularly bacterial wilt, the seed potato should not be grown there for three years.

Production/ Utilization method

Plating: In the context of Bangladesh, 15th November to 25th November is the best time for planting seed potato in the northern region. Seed rate 1.5 to 2.0 ton/ha and row to row 60 cm, seed to seed 25 cm spacing are suitable to obtain optimum tuber size and yield. The planting depth and soil ridging should be adjusted according to the soil condition (soil moisture & temperature). Usually, high ridging is needed for the production of processing potatoes in our country. High ridges protect tubers from direct sunlight (greening), insect damage & especially from high temperature.

Fertilizer dose and application method: Fertilizer dose depends on the soil type and weather condition. However, the following doses of fertilizer can be used per hectare: Urea 325-350 kg, TSP 200-220 kg, MoP 250-300 kg, gypsum 100-120 kg, magnesium sulphate (acidic soil) 140-160 kg, zinc sulphate 8-10 kg, boric acid 8-10 kg and cowdung/compost 8-10 tons. The entire quantity of cow dung /poultry manure/ compost, triple superphosphate, mureate of potash, gypsum, zinc sulphate, boric acid and half of the urea should be applied before planting and mixed with soil. The remaining urea should be side-dressed at 30-35 DAP (days after planting) at the time of earthing up (FRG, 2018).

Irrigation and drainage: Shortage of water is one of the most important yield limiting factors. Water is essential for plant growth. If there is a lacking of sufficient soil moisture, irrigation should be given after sowing, but care should be taken to ensure no stagnant water in the field. Two to three irrigation (20-25 days after planting during stolon initiation and 40-45 days after planting during tuber initiation and during tuber bulking stage) should be applied to saturate 2/3 part of the potato ridge. Irrigation should be stopped 7-10 days before potato harvesting. It should be noted that to control scab disease of potato, there should be no shortage of soil moisture during 30-50 days after sowing and no excess water is remained after 60-65 days.

Disease Management

1. Late blight of potato

Integrated Management:

- Resistant varieties (like, BARI Alu-46, BARI Alu-53, BARI Alu-77, BARI Alu-90 and BARI Alu-91) should be used.
- Certified seed should be used.
- Early planting (first week of November) and early harvesting should be followed.
- Weed management should be done properly.
- Haulm pulling to be done at 80 DAP.
- Under cool, foggy and wet conditions, the spray should be continued with effective fungicides like, Mancozeb (0.2%) as Dithane M-45 / Indofil @ 0.2% at 15 days interval to wet the whole plant including the lower side of leaves and stems.
- When symptoms appear, any one of the following fungicides or mixture of fungicides should be done at 7 days interval alternately or in combination.
  - Secure (0.2%), or
  - Acrobat M Z (0.2%), or
  - Melody Duo (0.2%), or
  - Curtzae (0.2%), or
  - Mona 28 SC (0.1%), or
  - Melody Duo 4 gm + Secure 2 gm /L of water, or
  - Acrobat M Z 2 gm + Secure 1 gm/L of water, or
  - Melody Duo 1 gm + Acrobat M Z 2 gm/L of water.
- High ridges need to be developed during earthing up.
- Proper irrigation should be done. Irrigation should be stopped when the first disease symptom appears in the field
- Harvested tuber heaps shouls not be covered with infected potato debris.
- Infected tubers should be sorted for storage.

- Fungicide is not recommended to use in wet conditions. If needed detergent 2-3 g/ L of water can be used as a sticker.

- Potato should be harvested at suitable soil moisture condition i.e. not too moist or not too dry
- Field visit should be done every day with keen eyes
- Fungicides under the Metalaxil group should not be used because the new resistant race of *Phytophthora infestans* has been developed
- Seed potato should not be collected from an infected potato field.

2. Bacterial wilt management

- Certified seed should be used
- Whole tuber should be planted
- High ridge should be made during earthing up
- Crop rotation should be followed with non-solanaceous crops.
- Stable bleaching powder (SBP) should be applied (@25-30 kg/ha) in the soil before planting (15 days ago).
- The incidence of bacterial wilt can also be reduced to a minimum level by integrating urea (325 kg/ha), lime (3 t/ha) and SBP (15 kg/ha).
- Intercropping with maize, wheat or rice.
- Minimum irrigation should be maintained and irrigation should be stopped at the moment of disease expression.
- The diseased plants should be removed including surrounding soil and SBP at the rate of 20-25 kg/ha should be applied.
- Crop rotation with cereals or leguminous crop to be followed.

3. Common scab management

- Tolerant varieties like BARI Alu-34 (Laura), BARI Alu-45 (Steffi) , BARI Alu- 41, BARI Alu-44(Elgar), BARI Alu-13 (Granola), BARI Alu- 25 (Asterix) and BARI Alu-28 (Lady Rosetta) should be used.
- Certified seed should be used
- Seed should be treated with Provax-200 @ 0.3% or Dithane M-45 @ 0.3 % before planting as whole tuber. In the case of cut tubers, the dose of fungicides is 0.2%
- Soil amendment to be done with well-decomposed and uncontaminated cow dung @ 10 t/ha.
- Proper irrigation should be done (first one at 10-15 DAP, second at 30-35 DAP and third at 55-60 DAP) depending on soil moisture conditions
- Crop rotation should be practiced with cereal crops like rice, wheat, maize etc. at least for 2-3 years
- Brown manuring with soybean and mustard may be done.
- Balance fertilizer application should be ensured.
- Liming should not be done

4. Stem canker and black scurf management

- Certified seed should be used
- Crop debris should be destroyed
- Crop rotation should be followed with cereals or leguminous crop
- Seed should be treated with Boric acid (3%)
- Diseased plants to be roguing out
- Bavistin (0.1%) to be sprayed at the base of the plant.
- Excessive irrigation should be avoided.

5. Black leg and soft rot management

- Certified seed should be used
- Early cultivation should be done to avoid high temperature
- Proper grading should be done before storage
- Soil amendment should be done with SBP @ 25-30 kg/ha
- The tuber should be treated with 3.0% Boric acid solution before storing as seed tuber
- Crop rotation to be followed with cereals or legumes
- Harvesting to be done in dry weather condition and care should be taken during harvest, transit & storage
- Stores should be kept dry and well ventilated
- Crop debris should be destructed.

Virus diseases

Viruses are the main problem in our country limiting potato production. Several virus diseases remain in plant and tuber in a latent condition. However, major viruses of potato are Potato Leaf Roll Virus (PLRV), Potato Viruses Y (PVY) and Mosaics (Potato Viruses X, S and M).

Integrated management of virus diseases

- Certified seed should be use.
- Early planting and early harvesting (15 Nov. and 15 Feb., respectively) needs to be followed
- Isolation distance should be maintained
- Proper weed management to be followed
- Virus to be eradicated through tissue culture
- Indexing of viruses to be done through ELISA
- Breeder seed should be produced in the net-house
- Haulm pulling to be done at 80 DAP

- Grading, sorting and storing in cold storage maintaining proper temp.
- All virus-infected plants should be roguing out
- Systemic insecticides like Admire (0.05%) to be sprayed to control vector like aphids and whitefly.

Insect-Pest Management

Potato cutworm /black cutworm management

- Incidence of seedlings cut off at the soil level or appearing altogether at night. The first generation of mature cutworm larvae does the major damage. So hand-picking of caterpillars at night by torch or very early morning is the most effective.
- Flooding of the field for a few days before sowing or transplanting can help kill cutworm caterpillars in soil.
- Potato crops grown for seed should be monitored closely and good sanitation to be followed.
- Poison bait can be used for controlling cutworm. Poison bait is prepared with 2 kg Padan 50 SP or Mipsine 75 WP, 100 kg wheat or rice barn and 15 kg molasses to be added adequate water for proper mixing. Then the poison baits directly set up under the potato plant before sunset. The preparation needed per hectare depends on the cutworm population.
- Sex pheromone mass trapping to be started at 15 DAP till to harvest + Furadan 5G (Carbofuran) @ 20kg/ha during land preparation + Furadan 5G (Carbofuran) @ 20kg/ha before last irrigation.
- Insecticides Chlorpyrifos (Chlorpyrifos 48EC/ Pyrifos 20EC)/ Carbofuran (Dursban 20EC) @ 5ml/1L water to be used at 15 days interval.

Potato tuber moth management

Integrated approach as follows

- High-quality seeds free from potato tuber moth infestation to be used.
- Irrigation to be done in a controlled way to prevent soil cracking that allows moths to reach the tubers.
- Harvested tubers should not be left in the fields overnight; the heaps of tubers should be covered with polythene sheet / dried straw/ cloth to avoid lying egg on the seed tubers
- Using pheromone traps+hilling-up for proper covering of tubers (through closing cracks and crevices in the soil) to control the PTM. Last hilling-up not more than 60 days before harvest.
- Lambda-cyhalothrin (Karate 2.5 EC) @2 ml/L of water should be sprayed at 15 days interval on plant foliage and soil.

- Deltamethrin (Decis 2.5 EC) @2 ml/L of water should be sprayed at 15 days interval on plant foliage and soil.

Integrated pest management for stored tubers

- Store room should be kept clean; stores should be kept closed (doors and windows closed with gauze for ventilation)
- Only healthy tubers to be stored and infested tubers should be destroyed (bury them or feed them to the livestock) and netting of the piled potato inside the storeroom is beneficial.
- Sex pheromone to be used for mass trapping along with dry sand and Neem Oil Cake (0.5 cm layer) - Sex pheromone + Potato tuber to be covered with a thin layer of dry sand + Neem oil cake @ 3:1 ratio.
- Repellent such as *Neem leaves*, Neem seed kernel, Neem oil cake, eucalyptus, or lantana can be used to protect stored tubers.

The PTM damage can be reduced by dipping tubers in the suspension of Phenthoat or Deltamethrin at 2 ml/L of water for 15 minutes and then drying in shade especially for seed tubers.

Intercultural operations: Weed management should be ensured for minimizing competition between potatoes and weeds during the critical period (about 20 to 65 days after emergence). Though weed is not a serious problem for potato in Bangladesh, it may occur in some locations and some uncared fields. The common weeds are Bathua, Durba, Mutha and locally important ones. Weeds can be managed through good pre-planting preparation, mulching and hand-weeding. Pre-emergence weedicide can also be used with recommended dose in proper soil condition. Weeding, fertilizer application, pesticide application to be done for pest control. The crop should be inspected regularly to observe the presence of colonizing aphids that transmit viruses by examining the undersides of leaves. Mixing of varieties to be avoided and off-types should be roguing out. Potato volunteers are the source of many diseases and must be controlled in seed production sites. Entrance in the seed potato field should be restricted to a minimum level.

Harvesting: Tubers should be harvested when they are physiologically mature, i.e. when the peel (skin) is well set. Immature tubers are prone to peeling during harvest and storage operations, which puts it at risk of disease infection. Tubers can be induced to mature by pulling the haulms 7-10 days before harvest. Avoid harvesting seed potato when the soil is wet or during rainy days, as the tubers may carry soil and be at risk of disease infection. If tubers are harvested in wet condition, they should be dried before storage. Drying should be done away from direct sunlight and heat.

Curing of potato: Before placing the potatoes in storage, the tubers need to be cured. After harvest, the tuber should be kept at 15-20°C and 85% relative humidity for 3 to 5 days. This process should be done at a shady place and open air. Curing makes tuber skin thick, hard and protects against disease and insect.

Yield/Output: Per hectare yield of tuber: 40 - 45 t/ha

Technology #22: Modern variety of potato “BARI Alu-83 (Cimega)”

Salient features of technology

- Early bulker and suitable for table and export purpose.
- Plant height medium; intermediate type; canopy habit semi-determinate; growth habit semi-erect; few branching; thickness of main stem medium; spreading of anthocyanin colouration of stem weak.
- Tuber shape oval; size medium; depth of eyes very shallow; smoothness of tuber skin medium; colour of tuber skin yellow; colour of the base of eye yellow; the colour of flesh is light yellow; eye distribution even; uniformity of tuber medium.
- **Dry matter** : 19% **(**17 - 20%)
- Average yield: 45 t/ha

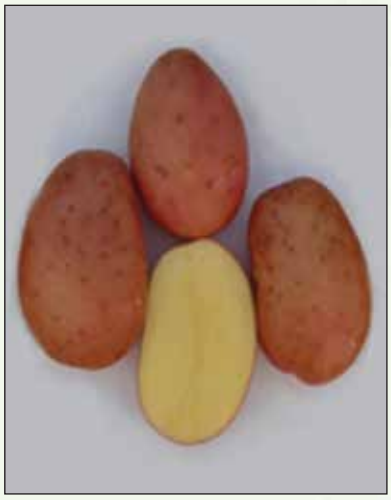
Suitable environment: Same as described for BARI Alu-82 (Technology #21)

Production/ Utilization method: Same as described for BARI Alu-82 (Technology #21)

Yield/Output: Per hectare yield of tuber: 38 to 51 t/ha

Technology #23: Modern variety of potato “BARI Alu-84 (Memphis)”

Salient features of technology



- The variety is suitable for table purpose.
- Plant height medium; intermediate type; canopy habit semi-determinate; growth habit semi-erect; few branching; thickness of main stem medium; spreading of anthocyanin colouration of stem medium.
- Tuber shape oval; size large; depth of eyes shallow; smoothness of tuber skin smooth; colour of tuber skin red; colour of the base of eye red; the colour of flesh light yellow; eye distribution even; uniformity of tuber medium.
- Dry matter: 19% (16 - 22%).
- Average yield: 43 t/ha

Suitable environment: Same as described for BARI Alu-82 (Technology #21)

Production/ Utilization method: Same as described for BARI Alu-82 (Technology #21)

Yield/Output: Per hectare yield of tuber: 32 to 52 t/ha.

Technology #24: Modern variety of potato "BARI Alu-85 (7 four 7)"

Salient features of technology

- Early bulker and suitable for table purpose.
- Plant height medium; intermediate type; canopy habit semi-determinate; growth habit semi-erect; few branching; thickness of main stem medium; distribution of anthocyanin colouration of stem very weak.
- Tuber shape oval; size large; depth of eyes shallow; smoothness of tuber skin medium; colour of tuber skin yellow; colour of the base of eye yellow; the colour of flesh white; eye distribution even; uniformity of tuber medium.
- **Dry matter:** 18% (15 – 20%).
- Average yield: 46 t/ha.

Suitable environment: Same as described for BARI Alu-82 (Technology #21) .

Production/ Utilization method: Same as described for BARI Alu-82 (Technology #21).

Yield/Outpu: Per hectare yield of tuber: 40 to 54 t/ha.

Technology #25: Modern variety of potato "BARI Alu-86"

Salient features of technology

- This variety is early bulker and suitable for table and export purpose.
- Plant height medium; canopy habit semi-determinate; growth habit semi-erect; few branching; thickness of main stem medium; distribution of anthocyanin colouration of stem strong.
- Tuber shape long oval; size medium; depth of eyes shallow; tuber skin smooth; colour of tuber skin red; colour of the base of eye yellow; the colour of flesh light yellow; eye distribution even; uniformity of tuber medium.
- **Dry matter**: 18% (17-19%).
- Average yield: 49 t/ha.

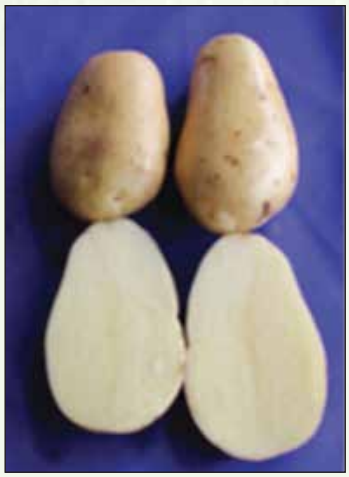
Suitable environment: Same as described for BARI Alu-82 (Technology #21)

Production/ Utilization method: Same as described for BARI Alu-82 (Technology #21)

Yield/Output: Per hectare yield of tuber: 35 to 61 t/ha

Technology #26: Modern variety of potato “BARI Alu-87”

Salient features of technology



- Suitable for table and export purpose.
- Plant height medium; intermediate type; canopy habit semi-determinate; growth habit semi-erect; few branching; thickness of main stem medium; spreading of anthocyanin colouration of stem very weak.
- Tuber shape long oval, oval; size medium; depth of eyes shallow; smoothness of tuber skin medium; colour of tuber skin yellow; colour of the base of eye yellow; the colour of flesh light yellow; eye distribution even; uniformity of tuber medium.
- **Dry matter**: 19% (18-20%).
- Average yield: 57 t/ha

Suitable environment: Same as described for BARI Alu-82 (Technology #21)

Production/Utilization method : Same as described for BARI Alu-82 (Technology #21)

Yield/Output: Per hectare yield of tuber: 53 to 63 t/ha

Technology #27: Modern variety of potato “BARI Alu-88”

Salient features of technology

- Early bulker and suitable for table and export purpose.
- Plant height medium; intermediate type; canopy habit semi-determinate; growth habit semi-erect; few branching; thickness of main stem medium; spreading of anthocyanin colouration of stem weak.
- Tuber shape long oval, oval; size medium; depth of eyes shallow; smoothness of tuber skin medium; colour of tuber skin red; colour of the base of eye yellow; the colour of flesh yellow; eye distribution even; uniformity of tuber medium.
- **Dry matter**: 19% (18-21%).
- Average yield: 48 t/ha

Suitable environment: Same as described for BARI Alu-82 (Technology #21)

Production/ Utilization method : Same as described for BARI Alu-82 (Technology #21)

Yield/Output: Per hectare yield of tuber: 32 to 62 t/ha

Technology #28: Modern variety of potato “BARI Alu-89 (Fortus)”

Salient features of technology

- Suitable for table and export purpose.
- Plant height medium; intermediate type; canopy habit semi-determinate; growth habit semi-erect; few branching; thickness of main stem medium; spreading of anthocyanin colouration of stem absent or very weak.
- Tuber shape oval; size medium; depth of eyes very shallow; smoothness of tuber skin medium; colour of tuber skin yellow; colour of the base of eye yellow; the colour of flesh light yellow; eye distribution even; uniformity of tuber high.
- Dry matter: 18% (18-20%).
- Average yield: 43 t/ha

Suitable environment: Same as described for BARI Alu-82 (Technology #21)

Production/ Utilization method : Same as described for BARI Alu-82 (Technology #21)

Yield/Output: Per hectare yield of tuber: 35 to 51 t/ha

Technology #29: Modern variety of potato “BARI Alu-90 (Aluette)”

Salient features of technology

- Late blight resistant and suitable for table and export purpose.
- Plant height medium; intermediate type; canopy habit semi-determinate; growth habit semi-erect; few branching; thickness of main stem medium; spreading of anthocyanin colouration of stem strong.
- Tuber shape oval; size medium; depth of eyes shallow; smoothness of tuber skin medium; colour of tuber skin red; colour of the base of eye yellow; the colour of flesh yellow; eye distribution even; uniformity of tuber high.
- Dry matter: 18% (18-19%).
- Average yield: 50 t/ha

Suitable environment: Same as described for BARI Alu-82 (Technology #21)

Production/ Utilization method : Same as described for BARI Alu-82 (Technology #21)

Yield/Output: Per hectare yield of tuber: 44 to 57 t/ha

Technology #30: Modern variety of potato “BARI Alu-91 (Carolus)”

Salient features of technology

- Late blight resistant and suitable for table and export purpose.
- Plant height medium; intermediate type; canopy habit semi-determinate; growth habit semi-erect; few branching; thickness of main stem thin; distribution of anthocyanin colouration of stem weak.
- Tuber shape short oval to oval; size medium; depth of eyes shallow; smoothness of tuber skin medium; colour of tuber skin yellow with red patches; colour of the base of eye red; the colour of flesh yellow; eye distribution even; uniformity of tuber low.
- **Dry matter**: 19% (18-20%).
- Average yield: 38 t/ha

Suitable environment: Same as described for BARI Alu-82 (Technology #21)

Production/ Utilization method : Same as described for BARI Alu-82 (Technology #21)

Yield/Output: Per hectare yield of tuber: 35 to 41 t/ha

Technology #31: Modern variety of sweetpotato “BARI Mistialu-17”

Salient features of technology

- Average number of tuber per plant is 6-7.
- Average fresh weight of tuber/plant is 640 g.
- Skin colour of tuberous root is purple, flesh colour is deep purple.
- Anthocyanin content is 35.30 mg/100 g in fresh weight basis (approx.)
- Tuber shape is long, irregular (length 14.79 cm × diameter 3.87 cm).
- Average yield: 23 t/ha

Suitable environment: Well drained sandy loam and deep loam soil with pH 6.1 to 7.7 is suitable for Sweet potato cultivation. The optimum temperature is 20-300 C. All the charland are more suitable to produce Sweet potato. Suitable for sweetpotato cultivation area throughout the country.

Production/ Utilization method

Planting: October- November is the optimum time for vine planting. Row to row distance 60 cm and vine to vine distance 30 cm. Seed rate (number of vine) 55555 vine cuttings per hectare.

