ANNEX V. IPM Training Modules for Master Trainers for Rabi and Kharif I Crops

IPM Training Module For Master Trainers

Rabi (winter) Season Crops

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Vegetables and spices are an important source of vitamins, minerals, and plant proteins in human diets throughout the world. Vegetable cultivation in Bangladesh is one of the more dynamic branches of agriculture due to its rising economic potential in agribusiness development. At the same time, vegetable cultivation is becoming more costly due to the increasing use of purchased inputs such as pesticides and fertilizers to sustain production levels and high cosmetic quality. These inputs are also a cause for concern due to their deleterious effect on human health and the environment. If one is targeting more discriminating markets then care must be taken to reduce pesticide usage as whole shipments can be rejected if high residue levels or residues of prohibited chemicals are detected. IPM technologies have been developed for many vegetables and spices in Bangladesh either without the usage of pesticides or with residue levels within the accepted WHO norms.

The pest control technologies presented in this tutorial were developed at various research entities -- BARI, AVRDC, as well as projects IPM-CRSP (USAID funded) and DAE sponsoring SPPSP (Danish funded). An effort has been made to minimize the use of pesticides in order to minimize costs as well as residues on the commodity.

I.PREVENTATIVE PEST CONTROL GUIDELINES FOR VEGETABLES AND SPICES

Accurate pest diagnosis is an important part of an integrated pest management program, both in the field and in storage. It is important that such pests be recognized early in their development so that effective practices can be implemented. Careful and regular monitoring of the crop (usually at least once a week) and a knowledge of the field history can provide valuable clues to

estimate the potential for pest damage. Seasonal weather patterns also have a major impact on pest incidence particularly diseases. The crop should be monitored to assess the types of pests present and to estimate the potential for yield loss from not only pests, but other stresses. This is why the first step in IPM is to ensure the crop is gowing to its agronomic potential, then the stress from pests will have less of an impact. This means that the crop should be well fertilized and cared for as a first priority as this is easier to do than to control pests, particularly if toxic pesticides are the only remedy available.

1. Seedbed and field management
For prevention of soil borne diseases, nematodes, and insects

a. Crop rotation
Planting vegetables and spices in seedbeds and fields that have been grown to wetland rice production within the same or previous crop year will result in minimal soil borne diseases, nematodes, and insects. Flooding for the duration of a rice crop kills damping-off fungi, bacterial wilt, root knot nematodes, cutworms, and other soil insects. If flooded rice was not grown in the field for vegetables and spices select sites for seedbed and field locations which have not been planted to crops of the same plant family for 3-4 years.

Rotate between plant families:

- Solanaceae (tomato, brinjal, potato)
- Malvaceae (okra, cotton)
- Cucurbitae (gourds, cucumber, squash, pumpkin)
- Cruciferae (cabbage, cauliflower, broccoli, radish etc)
- Amaryllidaceae (onion, garlic)
- Zingiberaceae (ginger, turmeric)

b. Soil amendments
Materials that reduce soil borne diseases (damping-off fungi, bacterial wilt) and root knot nematodes:

Seedbed and field *(apply either)*
Those that kill bacterial wilt and root knot nematodes in particular but less so for damping-off fungi:

- Mustard oil cake (@ 300 kg/ha) (should be 15 days old) Price about Tk 10/kg (best)
- Neem oil cake (@ 200 kg/ha) (best)
- Poultry waste (manure) (@ 3 t/ha) (should be at least 6 months to 2 years old (next best)
- Burning sawdust (@ 6 cm thick) (next best) (particularly good for seedbeds and after burning incorporate the ashes into the soil) Price about Tk 700/t)

Does not directly kill wilt or nematodes:

- Cow dung (@ 5 t/ha when dry) (good but will bring in weed seeds)

If mustard oil cake, neem oil cake, poultry waste or sawdust is used there is no need for cow dung or other organic matter to improve soil fertility

ii. Seedbed only (if not able to apply soil amendments)

- If the seedbed is a raised bed cover with polyethylene sheet (solarization or the sun's heat sterilizes the soil, however 3-4 weeks of sunny days is required for the sterilization effect to work)

2. Seed health

A number of pathogens are transmitted on the seed such as damping off fungi (*Pythium, Phytophthora, Rhizotonia, Fusarium, Sclerotium*) and various bacterial diseases. A small effort in prevention can be rewarded by large benefits if one of the following practices is followed to obtain seed free of fungal or bacterial spores:

- Purchase clean seed (tin)
- Sterilize seed with 2% solution of bleach/clorox (sodium hypochlorite) for 10 minutes and dry
- Clean seed with hot water (52^{o} C) for 15 minutes and dry (a special apparatus can be purchased in Bangladesh to carry out hot water seed treatment)
- Treat seed with fungicide seed treatment (Vitavax [= carboxin + thiram] or Bavistin [carbendazin])

3. Destruction of crop residue after harvest will prevent continuous source of diseases and insect pests. Use the residue as fuelwood, livestock feed or place in compost pit to make organic fertilizer.

Split nitrogen fertilizer applications in 3-4 times to encourage continuous root development to outgrow nematode damage as a tolerance mechanism against root knot nematode

Frequently recommended are biorational insecticide sprays from soap or neem:

Recipe for soap spray

(10 g of Wheel detergent powder per 10 liter sprayer)

Recipe for neem spray (either from kernels or leaves)

a. from kernel

Grind kernels to obtain oil or purchase neem oil

For 10 liters add

- 200 ml neem oil
- 50 ml liquid detergent (Treat)

b. from leaves soak leaves overnight

II. VEGETABLES TOMATO

Crop monitoring

Monitor the crop on a weekly basis by walking through the field examining plants (look on undersides of leaves) to note the presence of diseases and insect and mite pests.

1. Varietal selection

Select varieties with resistance or tolerance to bacterial wilt and fungal diseases such as early and late blight and leaf spot.

2. Damping-off fungi, bacterial wilt, and root knot nematode control

Follow the preventative guidelines outlined above including crop rotation, use of soil amendments or chemical control measures, and clean seed for both seedbed and field.

- Damping-off fungi: Five genera of fungi are listed in the order of prevalence -- *Pythium, Sclerotium, Rhizoctonia, Phytophthora, Fusarium*. Early symptoms are drooping of plants and eventual wilting and death as nutrients are blocked from passage both up and down the vascular system.
- Bacterial wilt *Ralstonia* (formerly *Pseudomonas*) *solanacearum*
- Root knot nematode *Meloidogyne* spp. Aside from direct damage to roots in blocking the uptake of nutrients nematodes also cause wounds that allow entry of soil borne fungi such as the damping off group that later affect older plants.

3. Bacterial wilt and root knot nematode control

- Select the most adapted disease and nematode resistant or tolerant varieties
- Purchase grafted tomatoes which have wild brinjal resistant root stock (in areas where bacterial wilt is common this method returns a profit of Tk 60,000)

4. Virus diseases are generally more serious than fungal diseases. Descriptions are given for three virus diseases. Aside from roguing which is a common recommendation for all three viruses each disease has different control measures:

Tomato yellow leaf curl (TYLC) belongs to the geminivirus group TYLC is vectored by the whitefly Bemisia tabaci. The whitefly can acquire this virus in 15-30 minutes on an infected plant. These infective whiteflies can then retain the virus for 10-12 days and introduce it into many healthy tomatoes. After this 10-12 day period, these infective whiteflies must reacquire this virus by feeding upon an infected plant again. Symptoms become visible in tomato in approximately 2–3 weeks after infection. Leaf symptoms include yellowing between the veins and along the margins, small leaves that are cupped, thick and rubbery. The plants become

stunted. The majority (up to 90%) of flowers fall off after infection, and therefore few fruits are produced.
Control is to spray soap or a neem product against the whitefly.

Tobacco mosaic virus (TMV) belongs to the tobamovirus group. There are a number of TMV strains and symptoms on tomato plants infected with TMV that vary with the cultivar and strain. Leaves show chlorosis, mottling, blistering and curling. Leaves become mottled with raised dark green areas and distorted and small. Necrotic patterns may develop on fruit. TMV is commonly encountered in transplants as viruses are easily mechanically transmitted. There are many sources of these viruses, including cigarette smoke, tomato seed, infected plant debris, and tools. The tobamoviruses are not transmitted by insect, nematode or fungal vectors. The tobamoviruses are very stable viruses and can survive in plant debris for a number of years.
Control. These viruses are seldom seen in direct-seed fields. Use seed that has been treated to eliminate seedborne inoculum. Sterilize the seed with bleach (sodium hypochlorite). Extreme sanitation is needed. The disease is difficult to control if the plants have to be handled. Some resistant varieties have been developed.

Tomato bushy stunt virus (TBSV) belongs to the tombusvirus group. Infected leaves are small in size, cupped, and curled downward. The youngest leaves are twisted and exhibit tip necrosis. A proliferation of lateral shoots leads to an overall bushy appearance. Lower leaves are chlorotic with a purple tinge. Plants may be stunted. Fruit yield is greatly reduced. There is no known vector of TBSV, although virus incidence is often associated with the soil, it may be spread with irrigation water. Tomato bushy stunt virus apparently gains entry to host plants through wounds in damaged root cells.
Control. There are no recommended measures aside from roguing.

5. Fungi attacking the standing crop
Early blight (*Alternaria solani*)
Plants infected with early blight develop black or brown spots, usually about 0.25 to 0.5 inch in diameter, on leaves, stems, and fruit. Leaf spots are leathery and often have a concentric ring pattern. They usually appear on older leaves first. Spots on fruit are sunken, dry, and may also have a concentric pattern; frequently they occur near the calyx end of the fruit. Early blight mainly affects tomatoes exposed to rain especially if conditions remain cool and humid for several days after a rain. The early blight fungus survives in the soil on residue of infected tomatoes, potatoes, and weeds. The fungus is spread by spores that are carried by the wind or splashed in water. Germination of spores and infection require free moisture. Disease development stops in dry, hot weather.

Late blight (*Phytophthora infestans*)
Leaf symptoms of late blight first appear as water-soaked areas that rapidly enlarge to form purple-brown, oily appearing blotches. On the lower side of leaves, rings of grayish white mycelium and spore-forming structures may appear around the blotches. Entire leaves die and infections quickly spread to petioles and young stems. Infected fruit turn brown but remain firm unless infected by secondary decay organisms; symptoms usually begin on the shoulders of the fruit because spores land on fruit from above. Late blight is found when humid conditions coincide with mild temperatures for prolonged periods. When humidity is above 90% and the average temperature is in the range of 60° to 32°C, infection occurs in about 10 hours. If conditions are ideal for disease development, disease development is rapid and losses can be severe. The fungus affects potato and solanecous weeds and possibly in the soil. Spores of the fungus are easily spread by wind to other plants.

Black leaf mold (*Pseudocercospora fuligena*)
Yellow spots appear on the upper leaf surface. Gray to black spores are found on the lower leaf surface. As the disease progresses, numerous lesions may coalesce to cover most of the leaves. Leafs roll and begin to dry. Many of the leaves remain on the plants, which appear covered with gray soot. Most of the leaves can be killed, thereby severely weakening the plant. Disease development is favored by long periods of leaf wetness from dew, high humidity, or rainfall; and by moderate to warm temperatures.

Treat when environmental conditions are favorable and damage first seen on leaves or fruit of either:
Spray at 7-day intervals during cloudy or rainy periods or in heavily diseased areas or at 14-day intervals if less disease pressure.

In order to prevent the development of fungicide resistance alternate among the following three fungicide families with each application

- carbendazin (Bavistin)
- mancozeb based (Penncozeb, Ridomil Gold)
- iprodione (Rovral)

6. Fruit worm (*Heliocoverpa armigera*)
The fruit worm has many hosts and the moth is particularly attracted to flowers and fruits which its larva feeds on. The large larvae can destroy flowers and tunnel into fruits.
Spray insecticide based on the following action threshold level (may be adjusted locally based on experience)
5% damaged fruits

- neem (neem oil or Nimbecidine)

- nuclear polyhedrosis virus NPV (biological insecticide now available in India). Better results occur if jaggery or concentrated cane syrup are added to the spray mixture.

If fruitworm is a persistant problem then plant a trap crop using African marigold plants

- Begin the marigold nursery 15 days earlier than the tomato nursery
- The first and last rows in the field should be planted to marigold
- Every 16 rows should be marigold
- Plant marigold at 30 cm between plants

(there is no need to spray the marigold or the tomato)

7. Sucking insects
Aphid *Aphis craccivora*
There are several aphid species that attack tomato but the cowpea aphid is the most prevalent. Most species range from dark green or brown with the winged forms being black. Aphids infest the upper shoots and leaves removing sap from the most actively growing areas where rich nutrients are being supplied by the plant. The aphids tap into the vascular tissues and remove the carbohydrate rich food. Damaged leaves curl as a result of the feeding. The crop can tolerate population densities of several colonies per plant but if leaf curling is evident then apply soap or neem.

8. Vertebrate pests
Crows and sometimes rats will feed on ripe fruit.
If the fruit damage rises above 5% then crows can be scared away by posting guards during the daytime while rats can be baited with commercial baits.

III. BOTTLE GOURD

Crop monitoring
Monitor the crop on a weekly basis by walking through the field examining plants (look on undersides of leaves) to note the presence of diseases and insect and mite pests.

1. Varietal selection

Select varieties resistant or tolerant to fungal diseases such as powery mildew, downy mildew, and leaf spot.

2. Damping-off fungi, bacterial wilt, and root knot nematode control
Follow the preventative guidelines outlined in section I including crop rotation, use of soil amendments or chemical control measures,

and clean seed. Soil amendments need only be applied for each planting hill rather than the whole field.

- Damping-off fungi: *Pythium, Sclerotium, Rhizoctonia, Phytophthora, Fusarium*
- Bacterial wilt *Ralstonia* (formerly *Pseudomonas*) *solanacearum*
- Root knot nematode *Meloidogyne* spp.

3. Bacterial wilt, fungal disease, and root knot nematode control
   - Select the most adapted disease and nematode resistant or tolerant varieties

4. Root knot nematode (*Meloidogyne* spp.)
Split nitrogen fertilizer applications in 3-4 times to encourage continuous root growth to outpace nematode damage

5. Melon fruit fly *Bactrocera* (formerly *Dacus*) *cucurbitae*
Melon fruit flies have more than 80 hosts. The damage results from 1) oviposition in fruit and soft vegetative tissues, 2) feeding by the larvae, and 3) decomposition of plant tissue by invading secondary microorganisms. Larval feeding damage in fruits is the most damaging. Young fruits become distorted and usually drop. The larval tunnels provide entry points for bacteria and fungi that cause the fruit to rot and render the crop unmarketable. Melon flies are strong fliers. Adults may be found resting in shaded areas of bushes or trees, often a considerable distance from a crop. Flight is most common in the morning and late afternoon. Adults feed on juices from decaying or damaged fruit, nectars, plant sap and bird feces. This attraction for food sources is a means to their control. Trapping adult flies is the most effective control method. There are two types mass attractant traps which work best when used together.

- A mashed gourd trap is made with 100 g of mashed sweet gourd fruit set in a clay pot mixed with 5 drops of insecticide (Mipcin or Dipterex). The height of the trap is adjusted to be just above the crop canopy. The mashed gourd should be changed every 3-5 days in the summer and each week in the winter. This trap is effective as it attracts both sexes of flies.
- Cuelure trap contain cuelure which is a chemical produced by the females to attract males. A soaked cotton wad with cuelure is placed in a plastic jar with two triangles cut out on two opposite sides. The jar is filled ¼ full with water and detergent is added to make the flies drown. The cuelure traps collect 5-10 times more flies than the mashed gourd trap.
- Sanitation should also be carried out by destroying damaged fruit breeding sites. Remove and bury (1 meter deep pits) all unmarketable fruits and dispose of crop residues immediately after harvest.

6. Chewing insect pests

Pumpkin beetle *Aulacophora* [=*Raphidopalpa*] *foveicollis, A. abdominalis*, *A. frontalis*

Adults of the three species feed on the foliage, flowers, and fruits while the larvae feed on roots. It is the adult stage where the three species can be distinguished. The adult of *A. foveicollis* is red orange, while *A. abdominalis* is orange, and *A. frontalis* is bluish. Leaf feeding results in circular holes as the beetle turns around while eating. Crop damage is most severe if adults mass attack seedlings, forcing replanting. Flowers can be so consumed that fruits will not develop. Circular scrapings on the fruit surface reduces marketability. Larvae can enter underground stems, killing the entire plant.

Epilachna beetle (*Epilachna 12-puntata, E. 24-punctata*)

Both larvae and beetles feed by scraping chlorophyll from epidermal layers of leaves which then gradually wither.

Both of these beetles can be collected by hand nets and destroyed.
Action threshold: 15% leaf loss
Select insecticides which are less harmful to pollinating bees

- Neem (neem oil or Nimbecidine)

7. Fungal diseases

Powdery mildew (*Oidium* sp. and *Erysiphae cicoracearum*)

Symptoms appear first as pale yellow spots on leaves (mostly on the upper surface) and stems. Soon thereafter sporulation becomes evident as white powdery masses of conidia are produced over the lesion surface. Lesions frequently are numerous and coalesce to cover the enter leaf surface. Leaves become chlorotic, then turn brown and dry prematurely. The whole plant may succumb. Conditions that favor disease development are warm days and cool nights that develop into long periods of dew on the leaves that are needed for the fungal spores to germinate and penetrate into the leaf tissue. The disease probably survives on wild hosts and is transmitted by the wind. Also spores can survive in the soil and germinate when a host is planted nearby.