Fertilizer dose and application method: Fertilizer doses depend on soil type and texture, variety and irrigation management etc. However, per hectare fertilizer dose for sweetpotato is: Urea 250-280 kg, TSP 140-170 kg, MOP 230-260 kg, gypsum 60-80 kg, zinc sulphate 10-12 kg, Magnesium sulphate 90-120 kg, boric acid 6-8 kg (zinc, magnesium and boron to be applied if the soil is deficient) and cowdung 10000 kg. Total amount of cowdung, TSP, gypsum, zinc sulphate, boric acid and half of both of urea and MOP fertilizers should be applied at the time of final land preparation. Rest of urea and MOP should be applied after 35-40 days of planting in both sides of row in furrow method (10 cm apart from row in both sides). Earthing up should done just after top dressed. Around 10-12% fertilizers of the above mentioned doses should be reduced and applied at the final land preparation especially in charlands or non-irrigated condition.

Disease and Insect-pest management: No disease found to appear in this variety in the field.

Sweetpotato weevil: Adult weevil is around 6 mm long and 1.4 mm in breadth. A mouth part like a snail is present. Head and upper portion is deep blue, eyes and legs are bright red-orange colour. Larvae damage the tuberous root by eating flesh and make irregular hole. Weevil affected tuberous roots become non edible. For controlling this pest first cut (30 cm) vine should be planted. Generally, no eggs present in the tip zone of vine. Besides, this insect could be controlled in a integrated way by setting sex pheromone trap, by doing earthing up and by applying Carbofuran 5 G. Set up sex pheromone trap + earthing up (at least three times at 30, 60, 90 days after planting) + apply Carbofuran 5 G (should be applied 60 days after planting followed by irrigation).

In case of storage, weevil non-infested tuberous roots should be covered by dry sand. At first dry sand should be kept on floor at 10 cm height, then sweetpotato spread over the sand up to 75 cm height, again sweetpotato should be covered by dry sand with 10 cm height.

Irrigation and drainage: Irrigation should be done thrice at 30, 60 and 90 days after planting. If excessive rainfall occurred, excess water should be drained out. Irrigation should be ensured depending on the available moisture content in soil, number of tuberous root, weight and quality should be increased.

Intercultural operations: As a first growing crop, it covers soil rapidly and suppressed weeds but at initial stage of plant growth, the crop field should be kept weed free. Vines of sweetpotato should be lifted up at 50-60 days after planting at least one time in a month. The production of secondary tuberous root should be discouraged following this practice. This operation should be done with a bamboo stick having 8-10 feet long.

Harvesting: Sweetpotato should be harvested at 120-140 days after planting, tuberous root become fibrous after 160 days of planting. Sweetpotato should be harvested with spade.

Yield/Output: Per hectare yield: 22-25 t/ha.

Technology #32: Improved variety of aroid "BARI Sahebikachu-1"

Salient features of technology

- Commercially preferable stage of rhizome started after 2 years and continued upto 5 years.
- Flesh colour of rhizome is creamy. One-gram flesh contains 58 mg β-carotene and 94 ppm iron
- Acridity free and boiled homogenously.
- Edible portion is 92%.
- Length of leaf is higher (172 cm) and broader that ensure more food reserve.
- Rhizome can be stored in ambient temperature up to 2 months (approximately).
- Average yield of rhizome: 75 t/ha.

Suitable environment: Well drained organic matter rich loamy soil with partial shade is suitable for Sahebi Kachu cultivation. Genarally Sahebi Kachu is produced by planting 2/1 sucker in around household areas. This variety is suitable for the southern region of Bangladesh. However, it can also be cultivated in all over Bangladesh.

Production/ Utilization method

Planting time: September-October is the best time for planting seedlings (sucker) to get commercially profitable crop.

Spacing and seed rate: Row to row distance should be 1.5 m seedling to seedling distance should be 1 m. If seedlings are planted at the above mentioned distance, 6666 number of seedlings (sucker) per hectare may be required.

Fertilizer dose and application method: Each plant is to be fertilized in pits with 6-8 kg cowdung, 100 g urea, 70 g TSP, 150 g MOP, 15 g gypsum. The above mentioned manures and fertilizers are to be applied in two equal installments around the base of the plant (ring method) before and after rainy season.

Disease and Insect-pest management: Incidence of disease and insect-pest infestation in this crop generally are not so severe. Leaf blight and Rhizome rot are the two main diseases. For controlling leaf blight, Dithane M-45 /Secure @ 0.2% to be sprayed at 15 days interval and for rhizome rot, Bavistin 1g/L (foot rot) and Ridomyl Gold 2g/L to be sprayed at 15 days interval. Leaf rot and foot rot diseases are rarely noticed. Red worm and snail are two main pests may attack if the land remains swampy constantly. Only clean cultivation i.e., removal of old and dried leaves after every two months keeps the crop free from pest and diseases.

Irrigation: Depending upon moisture condition of soil 1-2 irrigations are required in dry season (January-March). Even it can tolerate up to 3 months of dry period. Proper drainage facilities should be ensured during rainy season.

Intercultural operations: Weeding, mulching and removal of older leaves should be done as and when necessary.

Harvesting: August-September is the best although the operation can be continued round the year. Shahebikachu is a long duration crop. Harvesting usually starts at 18-24 months. However, when left for four to five years, individual rhizome weighing 45-60 kg may be obtained.

Yield/Output: Individual rhizome weight:

25-35 kg (after 3 years)

50-60 kg (after 5 years)

- Per hectare yield of rhizome: 60-90 t/ha

Technology #33: Improved variety of grasspea "BARI Khesari-6"

Salient features of technology

BARI Khesari -6 (Flowering stage) *Mature seed*

- Well fit for both relay cropping with T. Aman rice and sole cropping.
- Long plant type with high biomass
- Crop duration: 108-118 days
- Pods/plant (35-46) higher in number and bold seeded (1000 seed wt. 62.2-68.1 g)
- Blackish-grey seed coated and ODAP content below the toxic level (<0.04%)
- Tolerant to downy mildew disease.

Suitable environment: The variety is suitable for cultivation throughout Bangladesh. Relay cropping with T. Aman rice is a popular practice for grasspea cultivation. The agro-climatic condition prevailing during rabi season in Bangladesh is suitable for its cultivation. BARI Khesari-6 is suitable to cultivate under "B. Aman/T. Aman-Sole khesari/Relay Khesari-Jute/Sesame/Aus" cropping pattern.

Production/ Utilization Method

Sowing/planting: It is very important to sow the grasspea seed in time. For good tilth, 2-3 ploughing followed by laddering are necessary. Normally, mid November is the best time for sowing. For relay cropping, seeding should be done on standing T. Aman rice 10-15 days prior to harvesting. Grasspea can be sown either in line or broadcast. Line sowing with 40 cm distance from row to row and seeds are sown continuously in line. In case of sole crop, for broadcasting 55-60 kg/ha and for line sowing 45-50 kg/ha seed is required. For relay cropping, 60-65 kg seed is required per hectare. Sixteen to eighteen days after emergence excess plants should be thinned out and plant to plant distance should be maintained 3-4 cm.

Fertilizer dose and application method: For relay cropping farmers are not habituated to apply fertilizer but results showed that application of fertilizer might increase yield. In case of sole cropping, urea 40-45 kg, TSP 80-90 kg, MOP 30-40 kg, gypsum 50-55 kg and boric acid 7-10 kg per hectare can be applied during the time of final land preparation.

Irrigation and drainage: Land should be leveled and drains should be made for easy drainage of excess rain or irrigation water. It can be grown in residual soil moisture, but if the soil does not contain sufficient moisture, one irrigation at sowing is needed for seed germination.

Diseases and insect-pest management: Generally, grasspea is less infected by diseases or insects. Root rot and downy mildew are two main diseases of grasspea. During seedling stage root rot is occured due to *Sclerotium or Fusarium.* Seed treating with Provax 200 WP is effective to control root rot disease. In case of high infection, crop rotation with other than pulse crops may be effective. Downy mildew is caused by *Peronospora*. In case of heavy infestation, Tilt-250 EC @ 2 ml/liter or Thiovit @ 2 g/liter at 7-10 days interval is effective for controlling the disease.

Aphid is the major insect-pest of grass pea. It usually sucks the cell-sap from the tips, flowers and fruits. In case of severe infestation, application of Dimethoate (e.g. Tafgor 40 EC) @ 2 ml L^{-1} in the afternoon is effective for managing this pest. In case of storage, pulse beetle is one of the major problems. To keep free from pulse beetle, application of 1 alluminium phosphide tablet/100 kg seed may be effective.

Intercultural operations: Weeding should be done just once at 30-40 days after emergence. It is better to keep the field free from weeds up to flowering.

Harvesting and seed storage: Crop should be harvested within 108-118 days after sowing when it turns to straw color after ripening. Seeds can be collected manually or by using power thresher. Seeds should be properly dried in the sun to reduce moisture content to 8-10 per cent. After that, seeds should be stored in airtight containers or plastic drums for long time preservation.

Yield/Output: As a relay crop: 1.3-1.6 t/ha; and As a sole crop: 1.4-1.9 t/ha

Technology #34: Improved variety of chickpea – BARI chola-11

Salient features of technology

- Leaf and stem is light green colored
- Flower color is pink
- Seed testa is bright brown
- Short duration variety (100-106 days)
- Tolerant to BGM disease
- 100 seed weight is 19.5 to 20.5 g.

BARI Chola-11

Mature seed

Suitable environment: The variety is suitable for cultivation throughout Bangladesh. The agro-climatic condition prevailing during Rabi season in Bangladesh is suitable for its cultivation. Medium low land to high land with loam, clay loam and clay soil are suitable for its cultivation. BARI Chola-11 is suitable to cultivate under "Aus/Jute-Fallow-Chickpea, T. Aus rice-T. Aman rice-Chickpea, T. Aman-Chickpea-fallow" cropping pattern. But it can be grown in Barind area under the pattern of T. Aman-Chickpea-Green manuring crop. Beside these, chickpea can be grown as a mixed or relay crop with Niger, Coriander, Barley, wheat, sugarcane or corn etc.

Production/ Utilization Method

Sowing: For good tilth, 2-4 ploughing followed by laddering is necessary. Normally, mid November to mid December is the best time for sowing. Chickpea can be sown either in line or broadcast. Line sowing with 40 cm distance from row to row and seeds are sown continuously in line. For broadcasting, 55-60 kg/ha and for line sowing 45-50 kg/ha seed may be required. Sixteen to twenty days after emergence excess plants should be thinned out and plant to plant distance should be maintained as 3-4 cm.

Fertilizer dose and application method: Although pulse crops require less amount of fertilizer, still it is important for establishing healthy and profitable chickpea crop. In case of new or unfertile land, urea 40-45 kg, TSP 80-90 kg, MOP 40-50 kg, gypsum 60-75 kg and boric acid 7-10 kg per hectare can be applied during the time of final land preparation to increase chickpea yield. In new areas, *Rhizobium* may be added to the seed for obtaining better yield.

Irrigation and drainage: The land should be irrigated immediately after sowing in case of low soil moisture. Drainage system must be ensured otherwise the roots may rot and die if irrigation or rain water accumulates. In Barind region, in case of excessive drought, light irrigation may be applied once at 30-35 days after sowing for better crop performance.

Disease management: Seed treating with Provax 200 WP @ 2.5 g/kg seed is effective to control root rot and wilt disease. In case of high infection in the field, Carbendazim with Provax 200 WP @ 1 g each per liter to be sprayed. To reduce BGM infestation, thining should be done as early as possible. Irrigation should be controlled. At early stage of infestation, formulation like Diamethomorph with Mancojeb (Acrobet MZ) @ 2.0 g/litre or Carbendazim @ 1 g/liter should be applied 2-3 times at 7-10 days interval.

Insect management: Pod borer is the main problem of chickpea cultivation. Piercing is the effective way to reduce the problem at early stage. At the first sight of attack, Lamda-Cyhalothrin type insecticide (Karate 2.5 EC) or Cypermethrin @1 ml/liter water should be applied 2-3 times at 7-10 days interval. Aphid is another insect pest of chickpea. It usually sucks the cell-sap from the tips, flowers and fruits of chickpea. In case of severe infestation, application of Dimethoate (e.g. Tafgor 40 EC) @ 2 ml L^{-1} in the afternoon is effective for managing this pest. In case of storage, pulse beetle is one of the major problems. To keep free from pulse beetle, application of 1 alluminium phosphide tablet/100 kg seed may be very effective.

Intercultural operations: Weeding should be done just once at 30-40 days after emergence. It is better to keep free from weeds up to flowering.

Harvesting and seed storage: Crop should be harvested within 100-106 days after sowing when it turns to straw color after ripening. Seeds can be collected manually or by using power thresher. Seeds should be properly dried in the sun to reduce moisture content to 8-10 per cent. After that, seeds should be stored in airtight containers or plastic drums for long time. To keep free from pulse beetle, application of 1 alluminium phosphide tablet/100 kg seed can be very effective.

Yield/Output: Per hectare yield: 1.2-1.5 t/ha (Sole crop)

Technology-35: Modern variety of soybean "BARI Soybean-7"

Salient features of technology

- The variety is dwarf (18-23 cm), straight and drought tolerant;
- Color of the flower is white;
- Leaves are dark green;
- Number of shoots 15-20, length of shoots 3.2-3.5 cm, number of seeds per shoots 2-3;
- Seed size is large, weight of 100 seeds is 12-14 g;
- The variety is tolerant to jasside, thrips and leaves yellow mosaic virus;
- Life span is 115-120 days.

Suitable environment: It can be cultivated in loamy, sandy loam and clay loam soils. The soil and climate of this country are suitable for soybean cultivation in both Rabi and Kharif seasons. In Kharif season the land must be high and well drained. Soybean can be cultivated in medium to low lands during Rabi season. Coastal areas especially Noakhali and Laxmipur areas are suitable for cultivation in Rabi and Kharif-II seasons.

Production/ Utilization Method

Sowing/Planting: In winter season, optimum time of sowing mid-December to mid-January. It is better to sow soybean in rows. Row to row spacing is 30 cm in rabi season and 40 cm in Kharif season. Seeds to be sown at a distance of 4-5 cm. About 70-75 kg seed per hectare is required. Seed germination capacity should be at least 80%.

Fertilizer dosage and application method: Urea 50-60, TSP 150-175, MP 100-120, Gypsum 80-115 kg per hectare. Yield is increased by applying decomposed cowdung or compost at the rate of 5-10 tons per hectare along with chemical fertilizers. All organic and inorganic fertilizers should be broadcasted at the final land preparation and seeds should be sown after mixing fertlizers with soil.

Inoculum application: One kg seeds should be taken in a container. Soybean seeds should be stirred with wet hands so that all the seeds get wet. Then 15 to 20 grams of inoculum should be mixed with wet seeds so that the inoculum adhere evenly on the seeds. Inoculated seeds should be sown immediately. After mixing the inoculum powder, if the seeds are left in the sun light for a long time, the quality of the inoculum may be lost.

Irrigation and drainage: Irrigation is required depending on the season. In rabi season, irrigation is required during flowering and shoot formation. If there is no rain, then first irrigation

should be given at 20-30 days after germination and the second irrigation should be given at 50-55 days after germination. After irrigation when land attains 'joe' condition, spading/mulching should be done. In kharif season, no irrigation is required for this crop but proper drainage should be done when water accumulates in the field after rain. However, supplementary irrigation is to be given if there is less moisture in the soil during fruiting or shoot formation stage.

Insect management: Leaf caterpillar cause severe damage to soybeans. After hatching from eggs, the young caterpillars stay in groups in one place. The leaves of the infected plant become twisted like a net. Any one of the pesticides of Elsar 50 EC, Marshall 20 EC @ 2 ml should be mixed with per liter of water and sprayed on the affected plant. Stem fly insect bores the stem and eats the internal soft part. As a result, part or all of the affected plant dies soon. When 10% plants are infected then Dimecron 100 WEC @ 2 ml should be mixed with per liter of water and sprayed.

Intercultural operations: Weed should be controlled once at 15-20 days after seedling emergence. If the plants are very dense, it should be thinned. It is better to keep 50-60 plants per square meter in Rabi season and 40-50 in Kharif season.

Harvesting: Soybean takes 95-115 days from sowing to harvesting. When the crop matures, the plants turn yellow with the shoots and the leaves begin to fall off. At this time the plant can be cut and dried in the sun for 1 to 2 days, then it should be beaten gently with a stick to separate the grains.

Seed preservation: Soybean germination capacity is usually not maintained for the long time. Usually 2/3 months after storage the germination capacity of the seeds starts to decrease. Therefore, in order to save the seeds for planting in the next season, the following methods have to be followed.

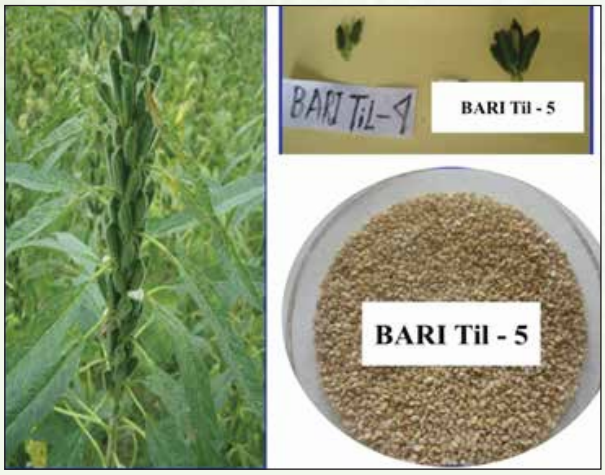
- After threshing, the seeds should be dried with special care. If the heat of the sun is very intense, it is not advisable to keep the seeds in the sun continuously for more than 3-4 hours at a time.
- Seeds should be thoroughly cleaned and diseased, rotten seeds should be discarded.
- Polythene bags, tin drums, tar coated clay pots or pitcher, biscuit tins etc. can be used for storing seeds.
- Seed pots must be kept in a cool place and it is better to keep them on a loft or wooden plank but not directly on the floor.
- Seed moisture should be monitored after certain interval. If the moisture content of the seeds increases then it should be dried in the sun as required and kept in container as mentioned above.

Yield/Output: Per hectare yield: 2.0 -2.8 tons

Technology #36: Modern variety of sesame “BARI Til-5”

Salient features of technology

- The plant is branchless and the leaves are light green in color.
- Pods are elongated and more number of seeds per pod.
- Seed coalar creamy white, thin and soft in color.
- Can be used directly in making confectionery items in factories without seperating seed husks.
- Seeds have single coat which is eligible for export.
- Life cycle is 80-90 days.
- Yield 1300-1600 kg per hectare.



Suitable environment: Sesame can be cultivated in all types of soils where water does not accumulate. High land with sandy loam soils is the best for sesame cultivation. Sesame is also found to grow in some clay soils. Sesame cannot tolerate waterlogging in the soil at all. Warm weather and moderate rainfall are good for sesame cultivation. Sesame grows well at a temperature of 25-26□ Celsius. If the temperature drops below 20□ C, seed germination is delayed and seedlings cannot grow properly. Sesame is drought tolerant but cannot grow without adequate moisture in soil. Sesame plants often die due to continuous rains.

Production/ Utilization method

Sowing: Sesame can be cultivated in two cropping seasons like Kharif-I & Kharif-II. The best time for sowing sesame seeds is in kharif-I season i.e. (mid-February to March) and Kharif-II season (mid-August to mid-September). The land must be ploughed and leveled well before sowing. Sesame lands should be well drained, making high beds facilitates easy drainage of water.

Fertilizer dose and application method: Sesame yield can be increased by applying balance fertilizer at the right time. Normally urea 100-120 kg, TSP 130-150 kg, MoP 40-50 kg, gypsum 100-110 kg, zinc sulphate 5 kg and boric acid 10 kg per hectare to be applied. Half of the urea fertilizer and the rest of the fertilizer should be applied during the final land preparation and mixed well with the soil. The remaining half of urea should be applied 25-30 days after sowing at the time of flower initiation. After top dressing, a light irrigation may be required depending on the soil moisture content.

Diseases and insect-pest management: The main disease of sesame is stem rot disease. In the early stages, deep brown spots like long lines are seen on the stems of infected plant. Later, the

spots may spread throughout the plant and turn into dark black spots. As a result, the leaves fall off and the plant dies. The prevalence of this disease is higher due to waterlogging in the land. Therefore, it is essential to have drainage facilities in the sesame cultivated field. It is a seed borned fungal disease. Therefore, before sowing the seeds, the disease can be controlled by treating seeds with Provex or Bevistin-2.5 gm per kg of dried seeds.

A total of 30 species of sesame insects have been identified in this country. Among them, sesame hawk moth, scorpion, leaf-wrapping insect and black caterpillar are major. The description of their damage patterns and integrated management are as follows:

Sesame hawk moth: It is the most damaging pest of the crop. The female moth lays about 84-102 eggs one by one on the upper surface of the half-crushed leaves of the sesame plant. Within 3-4 days, pale green larvae emerge from the eggs and start eating the young leaves. The adult larvae are quite large and yellow in color. They eat sesame leaves, stems, flowers and fruits like glutton and cause severe damage. As a result, the plant stops growing, flowers cannot bear fruit swith decrease in yield.

Integrated management

- Insects can be caught and controlled with the help of light trap at night.
- Insects can be collected and controlled by hand in the morning and afternoon.
- If 10-12 sticks/branches are placed (per bigha) in the field, the birds would sit on it and catch and eat the green worms.
- Subterranean pupae need to be destroyed by deep cultivation.
- Neem seed solution 50 g half broken seeds should be soaked for 12 hours and 3-4 g detergent should be mixed and sprayed twice in 10 days interval.
- If sesame is sown in early January, the infestation is much less.
- Insect infestation may be reduced by in time weed control, thinning and clean cultivation.
- In case of severe infestation, Diazinon 60 EC or Darsban 20 EC @ 2 ml with per litre of water and sprayed twice in 7 days interval in the affected field.

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Sesame scorpion: Scorpion is one of the main harmful insects of sesame plants. The female moth lays 500-1500 eggs on three leaves of the sesame plants. A pale yellow worm emerges from the female moth, clusters on a leaf, and eats the leaves to form spores. The large reddish-orange scorpion eats sesame leaves, stems, flowers and fruits like a glutton, causing severe damage to the plant. As a result, the growth and flowering of the plants is severely hampered and the yield is reduced by 20-30 percent. The level of attack is higher when flowers and fruits emerge.

Integrated management

- The moth is attracted to grow of insect on light trap at night and dies.

- In the early stages, the infested leaves can be destroyed by hand.
- If 8-10 stick/branches are placed in each bigha of sesame field, the insectivorous birds can control the insects by eating them.
- Neem leaf juice 10% or neem oil (10%) or neem seed solution can be sprayed and insects can be controlled.
- Irrigation channel should be made around the affected fields and water mixed with kerosene may used to kill the worms during the movement.
- Early sown of seed in the month of January, the attack is much less.
- Insect infestation is reduced by timely weed control, thinning and clean cultivation.
- Insects can be controlled by spraying Cithrin 10 EC 1 ml or Perfection 50 EC or Darsban 20 EC @ 2 ml per liter of water in the/r affected field twice in 10 days.

Irrigation and drainage: Sesame cultivation requires moderate moisture in the soil. However, if there is not enough moisture in soil at the time of sowing, then irrigation to be done to ensure optimum soil moisture condition for germination. In case of lack of moisture in the soil, irrigation is required once after 25-30 days of sowing, i.e. before flowering, and after 55-60 days, a second irrigation can be given at the time of pod setting. Proper drainage should be ensured for successful growth of the plants.

Intercultural operations: Seedlings germinate within 4-5 days of sowing. Within 10-15 days, the seedlings should be thinned out one by one at 5 cm intervals and if there are weeds in the soil, it should be cleared with a hoe. If there are weeds in the soil during seedling stage, it covers the sesame plants and causes considerable damage to the crop. If necessary, a second weeding can be done before flowering.

Harvesting and drying of seeds: Not all sesame seeds ripen at once, usually starting from the bottom and progressing to the top. If we wait for the upper shoots to be ripen, the lower shoots will burst and the seeds will fall to the ground and will reduce the yield. So without waiting, if the color of the leaves, stems and shoots of the sesame plant turns yellow, it is necessary to cut it along the base of the tree with scissors and tie it. The stalks have to be piled for two or three days at the place of threshing. So many immature shoots will ripen. Then plants should be dried well in the sun along with the stalks. The seeds should be separated by beating and threshing carefully with a stick.

Seed storage: It is better to store well dried seeds. Seeds should be dried for 4-5 days. Dried seeds should be kept in the shady place and stored after cooling. Sesame seeds can be stored in drums, kerosene tins, biscuit tins, kerosene coated earthenware jars on top, in jugs or pots or in thick polythene bags without holes. Dried sesame seeds can be easily stored for a year or more by keeping them in a clean dry container with 8-12% humidity. Preserved seeds are to be exposed to sunlight occasionally and then stored again.

Yield/Output: Seed yield per hectare: 1.3-1.6 tons

Technology-37: Improved variety of linseed “BARI Tisi-2”

Salient features of technology

- Height of the plants: 65-75 cm;
- From the base of the plant there are 4-10 main stems in clusters which are branchless;
- The stems are thick and stiff, so do not lodge;
- Number of capsules/plant: 25-70;
- Seeds per capsule: 7-12;
- The seeds are oval, smooth and flattened;
- The color of the seeds is white which can be distinguished from the variety Neela.

Suitable environment: Clay soil is most suitable for linseed cultivation. Linseed can be cultivated in silt loam and clay loam soils. It can be cultivated all over the country, but in the coastal areas, especially in Noakhali it is widely cultivated during the Rabi season.

Production/ Utilization Method

Sowing: Mid-October to mid-November. Since the seeds of linseed are small, the land has to be fine tilth with 4-5 horizontal ploughing and 2-3 laddering. Seed rate 7-8 kg/ha. Linseed is usually sown by broadcasting. But it is better to sow in rows. The distance from row to row should be 30 cm.

Fertilizer dosage and application method: Linseed is usually cultivated without fertilizer. However, to get higher yield, fertilizers should be applied at the rate of Urea 70-80 kg, TSP 110-130 kg and MP 40-50 kg per hectare. Half of the urea fertilizer and the rest of the other fertilizers should be mixed with soil at the time of final land preparation. The other half urea should be applied at 25-30 days after sowing.

Insect and Disease Control: Diseases and pests do not affect linseed crop significantly. However, sometimes there may be an attack of jassid. For controlling jassid, 5.8 g malathion should be mixed with 550 ml water and then sprayed.

Fusarium wilt is caused by *Fusarim* sp. This disease can be controlled by spraying Autistin 2 g/ liter of water for 7 days interval. This disease also can be controlled before sowing the seeds by treating the seeds with Provex or any other seed disinfectant.

Leaf blight is caused by a fungus called *Alternaria lini*. At first, there are dark brown unequal spots appear on the leaves. With the spread of the disease, the leaves become dry. It is a seed-borne disease that attacks plants in early stage. The disease is spread through the air borne spores of fungus. Humid weather is favourable for the prevalance of disease.

Control measures

Seed treatment: Before sowing, the seeds should be treated with Vitavax-200, Captan (25 g fungicide / kg seed) etc. to control the seed fungus.

Fungicide application: The prevalence of the disease can be reduced by spraying Rovral 50 WP at the rate of 0.2 percent (2 g fungicide per liter of water) 3 times at 10 days interval.

Irrigation: Irrigation to be applied 1-2 times as and when required for good yield.

Intercultural operations: The land should be kept free from weeds.

Harvesting and seed preservation: Linseed attains maturity in the month of March. When matured, the plants and fruit turn golden or slightly brown. Plants should be cut or uprooted after the crop is well matured, because if the fruit is immatured, the seeds remain unfilled. This reduces the weight of the seeds and reduces the amount of oil. Again, if the matured fruits kept in the field, there is a possibility of loss. The fruit (capsule) then explodes under pressure or shakes and the seeds fall off. Therefore, the crop should be harvested when it is seen that the fruits are about to mature. After cutting or uprooting, the plants to be tied in small bundles and piled up in the yard. After sun drying, the plants to be hit gently with a stick, for removing seeds from fruits. Then the plants can be separated from the seeds by sweeping. Seeds with debris and husks can be cleaned with the help of sieve and winnowing. Flax seeds should be dried in the sun two or three times. The seeds can be stored in a kerosene tin with a lid on the face or in a polythene bag.

Yield/Output: Yield per hectare: 1.15-1.56 ton.

Technology #38: Modern variety of chilli "BARI Ornamental Morich-1"

Salient features of technology

- Fruit erect, small and almost round in shape.
- Immature fruit pale yellow in color with purple anthocyanin spot sometimes, matured fruit orange and ripen fruit red in color. That means single plant bears 3 colored fruits.
- Single fruit weight 3-4 g having 80-100 seeds/fruit.
- Crop duration 210-240 Days.
- Number of fruits/plant 80-100 (if planted in pot), but produces 200-250 fruits/plant if planted in the field.

Suitable environment: All over Bangladesh, even roof-top gardens and balcony can be used for cultivation.This variety can be grown in organic matter rich sandy loam to loamy soils and also in pots. However, fertile loamy soil rich in organic matter is ideal for cultivation.

Production/ Utilization Method

Pot selection: Ornamental chilli plants are not very large, so it can be planted in small or medium (7-8 inches) sized pot. When planted in a very small pot, the growth of the plant restricts resulting in bonsai like structure but able produced flowers and fruits. For easy drainage, a hole should be made in the bottom of the pot and 1-2 inches of brick chips should be laid on the bottom of the pot for easy drainage of excess water.

Soil preparation: The pot should be filled by mixing half the size with loam soil and its equivalent amount of cow dung or vermi compost along with 10g TSP, 10g MOP and 5g urea. After mixing entire ingredients, the soil should be left for 8 to 10 days.

Sowing/planting season: It is mainly a winter variety but can be cultivated at any time of the year if planted in pots. The first week of October is usually the best time for sowing seeds and the first week of November is the best time for transplanting seedlings.

Seeds sowing and seedlings preparation: Generally in case of large number of seedlings, seeds should be sown in rows in the nursery bed. In this case, soil of the bed should be leveled evenly.

Then seeds should be dried in the sun for 1-2 hours and shallow (2-2.5 cm depth) lines should be drawn maintaining 3-4 inches distance on soil of the bed. The dried seeds should be continuously sown on each line then covered with loose soil. After that the seed bed should be mulched with a gunny cloth or rice straw. Light irrigation should be given on the top of the mulch from the day after sowing till the seedlings sprout. If the soil bursts and seedlings appear, the mulch has to be removed immediately. Thus after 25-30 days seedlings are suitable for planting in pots or in the field. On the other hand, 2-3 seeds can be directly placed in the middle of the pot.

Fertilizer dose and application method: Besides above mentioned fertlizers and manure applied before transplanting (during soil preparation), top dressing with 10g urea and 5g MoP fertilizer in each pot with gentle mixing followed by light irrigation is required (for 20-25 consecutive days).

Irrigation and drainage: The pot should be Irrigate immediately after transplanting seedlings. Other irrigations should be given in each day or every alternative day by observing the soil condition. It is necessary to drain out excessive water. Also over watering is harmful for the seedlings.

Disease control: No major disease found in BARI Ornamental Morich-1. However, due to excessive irrigation or water logging, foot rot disease may occur. In this situation the seedling turn light yellow in color and gradually falls to the ground. As a precautionary measure, Carbendazim group fungicide (Autistin) @ 2 g/L of water should be sprayed 2-3 times at 5-7 days interval during seedling stage.

Insect control: Thrips or sucking insects in winter and aphids with the increase in temperature after winter may appear. Thrips attack can be easily controlled by spraying Imidachlorpid group insecticide (Admire / Emitaf / Gain) @ 1 ml/L of water and Aphids can be controlled by spraying Dimethoate (Tafgor) @ 2 ml/L of water. In addition, if mites appear, can be easily suppressed by spraying Vertimec / Omit / Liker @ 2 ml/L for 2-3 times at 10 days interval.

Intercultural operations: The soil should be kept free from weeds for smooth and normal growth of the plant. As soon as 'Joe' comes after each irrigation, the soil should be loosened. If necessary, small sticking may be done for supporting the plant.

Harvesting: Mature fruits can be collected at 80-90 days after planting. Mature fruits are light orange but fully matured fruits are red. In case of seed collection, red fruits are to be collected. Thus fruits can be collected up to 210-240 days after planting.

Yield/ output: In the pot: 350-400 g/plant

In the field: 800-900 g/plant

Technology #39: Modern variety of chilli "BARI Ornamental Morich-2"

Salient features of technology

- Fruit erect, small and elongate in shape.
- Immature fruit white in color, mature fruit orange and ripen fruit red in color. That means single plant bears 3 colored fruits.
- Single fruit weight 2-3 g and 60-70 seeds/fruit.
- Number of fruits/plant 100-150 (if planted in pot), but produces 250-300 fruits/plant if planted in the field.

Suitable environment: Same as described for "BARI Ornamental Morich-1" (Technology #38).

Production/ Utilization Method: ame as described for "BARI Ornamental Morich-1" (Technology #38).

Yield/ output: In the pot: 350-450 g/plant
In the field: 800-1000 g/plant

Technology #40: Improved variety of sorghum "BARI Sorghum-1"

Salient features of technology

- This variety is comparatively short statured than local ones with strong stem system. Average plant height is 146 cm with minimum stem and root lodging by strong wind.
- The inflorescence of the variety is long, compact and straight.
- Average yield in winter season is 3.56 ton/ha. Yield under saline areas is 2.11 ton/ha (at 12 dS/m)

- Grains are round and white coloured
- This variety matures within 143-157 days in winter.

Suitable environment: Sorghum grows in all type of soil. Soil pH ranged 6-7.5 is suitable for sorghum. It can be grown all over Bangladesh including saline areas.

Production/ Utilization Method

Sowing: Sorghum can be grown year round. In Rabi season seed can be sown from 2nd week of Ashwin to 2nd week of Kartik (October- November). In Kharif season seed can be sown last week of June to 1st week of July. Seed rate for line sowing 7-8 kg/ha. Spacing in case of line sowing, row to row distance 45 cm and plant to plant 12-15 cm.

Fertilizer dose and application method: Urea 260 kg/ha, TSP 300 kg/ha, MOP 100 kg/ha, gypsum-75-90 kg/ha and zinc sulphate 4-5 kg/ha. One third of the urea along with all other fertilizers need to mix in the soil during final land preparation. Rest one third of the urea need to broadcast after 30 to 25 days after sowing, and the rest amount need to broadcast during flowering time.

Disease and insect-pest management: No disease infestation observed in this variety of Sorghum. The insect-pest attack in Sorghum is very low in Bangladesh. Stem borer fly can attack at 30-35 days of the plant. To control 18 kg Carbofuran/ha should be applied to the soil during seed sowing. To reduce the insect infestation, seed sowing should be done 7-10 days ahead of the seasonal rainfall. Stem borer caterpillar control can be done by Carbofuran 3G/ Furadan 3G @ 4-12 kg/ha at 20 to 35 days old plant.

Irrigation and Drainage: Depending on the rainfall usually 2-3 irrigations are required for sorghum. During rabi season 3-4 irrigations facilitate better yield.

Intercultural operations: Weeding is necessary at 20-25 days after sowing. Effective weed control can be done by spraying 0.5 kg Atrazine mixing with 650 litre water before germination of seeds.

Harvest: When panicles turn into straw colour and leaf becomes brown colour, it indicates the crop is matured enough for harvesting.

Yield/ output: In the non-saline area: 3.56 t/ha (on an average)

In the saline area (at 12 dS/m): 2.11 t/ha (on an average)

Technology #41: "BARI Lilium-1" Lilium variety suitable for cultivation in Bangladesh

Salient features of technology

- It is a bulbous flower.
- The flower color is white.
- Length of flower stick: 78-80 cm.
- Florets per stick: 7-8.
- Diameter of floret: 18-20 cm.
- Vase life 12 days.

Suitable environment

- Suitable for growing all over the country especially low temperature in the northern region.
- Lilium cultivation requires mild weather. The day temperature for producing good quality flowers is 20-25^0 C and the night temperature is 10-15^0 C. Most of the Lilium produce quality flowers in partial shade. Good quality flowers can be produced by using UV polythene/shade net which can resist 50% light.
- Well-drained sandy loam soil rich in organic matter is suitable for Lilium cultivation.

Production/ utilization method

Sowing/planting: October-November is the optimum time for sowing Lilium bulbs in Bangladesh. Row to row spacing 15 cm and plant to plant spacing should be maintained 15 cm. For Lilium propagation, the disease-free scale or bulblet is usually planted in 3-4 cm depth in cowdung mixed cocodust. It takes 2 years to produce suitable bulbs for flower production.

Fertilizer dosage and application method: Adequate amount of cocodust (about 10-15 kg per square meter) should be mixed with soil during land preparation so that the soil has adequate aeration. To get a good yield, it is necessary to apply more organic manure in the Lilium field. Lilium is a bulbous flower that stores most of the nutrients in the bulb. It is better not to apply any fertilizer in soil till the first 3 weeks of bulb sowing. After the first 3 weeks of bulb sowing, the fertilizer as NPK 30:20:20 g/m^2 should be applied Good results may be obtained by applying 1kg of calcium nitrate/100m^2 per week and 1kg of potassium nitrate/100m^2 after 6 weeks. In case of nitrogen deficiency, it is necessary to apply 1kg of ammonium nitrate/100m^2 at 3 weeks before harvesting of flower.

Control of Diseases and insect-pests: Rovral (0.2%) fungicide should be sprayed every 10 days interval to control leaf spot disease.

Irrigation and drainage: Irrigation is one of the most important determinants for Lilium cultivation. Regular watering ensures good flowering. Flower buds may suddenly fall due to a lack of water. Care should be taken so that the soil does not become dry. Drip irrigation method

is the most suitable for irrigating the Lilium field. There should be drainage facilities as excess water is very harmful to Lilium.

Inter-cultural management: Mulching keeps the Lilium soil cool, crumbly and free from weeds and reduces the incidence of soil-borne diseases. Generally, straw, water hyacinth, black polythene etc. can be used for mulching.

Flower collection: Usually when 1-2 florets start to open from the bottom of the spike, it is optimum time to cut the spike. The duration of life cycle of the flower is about 125-130 days.

Yield/Output: 30-40 flower sticks/m^2 may be obtained. It is possible to earn about Tk.13,73,000 per bigha (33 decimal).

Technology #42: "BARI Lilium-2" Lilium variety suitable for cultivation in Bangladesh

Salient features of technology

- It is a bulbous flower
- Possess attractive yellow colour floret
- Length of flower stick: 78-80 cm
- Floret/spike :8-9
- Floret diameter: 18-20 cm
- Vase life 10-12 days

Suitable environment: Same as described for "BARI Lillium-1" (Technology #41).

Production/ utilization method: Same as described for "BARI Lillium-1" (Technology #41).

Yield/Output: 30-40 flower sticks/m^2 may be obtained. It is possible to earn about Tk. 13,73,000 per bigha (33 decimal)

Technology #43: "BARI Gypsophila-1" - Gypsophila variety suitable for cultivation in Bangladesh

Salient features of technology

- It is a herbaceous flower
- Posses attractive white colour flower
- Spike length 28-30 cm
- Able to produce about 190000 flower bunch/ha
- Have potential to produce about 1000 kg seed (bulb)/ha

Suitable environment

- Well-drained sandy loam soil rich in organic matter is suitable for Gypsophila cultivation.
- Gypsophila cultivation requires mild weather. The day temperature for producing good quality flowers is 15-20^{0}C.
- October-November is the best sowing time for Gypsophila flower cultivation in Bangladesh.
- It is suitable for cultivation all over the country but Narayanganj, Jashore, Jhenaidah, Dhaka, Jamalpur, and Rangpur areas the most suitable.

Production/ utilization method

Sowing/planting: Continuous planting with 25 cm row to row spacing. Seed requirement is 2.5 kg per hectare.

Fertilizer dose and method of application: Cowdung 5 tons, 217 kg urea, 200 kg TSP, 120 kg MOP, 95 kg gypsum, 9 kg zinc sulphate and 14 kg boric acid are to be applied per hectare. At the time of ifnal land preparation, cowdung, zinc sulphate and boric acid should be well mixed with the soil. Urea and MOP fertilizers should be applied in two installments, the first is during final land preparation and the second installment is at 30 days after sowing

Disease and insect control: Disease and insect attack is less. Rovral (0.2%) fungicide should be sprayed every 10 days to control leaf spot disease

Irrigation: Irrigation should be done depending on the soil moisture condition. Generally, in absence of rain 10-12 irrigations may be required.

Inter-cultural operation: Weed control and thinning should be done 20 days and 40 days after sowing to maintain a 5 cm plant to plant distance

Flower collection: Flowers can be collected 60-65 days after planting. The duration of life cycle of the plants is about 100-110 days.

Yield/ Output

- Flower bunch per hectare: 1,90,000. Total income is about 19 lakh taka per hectare and the net profit is about 93 thousand taka per hectare.
- About 1000 kg seed (bulb) per hectare may be obtained.

B. Improved Technologies for Crop Production

As mentioned earlier, BARI is currently conducting research on 211 crops (excluding paddy, wheat, maize, jute, sugarcane and tea). In addition to the development of improved/modern varieties, improved production techniques of these crops such as, land preparation, sowing/planting time, sowing/ planting distance and depth, fertilizer and irrigation application time, intercropping (weed control, mulching, providing trail/support, removing of side brabnches, pollination, etc.), time of harvesting, etc. are being developed by conducting research. However, research is conducted on cropping pattern, intercropping, mixed cropping, relay cropping, etc. at research stations and farmers' fields to increase crop yield and production. Agronomy Division of BARI is playing a major role in this regard. Besides, On-Farm Research Division and different crop research centers of BARI are also involved in such research.

Technology #44: Cabbage-Okra-T. Aman rice: A profitable cropping pattern for Tangail region

Salient features of the technology

- The newly introduced crop in the farmers cropping pattern is Okra (Variety: BARI derosh-2) in Kharif season.
- A short duration T. Aman rice variety BRRI dhan72 may also used for in time sowing of cabbage.
- Rice equivalent yield (REY) for the improved cropping pattern (41.81 t $ha^{-1}yr^{-1}$) increased by 27% compared to the existing pattern Cabbage-Brinjal-T. Aman rice (32.96 t $ha^{-1}yr^{-1}$).
- With 10% more cost than existing pattern, improved cropping pattern may provide 17% higher net profit than existing cropping pattern.

Cabbage *Okra* *T.Aman rice*

Suitable environment: Tangail region and other areas having soils similar to AEZ 9 and AEZ 8.