- Downy mildew *Pseudoperonospora cubensis*

The fungal disease can be damaging to all cucurbit crops, bitter gourd and watermelon are particularly susceptible. Symptoms occur mainly on the leaves where they begin as yellow spots on upper leaf surfaces and later greyish fuzzy (like down) fungal growth on underside of spots. Yellow halos surround each spot and the spots coalesce as the disease spreads. Leaves turn brown and wilt with age causing high yield loss if widespread on the plant. Infection spreads quickly during periods of high moisture from dew, fogs, or rainfall. The fungus is spread by air currents or rain splash. The fungus perpetuates on crop residue so it should be removed after harvest.

Leaf spot (*Cercospora* sp.)
Leaf lesions are circular, about 1-cm in diameter, with brown borders and light gray centers (frog eye). Severe infection can cause leaf drop, with or without leaf yellowing. The fungus survives on seed and crop debris. Extended rainy periods, long periods of leaf wetness, and close plant spacing enhance disease development.

Each disease is controlled a different set of fungicides.
Rotate the following fungicides to prevent resistance
Apply when 10% of plants show disease symptoms and apply twice at a 15-day interval

Family	Fungicide	Powdery	Downy	Cercospora
Sulfur	Thiovit	Yes		Yes
Conazole	Score	Yes		Yes
	Tilt	Yes		Yes
Benomyl	Benlate	Yes	Yes	Yes
Maneb	Dithane M45			Yes
	Penncozeb		Yes	Yes
	Ridomil MZ		Yes	Yes
	Acrobat		Yes	Yes

8. Virus diseases (both are potyviruses)
- Mosaic virus or WMV2 (watermelon mosaic virus 2)
- Ringspot virus (papaya ringspot virus)

Each virus produces similar symptoms and mixed infections are common. The first symptom is a clearing of veins, followed by development of mosaic patterns or mottling consisting of irregularly shaped, dark green areas alternating with light green or yellow areas. Leaves on some species and cultivars are drastically reduced in size and growth is often retarded. Watermelon mosaic tends to cause raised, blister-like areas on leaves and to reduce leaf size severely. Both viruses are transmitted by many species of aphids. After feeding on an infected plant, aphids only retain the ability to transmit these viruses for very short periods of time (minutes to a few hours). In general, spread of potyviruses in the field occurs when aphid activity is high and is often very rapid and localized.

Control is by using mulches which reduce aphid colonization rates, roguing infected plants, and destroying them.
Control the aphid vector
Neem product or soap

9. Rats feed on the maturing fruit destroying market quality. They are abundant near wheat fields or abandoned areas where tall shrubs or grass grows

Rats can be controlled by baiting and removing brush and grasses from bordering areas

IV. CABBAGE/CAULIFLOWER

Crop monitoring
Monitor the crop on a weekly basis by walking through the field examining plants (look on undersides of leaves) to note the presence of diseases and insect and mite pests.

1. Varietal selection

Select varieties resistant or tolerant to bacterial and fungal diseases

2. Damping-off and root rot and leaf spot fungi, black rot, and root knot nematode control
Follow the preventative guidelines outlined in section I including crop rotation, use of soil amendments or chemical control measures.

Clean seed can eliminate most of the diseases such as damping-off, *Alternaria* leaf spot, and *Xanthomonas* black rot.

3. Root knot nematode, fungal and black rot (*Xanthonomas campestris*) disease control

- Select the most adapted disease and nematode resistant or tolerant varieties

4. Root knot nematode (*Meloidogyne* spp.)
Split nitrogen fertilizer applications in 3-4 times to encourage continuous root growth to outgrow nematode damage

5. Cabbage worms
There are three small leaf feeding species listed in order of normal prevalence:

- Diamondback moth (*Plutella xylostella*)
- Cutworms (*Spodoptera litura, Agrotis ipsilon*)
- Cabbage webworm (*Crocidolomia binotalis*)
- Cabbage headworm (*Hellula undalis*)
- Semilooper (*Plusia orichalcea*)
- Cabbage butterfly (*Pieris brassicae*)

Early signs are feeding damage between the leaf tissues on the undersides of the leaf. Later leaves appear with windows or holes in them. Damage is confined to areas between the veins. On young plants, the growing tips are eaten and seedlings appear stunted.

In young plants, carefully inspect the growing tips and determine if stunting has occurred. Look at the undersides of the leaves for chewing injury. Peel back the wrapper leaves of cabbage for signs of chewing injury and frass from caterpillars. Although diamondback moth originated in Europe, it is not a serious pest there. This is because natural enemies in that continent keep populations in check. It is essential to conserve as many existing natural enemies as possible. In nearly every country in the tropics, a high temperature-tolerant larval parasitoid *Cotesia plutellae* can be found in lowland areas. The following control measures should be used before considering applying insecticides in order to encourage natural enemies:

- Handpicking weekly using hired labor to remove the small larvae from the leaves and peel back the wrapper leaves to find more. For cutworm removal plants that have been recently (the night before) clipped at their bases. At the base of these plants dig around in the soil or plant debris with your fingers to find the larvae. They hide there during the day and come out to feed only at night.
- The field should be cleaned of plant debris after harvest, as diamondback larvae and pupae remain in plant debris.
- Keep the crop weed-free because these worms can multiply on certain weeds, especially crucifer weeds.
- Trap crop of Indian mustard (*Brassica juncea*) to attract cabbage worms. Plant the mustard as double rows on first and last row and every 25 rows (the bold seeded mustard used as an oil seed is better than mustad used as a spice)
- In some countries screening is used to prevent insect infestation, either by covering crucifer seedlings with a fine (#16) nylon mesh net or plastic sheet to prevent egg laying on their leaves. This method will postpone infestation.

Spray any of the following biorational insecticides which conserve natural parasitoids

- Neem (neem oil or Nimbecidene)
- Bt (*Bacillus thuringiensis*) is a bacterial disease of lepidopterous insects safe to man and is available in neighboring countries as a biological insecticide

6. Cabbage aphids (*Brevicoryne brassicae, Myzus persicae*, *Liaphis erysini*)
Female aphids fly into the crop and begin to give birth to nymphs which form colonies. Aphids suck out plant nutrients and plants in all growth stages can be damaged. Leaves are curled, wrinkled, or cup-shaped as a result of loss of nutrients to the aphids. With severe infestations the leaves wilt and the entire plant dies.

When 15% of plants show presence of aphid colonies apply one of the following:

- Spray soap solution (10 g of Wheel detergent powder per 10 liter sprayer)
- Neem based insecticide (neem oil or Nimbecidene)

These are selective insecticides which spare natural enemies such as ladybird beetles and parasitoids. Parasitized aphids turn brown and the bodies become hardened like shells called ‘mummies’. Look for signs of mummies.

7. Bacterial diseases

Black rot (*Xanthomonas campestris*)

Lesions typically begin at the leaf margin and progress inward forming V-shaped chlorotic spots. With time the lesions begin to dry and become necrotic (brown). Infection normally occurs through leaf pores, but it can occur any place on the leaf where insect or mechanical wounds allow for bacterial entry. The bacterium is a vascular invader and can move systemically in the plant. Invaded vascular tissue turns black in color which can be seen as dark veins in lesions or by observing the vascular bundles in cross sections of the leaf midrib, petiole, or main stem of infected plants. Black rot infections can serve as avenues for soft rot entry. The bacterium is seedborne and persists in debris from infected plants. High temperatures and periods of extensive rainfall favor black rot development. The bacterium is present in guttation droplets of infected plants and can be spread among plants by people or equipment moving through the field when the plants are wet.

Control methods:

- Roguing
- Use pathogen-free seed
- Rotate with non-cruciferous crops.
- Avoid working in the fields when the foliage is wet.
- Use resistant cultivars when available

Because it is a bacterium, fungicides are not effective against this disease.

Bacterial soft rot *Erwinia carotovora*

This disease is particularly prevalent in cabbage but also attacks the curd (white part) of cauliflower. Infected plant tissues first develop a water-soaked lesion that enlarges rapidly in diameter and depth. The affected area becomes soft and mushy and generally turns a dark color in advanced stages of disease development. Soft rot-infected cruciferous plants almost always give off an offensive odor, perhaps in part due to invasion by secondary organisms. Disease losses from soft rot may occur in the field, transit, or storage.

Soft rot bacteria persist in infected plant debris, in association with plant roots, in low numbers in the soil, and in association with several insects. Wounds such as leaf scars, insect injury, mechanical injury, lesions caused by other pathogens, etc. are the primary avenues of soft rot bacterial invasion. Rainfall and high temperatures enhance infection in the field.

Disease management is based primarily on sanitation and cultural practices:

- Remove and destroy crop residue
- Rotate with cereals or other non-susceptible crops
- Mulching will help prevent splashing of mud laden with spores.

8. Fungal diseases

Leaf spot (*Alternaria brassicae*)

Leaf spots vary in size from pin points up to 5 cm in diameter. Typically lesions begin as small yellow areas that enlarge to about 1.5 cm in diameter and are dark colored spots with concentric rings. A brown discoloration of cauliflower heads (curd) is caused by infections with these pathogens. The pathogens are seed-borne and the fungus survives on infected plant debris. They also multiply on debris from infected plants and persist on susceptible weeds and can spread in the wind also. Alternaria spores are readily spread by wind. The disease is enhanced by warm, wet weather with an optimum temperature between 25 and 30°C.

Downy mildew (*Peronospora parasitica)*

The distinctive feature of the disease is production of a fluffy white growth found mostly on the underside of leaves. A yellow irregular shaped area appears on the upper side of the leaf opposite where sporulation occurs. Cauliflower floral heads develop dark brown internal streaks. The fungus produces an abundance of spores that can be disseminated by wind and rain splash. Extended periods of leaf wetness caused by fog, rain, or dew are ideal for disease development. Downy mildew develops most rapidly when night temperatures are between 10 and 15°C. When night temperatures exceed 24°C, disease development is greatly restricted. Cultivars of other crucifers may vary in their reactions to downy mildew, but no high levels of resistance are available. Fungicidal treatment of crops is generally required if the disease is present and conditions are favorable for severe disease development.

When 15% of plants infected spray by rotating:

- iprodione (Rovral 50WP)
- mancozeb (Pencozeb, Ridomil Gold)
- difenoconazole (Score)

V. BRINJAL

Crop monitoring
Monitor the crop on a weekly basis by walking through the field examining plants (look on undersides of leaves) to note the presence of diseases and insect and mite pests.

1. Varietal selection
Select varieties with resistance to fruit and shoot borer and bacterial wilt

2. Damping-off fungi, bacterial wilt, and root knot nematode control:
Follow the preventative guidelines outlined in section I including crop rotation, use of soil amendments or chemical control measures, and clean seed for both seedbed and field.

- Damping-off fungi: *Pythium, Sclerotium, Rhizoctonia, Phytophthora, Fusarium*
- Bacterial wilt *Ralstonia* (formerly *Pseudomonas*) *solanacearum*
- Root knot nematode *Meloidogyne* spp. Aside from direct damage to roots in blocking the uptake of nutrients nematodes also cause wounds that allow entry of soil borne fungi such as the damping off group that later affect older plants.

3. Bacterial wilt, fungal disease and root knot nematode control

- Select the most adapted disease and nematode resistant or tolerant varieties
- Purchase grafted brinjal (preferable one resistant to BFSB) which have wild brinjal resistant root stock (in areas where bacterial wilt is serious this method returns a profit of Tk 60,000)

4. Brinjal fruit and shoot borer (BFSB) (*Leucinodes orbonalis*)
BFSB is the most destructive pest of brinjal. After hatching from eggs, the larvae search for and bore into tender shoots near the growing point, into flower buds, or into the fruits, adversely affecting marketable fruit yield. Wilted shoots in a brinjal field is the surest sign of damage by this pest. Currently most farmers rely exclusively on the application of insecticides to control this pest and to produce blemish-free brinjal fruit. Since newly hatched larvae can enter within only a few hours of hatching from eggs, insecticides have to be applied frequently in order to have sufficient toxic residues on the plant surface to kill the crawling larvae. Once in the shoots or fruits, larvae are inaccessible to the killing action of surface-applied chemicals. Dependence on insecticides leads to higher costs of production, environmental pollution, destruction of natural enemies, and development of pesticide resistance in BFSB. However even by spraying every day damage still reaches 30% damaged fruit. A large research effort has

led to the development of alternative methods of control which have been successfully field tested in Bangladesh.

Control methods are listed in order of priority:

(i) Use a resistant variety

Best yielding resistant varieties are:

- BL114 (yield potential of 27-38 t/ha)
- ISD006 (yield potential of 20-24 t/ha)
- Uttara
- Signath
- Nayantara BARI begun 5

(ii) Sanitation

Weekly until harvest beginning about a month after transplanting, prune all damaged shoots and remove fruits and bury 20 cm deep in soil or place in compost pit as neither cattle nor goats like to eat brinjal leaves and shoots. Results are even better if this is carried out on a community wide basis. Don't forget to also destroy the crop residue after harvest which also contains borer larvae. The initial infestation, particularly in the off season, is often due to the presence of old brinjal stubble heaped around farmers' dwellings or from old abandoned plantings during the off-season. Thus this woody material should not be piled but used up quickly as fuel.

(iii) Trapping of moths

There are companies in India supplying the pheromone (sex attractant) which can be used in locally constructed traps to remove the males. As with sanitation, better results occur if this is carried out by a community. Trap distances are 10 m in both directions.

(iv) Insecticide application as a last resort

Infestation generally does not begin until 4-5 weeks after planting so do not apply before then. The longer insecticide usage is held off, the greater will be the buildup of beneficial parasitoids such as *Trathala flavo-orbitalis* which attacks the larval stage.

If one must spray choose spray insecticide. Neem spares natural enemies more than other chemicals

- neem

5. Sucking insect pests

Jassid (*Amrasca biguttula biguttula*)(most common)

Nymphs and adults suck sap from the phloem of plants, usually from the under surfaces of the leaves. This leafhopper produces hopperburn when insect saliva reacts with plant tissue. Hopperburn is not a disease but is characterized by yellowing, chlorotic stippling, leaf malformation and tip burn. Adult leafhoppers fly or jump when disturbed. There are resistant varieties available. The

action threshold is 3 per leaf with hopper burn (yellowing) on the leaf margins beginning.

Aphid (*Aphis gossypii*)
Aphids are most abundant in the rabi season and feed by sucking sap from their hosts. The undersides of leaves are preferred, other leaf surfaces and flower buds are its next choice, but the entire host may be covered when populations are large. Infested leaves often become cupped downwards and may appear wrinkled. As with leafhoppers the symptom is often thought to be a disease but is the reaction of the plant to the feeding. Heavy infestations on some hosts may result in wilting. Young plants may have reduced or stunted growth. Like other soft bodied insects such as leafhoppers, mealybugs, and soft scales, aphids produce honeydew. Copious amounts of honeydew, a sweet and watery excrement, may be produced. Honeydew serves as a medium on which sooty mold grows. Sooty mold blackens the leaf and decreases photosynthetic activity. The action threshold is one colony per leaf.

When AT reached spray one of the following:

- Soap solution (10 g of Wheel detergent powder per 10 liter sprayer)
- Neem based insecticide (neem oil or Nimbecidine)

6. Leafbeetle (*Epilachna vigintioctopunctata, E. indica*)
This leaf eating beetle feeds both in the larval and adult stage and is most prevalent during drought periods.

When abundant hand pick or apply:

- neem based insecticide (neem oil or Nimbecidine)

7. Fungal diseases
Phomopsis blight (*Phomopsis vexans*)
This seed borne fungal disease affects all above-ground plant parts at all stages of development. Spots generally appear first on seedling stems or leaves. The fungal damage girdles seedling stems causing the seedling to wilt. Leaf spots are clearly defined, circular, up to 2 cm in diameter, and brown to gray with a narrow dark brown margin. Infected leaves show circular grey to brown spots with light colored centers with black specks which are thefruiting bodies of the fungus. Leaves turn yellow and die. The lesions on the stem are dark brown. Fruit spots are similar to those on leaves. Small sunken areas first appear on the fruit and the spot enlarges to cause the whole fruit to rot. Phomopsis persists in residue from diseased plants. It is spread by splashing water and the wind. Disease is promoted by wet weather and high temperatures.

Southern blight (*Sclerotium rolfsii*) (not very common)
This is not seedborne but also attacks the stems at ground level. This is one of the damping-off fungi but also attacks older plants

that have formed woody tissue. The plants are gradually girdled by lesions and eventually die. The first signs of infection, though usually undetectable, are dark-brown lesions on the stem at or just beneath the soil level; the first visible symptoms are progressive yellowing and wilting of the leaves. Following this, the fungus produces abundant white, fluffy mycelium on infected tissues and the soil.