Production/ utilization method

Item/operation	Cropping pattern		
	Cabbage	**Okra**	**T. Aman rice**
Variety	Autumn Queen	BARI Dherosh-2	BRRI dhan72
Spacing (cm)	60×45	45×30	20×15
Sowing date	September-October	2nd Week of March-Last Week of April Suitable time for sowing	1st week of July Optimum time of seeding in seed bed
Transplanting	2nd Week of November	-	Till 1st week of August suitable time
Fertilizer dose (kg/ha):			
Urea	300	150	150
TSP	200	100	75
MoP	250	150	70
Gypsum	110	60	25

Item/operation	Cropping pattern		
	Cabbage	Okra	T. Aman rice
Zinc Sulphate	5	-	5
Boric Acid	6	6	-
Fertilizer Application method	Expect Urea, half of Potash and other fertilizers should be applied during the final land preparation. Urea and half of Potash should be applied in three equal instalments at 15, 30 and 60 DAP as ring method.	A quarter of urea and all other fertilizers should be applied as basal at final land preparation and remaining urea should be applied in three equal instalments at 20, 40 and 60 days after germination.	All fertilizer except urea and half of Potash should be applied as basal at final land preparation and urea should be applied in three equal splits at 7, 22 and 42 DAT as top dressed. The remaining half of potash should be applied during application of last split of urea .
Intercultural operation	Weeds should be removed in time for growth and higher yield of the crop. After irrigation and fertilizers application as top dressed, soil should be chopped and loosened on the roots of the free.	The weeds should always be cleaned with finely weeding and timely weeding and the soil should be broken.	Weeding should be done at 10-15 DAT by hand or weeder.
Irrigation application	About 2-3 irrigation should be applied at 20-30 DAT for better and higher yield. However extra rain or irrigation water should be removed from the field.	Irrigation should be applied as per requirement in case of drought.	It is better to keep water in the field during planting to panicle initiation. Amount of water to be doubled when panicle initiation starts. Once the grains start hardening again water to be removed from the field.
Insect & pest control	Pest resistance variety, early sowing of seed, and application of fungicides.	Insects and pest can reduce the yield of Okra despite all the care given to the Okra. So integrated pest control management should be followed.	Insects and pest can greatly reduce the yield of rice despite taking all care. That is why integrated pest control management needs to be followed.

Item/operation	Cropping pattern		
	Cabbage	Okra	T. Aman rice
Harvesting	90 DAP is the suitable time for harvesting. If it is late to harvest cabbage, soil should be spade deeply or the root of the cabbage to be cut to avoid cracking of head.	About 40-45 DAS Okra starts flowering and 7-8 days after pollinations is the suitable time for harvesting. If the age of the fruit is more than 10 days, the fruit becomes fibrous and the nutritional value declines.	If 80% of the sheaf rice is hard and transparent, it is to be considered as ripened. After harvesting, rice should be threshed quickly without leaving it in the field any more.
Field duration (days)	92	96	78

Yield/Output

Crop	:	Cabbage	Okra	T. Aman rice
Yield (t ha^{-1})	:	83	17	5.25
Considering the whole pattern:				
Gross return (Tk. ha^{-1})		Total variable cost (Tk. ha^{-1})		Gross margin (Tk. ha^{-1})
6,82,810/-		2,19,590/-		4,63,220/-

Technology #45: Carrot – Sweet gourd + Indian spinach – T. Aman rice: A profitable cropping pattern for Manikganj region

Salient features of the technology

- The optimum time of sowing the first crop, carrot under the improved cropping pattern is late October to mid November and it may be harvested by mid January to mid February. Seeds of sweet gourd are to be sown in February. Indian spinach as an intercrop can be grown easily under the traili of sweet gourd as the seedlings of sweet gourd remains small from February to April. The field duration of Indian spinach is 50 to 60 days.
- Compared to farmers existing Carrot– Sweet gourd–T. Aman rice cropping pattern, Rice Equivalent Yield in the four crops pattern (Carrot–Sweet gourd+Indian spinach–T. Aman rice) may be increased by 45%.
- Production efficiency and gross margin of four crops based cropping pattern expected to be increased by 41% and 115%, respectively.

Suitable environment: Flood-free medium highland (of Singair, Manikganj) under AEZ-8 and similar areas.

Carrot *Indian spinach* *Sweet gourd* *T.Aman rice*

Production/ utilization method:

Item/operation	Cropping pattern			
	Carrot	Sweet gourd	Indian spinach	T. Aman rice
Variety	Red King	Lalteer hybrid	BARI Puishak-2	Binadhan-7
Spacing	Broadcast	2.5m x 2.5m	Broadcast	25cm x 15cm
Sowing/harvesting time	Late October to mid November	Early February	Early February	Mid July
Fertilizer dose (Urea-TSP-MoP-Gypsum-Zinc sulphate-Boric acid & Cowdung kg ha^{-1})	215-150-200-100-5-6 & 5000 kg Cowdung (CD)	240-190-102-50-20-0	100 kg urea	195-75-70-66-3-0 & 5000 kg Cowdung (CD)
Fertilizer application method	One-third of Urea and all of other fertilizers and cowdung to be applied during final land preparation. The remaining Urea to be top dressed in two equal splits at 25 and 45 DAS.	One-third of Potash and all other fertilizers to be applied during final land preparation. Urea to be top dressed in five equal splits at 10, 25, 60, 110 and 130 DAS. The remaining potash to be top dressed in two equal splits at 60 and 110 DAS.	Urea should be applied in three equal splits at 15, 30 and 45 DAS.	One-third of Urea and all of other fertilizers and cowdung to be applied during final land preparation. The remaining Urea to be top dressed in two equal splits at 20 and 35 DAS.
Intercultural operation	Two weeding are needed for carrot. Growth regulator (PGR) to be sprayed for proper growth of carrot. The field of indian spinach to be kept weed free for 30 DAS after germination. Rice field to be kept weed free with 10-15 cm standing water.			
Date of harvesting	Late January	Early June to July	Mid April	Mid October
Field duration (Approx.)	95 days	155 days	60 days	86 days
Turn around time	6 days	10 days	-	13 days

Yield/Output

Crop	Carrot	Sweet gourd	Indian spinach	T. Aman rice
Yield (t ha^{-1})	50 - 55	25 - 30	18 - 20	4.5 – 5.5
Considering the whole pattern:				
Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})		Gross margin (Tk. ha^{-1})	
11,18,222.00	5,80,055.00		5,38,167.00	

Technology #46: Potato/Sweet gourd-Jute-T. Aman rice: A profitable technology for Rangpur region

Salient features of the technology

- Potatoes are usually planted from the end of November and harvesting may start from second week of February. During mid-February to mid-April land remains fallow before sowing of jute.
- Seeds of hybrid sweet gourd are usually sown as a relay crop one month after planting of potato seeds, and sweet gourd harvesting continuous till mid-April.
- Rice equivalent yield of the cropping pattern Sweet gourd-Jute-T. Aman rice may be increased by 83% and inclusion of the new rop sweet gourd increases profitability by about 136%.
- Economically profitable and environmentally sustainable.

Potato *Sweet gourd* *Jute* *T.Aman rice*

Suitable environment: Rangpur region and other places with similar environment of AEZ 3.

Production/ Utilization method

Item/operation	Cropping Pattern			
	Potato	Sweet gourd	Jute	T. Aman rice
Variety	BARI Alu-25	BARI Hybrid Mistikumra-1	O-795	Binadhan-17
Spacing (cm)	60 × 25	180 × 200	Broadcast	20 × 15
Sowing/ Transplanting date	3rd to 4th week of November	Last week of November to 1st week of December	2nd to 3rd week of April	1st to 2nd week of August

Item/operation	Cropping Pattern			
	Potato	Sweet gourd	Jute	T. Aman rice
Fertilizer dose: (Urea-TSP-MoP-Gypsum-Zinc sulphate-Boric acid-cowdung kg ha^{-1})	300-150-220-120-6-6-5000	-	195-30-100-89-0-0-0	195-30-66-22-3-0-0
Fertilizer application method	Half of urea and all other fertilizers to be applied at final land preparation and remaining half of urea should be applied at 30-35 days after planting.	-	Half of urea and other fertilizers to be applied during final land preparation and remaining urea should be applied at 40 to 45 days after sowing.	All fertilizers were applied before transplanting. Urea should be applied into 3 equal split at 15, 30 and 45 days after transplanting.
Intercultural Operation	Forty jute plants per sq. m. should be maintained. Aman rice should be kept free from weeds for one third of life cycle. Proper protection measures are should be taken if Aman rice gets infested by pest and diseases. Furadan of 15 kg per hectare should be applied during second time wedding as protection against stem borers in rice field.			
Harvesting	15-18 February	1-6 April	19-24 July	4-10 November
Field duration (days)	86	48 (excluding the time with potato)	100	90
Turn around time	14 days	0	9 days	18 days

Yield/ Output

Crop	Potato	Sweet gourd	Jute	T. Aman rice
Yield (t ha^{-1})	25 - 30	30 - 33	3.0 – 3.5	4.5 – 5.0
Considering the whole pattern:				
Gross return (Tk. ha^{-1})		Total variable cost (Tk. ha^{-1})		Gross margin (Tk. ha^{-1})
866130		275011		571179

Technology #47: Intercropping winter vegetables with brinjal

Salient features of the technology

- Intercropping is a traditional practice in Bangladesh and it increases total productivity per unit area through maximum utilization of land, labour and growth resources.
- Brinjal (*Solanum melongena* L.) is an important vegetable crop cultivated round the year throughout the country. It is a tall, long durated (140-180 days) and wide spaced (80 cm × 60 cm) crop.
- Leafy vegetables like, red amaranth and spinach being short stature quick growing (30-45 days) crops can easily be intercropped in between two rows of brinjal at early growth stage for getting higher economic return.

Suitable environment: Brinjal growing areas in Bangladesh.

Production/ Utilization method

Variety: BARI Begun-8 as main crop and red amaranth (var. BARI Lalshak-1) and spinach (var. BARI Spinach-1) as component crop.

Sowing/Planting: Brinjal should be transplanted within 15 to 30 November and spinach and red amaranth should be sown 15 to 20 days after transplanting of brinjal. Spacing for brinjal is 80 cm × 60 cm, while that for spinach and red amaranth is 20 cm with continuous sowing.

Fertilizer dose and application method: Urea, TSP, MoP, gypsum, zinc sulphate, boric acid and cow dung manure to be applied @260-155-240-73-14-9-10000 kg/ha. For sole brinjal and intercrop full amount of all other fertilizer except urea and MOP should be applied in pit before 1 week of brinjal seedling transplanting. Urea and murate of potash should be applied in three equal splits at 21, 40 and 60 days after transplanting of brinjal as ring method followed by irrigation.

Harvesting: Brinjal can be harvested 4 to 5 times. Harvesting time starts at 140 to 170 days after transplanting. Both spinach and red amaranth can be harvested 35 to 40 days after sowing.

Yield/Output: Brinjal (Intercropped): 19-20 t/ha
Red amaranth (as intercrop): 12 -15 t/ha
Spinach (as intercrop): 20 - 24 t/ha
BCR: 2.89-3.44

Technology #48: Intercropping gardenpea with sorghum

Salient features of the technology

- Sorghum is popularly known as 'Jowar' in Bangladesh and India. Sorghum is popular all over the world as a food for humans and animals.
- Short duration vegetable like gardenpea can easily be cultivated as intercrop with sorghum without sacrificing sorghum yield.
- Inclusion of a legume crop like gardenpea in the cropping system may enrich soil health and provide production sustainability.
- Additional crop (garden pea) increases farmers' income to a good extent. Besides, the intercropping system increases productivity and cropping intensity.

Two rows of gardenpea in between two normal row of sorghum

Four rows of gardenpea in between two paired row of sorghum

Suitable environment: Loamy soil rich in organic matter and nutrients is suitable for sorghum and garden pea cultivation. As sorghum is a drought tolerant crop, it can be cultivated in char areas or in less fertile lands with sandy loam and clay soil.

Production/ Utilization method

Variety: Sorghum variety BARI Sorghum-1 and gardenpea variety BARI Motorshunti-1 or BARI Motorshunti-3 can be used for this technology.

Sowing: November (*Agrahayan* month) is the best time for sowing gardenpea as intercrop with sorghum. Two rows of gardenpea (30 cm × 10 cm) to be sown in between two normal rows (60 cm × 10 cm) of sorghum **or**, four rows of gardenpea (30 cm × 10 cm) can be sown in between 2 paired rows (30 cm/ 120 cm/ 30 cm × 10 cm) of sorghum. The appropriate seed rate of sorghum 12-15 kg / ha and gardenpea is 30-35 kg/ha.

Fertilizer dose and application method: Urea, TSP, MOP, gypsum and cowdung manure should be applied @ 550-260-220-260-5000 kg/ha. One third of urea and full dose of other fertilizers and manure to be applied during final land preparation. Rest of urea to be applied in two equal splits at 25-30 days after emergence (DAE) and at 55-60 DAE in sorghum row after harvest of gardenpea.

Irrigation: Sorghum cultivation usually does not require irrigation. If it is needed, the first irrigation should be given at 20-30 days after sowing and the second irrigation to be given at 50-60 days after sowing (before flowering).

Disease and insect-pest management

Sorghum: In the inter-crop cultivation, a very harmful insect fall army worm may attack the crops and can destroy crops over night. In order to control the insects, 5-6 pheromone traps per bigha should be placed in the field and monitored round the clock. As soon as the pheromone trap is full of fall armyworm insects, the surrounding land needs to be identified by direct signs of insect infestation or their feces. Eggs or newly budding moths from the affected plant should be identified and crushed or buried in a hole at least one foot below the ground. Infected plants and their adjoining areas (covering an area of at least 30-40 m) should be sprayed immediately with the organic pesticide *Spodoptera nucleopolyhydresis* Virus (SNPV) (0.2 g per liter of water or 3 g per 15 liters of water). Infected plants in particular need to be well watered. Thus SNPV sprays are required 2-3 times at 7 days interval. When it is time to irrigate the affected crop, flood irrigation should be done as much as possible.

Gardenpea: Gardenpea is less susceptible to diseases and insects.

Intercultural operations: Thinning may be required after seedling emergence. After 30-35 days of sowing, 10 cm distance between the seedlings to be maintained. The rest of the seedlings have to be picked up and thinned. If weeds appear, they should be cleaned with a hoe or a small spade. Herbicide atrazine can be sprayed @1.5 L/ha at 6 (six) leaves stage.

Harvesting: Green pods of gardenpeas can be picked 2/3 times from 60 to 75 days of sowing. Sorghum can be harvested 120-130 days after sowing, when the leaves turn slightly yellow is the optimum time for harvesting.

Yield/Output: Sorghum (Intercropped): 3.0 - 4.0 t/ha

Gardenpea (Intercrop): 7.0 - 8.5 t/ha

BCR: 2.93 -3.25.

C. Soil Fertility and Fertilizer Management

Maintenance of soil fertility is essential for crop production. The amount of agricultural land is gradually decreasing, on the other hand, population of the country is increasing. In addition to increasing crop intensity, high yielding varieties and technologies are being used to increase food production to provide food for the growing population. In particular, the use of chemical fertilizers has increased manifold, while the use of organic manures has decreased due to limitations in use and inadequate availability. Farmers are using higher or lower dose of chemical fertilizers as per their capacity. Another important factor is climate change. As a result of these, the soil health is deteriorating and the fertility is gradually decreasing and deficiency of secondary and micronutrients occuring one after another. Scientists are continuing research to improve soil fertility through integrated approach. They are developing appropriate fertilizer dose for each crop especially for newly invented varieties, and to reduce the use of chemical fertilizers. Fertilizer doses are also being determined on the basis of cropping pattern. In addition, efforts are being made to increase soil fertility through various types of organic manures and integrated nutrient management system. Soil Science Division of BARI is playing the major role. Besides, On-Farm Research Division and crop based research centers are also working for the improvement of soil health and sustainable crop production.

Technology #49: Application of mycorrhiza and phosphorus for higher productivity of cauliflower

Salient features of the technology

- Arbuscular Mycorrhiza is a microbial fertilizer that increases the availability of phosphorus in soil with phosphorus-deficient soil and helps the plant to absorb the phosphorus.
- Arbuscular mycorrhiza accelerates plant growth by increasing microbial activities which is helpful making nutrients (nitrogen, phosphorus, potassium, magnesium, etc) available to plant growth.
- Infected seedlings should be planted in the field using mycorrhiza in the seedbed.

Suitable environment: High or medium high land with loamy, clayey loamy and alluvial silty soils is good for cauliflower cultivation. Rabi season is the suitable time for cauliflower cultivation in Bangladesh.

Production/ Utilization method

Variety: BARI Fulcopi-1.

Sowing/Transplanting: Seeds to be sown in the seedbed during October to early November. Seed rate 300-350 gm ha^{-1}. Row to row distance is 60 cm and plant to plant distance is 45 cm.

Fertlizer dose and application method: Soil mixed mycorrhiza inoculum to be applied at the seedbed 1 kg m-2 (for seedling production in nursery bed). Fertilizer dose to be applied per hectare: urea 475 kg, TSP 250 kg, MoP 120 kg, gypsum 130 kg, zinc sulphate, heptahydrate 10 kg and boric acid 6 kg. At the time of final land preparation, 1/3 of urea, 50% TSP and other fertilizers to be applied evenly and mixed well with the soil. Two-thirds of the remaining urea to be applied in two installments at 25 and 45 days after planting.

Irrigation: For cauliflower cultivation, irrigation should be applied at 10-15 days intervals depending on the moisture content of soils.

Diseases and Insect pest control: Common cutworm to be controlled by using feromone trap. To control foot rot of cauliflower, Endosine 2 gm mixing with per liter water should be sprayed 2-3 times at 10-12 days intervals.

Intercultural operation: Soil needs to be loosed through mulching and proper weeding should be ensured.

Harvesting time: After 80-90 day of sowing.

Yield/Output: Marketable head yield: 40 - 43 t ha^{-1}.

The cauliflower yield may be increased by 20-30%. The dose of TSP may be reduced by 50% if this technology is adopted.

Total income: 4,30,000 Tk ha^{-1}
Total expenditure: 1,60,000 Tk ha^{-1}
Net profit: 2,70,000 Tk ha^{-1}.
BCR: 2.69 Tk ha^{-1}.

Technology #50: Integrated nutrient management and storage technique for increasing productivity and storage life of sweet potato

Salient features of the technology

- Integrated nutrient management results in higher productivity.
- Storability increases and maintains quality of the sweet potato.
- Reduces requirement of chemical fertilizers.
- Improves soil health.

Suitable environment: Well drained, upland and sunny land should be selected for sweet potato cultivation. In general, sandy loam soil is good for producing higher root yield. However, all types of soil can be brought under sweet potato cultivation providing with good management. Soil pH 5.6 to 7.5 is suitable for cultivation. Sweet potato growing area includes Jamalpur, Bogura, Rangpur, Dinajpur, Gaibandha, Jessore, Chuadanga, Meherpur, Gazipur, Cumilla and Barishal districts.

Production/ utilization method

Planting: Mid October to mid-November is the optimum time for sweet potato vine planting. For sweet potato, it needs deep ploughing up to 30 cm depth, with associated harrowing, rolling and pulverizing before planting. Row to row distance 60 cm and plant to plant distance 30 cm should be maintained for better accommodation. Cutting should be planted maintaining 2/3

nodes beneath the soil. About 56000 cuttings are needed for planting one hectare of land. Cutting should be considered first and second even third having 3 or 4 nodes. If the soil moisture is insufficient then light irrigation should be provided after vine planting at1- 2 days interval.

Fertilizer dose and method of application: Cowdung (6 t/ha)/ poultry manure (3 t/ha) along with chemical fertilizer (urea, TSP, MoP, gypsum @ 275-75-240 and 55 kg/ha) to be applied in an integrated manner. All cowdung/ poultry manure, TSP, gypsum and half of urea and MoP should be applied during final land preparation. Remaining urea and MoP to be side dressed at 30-35 days after planting (DAP) followed by earthing up. In charland and rainfed condition, all chemical fertilizer (10-12% reduction rate) should be incorporated at final land preparation. Before top dressing of urea, weeding should be done, required amount of water need to be applied.

Irrigation and drainage: Usually 2-3 irrigations are required depending on moisture content of soil. After establishment of plant, irrigation at 30, 60 and 90 days after transplanting are needed. If we provide irrigation timely then sweet potato yield, quality and total production may be increased. However, excess water must be drained out.

Disease control: Generally disease incidence is less for sweet potato. However, some diseases can be found in sweet potato such as soft rot, collar rot, feathery mottled virus, leaf roll virus etc. The TCRC recommended integrated disease management practice can be used which includes, (1) Use of disease free vine, (2) Practice of clean cultivation, (3) Careful handling to avoid physical injuries during harvest to preservation/ storage, (4) Good quality roots should be stored (cut, rotten and disease roots should be sorted out before storage), (5) Curing of roots should be done before storage, and (6) Proper management of the sweet potato weevil should be ensured.