Leaf spot (Cercospora)
Cercospora leaf spots are circular, about 1/8 to 3/16 inch in diameter, with light to dark tan centers and dark-brown to reddish-purple borders. Elliptical lesions may occur on leaf blades, veins, and petioles. Leaf spots coalesce and kill large areas of leaf tissue. Spores spread via wind, water, and insects. The diseases is favored by nearby infected crops during the field season, plant debris left after harvest, and warm, humid, rainy weather.
Control measures for all three fungal diseases:

- Use a resistant variety
- Use pathogen-free seeds
- Adopt a 3-4 year crop rotation
- Mulching and furrow irrigation will reduce infection caused by water and soil splashing.
- Destroy crop residue after harvest
- Last resort spray with mancozeb (Penncozeb, Ridomil Gold)

VI. OKRA or LADY'S FINGERS

Crop monitoring
Monitor the crop on a weekly basis by walking through the field examining plants (look on undersides of leaves) to note the presence of diseases and insect and mite pests.

1. Varietal selection
Select varieties with resistance or tolerance to virus disease.

2. Damping-off fungi, bacterial wilt, and root knot nematode control
Follow the preventative guidelines outlined in section I including crop rotation, use of soil amendments or chemical control measures, and clean seed for seedbed and field.

- Damping-off fungi: *Pythium, Sclerotium, Rhizoctonia, Phytophthora, Fusarium*
- Bacterial wilt *Ralstonia* (formerly *Pseudomonas*) *solanacearum*
- Root knot nematode *Meloidogyne* spp.

3. Bacterial wilt, fungal disease, and root knot nematode control

- Select the most adapted disease and nematode resistant or tolerant varieties

4. Root knot nematode (*Meloidogyne* spp.)
Split nitrogen fertilizer applications in 3-4 times to encourage continuous root growth to outgrow nematode damage

5. Shoot and fruit borer (*Earias vittella*)
The spotted larva feeds on the shoots, flowers and developing fruit and is also a pest of cotton. It is difficult to control with insecticide because it feeds internally on shoots and fruits. The resulting damage is loss of flowers, fruits dropping off the plant, and damaged fruits.

Control methods:

(i) Sanitation
- Destruction of crop residue after harvest
- Remove infested fruits

(ii) Adjust planting time

(iii) Insecticides when 10% of plants show damage
Spray
- Neem (neem oil or Nimbecidine)

6. Sucking insect pests

Cotton jassid (*Amrasca devastans*)
This yellow narrow insect feed from the lower leaf surface. They are very active and if the plant is struck they dart to neighboring plants. The adults and nymphs move side to side like crabs. Both the adults and nymphs remove plant sap and the saliva they inject causes a physiological reaction in the plant where the leaf yellows, particularly along the margins.
Control
If leaf yellowing is noticed spray soap or neem product

Cotton aphid (*Aphis gossypii*)
Female aphids disperse and are blown in the air by wind currents. Because they are small they disperse in the late afternoon when the wind currents are less strong and move from field to field. Once landed on the crop they multiply rapidly forming a colony around each female. A new generation from the offspring of the colonizing female occurs within 10 days. The new adults do not form wings and use all their energy to produce more offspring. Only when the crop is near maturity do the new adults form wings. Both nymphs and adults remove plant sap from the plant and excessive feeding causes leaf deformation and stunting.
Control
If leaf curling begins to occur spray soap or need product

7. Virus disease
Yellow vein clearing mosaic virus disease (YVCMV) vectored by the tobacco or sweet potato whitefly (*Bemisia tabaci*)

In comparison with other whiteflies the wings of B. tabaci are held tent-like above the body and slightly apart, so that the yellow-tinged body is more apparent. The life stages are most commonly found on the undersides of leaves. The whitefly occurs worldwide and attacks over 500 species of plants. Direct feeding damage is caused by the piercing and sucking sap from the foliage of plants. This feeding causes weakening and early wilting resulting in leaf yellowing. Injury reduces the plant growth rate and yield. The immature stages excrete a honeydew which makes the plants sticky and susceptible to colonisation by black sooty molds. The mold reduces photosynthesis and lessens the market value of the crop. Sweetpotato whitefly has become resistant to chemical insecticides quite rapidly in most parts of the world.

Whiteflies vector yellow vein clearing mosaic virus (YVCMV). This is generally the most serious disease of okra. The virus produces symptoms of yellow veins and green interveinal areas. Chlorosis and plant stunting occur. Fruits become small and malformed and can turn yellowish green. It is not seed borne nor mechanically transmitted.

Infected plants should be rogued and the others protected by controlling the whitefly vector during the most vulnerable period for transmitting the infection from the first to the fifth week after crop emergence with applications of soap or neem products.

8. Defoliator

Leafroller *Sylepta derogata*

The leafroller is a medium sized moth. The larva first cuts off the tip of a leaf. It then attaches silk strands coming from its mouth to opposite edges of a leaf which when they dry shrink making the leaf roll into a tube which serves as shelter. The larva then feeds by scraping the leaf tissue inside the rolled leaf. Its numbers are normally held in check by parasitoids but sometimes it can become abundant.

Control

- If more than 15% of the leaf area is defoliated by all pests then apply neem spray

9. Seed bugs

Red cotton bug *Dysdercus cingulatus*

The adult has a red body with white bands. The nymphs and adults use their long needle-like mouthparts to remove sap from shoots, buds, and flowers as well as young fruit. Feeding injury also occurs on the seeds within the fruit development affecting fruit quality.

Control

- Hand picking
- If more than 2 nymphs per plant then spray neem

10. Leaf spot fungal diseases

- *Cercospora*
- *Alternaria*

Both of these diseases cause spotting and lesions on the leaves and plants normally are infected by seed containing fungal spores. Thus both diseases can be prevented by using pathogen free seed.

Spray when 20 % of leaves show spots

- Mancozeb product (Pencozeb, Ridomil Gold)

VII. POTATO

Crop monitoring

Monitor the crop on a weekly basis by walking through the field examining plants (look on undersides of leaves) to note the presence of diseases and insect and mite pests.

1. Varietal selection.

Select varieties resistant or tolerant to fungal and virus diseases.

2. Damping-off fungi, bacterial wilt, and root knot nematode control
Follow the preventative guidelines outlined in section I including crop rotation, and use of soil amendments or chemical control measures for seedbed and field.

- Damping-off fungi: *Pythium, Sclerotium, Rhizoctonia, Phytophthora, Fusarium*
- Bacterial wilt *Ralstonia* (formerly *Pseudomonas*) *solanacearum*
- Root knot nematode *Meloidogyne* spp. Aside from direct damage to roots in blocking the uptake of nutrients nematodes also cause wounds that allow entry of soil borne fungi such as the damping-off group that later affect older plants.

3. Bacterial wilt, fungal disease, and root knot nematode control

- Select the most adapted disease and nematode resistant or tolerant varieties

4. Prevention of disease incidence in seed

Treat true seed with a fungicide before planting. Carboxin + thiram (Vitavax 200) or thiophanate methyl + thiram (Homai)

5. Root knot nematode (*Meloidogyne* spp.)
Root knot nematode larvae invade roots or tubers, establish feeding sites, and develop into the adult stage. Adult females are swollen, sedentary, and lay eggs in a gelatinous matrix just below the root surface. These eggs hatch and larvae invade other roots and tubers. Root knot nematode feeding reduces the vigor of plants and causes blemishes on tubers. Infestations may occur without causing any

above ground symptoms. In general, above ground symptoms include stunted, yellowed, chlorotic, and/or dead plants. Infected plants are likely to wilt earlier under temperature or moisture stress. Infested tubers left in the field after harvest can be a source of inoculum. Destroy potato plants that subsequently emerge from these tubers to restrict nematode reproduction.
Split nitrogen fertilizer applications 3-4 times to encourage continuous root growth to outgrow nematode damage

6. Soil insect pests
Cutworms and armyworms (*Agrotis, Spodoptera*)
Larvae hide during the day in cracks in the soil or in debris around the plants and feed on leaves or shoots during night by cutting them near the ground level. The destruction is much more than actual feeding. Controls include:

- Handpicking
- Larvae can be attracted to rest under piles of cut grass and weeds and these heaps can be inspected day to day and larvae removed
- Poison bait (1 litre chlorpyrifos + 100 kg wheat or rice bran + molasses) having a flake consistency

7. Foliar insect pests
Jassids (*Amrasca biguttula bigutula or A. devastans*)
Both nymphs and adults suck the sap from the lower surface of the leaves. A chemical in the saliva causes an adverse chemical reaction in the plant leading to chlorosis where damaged leaves curl upwards along the margins. This affect is much more than the result of removed plant sap and leads to plant stunting and dried up leaves.

Aphids (*Myzus persicae)*
Aphids are found in large colonies on underside of leaves and tender shoots. The nymphs and adults suck the sap. Therefore, the affected leaves turn yellow, and get wrinkled and destorted. They also act as a vectors for viral diseases.

Leaf feeding insect pests
Epilachna beetle (*Epilachna dodecastigam, E. vigintio otopunctata)*
Both grub and beetle eat the chlorophyll of the leaf in between the veins and cause characteristic skeletonised patches on leaves.

Control for foliar feeding insects is to apply

- Soap
- Neem (neem oil or Nimbecidine)

8. Foliar fungi
Early blight (*Alternaria solani)*
Early blight is primarily a disease of stressed or senescing plants. Despite the name it normally comes late in the crop cycle. Symptoms appear first on the oldest foliage. Affected leaves develop circular

to angular dark brown 3-4 mm in diameter. Concentric rings often form in lesions to produce characteristic target-board effect. Severely infected leaves turn yellow and drop. Infected tubers show a brown, corky dry rot. Between crops, the early blight fungus can overwinter on potato refuse in the field, in soil, on tubers, and on other solanaceous plants. Infection occurs when spores of the fungus come in contact with leaves and sufficient free moisture is present. Spore germination and infection are favored by warm weather and wet conditions from dew, light rain, or sprinkler irrigation. Alternate wet and dry periods with relatively dry, windy conditions favor spore dispersal and disease spread. Tubers can be infected as they are lifted through the soil at harvest. If sufficient moisture is present, spores germinate and infect the tubers. Early blight can be minimized by maintaining optimum growing conditions, including proper fertilization, irrigation, and management of other pests. Grow later maturing, longer season varieties.

Late blight (*Phytophthora infestans)*
Late blight lesions can occur on all above-ground plant parts. Despite its name, it comes early in the crop cycle. On leaves, lesions typically first appear as small pale to dark green that are irregular in shape and surrounded by a zone of yellowish tissue. Late blight breaks out usually most seriously where the weather is consistently cool and rainy. Under conducive conditions, lesions expand rapidly and become brown to purplish black as tissue is killed. Under sufficient humidity, white sporulation of the fungus can be observed at the periphery of lesions, principally on the underside of leaves. On stems and tubers, lesions are brown to black and may also support sporulation of the fungus. Infected tubers develop a firm brown decay that starts on the outside and may later extend to include the outer 1-2 mm of tissues.

Late blight inoculum can originate from seed tubers, cull piles, volunteers, closely related weed hosts, and adjacent plantings of potatoes or tomatoes that are infected. The disease is controlled by eliminating cull piles and volunteer potatoes. When disease has developed on foliage the tubers are at risk of infection, thus make sure that vines are completely dead for 2 to 3 weeks before harvest. Delay harvest. The fungus does not survive very long in dead foliage.

If any of the two fungal diseases begin to appear on 10% of the plants:
Spray at 7-day intervals during overcast or in heavily diseased areas or at 14-day intervals if less disease pressure. Spray 2-4 times depending on severity. With a systemic fungicide such as Ridomil the interval can be three days longer for each application.

In order to prevent the development of fungicide resistance alternate among the following three fungicide families with each application

- mancozeb based (Pencozeb, Ridomil Gold [+ metaxyl], Acrobat MZ [+ dimethomorph])
- iprodione (Rovral) (early blight only)
- chlorothanil (Secure)

9. Bacterial disease
Soft rot bacterium (*Erwinia carotovora*)
Symptoms of soft rot include rotten tissues that are wet, cream to tan in color, and soft. Rot begins on the tuber surface and progresses inward. Infected tissues are dark brown with black margins. Shallow necrotic spots on the tubers result from infections through lenticels. Rotting tissue is usually odorless in the early stages of decay, but develops a foul odor as secondary organisms invade infected tissue. Soft rot can also infect wounded stems and roots.
Bacteria are present on all tubers. Infections in the field are favored by high soil moisture and high temperatures. Other conducive factors include anaerobic conditions, enlarged lenticels, and invasion by other pathogens. Bacteria enter lenticels, growth cracks, or any injury. During and after harvest, soft rot is favored by immature tubers, high temperatures at harvest, mechanical damage, and free water on tuber surfaces.
Control is by:

- Roguing infected plant
- Maintain effective drainage in field
- Avoid injuring tubers during harvest (bacteria enter through wounds)
- Harvest mature tubers with well-set skins
- Avoid water films on tuber surfaces during storage.

10. Viruses
Potato leaf roll virus (PLRV)
The nature and severity of leafroll symptoms depend on the virus strain, potato variety, environment, and time and source of infection. Plants with chronic (seed-tuber borne) infections are most severely affected. They typically are stunted and appear more erect. Lower leaves roll upwards at the margins, have a stiff leathery texture, and may die prematurely. The number and size of tubers is reduced. In contrast, plants that become infected in the current season by aphid vectors normally develop symptoms in the upper (youngest) leaves first; the leaves develop an upright orientation, become chlorotic, and roll upwards. Late-season infections are not always accompanied by symptoms. PLRV can be introduced to a potato field by infected seed tubers or by a number of aphids that have fed on infected potato plants. The most

efficient vector of the virus is the green peach aphid. Several minutes to hours are required for the aphid vector to acquire the virus, but once the virus has been acquired, the aphid carries it for life. Winged aphids carried in air currents spread the virus for long distances between fields, and non-winged aphids are important in plant to plant spread. Aphid feeding introduces PLRV into the phloem tissue where the virus multiplies, spreads, and initiates disease. PLRV is not transmitted mechanically by machinery or contact with leaves.

Control

- Resistant varieties such as Heera, Dheera, Granola
- Roguing
- Use certified seed tubers.
- Control sources of the virus, including volunteer potatoes and scattered potato plants that are infected with PLRV early in the growing season.
- Complete plant resistance to PLRV is not available in popular varieties
- Chemical control of PLRV is aimed at controlling aphids in order to reduce spread of the virus within a field. Apply insecticides (soap or neem) from early to mid-season if aphids and PLRV are present. Late season vector control may offer no economic benefit.

11. Tuber formation

Dry rot *Fusarium* spp.

Fusarium attacks tubers as a dry rot, although a moist rot may occur if secondary infection by soft rot bacteria is also involved. Initially, lesions appear as brown to black flecks on the tuber surface. Lesions later form large, hollow cavities. Frequently, the lesions appear wrinkled on the tuber surface with numerous white tufts of mycelium. Infected seed pieces may completely decay. *Fusarium* spp. are present in all soils and are found on the surface of all tubers. Wounds are required for infection as the fungus cannot penetrate intact tuber skin.

Proper handling and curing is usually sufficient to give economic control of dry rot in storage. Allow tubers to mature before harvest and prevent bruising tubers both during harvest and storage operations. Wound healing reduces infection.

Potato common scab *Streptomyces* spp.

Tuber symptoms of common scab vary in extent and appearance. Common scab lesions 6-8 mm in diameter are usually circular, but they can be smaller in early stages of development and larger if they coalesce. Lesions typically possess a raised margin and slightly depressed center. Some characteristic symptoms have descriptive names: russet scab appears on tubers as superficial tan to brown corky lesions; pitted scab is characterized by lesions with

depressions beneath the tuber surface; and raised scab appears as cushionlike, warty lesions.

Streptomyces spp. are widely distributed and persist in soil on decaying organic matter. Inoculum is also carried on infected seed tubers. Disease severity is usually increased by continuous cropping to potatoes. Tubers become susceptible to infection when they start forming. Scab lesions expand as the infected tubers grow. Mature tubers with well-developed skins are not susceptible. The fungus can also persist in noncomposted manure from animals that have fed on infested tubers.

Control

- Use disease free tuber seed
- Practice crop rotation
- When applied before or at planting, some soil amendments such as sulfur, gypsum, and triple superphosphate, suppress common scab.

12. Stored potatoes

Potato tuber moth *Phthorimaea operculella*

The moth is active throughout the year and passes its life cycle on potato plants in the fields as a larval leaf miner and later boring into petioles, terminal shoots and tubers underground, thus is carried inside tubers in storage. The larvae bore the tubers and their feeding introduces bacteria which causes the tubers to rot. The presence of black excreta near the eye buds is a sign of its presence in tubers. On cutting such tubers one can find the larva in its tunnel.

Cultural controls include:

- Timely earthing up of the crop to cover the exposed tubers.
- Heaps of harvested potatoes should not be kept exposed in the field but covered with straw and infested tubers should be rejected before storage.
- Build a well ventilated storage shed and drying racks to keep potatoes for 6 months
    - Sell at higher price
    - Use as seed for next cropping season

13. Vertebrate pests

Rats tunnel in the soil and feed on tubers. Use a bait if this becomes an economic problem.

VIII. SPICES ONION

Crop monitoring

Monitor the crop on a weekly basis by walking through the field examining plants (look on undersides of leaves) to note the presence of diseases and insect and mite pests.