Insect management: Generally insect infestation is very few except weevil. The weevil infestation can be minimized through integrated pest management such as: (1) Early planting and harvesting, (2) Cultivation of sweet potato in the new field, (3) The char land and the land which remain under water in the rainy season should be selected, (4) Top 30 cm of vine should be selected as seedling, (5) Use of pheromone trap, (6) Hilling up of soil around the base of plants to prevent or fill soil cracks. Such practices not only protect the plants from weevil attack but can also result in increased crop yields. (7) In case of high infestation use Carbofuran (Furadan, Furatap, Sunfuran, Agrifuran 5G) @ 20 Kg/ha can be used.

Intercultural operation: Earthing up should be done after urea fertilization. At 50-60 days after transplanting,vines should be de-touched from the soil at least once in every month. It may be helpful for main root development of sweet potato. For this, 8-10 ft long bambo stick can be used.

Harvesting: Harvesting should be done after 130-140 days after transplanting of vines, but if kept for more than 180 days, the flesh becomes fibrous. Moreover, early harvesting sometimes protect from weevil infestation. Sweet potatoes are collected by spading in normal soil condition. After collection, the sweet potato is to be cured spreading on dry sand. After placing the harvested sweet potato on the clean and dried surface making upto 75 cm height flat heaps then it should be covereed with 10 cm thick sand on the top.

Yield/Output: Per hectare yield of sweet potato 35-40 t. Under normal room temperature, the sweet potato root can be stored over a period of 40-50 days..

Technology #51: Split application of potash fertilizer for Increasing productivity of ariod

Salient features of the technology

- Leaching and fixing of Potassium occurs in soil due to heavy rain and water logging, if Potash fertilizer is applied as basal at planting. But, if top dressing of Potash is done then K becomes more available to the plants as required for critical growth stages with significant reduction of loss due to leaching or wash out for a K loving crop like aroid.
- Potash fertilizer increases the productivity of root crops simultaneously the shelf life and vigourness of aroid.
- The use efficiency of K may be increased by 15-20% (approx.) than that of conventional method, if top dressing of potash fertilizer is done. As a result production cost reduces and income of farmer increases.

- The benefit cost ratio of the technology is 2.8.

Suitable environment: All over Bangladesh but grows well in Agro-ecological zone 8 and 9 (Greater Mymensingh and Tangail region). Loamy to clay loam soil is suitable for aroid cultivation.

Production/ utilization method

Variety: BARI pani kachu-2

Planting: Generally aroid is planted in kharif but mid October to mid November is more suitable.

Fertilizer dose and application method: Decomposed cowdung 15 t/ha, urea 280 kg, TSP 160 kg, MOP 300 kg, gypsum 100 kg, zinc sulphate 12 kg and boric acid 10 kg to be applied per hectare. Half of Potash fertilizer, half of decomposed cowdung and full dose of TSP, gypsum, zinc sulphate, boric acid to be applied as basal during final land preparation. Urea is to be applied into eight installments and to be applied after each harvest of stolon. Rest half of potash fertilizer to be applied in three installments at every one month interval. Rest of decomposed cowdung should be applied after three months of planting.

Disease and insect-pest control: Traser 45 SC @ 0.4 ml/L water should be sprayed at 15 days intervals (2-3 times) for controlling catterpiller of aroid. Moreover male insect can be controlled by using pheromone trap.

Irrigationt: A standing water level of 7-10 cm is suitable for aroid cultivation.

Intercultural operations: Land should be kept free from weed through entire growth period of aroid especially first three month. Sometimes, the standing water is to be shaken for proper aeration. Dead leaves are to be removed regularly from the field.

Harvesting time: Stolon harvest starts at last week of December while harvesting of rhizome from mid April to mid May.

Yield/Output: Yield**:** Stolon 26-30 t/ha and Rhizome 20-23 t/ha.

Total income: Tk. 4,51,124 per ha^{-1}.

Total cost: Tk. 1,59,812 per ha^{-1}.

Net income: Tk. 2,91,312 per ha^{-1}.

BCR: 2.8

Technology #52: Use of Azotobactor biofertlizer for increasing productivity of onion

Salient features of the technology

- The use of liquid *Azotobacter* inoculum for onion cultivation improves the yield and maintains good soil conditions.
- Liquid *Azotobacter* inoculum is a type of microbial fertilizer or bacterial fertilizer made by special beneficial microorganisms. They store nitrogen from the atmosphere because of symbiotic association with crops. These beneficial microorganisms can fix nitrogen from the atmosphere and give it to the onion plant and in return take carbohydrates from the onion plant for their survival.

` By using *Azotobacter* 10^8 cell ml^{-1} liquid inoculant and 80% urea in combination, it is possible to save 20% urea in onion production.

Suitable environmen: Gazipur region, Modhupur Tract (AEZ-28) and similar other area. Loamy, light loamy, sandy loamy & alluvial soils rich in organic matter are suitable for onion cultivation. Rabi season is the suitable time for onion cultivation.

Production/ utilization method

Variety: BARI Onion-4.

Sowing/planting: Sowing time is October-November. Row to row distance is 15 cm and plant to plant distance is 10 cm. Seed rate 3.5-4 kg ha^{-1}.

Fertilizer dose and application method: *Azotobacter* 10^8 cells ml^{-1} should be used as liquid inoculant. Besides, cowdung 5 t, Urea 217 kg, TSP 275 kg, MoP 150 kg, Gypsum 122 kg and zinc sulphate, heptahydrate 14 kg should be applied per hectare. *Azotobacter* biofertilizer to be applied @1 kg m^{-2} in nursery bed for seedling production. Cowdung should be mixed properly with soil in the field. At the time of final land preparation, all other fertilizers with one-third of urea and one-third of MoP should be broadcast evenly and mixed well with soil. The remaining urea and MoP to be applied in 3 installments and 2 installments, respectively at 20, 40 and 60 days after planting.

Disease and insect pest control: To control leaf blight disease, Rovral 50 WP 0.2% rate (2 gm along with per liter water) should be sprayed mixing with water for 3-4 times at 10-12 days intervals. The insect thrips can be be controlled by using a sticky white trap. It is controlled by spraying Sippronil or Dimethoate if attack is severe.

Irrigation: For onion cultivation, irrigation should be applied at 10-15 days interval (8/9 times) depending on the soil moisture condition.

Intercultural operations: Soil needs to be kept loose and weed-free by weeding 2 to 3 times or more.

Harvesting time: After 90-120 days of sowing (Mid-February to mid-March).

Yield/ Output: Bulb yield: 23 – 25 t ha^{-1}

Total income: Tk. 6,00,000 per ha^{-1}.

Total cost: Tk. 2,10,000 per ha^{-1}.

Net income: Tk. 3,90,000 per ha^{-1}.

BCR: 2.86

Technology #53: Balanced fertilizer dose for chilli + garlic intercropping

Salient features of the technology

- Chilli with garlic intercropping system can be practiced using 100% chemical fertilizers for chilli and only 40% chemical fertilizer for garlic along with 5 t/ha cowdung per hectare.
- Use of lower amount of fertilizers reduces cost of production.
- Increases total productivity and farmer's profit.

Suitable environment: Gazipur (AEZ-28) & Noakhali (AEZ-18) and similar other areas

Production/ Utilization method

Crop/Variety: Chilli (BARI Morich-3); and Garlic (BARI Rashun-2)

Sowing/planting: Last week of November is the suitable time for both transplanting of chilli and dibbling of garlic cloves. One row of garlic between two rows of chilli. Line to line spacing of chilli should be 40 cm and spacing between chilli and garlic 20 cm. Plant to plant spacing of chilli and garlic should be 40 cm and 10 cm, respectively.

Fertilizer doses (per hectare) and application method: Urea 320 kg, TSP 215 kg, MoP 175 kg, gypsum 115 kg, zinc sulphate (Monohydrate) 6 kg, boric acid 12 kg and cowdung 5 t. The whole amount of cowdung, TSP, gypsum, zinc sulphate (Monohydrate), boric acid and 1/4th of MoP to be applied at the time of final land preparation. Remaining MoP and whole amount of urea should be applied in three equal installments at 25, 50 and 75 days after transplantation from 10-12 cm away from the base of the plant which may be beneficial for the growth and yield of garlic.

Irrigation: Irrigation should be applied 6-7 times at 10-15 days interval.

Disease and insect-pest control: Infestation of thrips can be controlled by yellow sticky trap (for chilli) and blue sticky trap (for garlic). If thrips attack is severe, Fipronil or Dimethoate @ 1ml/L water to be applied for 2-3 times at 7-10 days interval. To control Fusarium wilt of chilli, seeds to be treated with Provax-200 or Autostin @ 2.5 g per kg seed before sowing. Drainage of water needs to be ensured. Crop residues and weeds to be removed from the field and destroyed. To control Stemphylium leaf blight of garlic, Mencozeb or Ridomil gold or Rovral @ 2 g/1 L of

water needs to be sprayed 3-4 times at 10-12 days interval.

Intercultural operations: Weeding is to be done for 2-3 times for loosening of top soil and removal of weeds.

Harvesting time: 1st week of March to last week of April.

Yield/ Output: Yield: Chilli-8.89 t ha^{-1}; and Garlic-3.55 t ha^{-1}, Chilli Equivalent Yield: 15.99 t ha^{-1}

Total income: Tk. 2,40,000 per ha^{-1}.

Total cost: Tk. 1,10,000 per ha^{-1}.

Net income: Tk. 1,30,000 per ha^{-1}.

BCR: 2.18.

Technology #54: Fertilizer management for cropping Pattern Potato-Boro-T. Aus-T. Aman rice

Salient features of the technology

- In Potato-Boro-T. Aus-T. Aman rice cropping pattern, using 100% soil test based fertilizer + 25% extra urea, TSP and MoP may increase the system productivity significantly.
- Requires lower amount of fertilizers that reduces production cost.
- Reduces production cost.
- May incraese profit of the farmers.

Suitable environment: Loamy and calcium rich soil. Jashore region and similar other areas of High Ganges River Floodplain (AEZ-11)

Production/ Utilization method

Item/operation	Cropping pattern			
	Potato	Boro rice	T. Aus rice	T. Aman rice
Variety	BARI Alu-62	BRRI dhan28	BRRI dhan48	BRRI dhan57
Seed rate (kg/ha)	150-200	28-30	28-30	28-30
Methods of sowing and transplanting				
Line to line	60	20	20	20
Plant to plant	25	20	15	20

Item/operation	Cropping pattern			
	Potato	Boro rice	T. Aus rice	T. Aman rice
Time of sowing and transplanting	First week of November	First week of February	Frist week of may	Last week of July
Irrigation	03	04	02	02
Weed control (number of weeding)	01	02	02	01
Insect control	Potato Spider mites- Diathan M-45 @ 2 ml/ L water to be applied 3 times at 10 days interval	To control brown plant hopper- light trap should be used. Besides, appropriate dose of urea needs to be applied.		
Disease control	Leaf blight – Rovral 50 WP @ 2g/ L water 3-4 times at 10-12 days interval to be applied	Blast and Heat shock: Organic manure should be applied. Adequate water should be maintained in the growing rice field.		
Harvesting time	Last week of January	Frist week of May	Last week of July	Frist week of November

Fertilizer dose:

Fertilizer (Kg/ha)	Potato	Boro rice	T. Aus rice	T. Aman rice
Urea	425	430	256	350
TSP	225	200	95	180
MoP	220	180	140	160
Gypsum	140	140	100	130
Zinc sulphate (monohydrate)	6	8	-	-
Boric acid	6	-	-	-

Method of fertilizer application

Potato: All fertilizer except urea to be applied during final land preparation. Urea to be applied in three installments at 20 DAS, 35 DAS and 50 DAS.

Boro rice: All fertilizer except urea to be applied during final land preparation, Urea to be applied in three installments at 7 DAT, 30 DAT (during tillering) and 50 DAT (5-7 days before panicle initiation).

T. Aus rice: Except urea all other fertilizers to be applied during final land preparation. Urea to be applied in three installments at 7 DAT, 25 DAT (during tillering) and 45 DAT (5-7 days before panicle initiation).

T. Aman rice: All fertilizer except urea to be applied during final land preparation. Urea to be applied in three installments at 7 DAT, 25 DAT (during tillering) and 45 DAT (5-7 days before panicle initiation).

Yield/ Output: Expected rice equivat yield : 25-28 t ha^{-1}

Total income: Tk. 5,50,000 per ha^{-1}.

Total cost: Tk. 3,60,000 per ha^{-1}.

Net income: Tk. 1,90,000 per ha^{-1}.

BCR: 1.53.

Technology #55: Strip tillage and nitrogen management for increasing yield and soil fertility under Mustard-Boro rice-T.Aman rice cropping pattern

Salient features of the technology

- Strip tillage along with 25% additional urea may increase crop yield in Mustard-Boro rice-T.Aman rice cropping pattern, compared to conventional cultivation system.
- Organic carbon in the soil may increase by 7-8% compared to conventional cultivation system, if the technology (strip tillage + 20% additional urea) is practiced in a field for consecutive 3-4 years. Moreover, it decreases soil bulk density, increases field capacity, water availability, soil moisture and microbial population, and finally reduces cost of production.

Suitable environment: Clay loam and slightly acidic soil under AEZ-28 (Modhupur Tract –Gazipur) and similar areas.

Production/ Utilization method

Item/operation	Cropping pattern		
	Mustard	Boro rice	T. Aman rice
Variety	BARI Sharisha -14	BRRI Dhan 28	BRRI Dhan 72
Seed rate (kg/ha)	8-10	28-30	28-30
Methods of sowing/planting:	Line sowing	Transplanting	Transplanting
Line to line (cm)	30	20	20
Plant to plant (cm)	Continuous (5 cm)	20	20
Time of sowing and transplanting	First week of November	First week of March	Second week of July
Irrigation (number)	04	04	02
Weed control (number of weeding)	02	02	01

Item/operation	Cropping pattern		
	Mustard	Boro rice	T. Aman rice
Insect control	Aphid- Admire @ 0.5 ml/ L water 2 times at 10 days interval to be applied	Brown plant hopper- Use light trap and appropriate dose of urea	Rice yellow stem borer: If the field shows 10-15% dead and 5% white panicles then authorized/ recommended pesticides should be sprayed.
Disease control	Leaf blight – Rovral 50 WP @ 2g/ L water 3-4 times at 10-12 days interval to be applied	Blast: Organic manure should be applied and rice field should be submerged with water (2-3 cm height).	Blast: Organic manure should be applied and rice field should be submerged with water (2-3 cm height).
Harvesting time	First week of February	Third week of June	Second week of November

Fertilizer dose:

Fertilizer	Mustard	Boro rice	T.Aman rice
Urea	225	332	147
TSP	110	65	40
MoP	110	145	95
Gypsum	63	75	45
Zinc sulphate (monohydrate)	3	3	-
Boric acid	6	-	-

Method of fertilizer Application

Mustard: Except urea, all other fertilizers to be applied during final land preparation. Urea to be applied in three installments at 7, 20 and 50 DAS.

Boro: Except urea, all other fertilizers to be applied during final land preparation. Urea to be applied in three installments at 7 DAT, 35 DAT (during tillering) and 52 DAT (5-7 days before panicle initiation).

T. Aman rice: All the fertilizers except urea to be applied during final land preparation. Urea to be applied in three installments at 7 DAT, 28 DAT (during tillering) and 45 DAT (5-7 days before panicle initiation).

Yield/Output: Yield per hectare: Mustard: 1.2 – 1.5 t, Boro rice: 5.5 – 6.0 t, and T. Aman rice: 5.0 – 5.5 t.

Total cost : Tk. 2,10,920/ha, **Total income:** Tk. 3,22705/ha, **Net income:** Tk. 1,11,785/ha, **Benefit-Cost ratio (BCR):** 1.52.

Technology #56: Minimum tillage and crop residues incorporation for increasing yield and soil fertility in Wheat-Mungbean-T.Aman rice cropping pattern

Salient features of the technology

- Use of strip tillage and crop residues in the wheat-Mungbean-T.Aman rice cropping pattern increases crop yield compared to conventional cultivation.
- Practicing of this technology (strip tillage + incorporation of crop residues) in the same field for consecutive 3-4 years may increase organic carbon content in the soil by 10-12% compared to conventional cultivation system. Moreover, it decreases soil bulk density, increases field capacity, soil moisture retention and microbial population and reduces cost of production with higher profitability.

Suitable environment: Loamy soil, calcium and organic matter rich soil under AEZ-11 (High Ganges Tidal Floodplain Soil in Jessore region) and similar other areas are suitable for practicing the cropping pattern: Wheat-Mungbean-T.Aman rice.

Production/ Utilization method

Item/operation	Cropping pattern		
	Wheat	Mungbean	T.Aman rice
Variety	BARI Gom-30	BARI Mung-6	BRRI Dhan 72
Seed rate (kg/ha)	120	28-30	28-30
Methods of sowing and transplanting Line to line (cm) Plant to plant (cm)	 20 Continuous (5 cm)	 30 10	 20 20
Time of sowing and transplanting	First week of November	Last week of March	First week of July
Irrigation (Number)	05	02	02
Weed control (Number of weeding)	02	01	01
Insect/rat control	Rat- 3-5 gram zinc phosphide poison lure to be applied in filed hole.	Fruit borer- Virtako 40 WG @ 0.15 gram/liter, 2-3 times at 7-10 days intervals to be applied.	Rice Yellow stem borer: If the field shows 10-15% dead and 5% white panicles, then recommended pesticides should be applied.

Item/operation	Cropping pattern		
	Wheat	Mungbean	T.Aman rice
Disease control	Blast- During panicle initiation apply folicure 250 EC @ 0.5 ml/10 L water for every 5 decimal land, 2 times at 12-15 days interval.	Leaf cercospora: Secure 600 WG @ 1g/Liter water to be applied for 2 times at 7-10 days interval.	Blast: Organic manure should be applied and desirable height of water should be maintained in the field.
Harvesting time	Third week of March	Third week of June	Third week of October

Fertilizer dose (kg/ha):

Fertilizer	Wheat	Mungbean	T.Aman rice
Urea	275	44	145
TSP	80	0	35
MoP	120	0	65
Gypsum	69	0	50
Zinc sulphate (monohydrate)	6	0	3
Boric acid	6	0	0

Method and time of fertilizer application

Wheat: Except urea, all other fertilizers to be applied during final land preparation. Urea to be applied in three installments @ 7 DAT, 20 DAT and 50 DAT.

Mungbean: All of urea fertilizer to be applied 10 days after germination.

T. Aman rice: All the fertilizers except urea to be applied during final land preparation. Urea to be applied in three installments @ 7 DAT, 28 DAT (during tillering) and 45 DAT (5-7 days before panicle initiation).

Yield/Output: Wheat 3.5 - 4.0 t/ha, Mungbean (seed) 1.3 – 1.5 t/ha, Mungbean (Biomass): 12-14 t/ha, T. Aman rice: 4.5 – 5.0 t/ha.

Cost benefit:

Total cost : Tk. 1,25,300/ha

Total income: Tk. 1,82,500/ha

Net income : Tk. 57, 200/ha

BCR: 1.46.

D. Diseases and Insect-pest Management

Diseases and insect-pests are the major constraints in crop production. The problem has become acute and devastating due to climate change impact. Cropping intensity is gradually increasing to provide food for the growing population, Most of the lands remain occupied by the crops throughout the year. The number of crops is increasing, new crops are being introduced to the cropping pattern providing with high yielding varieties and technologies. As a result, new diseases and insect-pests are invading. Many minor diseases and insects- pests have now become major problems. With the increasing use of pesticides/ insecticides to control pests and insects, the cost of production of farmers is increasing, on the other hand, environmental pollution is looming large and public health is under threat. Ensuring safe food production and supply is the biggest challenge of the present time. Plant Pathology Division and Entomology Division of BARI are playing the key role for controlling the pest and disease attack following GAP protocols (IPM, IDM, biorational way of pest control, etc). Besides, crop research centers of BARI are also contributing in this regard. Some of the notable technologies developed during the Mujib Centenary are documented here.

Technology #57: Management of fruit rot disease of brinjal

Salient features of the technology

- The technology effectively reduces 80% of the fruit rot disease of brinjal.
- The technology increase yield by 10-15 %.

Fruit rot infected plant *Healthy plant*

Suitable Environment: This technology is suitable for Gazipur, Narsingdi, Mymensingh, Pabna, Rajshahi, Bogura, Rangpur, Jashore, Satkhira, Faridpur, Chatttagram, Khagrachari and other brinjal growing areas.

Production/ utilization method

- Resistant variety such as, Jashore local, Botli begun, Khata begun, Dighinala and Ishurdi-1 should be cultivated.
- Seedling to be raised in clean seed bed with seed treatment followed by transplanting of seedling in the clean field.
- Seed to be treated with hot water (at 51^0 C) for 15 minutes. This disease also may be controlled by seed treatment with the mixer of carbendagim group of fungicide (Autostin) and Provex.
- Fungicide of carbendazim group to be sprayed @ 2g/L of water at 7 days interval for 2-3 times just after appearance of the disease.
- Severity of the disease may be reduced by spraying Autostin @ 2g/L of water just after appearance of the disease.
- Among the disease control approaches, seedling transplanting in clean field or raising seedlings in clean nursery is important factor to control the disease.
- Collection of seed from healthy plant and sowing healthy seed is the supplementary measure of disease control.
- Severity of the fruit rot disease of brinjal may be reduced by practicing crop rotation.
- After harvest, the crop residues to be destroyed by burning and mixing with soil properly.

Yield/Output: Expected brinjal yield: 55-60 t/ha (irrespective of varieties).