1. Varietal selection

Select varieties resistant or tolerant to fungal diseases.

2. Damping-off fungi and root knot nematode control
Follow the preventative guidelines outlined in section I including crop rotation, use of soil amendments or chemical control measures, and clean seed for seedbed and field.

- Damping-off fungi: *Pythium, Sclerotium, Rhizoctonia, Phytophthora, Fusarium*
- Root knot nematode *Meloidogyne* spp.

3. Root knot nematode and fungal disease control

- Select the most adapted disease and nematode resistant or tolerant variety

4. Soil insect pests
Cutworms and armyworms (*Agrotis* and *Spodoptera*)
Cutworms are soil inhabiting stout larvae which feed at night on the leaves and soft stems. Most commonly the plants are defoliated but small plants can be completely severed.

Onions can tolerate 25% defoliation until 45 days after planting before yield loss, but after 45 days the tolerance is much less.
Control methods

- Hand removal of larvae from the soil. Locate plants that have been recently damaged. At the base of these plants dig around in the soil or plant debris with your fingers to find the larvae. They hide there during the day.
- Make insecticide bait (1 litre chlorpyrifos (Dursban) + 100 kg wheat or rice bran + molasses) in the form of flakes applied to base of plants along the row

5. Thrips (*Thrips tabaci*)
Thrips are very small, just barely visible to the naked eye and begin attacking the crop within the first several weeks in the field. They are more prevalent in the absence of rain. Immatures are either yellow or white. Older individuals are yellowish-brown and move quickly. Feeding is the act of scraping the epidermis of leaves or stems and suck the plant sap resulting in white blotches. Severe infestations result in leaf wilting and bulbs become distorted and undersized.

Maintaining moisture in the soil reduces thrips damage. Moist soils develop fungi that kill pupae in the soil. Sprinkler irrigation will seal pests in soil while pupating. Heavy rains drown thrips in plant crevices and soil. Mulching with straw may provide shelter for thrips predators, thereby reducing thrips populations.

When 15% of plants show damage apply one of the following:

- Spray soap solution (10 g of Wheel detergent powder per 10 liter sprayer)
- Neem based insecticide (neem oil or Nimbecidine)

6. Fungal leaf diseases
Purple blotch fungal disease (*Alternaria porri*)

Taherpuri a local variety is highly susceptible so use a less susceptible variety

Stemphylium blight(*Stemphylium vesicarium*)

Purple blotch and stemphylium leaf blight have identical damage symptoms that begin on the leaves and leaf sheaths as small light yellow to brown water-soaked infections beginning at the leaf tips. As the lesions expand, they coalesce into oval-shaped tan and deep purple blight or blotch lesions. Concentric zones may develop within them. Yellow streaks, which turn brown, extend along the blade in both directions from the lesion. In advanced stages lesions may girdle and kill leaves and seed stems. Bulbs get infected and decay. Wet and warm conditions favor the disease spread. The pathogens survive on infected bulbs, seeds, and plant debris. Control measures are to obtain disease free seed and fungicides on the standing crop. Neem is effective against these diseases as determined by trials in Bangladesh.

Apply either

- iprodione (Rovral 50WP)
- mancozeb + metaxyl (Ridomil Gold),
- difenoconazole (Score)
- neem (neem oil or Nimbecidine)

7. Fungal bulb rot diseases
White rot (*Sclerotium rolfsii*)
Leaves of plants infected with the white rot pathogen show yellowing, leaf dieback, and wilting. Leaf decay begins at the base, with older leaves being the first to collapse. A semi-watery decay of the bulb scales results. Roots also rot, and the plant can be easily pulled from the ground. Associated with the rot is a fluffy white growth, the fungal mycelium, which develops around the base of the bulb. As the disease progresses, the mycelium becomes more compacted, less conspicuous, with numerous small spherical black bodies sclerotia forming on this mycelial mat. These sclerotia, the resting bodies of the pathogen, are approximately the size of a pin head or poppy seed. Plants can become infected at any stage of growth.

The pathogen persists as small, dormant structures, called sclerotia, in soil. Sclerotia can survive for over 20 years, even in the absence of a host plant. Disease severity depends on sclerotia levels in the soil at planting. As few as one sclerotium per 10 kilograms of soil can initiate disease. Only one sclerotium per kilogram of soil can cause measurable disease loss, and 10-20 sclerotia per kilogram result in infection of essentially all plants.

Sclerotia can be spread throughout a field or from field to field by flood water, equipment, or on plant material. Sclerotia remain dormant in the absence of onion or other *Allium* crops. Their germination is stimulated by *Allium* root extracts and exudates that extend into the soil about 1.5 cm from the root. Disease development is favored by cool, moist soil conditions.

Control

- Plant only clean stock from known origins that have no history of white rot
- Crop rotation is effective in slowing disease buildup
- Do not move cull bulbs, litter, and soil from infested to noninfested fields
- Always clean tools before moving from one field to another
- Onion seed is not likely to carry sclerotia, but transplants and sets can

Black mold (*Aspergillus niger*)

Black mold is first evident at the top or sides of the bulb where disease or injury has caused an opening in the skin. The fungus develops between dry, dead outer scales and the first inner fleshy scales of the bulb. Invaded scales initially become water soaked. Under dry conditions diseased scales dry and shrivel, and black masses of spores are visible between outer scales. Diseased scales may also be invaded by soft rot bacteria, causing the whole bulb to deteriorate into a watery soft rot.

Black mold occurs most commonly where onions or garlic are grown under warm dry conditions. It is more of a concern in onion crops than in garlic. The fungus survives on decaying organic matter such as plant debris.

Control

- There are no chemicals for the direct control of black mold.
- Handling of bulbs to avoid bruising also reduces injury and invasion sites for the fungus.

Blue mold (*Penicillium* spp.)

Blue mold generally appears during harvesting and storage. Initial symptoms include watersoaked areas on the outer surface of scales. Later, a green to blue green, powdery mold may develop on the surface of the lesions. Infected areas of fleshy scales are tan or

gray when cut. In advanced stages, infected bulbs may disintegrate into a watery rot.

Many species of *Penicillium* can cause blue mold. These fungi are common saprophytes on plant debris and senescent plant tissue. Invasion of onion bulbs and garlic is usually through wounds, bruises, or uncured neck tissue. Once inside the bulb, the mycelium grows through the fleshy scales, eventually sporulating profusely on the surface of lesions and wounds. Optimum conditions include moderate temperatures (21° to 25°C) and high relative humidity.
Control

- Harvest and handle onion bulbs with a minimum of bruising or wounding
- Promptly cure the bulbs so the necks are dry. Store bulbs at temperatures of 5°C or less with low relative humidity.

IX. FIELD CROPS HYBRID MAIZE

Crop monitoring
Monitor the crop on a weekly basis by walking through the field examining plants (look on undersides of leaves) to note the presence of diseases and insect pests.

1. Varietal selection
It is important to select varieties tolerant or resistant to local diseases as use of foliar fungicides is uneconomical.
Resistant sources have been identified against:

- Leaf blight
- Downy mildew
- Mosaic virus
- Stalk borers

2. Follow the recommended practice of acquiring healthy seed by:

- purchase from reliable commercial source
- sort the seed manually and reject off-color seeds
- sterilize seed with hot water (52^{o}C for 15 minutes) or clorox/bleach (2% sodium hypochlorite for 10 minutes)
- use a fungicide seed treatment (Vitavax)

Useful against seedling rot from damping-off fungi and other fungal diseases.

3. Crop rotation
In order to minimize soil borne pests, particularly damping-off diseases and nematodes, plant maize after vegetables to take advantage of the residual compost and manure. Maize makes a good rotational crop with vegetables as it belongs to the grass family and no vegetables belong to this family.

4. Destroy stalks and cobs after harvest to break the insect pest (stalk borers) and fungal disease cycles. Feed stalks and cobs to farm animals, use for fuel, or place in compost pits.

Split the nitrogen applications 3-4 times to encourage continuous root growth and tolerance to pests

4. Virus disease
Maize mosaic virus (MMV)
MMV is the most common virus disease. Infected plants have mottled upper leaves that are lighter in color than healthy leaves. The mottled or mosaic pattern consists of alternate yellow and green islands in the leaf tissue. Aphids transmit virus particles from surrounding grassy alternate hosts. Early infection may cause sterility. Late infection will reduce yields and quality of maize produced. Aphids transmit the disease too quickly for insecticide efforts to prevent disease spread.
Normally MMV can be controlled with a resistant variety but if present rogue and feed to livestock or place in compost pit.

5. Leaf fungal diseases
Leaf blight *Exserohilum* (= *Drechslera*) *turcicum*
The fungus lingers in fields on plant debris. Spores are windblown or splashed by rain from debris to the current season crop. Spores germinate and penetrate leaf tissue directly or through stomata. Infection occurs when free moisture (dew) is present on the leaf surface. Rainfall is beneficial as it washes spores off the plants. Symptoms develop on lower leaves first as small, yellowish, round or oval spots on the leaves and progress up the plant under favorable weather conditions. The spots extend along the leaf on a susceptible host into long elliptical lesions up to 15 cm in length. The affected tissues become thin and semi-transparent. Leaves gradually dry up. Lesions are grayish-green to tan in color. Spores from the primary lesions reinfect the host producing secondary cycles of the disease.
Crop rotation is an effective preventative measure. If serious one can spray propiconazole (Tilt) or carbendazin (Bavistin).

Downy mildew *Peronosclerospora* sp.
Infected leaves have a downy growth on the underside, toward the basal part. Potential infection is increased when the crop is grown in soil previously grown to maize. Although high populations of spores are produced on the leaf surface, they are short-lived and require extended periods of high humidity for infection. Spores can persist in the soil for several years. Removing crop residue will reduce the amount of inoculum carried over in the soil. Varieties vary in their reaction to this disease. Internodes become shortened and the plant becomes stunted. Cobs may not be produced or they may

have no grains. The fungus survives on the underground parts of the host. After rains the spores are spread by wind or rain drops.
If there is no resistant or tolerant variety, one can treat the seed with Vitavax or Ridomil.

6. Stalk rot fungi
Stalk rot is caused by a number of fungi each giving a different symptom.

- *Pythium aphenidermatum*
- *Fusarium moniloforme*
- *Diplodia maudis*
- *Colletotrichum gramionicota*
- *Rhizoctonia*

They all are seed borne and the spores build up on plant debris from a previous crop. The earlier the crop is infected, the more severe is the damage. Spores are dispersed by wind, rain, and insects and can infect the roots, mesocotyl, and the nodes above the soil. Crop stress can hasten the progress of the disease. Sources of stress are those that encourage heavy kernel set, leaf blights, extended cloudiness, dense plant stands, drought, and low K with high N.
Crop stress is minimized by good fertility practices of applying balanced fertilizer.
Cultural controls rely on crop rotation and destruction of crop residue after harvest.
One can treat the seed with a fungicide such as Vitavax

7. Smut *Ustilago maydis*
This fungus produces galls in the form of soft tumors on any part of the plant from the roots to the tassel and cob, most commonly the cob is affected. At first these tumors remain covered with a white membrane and thecentral part consits of mycelium growth of the fungus. At maturity the central part appears as black ordark brown powdery mass of spores. The coveing membrane becomes dry, breaks and the spores are disseminated in the wind.
Control
Smut is not seed borne and builds up on old stalks left in the field, therefore sanitaiton and crop rotation are the best control measures

8. Cob rot fungi
Several fungi can produce cob rot

- *Fusarium* sp.
- *Diplodia* sp.

Ear and kernel rots are a greater problem in areas with high rainfall from silking to harvest. The fungi growing in the rotten grain can be toxic to humans or livestock. Bird and insect damage to ear and stalks, along with lodging will increase stalk rots. Yield, quality, and feed value can be reduced.

Control

- Select hybrids resistant to disease and to lodging
- Crop rotation
- Harvest should not be delayed
- Balanced fertilizer also helps
- Proper storage below 15% moisture

9. Soil insect pests

Several insect pests can feed on roots and young seedlings.

- Cutworm
- Whitegrubs
- Wireworms

These pest are expected if maize is not rotated with flooded rice and if maize follows another maize crop or grass species.
Control cutworms by handpicking.

10. Stalk borers

There are two main species of borers whose larvae tunnel inside the stalks feeding on the more nutritious vascular tissues.

- Pink borer *Sesamia inferens*
- Spotted stalk borer *Chilo partellus*

Once inside the stalk they are difficult to control but on the other hand the crop can tolerate up to moderate infestations without loss if good agronomic practices are followed.

Best is to build up crop tolerance through balanced fertilizer and several split applications.

11. Maize leaf aphid (*Rhopalosiphum maidis*)

Aphids disperse by wind and aggregate on the more nutritious plant tassels where large colonies can build up especially during prolonged periods of dry weather. Heavy rainfall washes them off the plant and is a significant natural mortality factor.

Usually natural enemies and balanced fertilizer can reduce their impact but if the problem is serious one can apply soap or neem, spraying only the tassel of each heavily infested plant.

12. Maize cob borer (*Heliocoverpa armigera*)

The cob borer feeds on a wide range of crops but the moth is highly attracted to maize plants during the silk stage. Eggs are laid on the silk and the young larva enters from the end of the ear to feed on the developing grains. Due to cannibalism normally only one larva is found per ear, consequently growing maize is a method to reduce its numbers. Due to the limited time the larva is exposed outside of the ear, this pest is uneconomical to control with conventional insecticides, although NPV (a highly contagious virus) has had some

success when sprayed at the early silk stage. One only has to target only the silk.

In some countries *Trichogramma* egg parasitoids are mass reared and released during the period of silking

13. Vertebrate pests
Jackals uproot newly emerging plants and feed on the seed. Guards should be posted to keep them away.

Birds and rats feed on grains near harvest time. Timely harvest is a method to minimize damage.

14. Stored grain pests

Maize weevil *Sitophilus*
This small black weevil can infest maize in the field. Its larvae tunnel into mature grains and usually one larva develops per grain feeding on the internal endosperm. The grain becomes unable to germinate and if not controlled with decimate the stored seed.
Control
Harvest on time
Fumigate the grain if it will be stored for more than 3 months

X. FRUITS BANANA

Crop monitoring
Monitor the crop on a weekly basis by walking through the field examining plants to note the presence of diseases and insect pests.

1. Select a disease resistant or tolerant variety
Sources of resistance are known for the following fungal diseases:

- Panama disease
- Black sigatoka
- Yellow sigatoka

There is no true resistance against bunchy top but some varieties are more tolerant.

2. Pre-planting cultural practices
Rotate to a new area after the second season to minimize root burrowing nematode, banana weevil borer, and fruit beetle pests.

It is important to strengthen the crop’s tolerance to root burrowing nematode and banana weevil borer which occur in all plantations. Thus mix with soil in each planting hole either mustard oil cake, neem oil cake, or poultry waste along with compost before planting.

3. Root burrowing nematode (*Radophololus similis*)
The root burrowing nematode attacks the roots rather than the corm. Its damage is blocking the flow of water and nutrients throughout

the root system. The nematode is expensive to control with nematicides so a better strategy, aside from the organic amendments, is prevention by the hot water method (soak suckers in hot water bath 55^{o}C for 20 minutes) just before planting and later fertilize on a monthly basis to strengthen the plant and make it continually produce new roots.

4. Banana weevil borer (*Cosmopolites sordidus*)
More of a problem in older plantations. The larvae tunnel throughout the corm and extensive feeding damage results in slowed plant growth, reduced fruit production, and, sometimes, toppled plants. The tunneling by the grubs also makes the corms susceptible to invasion by secondary decay organisms. The adult weevils normally do not fly thus they have to walk from plant to plant.

Weevil adults are attracted to the freshly cut sections when walking about. Thus a simple trap to monitor adult density can be made from stacking two recently cut pseudostem sections (about 8 cm thick) placed on top of one another. Place 10 or so traps per hectare. A minimum of three survey counts should be made at 2- to 3-day intervals to obtain reliable estimates. An average of 5 adults per trap is the action threshold for implementing the split-pseudostem trapping method. The split-pseudostem trap uses fresh banana pseudostems cut into 1- to 1 1/2-foot lengths. The pseudostem logs are then split lengthwise through the center, and the halves are placed with the flat cut surfaces on the soil cleared of debris, one trap for every 10 plants. Remove the weevils every 5 days or so and feed them to chickens.

Trapping can be combined by using higher rates of fertilizer to strenthen the plants’ tolerance.

Practice sanitation by removing cut pseudostems and suckers out of the field to a compost pit or feed to livestock.
Select planting material for the next planting from fields with low infestation as determined from the monitoring traps.

5. Banana fruit beetle (*Nodostoma viridipennis, N. subcostatum*)
The adults feed on the surface of banana fruit causing cosmetic damage to the skin rendering the bunch unmarketable. The central leaves of the plants and fruits show scraping damage which turns dark. They do not feed on the flesh of the fruit but the appearance causes downgrading in quality. The larvae live in the soil and can tunnel to 6 inch depths to feed on banana roots.
A simple control method is to place a polyethylene plastic bag around the fruit as soon as the bunch forms. The bag (42 x 30 inches) is open at both ends and perforated by 20-30 holes made with a nail or sharp object to let the fruit breathe.