Technology #58: Integrated management of bacterial wilt disease of brinjal

Salient features of the technology

- The technology can reduce 75-80% of bacterial wilt disease of brinjal.
- Yield may be increased up to 15-20% by using this technology.

Disease infected plants *Healthy plants*

Suitable Environment: This technology is applicable for Gazipur, Narsingdi, Mymensingh, Pabna, Rajshahi, Bogura, Rangpur, Jashore, Satkhira, Faridpur, Chattagram, Khagrachori and other brinjal growing districts.

Production/ utilization method

- The field to be selected where brinjal was not planted earlier. For controlling bacterial wilt, brinjal should be cultivated in virgin soil having proper drainage system.
- Disease resistant variety viz. BARI begun -8 to be used.
- Crop residues of the infected plants to be destroyed.
- Irrigation to be applied in the infected field judiciously.
- Non-host crops like, rice, wheat, maize to be cultivated in the field after harvest of brinjal.
- Poultry refuse may be applied which may increase the population of beneficial organism in the soil and thus control the bacterial wilt disease to some extent.
- Brinjal seedling should be planted in raised beds and soil should be covered with black polythene.
- Bio-fungicide like, *Bacillus subtillis* @ 25g talc formulation per liter water to be applied before 20-30 minutes of seedling transplanting. Or, *Trichoderma harzianum* @ 5g /seedling can be applied.
- Bactericide of Thiozole group to be sprayed after 2 months of seedling transplanting at 15 days interval.

Yield/Output: Expected yield: 50-60 t/ha (irrespective of varieties).

Technology #59: Management of bacterial wilt and root knot nematode of Tomato

Salient features of the technology

- The technology may reduce bacterial wilt and root knot disease by 80-85%.
- Yield of tomato can be increased by 20-25%.

Symptom of Bacterial wilt disease

Symptom of Root knot disease

Suitable Environment: All tomato growing areas in Bangladesh.

Production/ utilization method

Seedbed preparation

- Soil to be kept exposed to direct sunlight for 4/5 days with proper ploughing.
- After leveling the soil, seed bed to be treated by burning 5-6 cm thick layer of saw dust on the soil.
- Before sowing, seed to be treated with Provax @ 2.5g /kg seed.
- Resistant variety viz. BARI Tomato-16 and BARI Tomato 17 to be used.
- Proper drainage system should be ensured in the seed bed. Seeds should be sown sparsely in the seed bed.

Land preparation and seedling transplanting

- Neem oil cake to be applied @ 600 kg/ha with proper ploughing and should be left for 15 days for allowing decomposition and proper mixing with soil. Or, tricho-compost/vermicompost can be applied @ 3 t/ha 5 days before transplanting.
- Stable bleaching powder to be applied @ 20 kg/ha at the final stage of land preparation.
- Furadan 5G should be applied (@2.0 g per plant) at the base of the plant at the time of planting to control the nematode disease.

Activities after seedling transplanting

- Flood irrigation should be stopped just appearance of bacterial wilt disease. The infected plants to be uprooted and burned. The infected area to be treated with stable bleaching powder.
- Autostin to be applied @ 2g/L of water at 12-15 days interval for 3 times if fungal wilt disease appears.
- Excess water to be drained out.
- Furadan 5G and stable bleaching powder should be applied at the base of the plant following the recommended dose as mentioned above.

Yield/Output: Expected yield: 80-85 t/ha (irrespective of varieties).

Technology #60: Management of seedling diseases of lentil by using Tricho-compost

Salient features of the technology

- This technology can effectively control seedling disease (foot and root rot) of lentil in addition to improving soil health.
- More than 80% of seedling disease can be reduced by using this technology.
- Controlling the disease using this technology may increase yield of lentil by 15-20 %.

Disease infected plot *Disease free plot*

Suitable Environment: Lentil growing areas in Bangladesh.

Production/ utilization method

- Lentil to be grown in well drained soils.
- Resistant variety of lentil like, BARI Masur-8 and BARI Masur-9 should be used.
- Land should be prepared properly.
- Proper drainage system to be maintained.
- Tricho-compost should be applied @ 3t/ha one week before seed sowing and to be mixed properly with soil.
- Crop residues should be burned out after harvest.

Yield/Output: Expected yield: 1.5-2.0 t/ha

Technology #61: Management of orobanche in mustard

Salient features of the technology

- Orobanche of mustard can be controlled effectively using this technology.
- Yield of mustard may be increased by 50% compared to the yield of orobanche infected plot.

Orobanche infested plant *Treated plot*

Suitable Environment: Mustard growing areas in Bangladesh particularly where Orobanche infestation is a problem.

Production/ utilization method: Variety: BARI Sharisa-14

Recommended production technologies for BARI-Sharisha-14 should be followed along with following suggestions:

- During final land preparation, urea & TSP should be applied at recommended dose of along with 25% extra of urea and TSP.
- After 20-30 days of sowing, 60 ml glyphosate per hectare and 1% ammonium sulphate to be applied for the 1st time.
- After 55 days of sowing, 120 ml Glyphosate per hectare and 1% solution of ammonium sulphate to be applied for the 2nd time.
- The soil of mustard field must be wet during application.

Yield/Output: Yield of mustard expected to be increased by 50% upon successful utilization of this technology.

Technology #62: Integrated management of rhizome rot disease of Ginger

Salient features of the technology

- Rhizome rot of Ginger caused *Pythium aphanidermatum, Fusarium, Erwinia caratovara, Ralstonia solancearum*, Nematode, Rhizome fly etc. can be controled successfully by this technology.
- The rhizome yield of ginger expected to be increased by by 130 -152%.

Rhizome treatment with Ridomil gold (0.25%) + Soil drenching with Bordeaux mixture treated plot

Rhizome treatment with Ridomil gold (0.25%) + Soil drenching with Crossin AG 10 SP (0.1%) treated plot

Control plot

Suitable environment: Ginger is cultivated at fertile loam soil. Yet sandy loam to clay loam is also suitable for ginger cultivation. Around 28-35^{0}C is optimum for ginger cultivation. Below 10^{0}C temperature is harmful for ginger plants. Kharif season is suitable for whole country. Lalmonirhat, Nilphamari, Rangpur, Dinajpur, Tangail, Rangamati, Bandorban and Khagrachori are good for cultivation of ginger.

Production/ Utilization Method

Planting: April to May suitable for planting of ginger.

Fertilizer dose and application method: Cowdung 5 t/ha and urea 304 kg, TSP 267 kg, MOP 233 kg, gypsum 111 kg and zinc sulphate 12 kg per hectare. The entire quantity of cowdung, TSP, gypsum, zinc sulphate and half of MOP should be applied during final land preparation. The rest urea and MOP to be applied in two equal splits at 80 and 110 DAP.

Irrigation: Five to six irrigations are needed during dry season.

Disease and insect control: Normally rhizome fly attacks rhizome of ginger. Chlorpyriphos 2 g/l water should be applied 2-3 times at an interval of 7-10 days at the base of plants.

Intercultural operations: Weeding should be done four times at 50, 95, 140 and 185 days after planting. Other intercultural operations should be done to maintain normal hygienic condition in the crop field.

Harvesting and preservation: Ginger is harvested during plant is fully died and preserved under soil.

Yield/Output: Expected yield: 30 - 38 t/ha (upon successful utilization of this technology).

Technology #63: Integrated management of leaf curl disease of Chilli

Salient features of the technology

- Chilli leafcurl disease can be reduced up to 70-80 % by using this technology.
- This technology is environmental friendly and profitable.
- Yield of chilli increases by 15-20%.

Treated plot *Untreated plot*

Suitable environment: Chilli growing areas of the country including Gazipur, Mymensingh, Pabna, Chadpur, Bogura, Khulna, Lalmonirhat, Jashore, Narsingdi, Faridpur, Magura etc.

Production/ Utilization method

- Seedling to be grown in insect proof net and one spray of Admire (Imidacloprid 0.1%) 1ml/L or bio-neem (0.2 %) 2ml/L to be done at 5-10 days before transplanting.
- Disease free healthy seedlings should be planted in the main field.
- The infected plants to be uprooted and destroyed at initial stage.
- Chilli field should be kept free from weeds.
- Maize to be sown in line at 10 cm spacing around the chilli plot as barrier crop at 15-18 days before transplanting of chilli. Bio-neem 2 ml/liter or Imidacloprid 1ml/liter of water to be sprayed at 12 days interval starting at 20 days after transplanting for vector control.
- The barrier crop maize should be removed at 50-60 days of sowing.

Yield/Output: Expected yield: 11-12 t ha^{-1} (upon successful utilization of this technology)

Technology #64: Management of leaf spot disease of betel vine

Salient features of the technology

- Controls the leaf spot disease of betel vine by 80-85%.
- Yield may be increased by 15-20 %.

Disease infested plant *Healthy plant*

Suitable environment: Betel vine growing areas in the country including Khulna, Barisal, Potuakhali, Khustia, Chuadunga and Rajshahi.

Production/ Utilization method

- Betel vine planting in shadow place having necessary light and air.
- Betel vine planting in well rich organic matter soil having well drainage system.
- Seedling/vine should be collected from at least two years old healthy plant
- Support should be provided by jute stick or bamboo stick in the little bit grown seedling.
- Infected leaves and vines should be destroyed.
- The mixer of Indofil 2g/L and Secure 2g /L of water should be applied at 7 days interval for 3-4 times.

Yield/Output: Expected yield: 3-4 t/ha (upon successful utilization of this technology).

Technology #65: Integrated mangement of Blast dsease of wheat

Salient features of the technology

- The technology able to control blast disease of wheat by 80-85%.
- Yield of wheat may be increased by 10-15%.

Blast disease *Conidia of fungi*

Suitable environment: All the wheat growing areas of Bangladesh.

Production/ Utilization method

- Resistant variety like BARI Gom-33 should be used
- Sowing by 15 - 30 November may reduce the disease infestation.
- Fertilizer and fungicide should be used at prescribed dose.
- Seed to be treated with Xelora (Thiphenate methyl) @ 4ml/kg seed or vitaflow (carboxin+thiram lequid) @ 3ml/kg seed or talc based Trichoderma @ 5 gm/kg seed.
- Urea fertilizer should be applied in three instalments. Half as basal dose, 1/4th at crown root initiation and rest 1/4th at maximum tillering stage.
- MCP (Methyl cyclopropene) should be applied at the heading stage @ 1gm/kg soil, to be spreaded on the soil followed by watering. As a result wheat head will be larger and yield will be increased.
- After head comes out, silicon di oxide (SiO_2) should be spayed @ 30gm/L of water.
- After 7-10 days of SiO2 spray, fungicide Opera @1 ml/L should be sprayed and after 7 days Cabrio @ 1 gm/L of water should also be sprayed.

Yield/Output: Expected yield: 4-5.5 t/ha

Technology #66: Bio-rational based management of lemon leaf miner

Salient features of the technology

- The technology is environment friendly, easy, effective, profitable and sustainable.
- Use of this technology does not require application of any harmful chemical pesticide.

Infested tender leaf *Infested twig* *Infested leaf with larva*

Suitable environment: All over Bangladesh.

Production/ Utilization method

1. **Mechanical method**: Infested leaves or twigs should be cut and taken away from the garden and destroyed. This practice may destroy the larvae and pupae of the insect and its attack is expected to be reduced.

2. **Use of bio-pesticide**: Need based rotation spraying of biopesticide Biotrin (0.5% Matrine) @ 1 ml/liter of water and Success 2.5 SC (Spinosad) @ of 1.2 ml per liter of water at an interval of 10-15 days. Once the Biotrin is sprayed, the next time Success 2.5 SC to be sprayed.

Yield/Output: The technology effectively controls lemon leaf miner and thus may increase farmers' income by 25-30% over the conventional method.

Technology #67: Management of rugose spiralling whitefly attacking coconut

Salient features of the technology

- Whitefly of coconut can be managed effectively at a low cost by using this technology.
- The technology is easily available and not dependent solely on chemical pesticide.

Suitable environment: All over Bangladesh.

Production/ Utilization method

1. Sanitation: Severely infested coconut leaves along with adults and nymphs of whitefly should be cut, removed and burned.

2. Rotation spraying of chemical insecticide Acetamiprid (e.g. Tundra 20 SP, Platinum 20 SP etc.) @ 1g/l of water and biopesticide Fizimite or Bioclean @ 1ml/l of water at 15 days interval. Usually, 2-3 sprays are required to obtain good result.

Whitefly infested coconut leaf

Sooty mold on coconut leaf

Seriously infested coconut leaflet

Yield/Output: The technology can reduce whitefly infestation in coconut up to 80% thereby productivity is expected to be increased to a great extent.

Technology #68: Bio-rational based management of pod borer in yardlong bean

Salient features of the technology

- The technology is easy, cheap and environment friendly.
- Use of this technology does not require spraying of any toxic chemical insecticide.

Suitable environment: All over Bangladesh.

Production/ Utilization method

1. **Sanitation:** Weekly removal of infested flowers and / or pods.
2. **Application of bio-pesticide:** Spraying of bio-pesticide Antario @ 1 g/ litre of water or spinosad (Tracer 45 SC @ 0.4 ml/ litre of water or Success 2.5 SC @ 1.2 ml/litre of water) in the infested field at 10 days interval. Usually, 3-4 sprays are required to obtain good result.

Pod borer infested yard long bean

Pod borer larva

Adult moth

Production after using bio-pesticide

Yield/Output: Farmers' income may be increased by 20-25% over conventional practice.

Technology #69: Management of root aphids of potato

Salient features of the technology

- Root aphid of potato can successfully be controlled by this technology.
- Yield may be increased by 15-20% for management of the pest.

Suitable environment: Potato growing areas in Bangladesh like, Bogura, Rangpur, Pabna, Thakurgaon, Dinajpur, Rajshahi, Tangail, Jamalpur, Munshiganj and Jashore. Incidence of the pest attack may increase under cloudy weather after tuber formation.

Production/ Utilization method: Production method is same as described for BARI Alu-82 (Technology #21) .

Besides, proper weeding and optimum irrigation to be done to avoid cracking in the soil. Thiamethoxam@0.5g/L or Imidacloprid @ 0.5ml/L should be applied at plant base when root aphid appears at the base of the stem, 1-2 spray needed at 10 day interval.

Yield/Output: Yield of potato may be increased by 15-20% due to management of the pest.

Technology #70: Bio-rational based management of mites and thrips of chilli

Salient features of the technology

- Effective to control mites and thrips in chilli.
- The technology is cheap and environment friendly and does not require spraying of any toxic chemical pesticide.
- Farmers' income may be increased by 30% over conventional practice.

Chili plant infested by Thrips

Mite infested chili plant

White sticky traps in research field

Suitable environment: All over Bangladesh

Production/ Utilization method

1. Installation of white sticky traps: White sticky traps @ 40 traps/ha to be installed in the infested field.

2. Application of bio-pesticide: Bio-pesticide Success 2.5 SC (Spinosad) @ 1.2 ml/ litre of water and Fizimite (10% sodium lauryl ether sulphate) @ 1 ml/ litre of water should be applied alternately at 7 days interval to control mites and thrips successfully.

Yield/Output: Success of this technology in controlling mites and thrips is 90% and 80%, respectively.

Technology #71: Safe control of rats using poison bait in the bait station

Salient features of the technology

- It is an effective method for controlling rats with acute or chronic poison
- Acute or chronic poison can be used safely in bait station
- Rat consumes sufficient amount of poison if it is placed in bait station
- Bait station can be prepared easily using locally available materials
- It is a safe method for human and non-target animals.
- In this method, rat consumes about 0.45 g poison per day, which is almost double than the poison placed at open place.

Wooden bait station *Plastic bait station*

Suitable environment: It can be used in rat infested field, store house and fruit trees. It can be used in any season and any places of Bangladesh.

Production/ Utilization method : Wooden box or plastic pipe having open ends at both sides is used to prepare this bait station. Length of bait station is 25 cm, breadth 10 cm and height 10 cm. There is a channel of 6 cm diameter inside it to keep the poison bait. It can be used in rat infested field or store house and also can be placed at active burrow side or runway of the rats. The rats easily get attracted to the poison bait and consumes sufficient amount of it if bait stations are placed in rat infested field or store house, near burrow opening or runway.

Yield/Output: Success of this technology in controlling rat is 80%.

F. Farm Machineries & Irrigation Technology

Bangladesh is now a middle income country. The crisis of agricultural workers is increasing gradually due to the creation of opportunities for multidimentional work at home and abroad. Demand of labor for crop production and post-harvest processing is increasing due to increase in cropping intensity, especially during sowing/planting and harvesting. There is an acute shortage of agricultural labor; labor is not available even at double rate of wages, resulting in disruption of production. On the other hand, due to scarcity of fodder and grazing land, number of cattle particularly bullocks has decreased significantly and land preparation has become a major problem. To increase in cropping intensity, land prepartion on time and within a short period of time is also a big challenge. So, there is no alternative of mechanization to solve all these problems. Agriculture in Bangladesh is thus gradually becoming machine dependent to fulfil demand of the present time. Scientists of FMPE Division of BARI are conducting research on the innovation of agricultural machineries considering the environment as well as needs and capabilities of the farmers.

Irrigation is another important aspect in agriculture. Crop production is almost impossible without irrigation especially in the rabi season. Irrigation and Water Management Division of BARI is conducting research to determine optimum level of irrgation and scheduling for different crops, ensuring efficient and economic use of irrigation water through development of modern irrigation equipments, minimze wastage of water and reduction of irrigation cost.

Technology #72: BARI Green Jackfruit Peeler

Salient features of the technology

- This jackfruit peeler can be used for peeling green jackfruit, sweet gourd, green papaya, and other vegetables
- Size: 1600 × 560 ×510 mm
- Operated by 0.50 hp electric motor
- It can be manufactured in local workshop
- Weight: 50 kg (mild steel); 70 kg (Stainless Steel)
- Price per machine: Taka 55,000 (mild steel) and Taka 90,000 (Stainless steel)

Suitable environment: Suitable for use in jackfruit growing season and in Jackfruit growing areas such as, Gazipur, Tangail, Mymensingh and Hill Tracts.

Production/ Utilization method: At first, the machine should be set on a level area. All moving parts and electric connection of the machine should be checked thoroughly. Fruits or vegetables should be placed vertically on the base of the machine and should be pressed with gripper. Then the cutting tools of the machine should be set on the skin of the fruits at desired depth and machine need to be started by connecting with electric switch. After starting the machine, fruit will start to rotate and the skin will be separated from the fruit. After completing the peeling the machine will be automatically stopped. After that a new batch of fruits may set for peeling.

Yield/Output: The capacity of the machine is peeling of 30-35 green jackfruit per hour. This machine can save 90% labour and 80% cost. Cost of peeling per fruit is Taka 2.40 for mild steel machine and Taka 3.70 for stainless steel machine.

Technology #73: BARI Cream Separator

Salient features of the technology

- It can separate cream from whole milk hygienically without any kind of hand touch.
- It is operated by an electric motor. If there is no electricity or load shedding, then operated by leg or hand.
- The machine can save 50% cost, time, and labour.
- One person is required to operate the machine, male or female both can do this work.
- Price: Taka 80,000.00 (Eighty thousand taka) per machine.

Suitable environment: Milk producing areas/ farms around the country. Can be used anywhere and as and when necessary round the year.

Production/ Utilization method: The machine should be placed on a plain surface where electricity is available. Before starting the machine, all parts need to be set up well and check the electric connection. Firstly, the whole milk needs to filter to separate the foreign materials then feeding on a bucket of the machine. Then ON/OFF button should be pressed to start the motor. The liver of feeding bucket to be 'ON' just one minute later when the motor speed gets stable. The cream and skim milk could be separated and stored in different bucket. When the whole milk almost finished, then half-liter water should be added with whole milk in the feeding bucket.

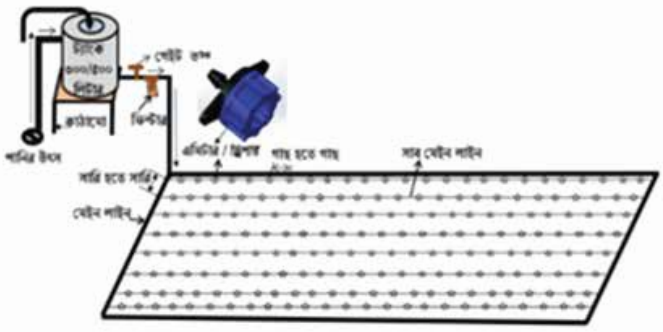
Yield/Output: Cream separation capacity of the machine is 7.5 kg cream from 150 liter raw milk per hour. Cream separating efficiency is 90%. Cost of separation is Taka 14.00 per kg of cream.

Technology #74: Low cost dripper - for reducing cost of drip irrigation in cultivating high value crops

Salient features of the technology

- The main constituent of a drip irrigation system is the emitter or dripper, which makes water droplets through controlling the flow of water and applies water in drops at base of every plant.
- Discharge rate of the newly developed dripper is generally 3.2 – 3.6 litre/hour depending on the water pressure as well as the manufactiring accuracy.
- Dripper discharge does not vary significantly with changes in water pressure. Therefore, uniformity in discharge rate can be achieved using the traditional practice of placing a 200-500 liter tank at a height of 1.5m from the ground.
- Uniform plant growth is ascertained as each plant receives equal amount of water through this improved dripper.
- The price of the new dripper is only 8 – 10 taka/dripper. (Dripper imported from China and India with similar performance costs around 15 – 25 taka/dripper).
- This technology can be applied to cultivate high value cash crops planted in lines in areas where water is truly a limited resource. Thus, in water scarce areas, this technology will not only enhance food productivity but also may improve livelihood of farmers.