6. Banana bunchy top virus

Bunchy top is the most important virus disease of banana and is transmitted by the brown banana aphid, *Pentalonia nigronervosa*, which commonly occurs in the funnel leaf and between leaf sheaths. The disease is called bunchy top due to the progressively shorter leaves that emerge as it ages. Dark green broken dashes can be seen along the basal region of the leaf blade during the early stage of infection. The systemic virus stays in the plant throughout its life and multiplies and spreads to all its parts.
There are no resistant varieties but some are more tolerant. Infected bananas seldom bear fruit and form deformed bunches and become stunted.
The two main control measures are:

- Use of virus-free planting material
- Early detection and immediate removal and destruction of infected plants (roguing).

7. Banana fungal diseases
Panama disease *Fusarium oxysporum* f. *cubense*
This soil borne disease is the most important fungal disease of bananas. Yellow streaking begins the disease manifestation leading to collapse of leaves without chlorosis. The leaf stem breaks off and the leaf blade hangs down and withers. Affected plants totally wilt and the disease is highly contagious and can destroy whole plantations very quickly.

Gros Michel and Shobra varieties are susceptible so these should be avoided and this disease made Cavendish varieties the most popular in the world.
Control:

- Use clean planting material taken from a disease free location.
- Rogue infected plants.

8. Leaf spot diseases of bananas involve four fungi. The first two are sigatoka:

- Black sigatoka *Mycosphaerella fijiensis* or (black leaf streak)
- Yellow sigatoka disease *Mycosphaerella musicola*

Black sigatoka is characterized by its stronger pathogenicity on a broader range of hosts, making it more important than yellow sigatoka.

Cordana leaf spot *Cordana musae*
A third fungal leaf disease cordana leaf spot often accompanies sigatoka. Cordana has small raised brown spots on the upper leaf surfaces. New spots are brown bordered by delicate concentric zonation and red brown margins. These gradually develop and as they enlarge the spots become pale brown oval patches, then turn grey with deeply colored zonations. The bright yellow or orange color bands make the infected leaf very conspicuous.

Black spot or feckle *Phyllostictina musarum*
The fourth disease occurs on the foliage and fruit. Numerous small and slightly raised reddish or dark brown spots appear after infection. They appear on the fruit 2-4 weeks after fruit emergence. Spots are rounded and rough.
Sanitation is carried out to remove infected lower leaves (not the whole plant) and destroying them by feeding to livestock or making compost.

As a last resort fungicides such as propiconazole (Tilt) or carbendazin (Bavistin) are applied on a 15-day schedule. Petroleum spray oil is also effective and is used in India and other countries.

9. Bacterial wilt or moko disease *Pseudomonas solanacearum*
This widespread disease causes wilt to brinjal and other vegetables and also can attack banana. The disease starts with the infection of the youngest leaf. Beginning at the tip, the disease develops downwards until the entire central part of the plant is attacked. The affected part first turns yellow and later becomes black and rotten, sometimes accompanied by a slight odor. Initially the rot is confined to the centrla heart leaf and does not penetrate into the surrounding older sheaths but as the diesase advances the entire central portion becomes rotten and the plants die.
Control
No sucker should be collected from an infected grove
Roguing (infected plants should be romoved with their roots cut into pieces and burnt)
Tools should be sterilzed in alcohol or bleach

10. Fruit-eating bats
Bats attack half ripe to ripe fruit ruining them for sale. Plastic bags placed for banana fruit beetle control will also protect against bats.

IPM Module for Master Trainers

Kharif I (summer) Season Crops

Table of Contents

Vegetables and spices are an important source of vitamins, minerals, and plant proteins in human diets throughout the world. Vegetable cultivation in Bangladesh is one of the more dynamic branches of agriculture due to its rising economic potential in agribusiness development. At the same time, vegetable cultivation is becoming more costly due to the increasing use of purchased inputs such as pesticides and fertilizers to sustain production levels and high cosmetic quality. These inputs are also a cause for concern due to their deleterious effect on human health and the environment. If one is targeting more discriminating markets then care must be taken to both reduce pesticide usage as well as use pesticides that are not registered in the importing country. Whole shipments can be rejected if residues of prohibited chemicals are detected or exceed allowable tolerance limits. IPM technologies have been developed for many vegetables and spices in Bangladesh for which pesticide residues are within the accepted WHO levels required for Good Agricultural Practices among importing nations.

The pest control technologies presented in this tutorial were developed at various research entities -- BARI, AVRDC, as well as projects IPM-CRSP (USAID funded) and DAE sponsoring SPPSP (Danish funded). An effort has been made to minimize the use of pesticides in order to minimize costs as well as residues on the commodity. Those pesticides being recommended were selected as being the least toxic and at the same time effective against the target pest.

I.PREVENTATIVE PEST CONTROL GUIDELINES FOR VEGETABLES AND SPICES

Accurate pest diagnosis is an important part of an integrated pest management program, both in the field and in storage. It is important that such pests be recognized early in their development so that effective practices can be implemented. Careful and regular monitoring of the crop (usually at least once a week) and knowledge of the field history regarding pests can provide valuable clues to estimate the potential for pest damage. Seasonal weather patterns also have a major impact on pest incidence particularly diseases. The crop should be monitored to assess the types of pests present and to estimate the potential for yield loss from not only pests, but other stresses. This is why the first step in IPM is to ensure the crop is managed to attain its agronomic potential, then the stress from pests will have less of an impact. This means that the crop should be well fertilized and cared for as a first priority as this is easier to do than to control pests, particularly if toxic pesticides are the only remedy available.

1. Seedbed and field management

For prevention of soil borne diseases, nematodes, and insects

a. Crop rotation
Planting vegetables and spices in seedbeds and fields that have been grown to wetland rice production within the same or previous crop year will result in minimal soil borne diseases, nematodes, and insects. Flooding for the duration of a rice crop kills damping-off fungi, bacterial wilt, root knot nematodes, cutworms, and other soil insects. If flooded rice was not grown in the field for vegetables and spices, select sites for seedbed and field locations, which have not been planted to crops of the same plant family for 3-4 years.

Rotate between plant families:

- Solanaceae (tomato, brinjal, potato)
- Malvaceae (okra, cotton)
- Cucurbitae (gourds, cucumber, squash, pumpkin)
- Cruciferae (cabbage, cauliflower, broccoli, radish etc)
- Amaryllidaceae (onion, garlic)
- Zingiberaceae (ginger, turmeric)
- Leguminosae (country bean, garden pea)

b. Soil amendments
Materials that reduce soil borne diseases (damping-off fungi, bacterial wilt) and root knot nematodes:

Seedbed and field *(apply either)*
Research at BARI has shown that the following amendments kill bacterial wilt and root knot nematodes (less so for damping-off fungi). Select one of the following amendments:

- Mustard oil cake (@ 300 kg/ha) (should be 15 days old) Price about Tk 10/kg (best)
- Neem oil cake (@ 200 kg/ha) (best)
- Poultry waste (manure) (@ 3 t/ha) (should be at least 6 months to 2 years old (next best)
- Burning sawdust (@ 6 cm thick) (next best) (particularly good for seedbeds and after burning incorporate the ashes into the soil) Price about Tk 700/t)

Does not directly kill wilt or nematodes:

- Cow dung (@ 5 t/ha when dry) (good but will bring in weed seeds)

If mustard oil cake, neem oil cake, poultry waste or sawdust is used, there is no need for cow dung or other organic matter to improve soil fertility

ii. Seedbed only (if soil amendments were not possible to use)

- If the seedbed is a raised bed, cover with polyethylene sheet and seal the edges with soil to make it airtight (solarization or the sun’s heat sterilizes the soil, however 3-4 weeks of sunny days is required for the sterilization effect to work)

2. Seed health
A number of pathogens are transmitted on the seed such as damping off fungi (*Pythium, Phytophthora, Rhizotonia, Fusarium, Sclerotium*) and various bacterial diseases. A small effort in prevention can be rewarded by large benefits if one of the following practices is followed to obtain seed free of fungal or bacterial spores:

- Purchase clean seed (tin or tightly sealed packet from a commercial seed company)
- Sterilize seed with 2% solution of bleach/Clorox (sodium hypochlorite) for 10 minutes and dry
- Clean seed with hot water (52^{o} C) for 15 minutes and dry (a special apparatus can be purchased in Bangladesh to facilitate hot water seed treatment)
- Treat seed with fungicide seed treatment (Vitavax [= carboxin + thiram] or Bavistin [carbendazin])

3. Destruction of crop residue after harvest will prevent continuous source of diseases and insect pests. Use the residue as fuelwood, livestock feed, or place in compost pit to make organic fertilizer.

4. Split nitrogen fertilizer applications in 3-4 times to encourage continuous root development to outgrow nematode damage as a tolerance mechanism against root knot nematode.

Frequently recommended are biorational soap and neem sprays:

Recipe for soap spray
(10 g of Wheel detergent powder per 10 liter sprayer)

Recipe for neem spray (either from kernels or leaves)
a. from kernel
Grind kernels to obtain oil or purchase neem oil
For 10 liters add

- 200 ml neem oil
- 50 ml liquid detergent (Treat)

b. from leaves soak leaves overnight

II. VEGETABLES GOURDS

Three gourds will be considered together as their pest complexes are similar. These are pumpkin (sweet gourd), pointed gourd, and bitter gourd.

Crop monitoring

Monitor the crop on a weekly basis by walking through the field examining plants (look on undersides of leaves) to note the presence of diseases and insect and mite pests.

1. Varietal selection.
There are varieties of pointed gourd, bitter gourd, and sweet gourd having resistance or tolerance against any number of pests including root knot nematode, bacterial wilt, powdery mildew, leaf spot, and downy mildew plus virus diseases. Review the pest resistance ratings for the varieties available to you. Select a variety having resistance or tolerance against a particular pest if it is prevalent in your area. Genetic resistance is the least expensive of pest control measures.

2. Damping-off fungi, bacterial wilt, and root knot nematode control
Follow the preventative guidelines outlined in section I including crop rotation, use of soil amendments or chemical control measures, and disease free seed. Soil amendments need only be applied for each planting hill rather than the whole field.

- Damping-off fungi: *Pythium, Sclerotium, Rhizoctonia, Phytophthora, Fusarium*
- Bacterial wilt *Ralstonia* (formerly *Pseudomonas*) *solanacearum*
- Root knot nematode *Meloidogyne* spp.

3. Bacterial wilt, fungal disease, and root knot nematode control

- Select the most adapted disease and nematode resistant or tolerant varieties

4. Root knot nematode (*Meloidogyne* spp.)
Split nitrogen fertilizer applications in 3-4 times to encourage continuous root growth to outpace nematode damage

5. Melon fruit fly *Bactrocera* (formerly *Dacus*) *cucurbitae*
Melon fruit fly inserts its eggs in more than 80 hosts. It attacks all the gourds but pointed gourd less than others. The damage results from 1) oviposition in fruit and soft vegetative tissues, 2) feeding by the larvae, and 3) decomposition of plant tissue by invading secondary microorganisms let in by the entry wounds. Larval feeding damage in fruits is the most damaging. Young fruits become distorted and usually drop. The larval tunnels provide entry points for bacteria and fungi that cause the fruit to rot and render the crop unmarketable. Melon flies are strong fliers. Adults may be found resting in shaded areas of bushes or trees, often a considerable distance from a crop. Flight is most common in the morning and late afternoon. Adults feed on juices from decaying or damaged fruit. This attraction for food sources is a means to their control using baits. There are two types mass attractant bait traps, which work best when, used together.

- A mashed gourd trap is made with 100 g of mashed sweet gourd fruit set in a clay pot mixed with 5 drops of insecticide

(MICP, Dipterex or Lebaycid). The height of the trap is adjusted to be just above the crop canopy. The mashed gourd should be changed every 3-5 days in the summer and each week in the winter. This trap is effective as it attracts both sexes of flies.

- Cuelure trap contain cuelure which is a chemical produced by the females to attract males. A soaked cotton wad with cuelure is placed in a plastic jar with two triangular sections cut out on two opposite sides. The jar is filled ¼ full with water and detergent is added to make the flies drown. The cuelure traps collect 5-10 times more flies than the mashed gourd trap.
- Sanitation should also be carried out by destroying damaged fruit breeding sites. Remove and bury (1 meter deep pits) all unmarketable fruits and dispose of crop residues immediately after harvest.

6. Chewing, sucking, and boring insect pests

- Pumpkin beetle *Aulacophora* [=*Raphidopalpa*] *foveicollis, A. abdominalis*, *A. frontalis*

Adults of the three species feed on the foliage, flowers, and fruits while the larvae feed on roots. It is the adult stage where the three species can be distinguished. The adult of *A. foveicollis* is red orange, while *A. abdominalis* is orange, and *A. frontalis* is bluish. Leaf feeding results in circular holes as the beetle turns around while eating. Crop damage is most severe if adults mass attack seedlings, forcing replanting. Flowers can be so consumed that fruits will not develop. Circular scrapings on the fruit surface reduces marketability. Larvae can enter underground stems, killing the entire plant.

- Epilachna beetle *Epilachna 12-puntata, E. 24-punctata*

Both larvae and beetles feed by scraping chlorophyll from epidermal layers of leaves making characteristic feeding marks which then gradually wither.

Control

- Both of these groups of beetles can be collected by hand nets and destroyed
- Action threshold: Monitor the crop weekly and when 15% leaf loss occurs (note this is actual leaf area removed not 15% damaged leaves)
- Select insecticides which are less harmful to pollinating bees such as:

  - Neem (neem oil or Nimbecidine)

Method of making neem oil
Grind kernels to obtain oil or purchase neem oil
For 10 liters add:

- 200 ml neem oil

- 50 ml liquid detergent (Treat)
- 10 liters water

Another method is to soak neem leaves overnight in water or to grind the leaves and make a solution to spray.

- Aphids Melon aphid *Aphis gossipyi*

Aphids can become very abundant especially during a dry spell and make large colonies under the leaves of gourds. The gourd leaves protect them from the rain, which would otherwise wash them off the plants if they were exposed. Several species attack gourds and they are generally light green in color. Aside from the direct damage of removing plant sap thus weakening the plant they also transmit several virus diseases such as mosaic and ringspot.
Control

- Aphids can be controlled with neem or soap

- Whiteflies *Bemisia tabaci*

These small white insects occur on all gourds and become very abundant if one sprays frequently with the more toxic insecticides (such as cypermethrin etc). If the leaves on which they are resting are disturbed they dart off in all directions in flight. The toxic insecticides kill their natural enemies causing them to increase in number greatly. They can be controlled if toxic insecticides are substituted with soap and neem products.

- Stem fly *Lasioptera falcata* Cecidomyiidae

This is a small fly, much the same size as a mosquito whose larvae feed on plants in the same way as fruit flies. It is more important on bitter gourd. Larval feed on the tips of shoots or along the vine, which produces a gall or thickening to protect them. Opening of the gall reveals the maggot like larva. Incidence is low and the damage appears to be minor. Control is not necessary.

- Shoot borer *Melittia indica* Sessidae

The shoot borer is more prevalent on pumpkin. The white stout larva of this moth tunnels within the stem. Damage first appears as a sudden wilting of a long runner or an entire plant. Closer examination reveals masses of coarse, greenish-yellow excrement which the borer has pushed out from the stem. Splitting the stem may reveal a thick, white, wrinkled, brown-headed caterpillar up to 1 inch long and almost 1/4 inch thick. Larvae leave their burrows and make a cocoon in the soil. Injured vines often decay and become wet and shiny. The adult is a day flying moth that has a metallic green black body and clear hind wings. Its appearance and behavior mimics that of large wasps which scare off potential predators. The moths fly slowly in zigzagging around plants, and lay eggs singly on stems.
Control

- Vines should always be destroyed following harvest to prevent late caterpillars from completing their development
- Heavy fertilization to promote rapid growth
- Sometimes injury can be offset by late and staggered plantings
- Planting early susceptible varieties as "trap crops" only serves as an indicator of shoot borer's initial presence and that control practices should commence

➢ Gourd shoot borer *Apomecyna neglecta* longhorned beetle Cerambycidae

The larva of this small long horned beetle is more a pest of pumpkin and bottle gourd. Longhorned beetles are normally pests of trees but some small ones have adapted to annual crops. The adult is grey with white spots on the wing covers and less than 2 cm in length with long antennae reaching 2/3 of the body length. The adult beetle chews a hole in the stem in which to deposit eggs. At times the stem is severed during this process. Fortunately this is an infrequent pest. Its larvae bore into the main vines and produce a swelling of the stem. The feeding tunnel is usually directed towards nodes and is filled with glutinous waste material. Other than scar tissue at the site where the larvae entered the stem, infested plants usually show no conspicuous symptoms. Pupation takes place within the stem. Under very severe infestations young plants may die, but older plants often live to produce fruit at reduced yields.

Control

- Grow a vigorous crop that can tolerate the damage

7. Fungal diseases

➢ Powdery mildew *Oidium* sp. and *Erysiphae cicoracearum*

Symptoms appear first as pale yellow spots on leaves (mostly on the upper surface) and stems. Soon thereafter sporulation becomes evident as white powdery masses are produced over the lesion surface. Lesions frequently are numerous and coalesce to cover the enter leaf surface. Leaves become chlorotic, then turn brown and dry prematurely. The whole plant may succumb. Conditions that favor disease development are warm days and cool nights fostering long periods of dew on the leaves that are needed for the fungal spores to germinate and penetrate into the leaf tissue. The disease probably survives on wild hosts and is transmitted by the wind. Also spores can survive in the soil and germinate when a host is planted nearby.

➢ Leaf spot *Cercospora* sp.

Leaf lesions are circular, about 1-cm in diameter, with brown borders and light centers. Severe infection can cause leaf drop, with or without leaf yellowing. The fungus survives on seed and crop debris. Extended rainy periods, long periods of leaf wetness, and close plant spacing enhance disease development.

➢ Downy mildew *Pseudoperonospora cubensis*

The fungal disease can be damaging to all cucurbit crops, bitter gourd and watermelon are particularly susceptible. Symptoms occur mainly on the leaves where they begin as yellow spots on upper leaf surfaces and later greyish fuzzy (like down) fungal growth on underside of spots. Yellow halos surround each spot and the spots coalesce as the disease spreads. Leaves turn brown and wilt with age causing high yield loss if widespread on the plant. Infection spreads quickly during periods of high moisture from dew, fogs, or rainfall. The fungus is spread by air currents or rain splash. The fungus perpetuates on crop residue so it should be removed after harvest.

All three diseases can be controlled by a different set of fungicides. Rotate the following fungicides to prevent resistance

Apply twice (again after 15 days) when 10% of plants show disease symptoms. Additional sprays should only be given if the disease continues to spread

Family	Fungicide	Powdery	Downy	Cercospora
Sulfur	Thiovit	Yes		Yes
Conazole	Score	Yes		Yes
	Tilt	Yes		Yes
Benomyl	Benlate	Yes	Yes	Yes
Maneb	Dithane M45			Yes
	Penncozeb		Yes	Yes
	Ridomil MZ		Yes	Yes
	Acrobat		Yes	Yes

8. Virus diseases (both are potyviruses)
   - Mosaic virus or WMV2 (watermelon mosaic virus 2)
   - Ringspot virus (papaya ringspot virus)

Each virus produces similar symptoms and mixed infections are common. The first symptom is a clearing of veins, followed by development of mosaic patterns or mottling consisting of irregularly shaped, dark green areas alternating with light green or yellow areas. Leaves on some species and cultivars are drastically reduced in size and growth is often retarded. Watermelon mosaic tends to cause raised, blister-like areas on leaves. Leaf size is reduced severely. Both viruses are transmitted by many species of aphids. After feeding on an infected plant, aphids only retain the ability to transmit these viruses for very short periods of time (minutes to a few hours). In general, spread of potyviruses in the field occurs when aphid activity is high and is often very rapid and localized.

Control
   - Mulch reduces aphid colonization rates
   - Rogue infected plants and destroy them.
   - Control the aphid vector

Neem product or soap

9. Rats feed on the maturing fruit destroying market quality. They are abundant near wheat fields or abandoned areas where tall shrubs or grass grows

Control

- Rats can be controlled by baiting and removing brush and grasses from bordering areas

III. COUNTRY BEAN AND FRENCH BEAN

Crop monitoring

Monitor the crop on a weekly basis by walking through the field examining plants (look on undersides of leaves) to note the presence of diseases and insect and mite pests.

1. Varietal selection

There are varieties having resistance or tolerance against a number of pests including root knot nematode, anthracnose, and virus diseases. Review the pest resistance ratings for the varieties available to you. Select a variety having resistance or tolerance against a particular pest if it is prevalent in your area. Genetic resistance is the least expensive of pest control measures.

2. Nematodes

Root knot nematode *Meloidogyne incognita*

Plant parasitic nematodes are microscopic roundworms that feed on plant roots. They survive in soil and plant tissues, and several species may occur in a field. They have a wide host range and vary in their environmental requirements and in the symptoms they cause. Not only do they cause physical damage from their feeding that blocks the uptake of water and nutrients, but the wounds they cause while invading roots allow the entry of rot causing organisms. Symptoms described below are indicative of a nematode problem, but are not diagnostic as they could result from other causes as well. Above ground symptoms of severe root knot infestation include patches of chlorotic, stunted, necrotic, or wilted plants. Infested plants that are also under moisture or temperature stress may wilt earlier than other plants. Feeding by root knot nematode incites cell enlargement and proliferation resulting in swellings, called galls, on roots. These galls are diagnostic for root knot nematode. Severely galled roots may be shortened and thickened. Galls caused by root knot nematodes may be confused with nodules of nitrogen-fixing Rhizobium bacteria. Rhizobium nodules when opened, however, are pink inside and come off the root easily when rubbed. Root knot galls cannot be separated from the root.

Control

- Crop rotation

- Flooded rice in particular greatly reduces root knot populations
- Soil amendments (mustard oil cake, neem oil cake, poultry waste, burning sawdust)
- Plowing during the fallow season will expose nematodes to drying and eliminate weeds that can host this pest
- Some resistant or tolerant varieties are available

3. Soil borne diseases

Damping-off fungi
These soil-borne fungal diseases attack newly planted seedlings. Five genera of fungi are listed in the order of prevalence -- *Pythium, Sclerotium, Rhizoctonia, Phytophthora, Fusarium*. Early symptoms are drooping of plants and eventual wilting and death as nutrients are blocked from passage both up and down the vascular system.

Pythium spp. usually cause pre-emergence rot and in some cases damping-off of young seedlings. Symptoms include water-soaked lesions with eventual collapse of the base of the stem at or below ground. Occasionally, older plants are infected and develop water-soaked lesions that extend some distance up the stem, causing a linear band of dead tissue. *Rhizoctonia solani* causes post-emergence damping-off of the seedlings that is characterized by sharp-edged oval to elliptical reddish brown lesions on the stem base. Heavy infection may girdle the stem and the seedlings may die.
Control
- Fungicide seed treatment Carboxin + thiram (Vitavax 200) or carbendazin (Bavistin)

4. Leaf and stem fungal diseases

Stem rot *Sclerotium sclerotiorum*
This damping-off soil fungus is among the most nonspecific, omnivorous, and successful of plant pathogens. Aside from attacking newly emerged seedlings it can persist in the plant and infect at later stages. The more common symptoms in later stages are water-soaked spots on fruits, stems, leaves, or petioles which usually have an irregular shape. These spots enlarge and a cottony mycelium covers the affected area. The fungus spreads and the plant becomes a soft, slimy, water-soaked mass. The cottony fungal growth usually produces numerous black seed-like resting bodies the size of mustard seed, a reliable diagnostic sign of Sclerotium (these usually do not form until after host death). In contrast to the water-soaked symptoms, the host may exhibit "dry" lesions on the stalk, stems, or branches, with an obvious definition between healthy and diseased tissues. The lesions enlarge and girdle the plant part. Upper portions of the plant become yellow, then brown, before dying. The girdled portion is often the base of the plant which blocks

nutrients and water causing the plant to wilt. Pods can become infected, while on the plant and post-harvest.

Control

- Crop rotation
- Remove plant residue from the field after harvest to remove sources of inoculum
- Plow deeply to bury spore resting bodies and plant debris.
- Disease free seed or fungicide seed treatment (Vitavax 200)
- Soil amendments (mustard oil cake, neem oil cake, etc)

Phomopsis stem and seed blight

The fungus attacks all parts of the plant. Infection begins in the seedling usually from infected seed and can cause seedlings to wilt. Infected leaves show circular grey to brown spots with light colored centers. Symptoms of the fungus are readily apparent after the plants reach physiological maturity. Dead petioles, stems, and pods result and the diseased areas may be covered with small black specks, which are the fruiting bodies of the fungus. Seeds that are infected have a range of symptoms from none to severe. Affected seed are usually cracked, shriveled, and covered with white mold. These severely infected seeds rarely germinate when planted. The disease is spread in two ways. Its spores are carried with the seed and but it also multiplies in the field on crop residue left from previous crops. Rain splashes and spreads the spores emanating from the residue to nearby plants.

Leaf spot *Cercospora*

This common fungal disease is most notable on bean leaves. Leaf lesions are circular, about 1-cm in diameter, with brown borders and light gray centers. Severe infection can cause leaf drop, with or without leaf yellowing. Lesions on stems, leaf petioles, and pod peduncles are elliptical with dark borders and grey centers. The pods do not become infected. The fungus survives on seed and in infected crop debris possibly for one year. Disease usually gets started in the seedlings infected from the seed. Extended warm rainy periods, long periods of leaf wetness, and close plant spacing enhance disease development.

Anthracnose *Colletotrichum*

Seedlings grown from infected seeds often have dark brown to black sunken lesions on the stems and growth of the plants is stunted. Diseased areas may girdle the stem and kill the seedling. Under moist conditions, small, pink masses of spores are produced in the lesions. Spores spread to the leaves. Symptoms generally occur on the underside of the leaves as linear, dark brick-red to black lesions on the leaf veins. As the disease progresses, the discoloration appears on the upper leaf surface. The most striking symptoms develop on the pods. Small, reddish brown to black blemishes and distinct circular, reddish brown lesions are typical symptoms. Mature lesions are surrounded by a circular, reddish brown

to black border with a grayish black interior. During moist periods, the interior of the lesion may exude pink masses of spores. Severely infected pods may shrivel, and the seeds they carry are usually infected. The disease spreads in infected seeds and from plant debris left in the field.

Control for the above three fungal diseases:

- Resistant varieties
- Crop rotation
- Clean seed
- Remove crop residue after harvest
- Spray mancozeb (Dithane M45 etc), carbendazim (Bavistin), or propiconazole (Tilt)

5. Virus diseases

Yellow mosaic virus Potyvirus

Aphids vector this virus. The diagnostic symptom of bean yellow mosaic is the bright yellow to green mosaic or mottle appearance of infected leaves, which becomes most apparent on leaves as they become older. Infected leaves also show varying degrees of leaf distortion, down cupping, and wrinkling. Plants infected at a young age may show stunted growth. The striking yellow mosaic symptoms differentiate bean yellow mosaic infections from those of bean common mosaic, which causes light and dark green mosaic patterns of infected leaves. In infected plants leaf size becomes reduced and fewer and small pods occur. Pods are deformed and contain shriveled and undersized seeds. The size of leaves and pods is not reduced in plants showing necrotic mottle. The virus is not transmitted by sap, seed, or mechanically.

Control

- If the virus symptoms are seen rogue infected plants and spray for aphids with soap or neem product

Yellow leaf curl virus (YLCV) Gemini virus

V is the same virus that attacks tomato. It is vectored by whiteflies. The whitefly can acquire the virus in 15-30 minutes on an infected plant. Infective whiteflies can then retain the virus for 10-12 days and introduce it into many healthy tomatoes. After this 10-12 day period, these infective whiteflies must reacquire this virus by feeding upon an infected plant again. Symptoms become visible in approximately 2–3 weeks after infection. Leaf symptoms include yellowing between the veins and along the margins, small leaves that are cupped, thick and rubbery. The majority (up to 90%) of flowers fall off after infection, and therefore few fruits are produced.

trol

- If the virus symptoms are seen rogue infected plants and spray for whiteflies with soap or neem product

Bean common mosaic virus BCMV

This virus is spread worldwide and has many genes for resistance thus check if the variety you have selected has resistance. Typical symptoms in bean consist of green mosaic and downward cupping along the main vein of each leaflet. Green vein banding, blistering, and malformation are common in leaves of the same plant. Plants are reduced in size, and pods may be mottled and malformed. BCMV is seed borne in bean, especially if the seed was produced locally. The virus is efficiently transmitted by several aphid species including cowpea aphid, pea aphid, potato aphid, and the green peach aphid.

Control

- Seed sterilization with bleach if the area has a history of the disease
- Spray the aphids with neem or soap product

6. Seedling insect pests

Beanfly *Ophiomyia phaseoli*

The bean fly is a small, black and shiny (the size of the head of a match stick). It can best be seen resting on the leaves of young plants early in the morning but will fly off to neighboring plants if disturbed. The adult punctures the leaf and laps up the plant sap that emerges. Each feeding site results in a small yellow spot on the leaf top. The many yellow spots (stippling) are a sign of its presence. The female inserts her eggs singly into the leaf tissue and the emerging larva becomes a leaf miner, tunneling to the midrib of the petiole and then down the stem, feeding on the plant tissue as it goes. The vascular system is injured and seedlings become yellow and stunted. Its damage can kill seedlings particularly if they are under moisture stress at the same time. Stems are often thicker than normal and cracked lengthwise just above the soil line. The pupae form at the soil line. The larvae can be seen by splitting the stem.

Control

- If the plants are well watered and fertilized the crop can tolerate the damage
- If however damage is common in the area it can be controlled with seed treatment insecticide imidachlorprid (Gaucho, Cruiser)

7. Sucking insect pests

Bean aphid *Aphis craccivora*

Winged aphids find new plantings and begin to multiply. A colony of young forms around the winged female and as the life cycle is short they produce many offspring within a few weeks. They remain in one place most of the time feeding by inserting their long straw-like mouthparts and such up plant sap rich in sugars. Aphids damage plants by: (1) sucking plant sap which causes heavily infested leaves to curl and stunts plants, (2) excess plant sap is excreted (honeydew) which falls like rain over the plant and becomes infected

by black sooty-mold fungus growth and ruins the quality of the pods, and (3) spreading plant diseases (most bean viruses are vectored by aphids). Injured leaves curled downward. The common bean aphid is black. Aphids are more of a problem in kharif as monsoon rain normally keeps them in check.

Control

- Spray soap or neem when several colonies are found per plant

Stem bug *Coptosoma*

This shiny black bug the size of one's small fingernail can be seen feeding in groups on the young stems removing plant sap. It is a minor pest and can be tolerated. It rarely would become sufficiently abundant to cause injury. It has a wide host range among legume crops and weeds.

Jassid *Amrasca devastans*

Jassids are small, bright green, with elongated bodies. The small, wingless nymphs (immatures) are also green and move rapidly forward, backward, and from side to side. Both adults and immatures are found primarily on the underside of leaves. Jassids cause a symptom known as hopperburn in which the leaf margins turn yellow, particularly at the leaf tip, and these areas soon dry up. The entire leaf may become yellowed and the symptoms often resemble virus symptoms. The presence of adult and immature leafhoppers on the undersurface of the leaf serve to distinguish leafhopper injury from virus symptoms. Healthy, actively growing crops tend to tolerate jassid infestation and do not generally require spraying.

Control

- AT is 1 hopper per trifoliate leaf or when hopperburn symptoms first appear spray soap or neem solution

Thrips *Thrips palmi, Megalurothrips usitatus*

Thrips palmi is yellowish while Megalurothrips is black. Both species attack young developing leaves. They hide and feed within the small terminal leaves of new shoots. The saliva they inject while feeding causes the leaves and flowers to become deformed. They are very small insects that feed within the flowers once they are open. These sucking insects cause flower drop. Thrips can be detected by opening up the flowers and inspecting inside. Flowers and flower parts become brown, dried, and drop early. Pod production is low and pods are deformed. They pupate in the soil so during the monsoon season their numbers are usually low. They can reproduce rapidly and disperse in the wind.

Control

- AT is 2 thrips per leaf terminal or 4 thrips per flower, if exceeded spray with applications of soap or neem

8. Insect defoliators

Foliage feeding caterpillars that can often be found in bean crops, but rarely warrant spraying unless they occur in very high numbers.

There are many species that feed on foliage. Control is based on the collective defoliation of all of them.

Leaf miner *Cosmopteryx* sp.
Two types of leaf miners attack beans, flies and moths. Cosmopteryx is a small (5-6 mm) moth that lays its eggs on a leaf blade. The emerging larvae immediately tunnel within the blade feeding as they go. Their tunnels can be seen on the leaf blade and often are spiral or irregular patterns. The tunnel widens as the larva ages. The actual damage that a leaf miner causes is minimal except if there are many or that they are present on young plants. They are normally kept in check by parasitoids but become highly abundant if very toxic insecticides are used which kill off the parasitoids.

Hairy caterpillar *Spilosoma* (= *Diarcrisia*) *obliqua* Arctiidae
The hairy caterpillar feeds on a very wide range of plants. This large hairy caterpillar feeds gregariously as young larvae that hatched from the same egg mass. As such the damage can be highly concentrated and can even kill a young plant. As the larvae age they disperse. The larvae are so large that even one can cause extensive damage to a plant. The adult moth is white with red markings. Normally the damage can be tolerated.

Semilooper *Plusia orichalcea*
The light green larvae of is small moth are not true loopers as they have more than one set of legs at their rear, but the central legs are missing and it moves by arching its back forming loops as it moves. They are often difficult to see on a leaf as they blend in well. The larvae reach 5 cm in length. The larvae attack and feed on the leaves between the large veins and midribs. It pupates on the plant and like most defoliators has a wide host range.

Leaffolder *Hedylepta indicata*
This medium sized larva binds several adjacent leaves together with the silken thread it produces to make a protective shelter in which to feed, hiding from natural enemies. The larvae feed on the leaves and when they are consumed move to form new shelters elsewhere on the plant.