Dripper



A schematic view of drip-irrigation layout

Suitable environment: The technology is suitable for any areas of Bangladesh; however, it is particularly suitable for water scarce areas. It is noted that, the technology is suited for crops planted in lines.

Production/ Utilization method

- Drip irrigation is a technique in which water is applied at the base step of crops in drops through a network of valves, pipes, tubes, and drippers or emitters.

- Drippers or emitters are the main constituents of a drip irrigation system. Drippers make water droplets ready for application at the base of crops through controlling the flow of water from the overhead tank.
- To apply drip irrigation, a 200-liter capacity plastic tank is set at a height of 1.5m from the ground surface to create adequate water pressure. The water tank is placed at one corner of the crop field on a stand made of either bamboo or iron bar. The flow of water from the tank is controlled through a gate/ball valve placed at the bottom part of the tank. Generally, two lateral pipes, each with a length of 12 – 14m and a diameter of 1.25cm, are placed along the crop rows. Drippers are set at the lateral pipes at distance determined by the plant-to-plant distance. Water is applied at the base of the plant through these drippers. Lateral pipes are joined through a T-joint to a 2.5cm diameter main pipe attached to the water tank.
- Drip irrigation is water saving technology compared to other methods of irrigation, because unlike other irrigation methods, drip irrigation applies water for wetting only the root zone of crops.
- This technique increases crop yields by 28 – 31%. On top of that, it can save 45 – 55% urea and potash fertilizers.

Yield/Output: Productivity of crops may be incrased by 15 – 20% upon successfully utilization of this technology (dripper).

G. Seed and Seedling Production/ Preservation Techniques

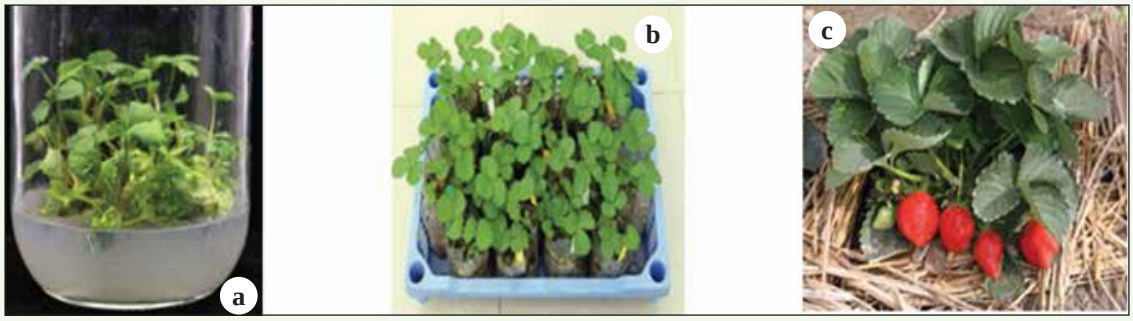
Quality seeds/seedlings are essential to get desired yield of a crop. There is a huge shortage of quality seeds and seedlings in the country. Farmers faces loss due to lack of quality seeds every year and the production target of country can not be achieved. For getting quality seeds and seedlings, special care and techniques are needed at both stages of production and preservation and it varies from one crop to another. Scientists of Seed Technology Division of BARI are working hard to develop technologies for production and preservation of quality seeds and seedlings of BARI mandated crops and a good number of technologies have already been developed. Horticulture Research Center, Tuber Crops Research Center, Pulses Research Center, Oilseed Research Center and Spices Research Center of BARI are also conducting such research, in their respective areas.

Biotechnology Division of BARI is conducting research for developing stress tolerant varieties using biotechnological interactions/tools. In particular, they are doing research for developing varieties of different crops with special quality (e.g. high yielding, disease/insect-pest resistant, drought/waterlogging tolerant, etc.). They have already developed Bt brinjal varities those are resisitant shoot to fruit borer, those are widely adopted by the farmers. Besides, scientists of this division are continuing research on tissue culture for developing disease free seedlings keeping varietal characteristics intact and have achieved success in producing tissue culture seedlings of several crops. Horticulture Research Center and Tuber Crops Research Center of BARI are also conducting research on tissue culture.

Technology #75: BARI Strawberry-2 seedling production through micro-propagation

Salient features of the technology

- Production of vigorus and disease free plantlets
- Production of large number of plantlets



Photographs: a) Multiple shoot in media, b) Plantlets transferred in poly pot, c) Plant with fruits in the field.

Suitable environment: Any where in Bangladesh.

Production/ Utilization method

- Runners should be collected from vigorus and disease free plants of BARI Strawberry-2
- The apical buds collected from runners should properly be washed in tap water with Ridomil gold for 5 minutes, followed by jet and trix solution for 5-6 minutes in tap water. The washed buds should be taken in sterile beaker and again washed by clorox (60%) for 3 minutes in sterile distilled water. This step should be carried out in laminar air flow cabinet.
- After sterilization, explants should be transfered to different hormone-rich media for shoot initation. After initiation of shoots , subculture should be done in same fresh media for shoot elongation. Maximum shoot is induced in 1mg/L BAP, 0.05 mg/L Kn and 1.5 mg/L GA3 enrich MS media.
- Individual shoots should be separated and placed in hormone free MS media for root initiation. Root initiation starts within 3-10 days and become mature in 20-30 days.
- The tubes carryng the plantlets should be transfered from growthroom to normal condition and should be kept for 3-5 days. Then plantlets should be removed from the tube and the roots should be washed properly and planted to soil, sand and compost mixed media in poly pots. The poly pots along with the plantlets should be covered with polybag to keep moisture .
- After 10-15 days poly bags can be removed. After 1 month the plantlets become ready to transfer to normal field condition.

Yield/Output: BARI Strawberry-2 plants produced by micro-propagation may produce 50 fruits per plant.

Technology #76: Cassava seedling production by micropropagation technique

Salient features of the technology

- MS medium supplemented with 1.5 mg/l BAP may produce 3-4 shoots/explant
- ½MS medium supplemented with 0.5 mg/l NAA may produce 5-6 roots/explant
- 100% plantlets may survive at hardening stage under field conditions
- Allows rapid multiplication of cassava for true to type propagules.
- This technology is suitable for the commercial production of disease free cassava plantlets.

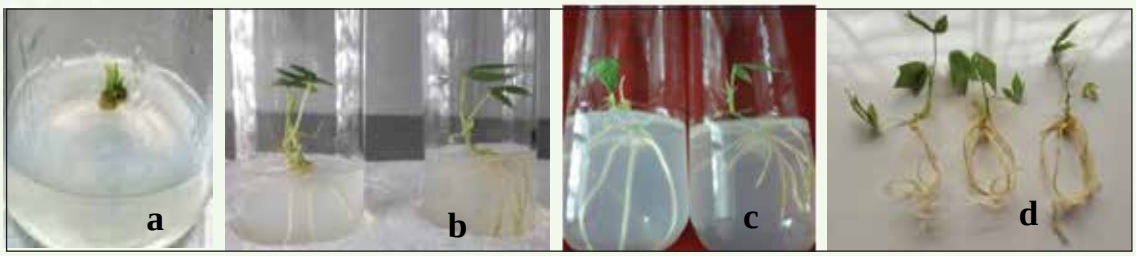


Plate 1: In vitro plantlet production (a-d)

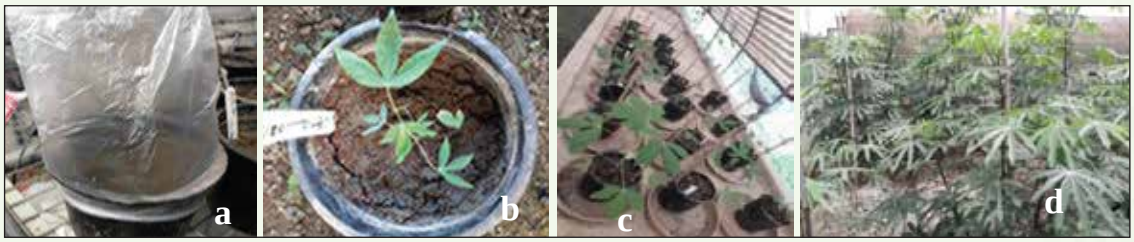


Plate 2: Hardening and *ex vitro* establishment of plantlets (a-d)

Fig. Micropropagation of Cassava

[Plate 1: *In vitro* plantlets production (a-d): a. Explant initiation, b. *In vitro* plantlets, c-d. Rooted plantlets. Plate 2: Hardening process and ex vitro establishment (a-d): a. plantlet transfer in pot, b-c. *Ex vitro* established plants (2 month age), d. Established plants at field conditions]

Suitable environment: Tissue culture lab of public and private sectors are suitable for commercial production of Cassava seedlings.

Production/ Utilization method

- Single node from *in vitro* raised plantlets are cultured in MS (Murashige and Skoog, 1962) medium supplemented with 1.5 mg/l BAP for shooting where 3-4 *in vitro* shoots/explant are found.
- Explants having 3-4 nodes (approx. 4-5 cm length) are cultured in ½MS medium supplemented with 0.5 mg/l NAA for rooting where well-developed 5-6 roots might be found within 4-5 weeks.
- Plantlets are to be transferred from growth room and kept in room temperature (24±1^{0}C) for 3 days for pre-hardening. After 3 days well rooted plantlets are to be taken out from

the culture vessels carefully without disturbing the roots and washed with tap water to remove the adhering media from the root zone.

- The plantlets are to be transplanted in a plastic pot having 1:2:1 ratio of sterilized soil, sand and coco dust, respectively. At the bottom of the pots, 3-4 holes are made where 4-5 pieces of a brick are to be placed.
- Two-third of the pots to be filled with soil, sand and coco dust (1:2:1) media and water to be applied for maintaining moisture. Single plantlet is to be transplanted in each of the pot. The pots should be covered with white transparent polythene bag and kept in the shade house for 3 weeks.
- After 3 weeks, polythene bags should be removed gradually following @ 1st day opened 1 hour, 2nd day 3 hour, 3rd day 5 hour, 4th day 7 hour, 5th day 9 hour and at 6th day 12 hour. At 7th day polythene bags have to be removed completely.
- Compost should be added in the remaining empty part of the pots and then plantlets to be transplanted in each pot and up to 45 days of planting, plantlets are to be watered 2 times in a day.
- After 2 months of hardening, the plantlets are to be transplanted in the field. At the end of the process, 100% plantlets are expected to survive under field conditions.

Yield/Output: Huge number of disease free quality seedlings of cassava produced at a time. No negative effect on land, water, air, biodiversity etc. is expected from this eco-friendly technology.

Technology #77: Quality Bushbean seed production following integrated nutritrient management

Salient features of the technology

- The germination percentage of seeds is above 90%.
- 100 seed weight: 25-28 g
- Number of pods per plant: 22-29
- Average yield of seed: 1.25 t/ha

Suitable environment: Well drained loamy soil is suitable for bushbean cultivation. Rabi season (temperature 10-25^{o}C) is suitable for bushbean seed production. Gazipur district and other areas having similar environment are suitable for bushbean seed production.

Production/ Utilization method

Sowing: November is the optimum time for sowing. Seed rate 120-125 kg/ha. The optimum row to row spacing 25-30 cm and seed to seed 15 cm spacing.

Fertilizer dose and application method: Integrated Nutrient Management System (IPNS) should be followed in fertilizer management. Urea 150 kg, TSP 150, MoP 90, gypsym 45, boric acid 8, zinc sulphate 5.5, cowdung 3000 and Biochar 3000 kg should be applied per hectare. One third of urea and all other fertilizer should be given during final land preparation. Rest of urea should be applied at 20 and 30 DAS.

Irrigation: Irrigation should be done considering moisture content in the soil.

Disease and Insect-pest management: To control pod borer, the insecticide "Tracer" can be applied. For controlling root rot disease, Autostin can be used as per recommendation.

Intercultural operation: Weeding should be done as per requirement.

Harvesting Time: February-March.

Yield/Output: Seed yield per hectare: 1.5 - 1.7 t with 20-25% increased yield than traditional practice.

Technology #78: Collection and storage method of quality chilli seeds

Salient features of the technology

- This is the easiest and cheapest way of collecting huge amount of chilli seeds in a short period of time.
- There is no health risk in this process of seed extraction.
- Seeds collected through this method germinate faster (60% in 7 days).
- The germination rate of seeds collected in this method is much higher.
- Color of the seeds is much brighter and hence market value is higher.
- Seed quality remains intact till the next sowing period.
- Seeds can be extracted in this method immediately after harvesting of red ripe chillies both in winter and summer at normal temperature.

Suitable environment: All over Bangladesh. Suitable for any preferable chilli variety.

Production/ Utilization method

- Harvested ripe chilli to be kept 4 to 5 days wrapping with gunny cloth and polythene for air fermentation.
- Seeds to be taken in a net bag.

- Net bag with seeds to be kept submerged in water for 48 hours for water fermentation.
- Then the fruits should be mashed with hand or a stick.
- The seeds are to be separated and allowed to settle down under water at the bottom of the cartainer.
- Then the settled seeds to be collected and dried under full sun light until the seed moisture content becomes 8-10%.

Pictorial view of collection and storage method of chilli seeds is given below:

Pictures showing the collection and preservation method of chilli seeds

Yield/Output: About 8 kg of seeds can be extracted from 100 kg of ripe chilli.

Technology #79: Storing technique for quality Lilium bulb/tuber

Salient features of the technology

- Immediately after drying, the bulbs are to be placed in an airtight polythene/zip bag in a moist sawdust in a plastic crate under cold storage for 2.1-2.5^0 C. It can be stored in good condition for 6-8 weeks at that temperature with 85-91% relative humidity. But it can be stored up to 15-16 weeks for getting the optimum planting time due to variation in growing season.
- Either moist cocodust (moist) or mixture of sawdust and cocodust (50:50) can also be used as media.

[In the picture above: Lilium bulbs preserved in different media at a temperature 2.1-2.5^0 C. and 85-91% relative humidity - (a) Lilium bulbs in sawdust (b) Lilium bulbs in cocodust and (c) Lilium bulbs in a mixture of sawdust and coco dust]

Suitable environment

- Suitable for growing all over the country especially low temperature in the northern region
- Lilium cultivation requires mild weather. For producing good quality flowers, 20-25^0 C day temperature and 10-15^0 C night temperature is favourable. Most of the Lilium produces quality flowers under partial shade. Good quality flowers can be produced by using UV polythene/shade net which can resist 50% sun light.
- Well-drained sandy loam soil rich in organic matter is suitable for Lilium cultivation.

Production/ utilization method

Sowing/planting time: October-November is the optimum time for sowing Lilium bulbs in Bangladesh. Row to row spacing 15 cm and plant to plant spacing should be maintained 15 cm.

For Lilium propagation, the disease-free scale or bulblet is usually planted in 3-4 cm depth in cowdung mixed cocodust. It takes 2 years to produce suitable bulbs for flower production.

Fertilizer dose and application method: Adequate amount of cocodust (about 10-15 kg per square meter) should be mixed with soil during land preparation so that the soil has adequate aeration. To get a good yield, it is necessary to apply more organic fertilizer in the Lilium field. If organic manure is used, fertility of the soil and quality of the environment would be sustained. Lilium is a bulbous flower that stores most of the nutrients in the bulb. It is better not to apply any fertilizer in the soil till the first 3 weeks of bulb sowing. After 3 weeks of bulb sowing, the fertilizer as NPK 30:20:20 g/m^2 should be applied. Good results can be obtained by applying 1kg of calcium nitrate/100 m^2 after three weeks and 1kg of potassium nitrate/100 m^2 after six weeks.

Control of diseases and insect-pests: Rovral (0.2%) fungicide should be sprayed at 10 days interval to control leaf spot disease.

Irrigation and drainage: Irrigation is one of the most important issues for Lilium cultivation. Regular watering ensures better flowering. Flower buds may suddenly be dropped down due to a deficit of soil moisture. Care should be taken so that soil does not become dry. Drip irrigation method is the most suitable for irrigating the Lilium field. Proper drainage facilities should be maintained for rapid exit of excess water.

Intercultural management: Mulching should be done to keep soil cool, crumbly and free from weeds. It also can reduce the incidence of soil-borne diseases. Generally, straw, water hyacinth, black polythene, etc. are used for mulching.

Flower collection: Usually when 1-2 florets start to open from bottom of the spike, it is optimum time to harvest the spike. The duration of the flower harvest is about 125-130 days.

Bulb collection: After harvest of all flowers, the plants should be left in the field for 4-5 weeks to produce a good quality bulb. When the stems become dried, it is right time to pick the bulbs. The bulbs along with the dried stem should be collected from the soil very carefully so that no injury occurs to bulbs any way.

Preservation of collected bulbs: Collection of propagating material of Lilium i.e. bulbs/tubers is very expensive. For continuing Lilium flower production, preservation of bulbs is very essential. Bulbs must be stored at low temperature for maintaining their quality. After harvesting, large, disease-free bulbs should be selected for storage, washed with clean water and dried under the shade. Care should be taken so that only the moist part of the bulb surface dries out. Excess

drying must be avoided to protect the bulbs from shrinking or deforming. Immediately after drying, the bulbs are to be kept in an airtight polythene/zip bag and placed in a plastic crate having moist wooden powder and then stored in cold storage at 2.1-2.50 C. Bulbs can be stored in good condition for 6-8 weeks at that temperature with 85-91% relative humidity but can be stored up to 15-16 weeks depending on the time of flower production. However, a mixture of moist coco dust and wood powder (50:50) can also be used as media.

Yield/ Output: Following this technology, Lilium bulbs/tubers can be stored till the next growing season. Lilium bulbs can also be stored in cold storage. This will help save a lot of foreign currency as needed for importing of lilium bulb.

H. Post-harvest Technologies

In Bangladesh, depending of crops, 10-30% of the produce damaged or wasted in various ways after harvesting. In particular, a large protion of vegetables, fruits, spices and tuber crops are wasted due to lack of proper processing and storage. Prevention of this huge wastage of crops at post-harvest stage will benefit farmers and tradres and would be helpful in attaining food and nutrition security in the country. With this goal in mind, Post-Harvest Technology Division (PHTD) of BARI has been conducting research to find suitable and effective storage methods for all these crops, expansion of storage period/shelf life, preparation of various delicious processed food items etc. A good number of food processing and value added technologies have already been developed by PHTD and many of those are being used by the private and household female entreprenuers. However, horticulture, tuber crops, pulses, oilseeds and spice research centers of BARI also handling post-harvest research of their respective crops.

Technology #80: Amchur – an effective technique of preserving green mango

Salient features of the technology

- Amchur is prepared using green mangoes. It helps reduce wastage of huge amount of green mangoes dropped by hail storm or other reasons.
- Amchur can be preserved for 8-10 months in HDPE or metalex foil packets.
- The amchur is used to enhance taste of cooked pulses and other foods.

Preparation of Amchur with green mango

Suitable environment: Mango growing areas in the country.

Production/ Utilization method

- Both mature and immature mangoes can be used for the preparation of Amchur.
- All equipments and utensils required for this purpose should be washed with clean water.
- The selected mangoes should be peeled by hand peeler.
- After peeling, the seeds (if any) of the mangoes should be removed.
- Then the mangoes should be sliced for 6-8 cm length and 2-3 cm thickness by a sharp stainless steel (SS) knife.
- The slices should be immersed in to 500 ppm (0.5 g/L of water) potassium metabisulfite (KMS) solution for 5 minutes to avoid the browning.
- After drained out from the KMS solution, the slices should be blanched at 80°C for 2-3 minutes.
- Then the hot slices should be immersed into cold water for 5 minutes.
- Then the water should be drained out and mixed with 0.20 % turmeric.
- The turmeric mixed slices should be dried using cabinet dryer at 55±1°C temperature for 48-72 hrs or 2-3 days in case of sun drying.
- The moisture content of the amchur should be maintained below 5 %.
- In mechanical drying, temperature and drying time should strictly be controlled. In case of sun drying, direct sunlight should be avoided to save the product from discoloration and to protect adequate levels of vitamins and minerals.

Yield/Output: Amchur can be preserved for 8-10 months keeping in HDPE or metalex foil packets.

Technology #81: Integrated waxing machine - for increasing shelf life of fruits and vegetables

Salient features of the technology

- The shelf life of the citrus fruits and vegetables can be extended for 3-4 weeks using this technology.
- Postharvest loss of fruits and vegetables can be reduced to a good extent.
- Whole saler and retailer of fruits and vegetables can be benefited through this technology.

Integrated waxing machine

Suitable environment: Citrus fruits and vegetable growing area of the country. The round shaped fruits and vegetables are more suitable for using this technology.

Production/ Utilization method

- Insect, pest and disease infestation free fresh citrus fruits and vegetables should be selected.
- Fresh citrus fruits and vegetables should be kept in tray of the washing line. Then it should be washed with detergent (10-12 g/ L of water) using brash pad for 1-2 minutes.
- Then the fruits and vegetables should be placed in foam pad of the washing unit through conveyer belt.
- The fruits and vegetables should be coated with edible carnova wax for 30-60 seconds.
- Then the hot air should be blown from drying unit (55±2°C) through conveyer belt for uniform mixing of carnova wax.