Control of defoliators

- Before flowering the crop can tolerate up to 40% leaf loss without loss in yield, after flowering the amount that can be tolerated is around 25% or less. These are guidelines to judge if control measures are warranted
- The large larvae can be removed by hand
- Otherwise spray neem

9. Spider mite *Tetranychus* sp.
Spider mites are very small plant feeding relatives of insects. They have eight legs instead of six as in insects. They have needle like

mouthparts and remove the plant sap from tissues leaving a clear mark on the leaf denoting that the green color has been removed. The characteristic damage symptom is observable from the tops of leaves. They are very vulnerable to being washed off the plants by heavy rains thus they live on the protected undersides. They are called spider mites because they secrete silk webs in which they hide from predators. Many of them are normally present and collectively can do much damage to the plant. They can complete a generation in less than a week and thus multiply quickly. They are normally held in check by their predators (usually other mite species). They become abundant during periods of drought and if toxic insecticides have been used that kill the predatory mites.

Control

- If the population is causing leaves to wilt then apply neem or soap solution

10. Pod borers

There are three species of pod borers which can all be in the same field. Each has different behavior and preferred seasons when they are most abundant. The bean pod borer and bean lycaenid are specialists on legumes whereas Heliocoverpa the earworm feeds on many species, thus its abundance is a function of the presence of hosts or nonhosts.

Bean pod borer *Maruca testulalis*

Maruca is the most common bean pod borer and thus the most important. It first appears at flowering. The female moth lays eggs on the flower and the young larvae feed on the petals and later enter the green pods. Their preferred food is the developing seeds which are most nutritional. Usually there is only one larva per pod and it feeds on all the seeds from the inside. Can infest beans during budding and flowering. The larvae are up to 1.8cm long and are yellow-green in color with rows of dark spots along the sides of the body. The larvae feed on buds, flowers and pods and early detection and control is important.

Control

- Spray neem if more than 3 larvae per meter are detected.

Earworm *Heliocoverpa armigera*

Heliocoverpa does most of its economic damage by feeding on flowers and seed pods as they develop. While infestations may sometimes also occur during the vegetative stage, the crop will tolerate a moderate amount of leaf feeding and defoliation. When the green pods develop it feeds, on the seeds from the outside and is often seen with its head stuck in the pod in feeding position. When scouting for open flowers and check for the small larvae. Look into the first forming green pods for signs of the larvae feeding on seeds.

Control

- Spray neem when there is more than 1 larva per two meters of row. Better control is attained the younger the larva. The large stage larva is essentially impossible to control.
- In India a virus disease (NPV) of Heliocoverpa has been commercialized. It is highly contagious and farmers can collect diseased larvae which they mash about 1-2 per 10 liters and spray directly and obtain good control.

Bean lycaenid *Euchrysops cnejus*
The bean lycaenid is a small blue butterfly whose larva feeds on the seeds in the bean pods. It is most prevalent on country bean. The blue butterflies are often seen flying during the day over the crop when the crop is flowering or setting pods. Eggs are laid on flowers and the larvae feed on the flowers and finally the developing seeds in the pods. The larvae have an unusual shape, being very flat and broad. They are green and blend in well. It is rare however to find them very abundant.
Control
- Spray neem if more than 3 per linear meter occur.

11. Seed and storage pests

Stink bugs
Stink bugs are the main insect pests of bean seeds. These insects feed on the developing seed, and while they can significantly reduce yields their biggest impact is on seed quality. Bugs damage beans by piercing the pods and sucking on the developing seed inside with their long needle-like mouthparts. As a result, small pods and seeds abort, partially developed seeds shrivel, and larger developed seeds are spotted and stained. Beans can usually compensate for early damage by increasing the size of undamaged seed. Check crops twice weekly from pod set onwards. Distribution is usually patchy through a field, so check extensively. Bugs often come to the top of the canopy to bask for sunlight between 7 to 9 am so a check at this time is best. During the heat of the day they move further down into the canopy.
Control
- AT is 1 bug per 5 meters of row
- Spray neem

Bruchid weevil *Callosobruchus chinensis*
Bruchids are small weevils that are a major pest of beans in store. However, field infestation is also common with the female depositing eggs on the surface of seeds and green or ripe pods. The young grubs burrow into the pod or grain and continue to develop inside the grain. Harvested grains carry the weevils to the store. The holes seen on pulses are the exit holes from where the adults have emerged. Such grains are unsuitable for sowing.
Control
- Fumigation of grain

IV. GARDEN PEA

Crop monitoring
Monitor the crop on a weekly basis by walking through the field examining plants (look on undersides of leaves) to note the presence of diseases and insect and mite pests.

1. Varietal selection
Select varieties that may be tolerant or resistant to fungal diseases and nematodes

- Powdery mildew
- Downy mildew
- Root knot nematode

2. Nematodes

Root knot nematode *Meloidogyne incognita*
Plant parasitic nematodes are microscopic roundworms that feed on plant roots. They survive in soil and plant tissues, and several species may occur in a field. They have a wide host range and vary in their environmental requirements and in the symptoms they cause. Not only do they cause physical damage from their feeding that blocks the uptake of water and nutrients in the root vascular system, but the wounds they cause in entering the roots also allow the entry of rot causing organisms. Symptoms described below are indicative of a nematode problem, but are not diagnostic as they could result from other causes as well. Above ground symptoms of severe root knot infestation include patches of chlorotic, stunted, necrotic, or wilted plants. Infested plants that are also under moisture or temperature stress may wilt earlier than other plants. Feeding by root knot nematode incites cell enlargement and proliferation resulting in swellings, called galls, on roots. These galls are diagnostic for root knot nematode. Severely galled roots may be shortened and thickened. Galls caused by root knot nematodes may be confused with nodules of nitrogen-fixing Rhizobium bacteria. Rhizobium nodules, however, are pink inside and come off the root easily when rubbed. Root knot galls cannot be separated from the root.
Control

- Some resistant or tolerant varieties are available
- Crop rotation (planting after flooded rice in particular greatly reduces root knot populations)
- Soil amendments (mustard oil cake, neem oil cake, poultry waste, burning sawdust)
- Plowing during the fallow season will expose nematodes to drying and eliminate weeds that can serve as a host

3. Soil borne fungal diseases

Damping-off fungi
These soil-borne fungal diseases dwell in the soil for long periods and attack newly planted seedlings. Five genera of fungi are listed in the order of prevalence -- *Pythium, Sclerotium, Rhizoctonia, Phytophthora, Fusarium*. Early symptoms are drooping of plants and eventual wilting and death as nutrients are blocked from passage both up and down the vascular system.

Pythium spp. usually cause pre-emergence rot and in some cases damping-off or wilting of young seedlings after emergence. Symptoms include water-soaked lesions with eventual collapse of the base of the stem at or below ground. Occasionally, older plants are infected and develop water-soaked lesions that extend some distance up the stem, causing a linear band of dead tissue. *Rhizoctonia* causes post-emergence damping-off of the seedlings that is characterized by sharp-edged oval to elliptical reddish brown lesions on the stem base. Heavy infection may girdle the stem and the seedlings may die.
Control

- Fungicide seed treatment carboxin + thiram (Vitavax 200) or carbendazin (Bavistin)

4. Foliar fungal diseases

Powdery mildew *Erysiphe polygoni*
The infection begins as small white specks and the powdery patches appear on both sides of the leaf and pods. The typical white powdery mass is produced on all above ground parts. These spots are easily rubbed off and there are no visible symptoms underneath them. Later, yellow blotches develop on both upper and lower leaf surfaces, which eventually turn purple-brown. At this stage, small, black fruiting bodies can be found in the infected tissue. Powdery mildew spreads rapidly, and can cover a large portion of the plant in a matter of days. Pods are generally malformed, small, poorly filled, and may fall off from the plant. In cases where the disease epidemic starts early and causes severe symptoms, the crop may become stunted and seed yield and quality are reduced. Powdery mildew can be seed-borne but usually is wind dispersed. The disease is harbored in plant debris after harvest. Dew formation and lack of rainfall also favor the development of the disease. Optimum temperatures for development are between 20-25^{o} C. Rain showers are actually disruptive to the spread of powdery mildew. The inoculum is spread by wind. Once it is established, powdery mildew increases very rapidly.
Control

- Crop rotation
- Resistant variety
- Early maturing variety
- Disease free seed
- Sanitation by destroying crop residue after harvest

- Field isolation may assist in reducing infection which occurs by wind movement
- Avoid heavy application of fertilizer
- Foliar fungicides sulfur (Kumulus, Thiovit), propiconazole (Tilt), carbendazin (Bavistin), difenoconazole (Score)

Downy mildew *Peronospora pisi*
This fungal disease first appears on the lower leaves of the plant and then progresses upward. Diseased tissue turns grey and dries up causing premature leaf fall. The underside of the leaves becomes covered with a fluffy grey spore mass; the tops of the leaves develop pale yellow-brown blotches directly over the spore masses. In severe infections, plants are a pale-yellowish green color, stunted and distorted. Flowers and pods may also become infected. On the pods, the patches are pale green and elliptical and gradually turn brown and may be deformed in appearance. The downy mildew fungus infects seeds and survives in the soil and on crop residue. Systemic and leaf infections of seedlings may occur from these sources. The infected seedlings then act as a source of disease for surrounding plants.
Control
- Rotate the crop
- Use disease free seed
- Dispose of plant residue after harvest
- Spray mancozeb (Dithane M45, Penncozeb, etc), benomyl (Benlate)

5. Seedling insect pest
Beanfly *Ophiomyia phaseoli*
This is a major insect pest of the seedling stage. The bean fly is a small, black, and shiny (the size of the head of a match stick). It can best be seen resting on top of leaf blades of young plants early in the morning but will fly off to neighboring plants if disturbed. The adult punctures the leaf and laps up the plant sap that emerges. Each feeding site results in a small yellow spot on the leaf top. The many yellow spots (stippling) are a sign of its presence. The female inserts her eggs singly into the leaf tissue and the emerging larva becomes a leaf miner, tunneling to the midrib of the petiole and then down the stem, feeding on the plant tissue as it goes. The vascular system is injured and seedlings wilt and become stunted. Its damage can kill seedlings particularly if they are under moisture stress at the same time. Stems are often thicker than normal and cracked lengthwise just above the soil line. The pupae form at the soil line. The larvae can be seen by splitting the stem. If the plants are well watered and fertilized the crop can tolerate the damage
Control
- If damage is common in the area it can be controlled with seed treatment insecticide imidachlorprid (Gaucho, Cruiser)

6. Plant sap sucker insect pests

Jassid *Amrasca devastans*
Jassids are small, bright green, with elongated bodies. The small, wingless nymphs (immatures) are also green and move rapidly forward, backward, and from side to side. Both adults and immatures are found primarily on the underside of leaves. Jassids cause a symptom known as hopperburn in which the leaf margins turn yellow, particularly at the leaf tip, and these areas soon dry up. The entire leaf may become yellowed and the symptoms often resemble virus symptoms. The presence of adult and immature leafhoppers on the undersurface of the leaf serve to distinguish leafhopper injury from virus symptoms.
Control

- When hopperburn symptoms appear spray soap or neem solution

Aphid *Aphis craccivora*
Winged aphids find new plantings and begin to multiply. Females do not lay eggs but give birth to young nymphs. A colony of nymphs forms around the winged female who may give birth to 20 at a time. As the life cycle is short a new generation begins within a few weeks. Aphids remain in one place most of the time feeding by inserting their long straw-like mouthparts and such up plant sap rich in sugars. Aphids damage plants by: (1) sucking plant sap which causes heavily infested leaves to curl and stunts plants, (2) excess plant sap is excreted (honeydew) which falls like rain over the plant and becomes infected by black sooty-mold fungus growth and ruins the quality of the pods. Injured leaves curled downward. The common pea aphid is black. Aphids are more of a problem in kharif as monsoon rain normally keeps them in check.
Control

- Spray soap or neem when several colonies are found per plant

Thrips *Thrips palmi, Megalurothrips*
Thrips palmi is yellowish while *Megalurothrips* is black. Both species attack young developing leaves. They hide and feed within the small terminal leaves of new shoots. The saliva they inject while feeding causes the leaves and flowers to become deformed. Later on they feed within the flowers. Thrips can be detected by opening up the flowers and inspecting inside. Flowers and flower parts become brown, dried, and drop early. Pod production is low and pods are deformed. They pupate in the soil so during the monsoon season their numbers are usually low. They can reproduce rapidly and disperse in the wind.
Control

- Action threshold is 2 thrips per leaf terminal or 4 thrips per flower and when reached spray with applications of soap or neem

7. Defoliator insect pests
Foliage feeding caterpillars that commonly occur on bean crops, but rarely warrant spraying unless they are abundant. There are many

species that feed on foliage. Control decisions are based on the collective defoliation of all of them.

Hairy caterpillar *Spilosoma* (= *Diarcrisia*) *obliqua* Arctiidae
The hairy caterpillar feeds on a very wide range of plants. This large hairy caterpillar feeds gregariously as young larvae that hatched from the same egg mass. As such the damage can be highly concentrated and can even kill a young plant. As the larvae age they disperse. The larvae become so large that even one can cause extensive damage to a plant. The adult moth is white with red markings.

Semilooper *Plusia orichalcea*
The light green larvae of is small moth are not true loopers as they have more than one set of legs at their rear, but the central legs are missing and it moves by arching its back forming loops rather than by crawling as the hairy caterpillar does. They are often difficult to see on a leaf as they blend in well. The larvae reach 5 cm in length. The larvae attack and feed on the leaves between the large veins and midribs. It pupates on the plant and like most defoliators has a wide host range.

Leaf miner *Cosmopteryx* sp.
Two types of leaf miners attack peas, flies and moths. Cosmopteryx is a small (5-6 mm) moth that lays its eggs on a leaf blade. The emerging larvae immediately tunnel within the blade feeding as they go. Their tunnels can be seen on the leaf blade and often are spiral or irregular patterns. The tunnel widens as the larva ages. The actual damage that a leaf miner causes is minimal except if there are many or that they are present on young plants. They are normally kept in check by parasitoids but become highly abundant if very toxic insecticides are used which selectively kill off the parasitoids.

Leaf beetle *Monolepta signata*
The orange adults look like the pumpkin beetle of gourds and move about during the day. The beetle feeds on leaves and can contribute to the overall leaf loss. The larvae live in the soil feeding on roots but do not contribute to economic loss.

Control of defoliators
Before flowering the crop can tolerate up to 40% leaf loss without loss in yield, after flowering the amount that can be tolerated is around 25% or less. These are guidelines to judge if control measures are warranted.

- The large larvae can be removed by hand
- Spray a neem product if the defoliation exceeds the above amounts

9. Pod borers

There are three species of pod borers which can all be in the same field. Each has different behaviors and preferred seasons when they are most abundant. The bean pod borer and bean lycaenid are specialists on legumes whereas the earworm feeds on many species, thus its abundance is a function of the presence of hosts or nonhosts.

Bean pod borer *Maruca testulalis*
Maruca is the most common bean pod borer and therefore the most important. It first appears at flowering. The female moth lays eggs on the flower and the young larvae feed on the buds, petals and later enter the green pods. Their preferred food is the developing seeds which are most nutritional. Usually there is only one larva per pod and it feeds on all the seeds from the inside. The larvae are up to 1.8 cm long and are whitish in color with rows of dark spots along the sides of the body. Early detection is important.
Control

- Spray neem if more than 3 larvae per meter are detected

Earworm *Heliocoverpa armigera*
Earworm does most of its economic damage by feeding on flowers and seed pods as they develop. While infestations may sometimes also occur during the vegetative stage, the crop will tolerate a moderate amount of leaf feeding and defoliation. After the green pods develop it feeds on the seeds from the outside and is often seen with its head stuck in the pod in feeding position. When scouting check for the small larvae in flowers and look into the first forming green pods for signs of the larvae feeding on seeds.
Control

- Spray neem when there is more than 1 larva per two meters of row. Better control is attained the younger the larva. The large stage larva is essentially impossible to control.
- In India a virus disease (NPV) of Heliocoverpa has been commercialized. It is highly contagious and farmers can collect diseased larvae which they mash about 1-2 per 10 liters and spray directly and obtain good control

Bean lycaenid *Euchrysops cnejus*
The bean lycaenid is a small blue butterfly whose larva feeds on the seeds in the pea pods. The blue butterflies are often seen flying during the day over the crop when the crop is flowering or setting pods. Eggs are laid on flowers and the larvae feed on the flowers and finally the developing seeds in the pods. The larvae have an unusual shape, being very flat and broad and slug like. They are green and blend in well. It is rare however to find them very abundant.
Control

- Spray neem if more than 3 per linear meter occur

10. Seed pest

Bruchid weevil *Callosobruchus chinensis*
Bruchids are small weevils that are a major pest of beans in store. However, field infestation is also common with the female depositing eggs on the surface of seeds and green or ripe pods. The young grubs burrow into the pod or grain and continue to develop inside the seed. Harvested seeds carry the weevils to the store. The holes seen on pulses are the exit holes from where the adults have emerged. Such seeds are unsuitable for sowing.
Control

- Fumigation of seeds

V. CARROT

Crop monitoring
Monitor the crop on a weekly basis by walking through the field examining plants (look on undersides of leaves) to note the presence of diseases and insect pests.