Yield/Output: The shelf life of the fruits and vegetables can be extended up to 3-4 weeks more by using this technology.

I. Crop Production in the Unfavourable Ecosystems

The environment in some parts of Bangladesh is not conducive to crop production. These include unfavourable ecosystems like, char areas, saline areas, haor-baor-beels, hilly areas and the High Barind Tracts. The cropping intensity of these areas is much less than other parts of the country. Increasing crop production in all these areas has emerged as an important issue to provide food for the growing population. Bangladesh is one of the countries severely affected by climate change. Due to the affects of climate change, crop production is being severely disrupted due to drought, flood, excessive/insufficient rainfall, waterlogging, salinity intrution, abnormal temperature fluctuations, increase in disease and insect infestation, invading of new diseases and insects, etc. For producing crops combating all these adversities, scientists of On-farm Research Division, Agronomy Division, Soil Science Division and other centers/divisions of BARI are conducting research on selection of crops suitable for different adversed ecosystems, development/selection of stress tolerant varieties, development of climate smart technologies for intensifying crop cultivation in the unfavourable ecosystem.

Technology #82: Gardenpea- Boro rice- T. Aman rice: A profitable cropping pattern for Satkhira region

Salient features of the technology

- Fallow-Boro rice-T.Aman rice is one of the major cropping patterns in Satkhira region that covers about 33% (62250 ha) of total cropping area of the region.
- High yielding short duration Gardenpea variety (BARI Motorshuti-3) can easily be cultivated in fallow period between T.Aman rice and Boro rice.
- Compared to farmers existing pattern (Fallow- Boro-T. Aman rice), Rice Equivalent Yield of the improved cropping pattern Gardenpea- Boro-T. Aman rice can be increased by about 60% (30 t/ha) while gross margin may increase by 74%.
- Increases cropping intensity and productivity. On the other hand, farmers may get much higher profit with small amount of investment.

Gardenpea

Boro rice

T.Aman rice

Suitable environment: Medium to medium high land under AEZ-11 of Satkhira region and similar other areas of the country are suitable for this improved cropping pattern.

Production/ Utilization method

Item/operation	Cropping Pattern		
	Gardenpea	Boro rice	T. Aman rice
Variety	BARI Motorshuti-3	BRRI dhan 28	Binadhan 7
Seed rate (kg ha^{-1})	50-55	20-25	20-25
Spacing (cm)	30 cm line	20×15	20×15
Sowing/Transplanting date	1st to 2nd week of November	1st to 2nd week of February	1st to 2nd week of August
Fertilizer dose (Urea-TSP-MoP-Gypsum-Zinc sulphate kg ha^{-1})	100-150-100-50-0	300-98-165-114-21	170-70-100-0-0
Fertilizer application	Half of Urea and full doses of others as basal. Rest of Urea should be applied before flowering	Except Urea, full doses of others as basal. Urea in two equal splits at 15-20 and 30-35 DAP.	Except Urea, full doses of TSP & MoP as basal. Urea in three equal splits at 10-15, 25-30 and 40-45 DAP.

Item/operation	Cropping Pattern		
	Gardenpea	Boro rice	T. Aman rice
Intercultural operations			
a) Weeding (after top dress of urea)	1 time	2 times	1 time
b) Irrigation	irrigated	irrigated	Rainfed
Harvesting time	Late January to mid Feb	Early to mid May	Late October to early November
Field duration (days)	83-91	89-90	84-85
Turn around time (days)	6-9	4-13	86-93

Yield/Output

Crop	Gardenpea	Boro rice	T. Aman rice
Yield (t ha^{-1})	8-9	6.5-7.0	5.5-6.0
Considering the whole cropping patterns			
Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	
526011	**264589**	**261422**	

Technology #83: Mustard-Red amaranth-Okra-T. Aman rice: A highly productive and profitable cropping pattern for Cox'sbazar region

Salient features of the technology

- Two more crops like, mustard (BARI Sarisha-14 or 17) and red amaranth (BARI Lalshak-1) may be included in the exisitng cropping pattern (Fallow-Okra-T. Aman rice) during rabi season.
- Short duration T. Aman rice variety BRRI dhan75 to be used for ensuring sowing of mustard in time.
- Rice equivalent yield (REY) obtained from improved cropping pattern (Mustard-Red amaranth-Okra-T.Aman rice) is 55-58 t ha^{-1} which is 37% higher than that of existing pattern (36.0 t ha^{-1}).
- Improved pattern may provide 45-48% higher gross margin compared to existing pattern.


Mustard


Red amaranth


Okra


T. Aman rice

Suitable environment: Cox'sbazar and adjacent region with similar soils of AEZ 23.

Production/ Utilization method:

Item/operation	Cropping Pattern			
	Mustard	Red amaranth	Okra	T. Aman rice
Variety	BARI Sarisha-14/17	BARI Lalshak-1	BARI Dherosh-2	BRRI dhan62/75
Seed rate (kg ha^{-1})	6-7	2.0-2.5	4-5	25-30
Spacing (cm)	30 cm × Continuous in line	Broadcasting	50 cm × 40 cm	20 cm × 15cm
Sowing/Transplanting date	2 nd week to 3rd of November	2 nd week to 3rd of February	3 rd week to 4th of March	1st week of August
Fertilizer dose (Urea,TSP, MoP, Gypsum, Zinc sulphate, Boric acid & CD kg ha^{-1})	250-300,170-180, 85-100, 150-180, 5-7, 10-15 & 5000	200, 100, 150, 100, 5-7, 0 & 0	150, 100, 150, 0, 0, 0 & 5000	150-180, 110-120, 50-70, 55-65, 7-10, 0 & 0
Fertilizer application	Except urea, all others fertilizers to be applied as basal. Urea to be applied in two equal splits at 07 and 20 DAS	Half of urea & potash and all other fertilizers to be applied as basal. Rest of urea and potash should be applied as top dressed at 20 DAS	Full dose of TSP and half of urea and potash to be applied at final land preparation. Rest of urea and potash to be applied as top dress in three equal splits at 30, 50 and 80 DAS	Except urea, full dose of all fertilizers and half of potash should be applied as basal at final land preparation. Urea to be applied in three equal splits at 07, 22 and 45 DAT as top dress. Rest half of potash to be applied at the time of final application of urea.
Intercultural operations	Weeding, irrigation, disease & insect management etc. should be done whenever necessary to support the normal growth of the crops.			
Harvesting time	1st to 2nd week of February	2nd week to 3rd of March	2nd week of May to 2nd - 3rd week of July	1st week of November
Field duration (days)	75	45	120	95
Turn around time (30 days)	10	5	7	8

Yield/Output

Crop	Mustard	Red amaranth	Okra	T. Aman rice
Yield (t ha^{-1})	1.3-1.5	9-10	15-17	4.5-5.0

Considering the whole cropping patterns

Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
497000	**257330**	**239670**

Technology #84: Mustard- Boro rice- Fallow: A more profitable and productive cropping pattern for Haor areas in Kishoreganj

Salient features of the technology

- Short duration mustard variety (BARI Sharisha-17) may be grown in the haor areas before Boro rice for intencification of crop cultivation.
- Mustard-Boro rice-Fallow cropping pattern may provide higher Rice Equivalent Yield (12-13 t/ha) which may be 62% higher than existing cropping pattern (Fallow-Boro rice-Fallow).
- Mustard-Boro rice-Fallow cropping pattern could provide 105% higher gross margin (113605 Tk/ha) than the existing cropping pattern.
- BCR of the improved cropping pattern (Mustard-Boro rice-Fallow) is expected to be 2.05 that indicates superiority of improved pattern over existing cropping pattern.

Suitable environment: Haor area of Nikli upazila in Kishoreganj district and similar other areas of AEZ- 19.

Production/ Utilization method

Item/operation	Improved cropping pattern		Existing CP
	Mustard	Boro rice	Boro rice
Variety	BARI Sharisha-17	BRRI dhan29	BRRI dhan29
Seed rate (kg ha^{-1})	7-8	45-50	40-50
Spacing (cm)	Broadcast	25cm × 15cm	25cm × 15cm
Sowing/transplanting date	1st week of November	1st week of February	Last week of Dec to 1st week of January
Fertilizer dose: (Urea, TSP, MoP, gypsum, zinc sulphate & boric acid kg ha^{-1})	250-160-80-156-6-2.0	300-90-106-50-9-0	300-90-106-50-9-0

Item/operation	Improved cropping pattern		Existing CP
	Mustard	Boro rice	Boro rice
Fertilizer application	Except urea, full dose of other fertilizers to be applied as basal. Urea to be applied in two equal splits as top dress at 25 at 45 DAS.	Except urea and half of potash, all of other fertilizers should be applied as basal. Urea to be applied in three equal splits as top dress at 10, 30 and 45 DAT. Rest half of potash to be applied during last top dressing of urea.	Except urea and half of potash, all other fertilizers to be applied as basal Urea to be applied in three equal splits as top dress at 10, 30 and 45 DAT. Rest half of potash to be applied during last top dressing of urea.
Intercultural operations	In case of rice, two weeding and top dressing of urea should be done in time and 10 to 15 cm water should be retained in the field. In case of mustard, irrigation to be done once and Rovral to be sprayed at 60 to 65 DAS.		
Harvesting time	1st week of Feb	Mid May	Last week of March
Field duration (days)	87	111	117

Yield/Output

Crop	Mustard	Boro rice	Boro rice
Yield (t ha^{-1})	1.8 – 2.2	6.8 -7.5	6.5-7.3

Considering the whole cropping patterns:

Cropping pattern	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Mustard-Boro rice-Fallow	228545	114940	113605
Fallow-Boro rice-Fallow	138780	81638	57142

Technology #85: Mustard-Boro rice-Fallow: An improved cropping pattern for Chalan beel area

Salient features of the technology

- Beel (Low lands that remain under water for about 4-5 months generally from July to November) area is one of the unfavourable ecosystems in Bangladesh that covers an area of 2.43 million hectares.
- Agricultural land use in this area is less productive and remains fallow in most of the part of the year.
- The existing major cropping pattern in chalanbeel area is Fallow- Boro-Fallow. Land remains fallow in the *Rabi* and also in the *Kharif* season after *Boro* rice.
- Fallow land can be utilized through cultivation of mustard after receding of water from the land.

- Increases crop productivity and cropping intensity.
- Increases farmer's income.

Suitable environment: Chalan beel as well as similar other beel areas. Loamy and sandy loam soil are the most suitable for mustard cultivation.

Production/ Utilization method

Variety: Mustard variety BARI Sarisha-14 is suitable for chalanbeel area. BARI Sarisha-15 also can be cultivated. The variety of *Boro* rice: BRRIdhan86.

Sowing/Transplanting: Mustard is to be sown after receding of water from the land and mustard seed should be sown within 10 October to 10 November. Seedlings of *Boro* rice to be planted on 2nd week of February after harvesting of mustard. Seed rate of Mustard 6-7 kg/ha and that of Boro rice 50 kg/ha. Sowing method of Mustard is broadcast and *Boro* rice to be transplanted at spacing of 25 cm × 15 cm.

Fertilizer dose and application method: In case of mustard, urea, TSP, MOP, gypsum, zinc sulphate, boric acid and cow dung manure should be used @ 230-160-80-120-5-5-5000 kg/ha. All fertilizers and manure including half of urea to be applied during final land preparation before sowing of seeds. Rest half of urea to be top dressed at 30 days after sowing followed by light irrigation.

Fertilizer dose for Boro rice, urea, TSP, MOP, gypsum, zinc sulphate, boric acid and cow dung manure @ 300-100-120-100-5-5000 kg/ha. Except urea, all other fertilizers and cowdung manure should be applied during final land preparation and before planting of rice. Urea to be applied in three equal splits at 15 days, 35 days and 45 days after planting and then light irrigation should be given.

Irrigation: In case of mustard, one irrigation to be applied at 20 days after mustard sowing. In

case of Boro rice, irrigation should be done several times (7-8 irrigation) as per requirement.

Intercultural operations: One weeding is needed for mustard at 15-20 days after sowing. In case of Boro rice, weeding should be done twice, 1st one at 15-20 DAT and 2nd at 40 DAT.

Harvesting: Mustard can be harvested during 1st week to 2nd week of February. Boro rice can be harvested during 1st week to 2nd week of May.

Yield/Output: Per hectare yield: Mustard 1.7-2.0 t and Boro rice 5.5-5.8 t. **BCR**: 2.15 - 2.53.

Technology #86: Integrated use of vermicompost and chemical fertilizer for sunflower cultivation at the coastal charlands

Salient features of the technology

- Application of 1.5 t ha^{-1} vermicompost along with IPNS based inorganic fertilizer apper to be suitable for sunflower cultivation in the coastal charland for getting higher yield and economic return.
- Soil fertility can be increased due to use of vermicompsot.
- Requires lower amount of chemical fertilizers that may reduce production cost.

Suitable environment: Coastal saline char areas of Noakhali (AEZ-18), Patuakhali (AEZ-13) & Satkhira (AEZ-13).

Production/ Utilization method

Variety: BARI Sunflower-2.

Sowing: Mid November to mid December is suitable for sowing. Seed rate: 12-15 kg ha^{-1}. Seeds to be sown at row to row distance of 50 cm and plant to plant distance 25 cm.

Fertilizer dose (per hectare) and application method: Urea 235 kg, TSP 125 kg, MoP 60 kg, gypsum 10 kg, zinc sulphate (monhydrate) 3 kg, boric acid 6 kg and Vermicompost 1.5 t per hectare. All of vermicompost, TSP, MoP, gypsum, zinc sulphate, boric acid and half of urea should be applied as basal during final land preparation. Remaining half urea should be applied as top dress in two equal splits at 20-25 DAS and 40-45 days after seed germination (before flower initiation stage) and mixed thoroughly with the soil as soon as possible for better utilization.

Irrigation: Iirrigation should be applied 1st at 30 DAS (before flower initiation). 2nd at 50 DAS (during head formation) and 3rd irrigation at 70 DAS (before seed maturity).

Intercultural operations: First weeding should be done at 20-25 days and second weeding at 45-50 days after seedling emergence.

Disease and insect-pest management: If hairy caterpillars attack severely, Nitro @ 2 ml per litre of water should be sprayed twice at 10-12 days interval for controlling hairy caterpillar.

Leaf blight *(Alternaria helianthi)* and stem rot (*Sclerotium rolfsii)* are the major diseases of sunflower. For controlling the diseases, Rovral 50WP @ 2 g per litre of water should be sprayed 3-4 times at 10-12 days interval.

Harvesting time: Mid February to mid March

Yield/Output: Seed yield of sunflower 2.0-2.3 t/ha

By adopting this technology, sunflower yield may be increased by 20-30%.

Technology #87: Zero tillage garlic cultivation in the coastal saline areas

Salient features of the technology

- Coastal area covers 20% of the total land area of Bangladesh of which about 53% area affected by different magnitude of salinity.
- Land remains fallow after T.Aman rice which could be utilized through zero tillage cultivation of garlic with mulching.
- Crop productivity and cropping intensity as well as farmer's income would be increased.

Suitable environment: Coastal area where land remains free after T.Aman rice and recession of water in December. Water logging and late recession of water is a problem in clay textured coastal saline soil. Soil having pH about 6-7.5 is suitable for garlic cultivation at coastal region, but salt tolerant variety can be cultivated above pH 7.0.

Zero-tillage garlic production in coastal saline area (Dacope, Khulna)

Production/ Utilization method

Variety: BARI Roshun-4 is suitable for coastal area. BARI Roshun-1 also can be cultivated.

Sowing/planting: Cloves of garlic should be planted in muddy soil after harvesting of T.Aman rice. One third of a clove to be dibbled into muddy soil maintaining 20 cm × 10 cm spacing. Seed rate of garlic is about 300-400 kg/ha.

Fertilizer dose and application method: Urea, TSP, MOP, gypsum, zinc sulphate, boric acid and cow dung manure should be used @ 240-250-260-160-6-8-5000 kg/ha, respectively. All fertilizers and manure along with half of urea should be applied before planting of cloves. Rest half of urea to be top dressed at 40-45 days after planting and then light irrigation should be given depending on the soil moisture.

Mulching and weeding: After planting, cloves should be covered with 8-10 cm thick rice straw mulch. About 5-6 t rice straw is needed for mulching the cloves in one hectare of land. Mulching should be done twice: thinner mulching to be done first for aeration, then heavy mulching should be done 15-20 days after planting to suppress weeds and conserve soil moisture. Weed infestation remains low due to mulching. One weeding may be needed in case of greater weed infestation.

Harvesting: Harvesting may be done during last week of March to first week of April. Suitable harvesting time arrives after 110-120 days of planting when leaves of garlic plants become yellowish. After harvesting, garlics along with whole plants are to be dried for two days and then stored in small bundles hanging over bamboo or ropes in the room.

Yield/Output: **Bulb yield**: 5-6 t/ha and **BCR**: 2.97-3.18

Technology #88: Drip irrigation and mulching for cultivation of crops in the coastal saline areas

Salient features of the technology

- Drip irrigation in raised bed with mulch is an integrated management practice that facilitates crop cultivation in coastal areas through reducing soil salinity significantly (from 10 dS/m to 4.5 dS/m).
- Depending on the soil type, crop, crop stages and crop evapotranspiration, drip irrigation may be required for a duration of 15 - 25 minutes with an interval of 2 - 3 days.
- It facilitates to cultivate crops in a highly saline soil. Since it is a water saving technology, more land in coastal areas can be brought under crop cultivation.
- This technology is more suitable for cultivation of high-value crops.

Suitable environment: Coastal saline areas of Bangladesh where lack of good quality water for irrigation is one of the major constraints for crop cultivation in dry season.

Production/ Utilization method

- At first, 30 cm raised bed should be formed keeping 30 cm gaps between two adjacent beds in order to use this technology for crop cultivation.
- Seeds/seedlings to be sown/transplanted in the raised beds at the spacing specified for a particular crop. Then the raised beds should be covered with rice straw or polyethylene mulch.
- To apply drip irrigation, a 200-liter capacity plastic tank to be placed at a height of 1.5 m from the ground surface to create adequate water pressure. The water tank may be placed on a stand made of either bamboo or iron bar at a corner of the crop field. The flow of water from the tank is controlled through a gate/ball valve attached at the bottom part of the tank. Generally, two lateral pipes, each with a length of 12 – 14 m and a diameter of 1.25 cm, should be placed along the crop rows. Drippers to be set at the lateral pipes at distances considering plant to plant spacing of the cultivated crops. Water should be applied at the base of the plants through these drippers. Lateral pipes can be joined through a T-joint to a 2.5 cm diameter main pipe attached to the water tank.
- Discharge of the drippers generally varies between 3.6 and 4 liter/hour. Drip irrigation could be applied at an interval of 2-3 days for the duration of 15 – 25 minutes depending on the type of crop cultivated.

Yield/Output: Dip irrigation may increase farmers' income by 30 to 35%. Depending on the type of crops cultivated, the benefit cost ratio (BCR) may be varied from 2.0 to 4.7.

J. Technologies Developed by BARI in the Mujib Centenary - At a Glance

Serial #	Center/Division	Technologies developed									
		Improved/ modern variety	Crop production techniques	Soil fertility & fertilizer management	Disease management	Insect-pest management	Farm machinery & Irrigation	Seed & Seedling production/ preservation	Post harvest techno.	Crop Production In adverse ecosystem	Total
1.	Pomolo Division, Horticulture Research Center (HRC)	10	-	-	-	-	-	-	-	-	**10**
2.	Olericulture Division, HRC	10	-	-	-	-	-	-	-	-	**10**
3.	Floriculture Division, HRC	3	-	-	-	-	-	1	-	-	**4**
4.	Tuber Crops Research Center	12	-	1	-	1	-	1	-	-	**15**
5.	Pulses Research Center, Ishwardi, Pabna	2	-	-	1	-	-	-	-	-	**3**
6.	Oilseed Research Center	3	-	-	-	-	-	-	-	-	**3**
7.	Spices Research Center, Shibganj, Bogura	2	-	-	1	-	-	1	-	-	**4**
8.	Plant Breeding Division	1	-	-	-	-	-	-	-	-	**1**
9.	Agronomy Division	-	2	-	-	-	-	-	-	2	**4**
10.	Soil Science Division	-	-	7	-	-	-	-	-	1	**8**
11.	Entomology Division	-	-	-	-	4	-	-	-	-	**4**
12.	Pathology Division	-	-	-	7	-	-	-	-	-	**7**
13.	On-Farm Research Division	-	3	-	-	-	-	-	-	3	**6**
14.	FMPE Division	-	-	-	-	-	2	-	-	-	**2**
15.	Irrigation and Water Management Division	-	-	-	-	-	1	-	-	1	**2**
16.	Seed Technology Division	-	-	-	-	-	-	1	-	-	**1**
17.	Biotechnology Division	-	-	-	-	-	-	1	-	-	**1**
18.	Vertibrate Pest Division	-	-	-	-	1	-	-	-	-	**1**
19.	Post-harvest Technology Div.	-	-	-	-	-	-	-	2	-	**2**
	Total =	**43**	**5**	**8**	**9**	**6**	**3**	**5**	**2**	**7**	**88**

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