The marketable portion of the crop, the carrot root, is subjected to a wide range of field stresses which include diseases, nematodes, insects, and variations in soil conditions, notably moisture. It is important to recognize and diagnose the causal agent of injuries to carrots. Nematodes such as root knot, root lesion and cyst cause some unique symptoms, which can be easily confused with diseases. Forked and split carrots are a major problem in many areas. Misshapen roots can be caused by overcrowding and lumpy soil. Root tops that turn green are due to exposure above the soil surface. These losses are often associated with inconsistent moisture patterns, soil compaction or disturbance patterns. It is important to properly diagnose carrot root diseases before initiating a management strategy. Very few studies on the pests of carrots has been carried out in Bangladesh but below is a description of the most common pests in neighboring countries and should occur in Bangladesh.

1. Physiological damage
Root splitting can be caused by an irregular supply of moisture in the soil resulting in the roots cracking lengthwise.
Control

- Maintain even growth throughout the season by mulching to conserve moisture and watering the soil before it dries out completely. Do not store cracked roots as they develop rots.

2. Nematodes

Nematodes can build up on previous crops to attack carrots, as there is no other food source. Symptoms include plants stunted and yellowed, roots misshapen, and small knots on fibrous roots. If the area is seasonally flooded nematodes will not be a problem. However

if it is an intensive vegetable growing area where rice is not rotated, nematode problems can be expected thus the use of soil amendments is suggested before planting.
Apply either of four products that kill nematodes and soil bacteria and will minimize soil borne fungi:

- Mustard oil cake (@ 300 kg/ha) (should be 15 days old) Price about Tk 10/kg (best)
- Neem oil cake (@ 200 kg/ha) (best)
- Poultry waste (manure) (@ 3 t/ha) (should be at least 6 months to 2 years old (next best)
- Burning sawdust (@ 6 cm thick) (next best) (particularly good for seedbeds and after burning incorporate the ashes into the soil) Price about Tk 700/t)

Cow dung does not directly kill nematodes:

- Cow dung (@ 5 t/ha when dry) (good but will bring in weed seeds)

If mustard oil cake, neem oil cake, poultry waste or sawdust is used, then normally there is no need for cow dung or other organic matter to improve soil fertility. This is preferred for carrots as if they are grown in soil with high organic matter the roots split and become hairy.

3. Soil borne fungal diseases

Damping-off fungi
A group of common soil-borne fungi is often associated with diseases throughout the crop cycle that contaminate the seed, young plants, older plants, and even into storage. Damping-off fungi (*Pythium, Phytophthora, Rhizoctonia, Fusarium, Sclerotium*) get their name from seedling mortality they can cause; some have been reported from carrots. Most of the diseases that affect carrot roots are soil-borne which are greatly influenced by soil temperature, soil moisture, and nutritional levels. These have wide host ranges and under the right environmental conditions can attack any crop.

White rot *Sclerotium sclerotiorum*
This is the most destructive disease of carrots in India. The disease is present in soil, harvesting containers, or storage areas and often shows up after the crop has been harvested. Plants can be attacked by white rot during the growing period but most commonly it causes storage rot. White fluffy fungal growth develops on the rotting roots and hard black round pearl-shaped sclerotia soon form on the diseased tissues, usually on the crown of infected carrots. These are the resting bodies of the fungus. They remain dormant during the kharif and germinate the following rabi to give rise to spores which attack first dead, then living, tissues. In storage, the disease is characterized by a soft, watery rot with white mold and black sclerotia present.
Control

- Use healthy seed or treat seed with Vitavax if a history of this disease has occurred
- Crop rotation after > 2 years with a crop in the same family
- Weed control to improve air circulation and lower moisture on the leaves
- Planting on raised beds
- During the growing season destroy any plants which show rotting shoots covered by a white fluffy fungus, preferably before the resting bodies form, otherwise they fall off into the soil and contaminate it.
- Field applied fungicides are available, however, heavy disease pressure in the field or placement of carrots into infected storages will still lead to severe losses.
- Apply benomyl (Benlate) fungicide as a foliar spray as a last resort
- Rapid cooling prior to storage and meticulous sanitation of all storage containers
- Store only healthy roots in a well ventilated and fairly dry place. Check them regularly and remove and burn any rotting roots before the sclerotia are produced and fall to the floor, thus contaminating the storage area.

Black root rot and crown rot *Rhizoctonia, Pythium, Fusarium*
Crown rot is also caused by some of the same fungi which cause damping-off when seedlings are small. On carrot roots, early symptoms are horizontal dark brown lesions; as the crop matures the tops may die in patches in the field. Symptoms appear as wilting and a slow or rapid collapse of the plant. The roots can appear brown and water-soaked instead of white. A water-soaked lesion can often appear at the base of the stem. It often happens that infection can occur early in the growing season during wet periods, but symptoms may be delayed. Near harvest the lesions join to form large, deep, rotten areas on the top part of the root (crown). Control of this disease is nearly impossible if weather conditions are wet.
Control

- Use healthy seed or treat seed with Vitavax if a history of this disease has occurred
- Two-year rotation with non-susceptible plants to prevent the buildup of pathogenic organisms in the soil
- Earlier harvest
- Planting on ridges
- Careful handling during harvest
- Storage sanitation and well maintained storage conditions might reduce losses to the disease

Violet root rot *Helicobasidium purpureum*
This fungus attacks the roots while still in the soil. The fungus grows over the surface forming a violet or purple web of fungal threads. The root tissues shrink and rot due to the feeding by the fungus.

Control
- Destroy affected carrots
- Apply benomyl (Benlate) fungicide

Soft rot *Erwinia carotovora*
This bacterial disease can occur on carrots that are overripe and have been stored in too warm and moist condition. Affected carrots become soft and slimy, and develop a foul smell. The bacteria can only enter through wounds.
Control
Harvest on time
- See that storage conditions are not too moist
- Do not store roots that show any damage

4. Foliar diseases

Powdery mildew *Oidium* and *Erysiphae*
Symptoms appear first as pale yellow spots on leaves and petioles. Soon thereafter sporulation becomes evident as white powdery masses of conidia (spores) are produced over the lesion surface. Lesions frequently are numerous and coalesce to cover the enter leaf surface. Leaves become chlorotic, then turn brown and dry prematurely. The whole green portion of the plant may wilt. Conditions that favor disease development are warm days and cool nights which result in long periods of dew on the leaves that are needed for the fungal spores to germinate and penetrate into the leaf tissue. The disease probably survives on wild hosts and is transmitted by the wind. Also spores can survive in the soil and germinate when a host is planted nearby.
Control
- Use healthy seed or if a history of the disease has occurred apply Vitavax seed treatment
- Destroy crop residue
- Spray a sulfur based fungicide (Thiovit) or propiconazole (Tilt) on the foliage as a last resort

Leaf spot *Cercospora* sp.
Leaf spots caused by Cercospora first appear along the margins of the leaves, often causing the leaves to curl. Spots inside the leaf edges are small (oval or circular) and tan or grey to brown with a pale center. As the lesions increase in number and size, they grow together and the entire leaflet withers. The fungus attacks younger leaves and plants in preference to older ones. In heavily infested fields, however, both older and younger leaves are attacked. The pathogen also produces the same type of lesions on the petioles and stems that significantly weaken them where they may detach from the crown prematurely. The roots are not attacked. Because Cercospora leaf blight develops rapidly in hot or humid weather, it is more likely to occur in the rainy season. Cercospora spores linger in the soil in crop residues in between crops. To cause infection,

Cercospora requires 6 hours of dry weather (less than 90% humidity) for dissemination of the spores by the wind. It then needs a period of leaf wetness of at least 24 hours. The spores can survive interruptions in this wet period of up to 12 hours. The leaf blight pathogens can survive from one year to the next in infected plant debris.

Control

- A two-to three-year rotation is recommended to allow for natural decline in the pathogen population
- Plowing is recommended to hasten the decomposition of plant residues
- The use of disease-free seed is strongly recommended because the pathogens can survive on or in the seed
- As a last resort apply mancozeb (Dithane M45, Penncozeb, etc)

5. Insects pests

Carrot fly *Psila rosae*

This small fly is the most damaging pest of carrots in India and may be in Bangladesh. There are two generations of the maggots during the summer with damage occurring from June to July and from August to October. The maggots are thin, orange-white larvae up to 1/2 inch long. They tunnel just below the surface of the carrot root causing a rusty-brown discoloration and giving the carrot an unpleasant taste. When it attacks young plants growth can be stunted. But attacks later in the season can allow secondary rots to develop which cause the carrot to decay in the soil or later during storage. Sowings made after the end of May will miss the first generation of maggots, while early sowings will be ready for eating before the second generation appears in August. The egg-laying females flies locate suitable host plants by scent and are strongly attracted to recently thinned rows because the process of thinning bruises the foliage and releases the attractive odor.

Control

- Reduce the need for thinning by careful spacing
- Spray a neem product

VI. SPICES CHILLI

Crop monitoring

Monitor the crop on a weekly basis by walking through the field examining plants (look on undersides of leaves) to note the presence of diseases and insect and mite pests.

1. Varietal selection.

There are chilli varieties possibly having resistance or tolerance against any number of pests including root knot nematode, soil borne and foliar fungal and bacterial diseases plus virus diseases. Review the pest resistance ratings for the varieties available to you. Select a variety having resistance or tolerance against a particular

pest if it is prevalent in your area. Genetic resistance is the least expensive of pest control measures.

2. Nematode

Root knot nematode *Meloidogyne incognita*

These tiny worms live in the soil and feed on the roots of chilli. Not only do they cause physical damage from their feeding that blocks the uptake of water and nutrients, but the wounds they cause in entering the roots allow the entry of rot causing organisms. Nematode infected plants are generally stunted with pale green to light yellow foliage. Symptoms may be temporarily masked by supplying additional fertilizer and water. Severely affected plants may wilt. A careful look at the root system will reveal small galls. The root knot nematode has a very wide host range and can survive as dormant eggs for many months. Warm temperatures and light sandy soils favor its development and survival.

Control

- Crop rotation
- Flooded rice in particular greatly reduces root knot populations
- Soil amendments (mustard oil cake, neem oil cake, poultry waste, burning sawdust)
- Plowing during the fallow season will expose nematodes to drying and eliminate weeds that can host this pest
- Some resistant or tolerant varieties are available

3. Soil borne diseases

Bacterial wilt *Pseudomonas solanacearum*

Bacterial wilt has a large host range and the bacteria. It survives many years and can attack the crop as soon as it is planted. The initial symptom is wilting of lower leaves (or upper leaves of seedlings) followed by a sudden and permanent wilt of the entire plant without yellowing. The disease occurs randomly rather than in one area. If the stem is split, one notices brown vascular tissues instead of a healthy green. The stem at the soil line may also decay and shrink which is also a sign of infection. When stem is cut and the cut end is placed in warm water, a milky ooze of bacteria streams out. It gains entry through natural root wounds or wounds created by insects, nematodes, or mechanical damage. High temperature and high soil moisture favor disease development.

Damping-off fungi

These soil-borne fungal diseases attack newly planted seedlings. Five genera of fungi are listed in the order of prevalence -- *Pythium, Sclerotium, Rhizoctonia, Phytophthora, Fusarium*. Early symptoms are drooping of plants and eventual wilting and death as nutrients are blocked from passage both up and down the vascular system.

4. Leaf and stem fungal diseases

Stem rot disease *Sclerotium rolfsii*
Stem rot is one of the damping-off fungi that also commonly attacks older plants. The disease occurs as a sudden wilt of individual plants scattered about the field rather than in patches. Initially there is no foliar discoloration, but later the leaves may turn yellow. The cortical tissue at the base of the stem is brown and decayed above and below the soil line. White fungal growth usually is visible on the base of the stem and on the soil around the base of the plant, creating collar rot. Brownish sclerotia about the size of mustard seed are produced in the fungal mat. Fruit or branches may become infected. High soil moisture and temperature favor disease development, although symptom expression may be more severe during dry conditions following a wet period. The fungus has an extremely broad host range. Sclerotia or resting bodies of spores are its principal means of long-term survival in the absence of a host or suitable substrate. They float on water and are dispersed during runoff from heavy rains.
Control
- Crop rotation
- Remove plant residue from the field after harvest to remove sources of inoculum
- Plow deeply to bury sclerotia and plant debris
- Disease free seed or fungicide seed treatment (Vitavax 200)
- Soil amendments

Leaf spot *Cercospora capsici*
This common fungal disease is most notable on the leaves. Leaf lesions are circular; about 1-cm in diameter, with brown borders and light grey centers. Severe infection can cause leaf drop, with or without leaf yellowing. Severely affected leaves turn yellow and drop. Lesions on stems, leaf petioles, and fruit stems are elliptical with dark borders and grey centers. The fruit do not become infected. The fungus survives on seed and in infected crop debris possibly for one year. Disease usually gets started in seedbeds. Extended warm rainy periods, long periods of leaf wetness, and close plant spacing enhance disease development.
Control
- Crop rotation
- Clean seed
- Wide spacing
- Destroy crop residue
- Mancozeb spray

Die back or soft rot *Choaniphora cucurbitarum*
This fungal disease attacks all stages of growth. Tips of branches die back. Careful inspection will reveal silvery, spine-like fungi with dark heads. The fungus may also kill flowers and flower buds. Black discoloration appears on the stem and branches producing a soft rot. Plants wither and die. Extended rainy periods and high temperatures are favorable for its development.

Control

- Planting time, October sowing date with least disease
- Disease free seed
- Fungicide carbendazin

5. Leaf and fruit bacterial disease

Bacterial spot *Xanthomonas campestris*

Bacterial spot is a soil borne bacterium. On leaves, small water-soaked spots become necrotic with a yellow border. The lesions may be sunken on the upper surface and raised on the lower surface. Heavily infected leaves may turn yellow and drop, resulting in severe defoliation. Dark, raised lesions have a corky or wart-like appearance on fruits. Elongated necrotic spots or streaks appear on stems and petiole. Bacterial spot is seed-borne and can survive in crop debris from infected plants. Many strains attack both tomato and pepper. The disease is enhanced by overhead watering, heavy dew formation, and high temperatures.

Control

- Rotate with cereals and other non-susceptible crops
- Resistant cultivars are becoming available, but may not be resistant to all strains of the disease
- Use pathogen-free seed and transplants
- Sprays of copper or copper + maneb will reduce damage

6. Virus diseases

There are many viruses that infect chillies and are transmitted by insects (aphids or whiteflies) or mechanically or by tobacco smoke

- Potyvirus Y (Potyvirus) PVY transmitted by aphids
- Cucumber mosaic virus (cucumovirus) CVMV transmitted by aphids
- Yellow leaf curl virus (Gemini virus) YLCV transmitted by whitefly
- Tobacco mosaic virus (tobamoviruses) TMV mechanically transmitted or by tobacco smoke

There are at least four virus diseases of chillies. Sometimes, plants are infected by a combination of viruses. This, and the variation in symptoms produced as a result of cultivar and environmental differences, make identification of virus diseases by symptoms alone unreliable.

Symptoms of PVY on plants can vary, but in general, plants show an overall lighter color along with mosaic patterns (alternating light and dark green areas) on at least some leaves, especially on the younger leaves. Plants will often show stunting, leaf curling, and fruit distortion and mosaics. Aphids are able to transmit these viruses for very short periods of time (minutes to a few hours). The type of aphid activity that promotes virus spread occurs when aphids are actively moving through the chilli crop and are probing the plant tissues before they begin feeding. Once aphids colonize plants, settling down to feed, virus transmission is greatly

reduced. Thus, spread is often very rapid. In general, field spread of pepper potyviruses occurs when aphid activity in fields is high.

Symptoms on plants affected with CVMV can vary, but in general, plants show an overall lighter color along with mosaic patterns on at least some leaves, especially on the younger leaves. Often, the main leaf vein is distorted and somewhat zigzag in appearance. Plants generally show stunting, leaf curling, and mosaic symptoms. Affected plants take on a bushy shape. Resulting fruit from infected plants are usually malformed. Once an aphid acquires CVMV, it retains the ability to transmit the virus for only a short time (minutes to hours) and the spread of the virus is thus local and very rapid within fields. In general, field spread is related to overall aphid activity, not to the presence of colonizing aphids.

YLCV, spread by whiteflies, causes a yellowed, mottled appearance in addition to leaf curling and distortion. Affected plants are also stunted.

TMV symptoms can include necrosis on any plant part, defoliation, and/or mosaic symptoms on leaves, stems, and fruit. Mosaic symptoms are streaking patterns of green and yellow color. TMV is mechanically transmitted which means the virus can be spread by touching an infected plant immediately before touching a healthy one. TMV may be also be transmitted by smoke or people smoking before touching chilli plants.

Control

- For whitefly and aphid transmitted viruses control is directed at the vectors. Soap and neem products are as good as any available. Both irritate the vectors and act as antifeedants. Stylet oil formulations have proven more effective in preventing virus transmission in other countries but petroleum products are not available in Bangladesh.

7. Fungal fruit disease

Anthracnose fruit rot *Colletotrichum*
The fungus is capable of infecting all parts of the chilli plant during any stage of plant growth. Economic loss is associated with infection of stems and fruit. Stems start drying up from the top downwards or die back. Although infection can occur anytime after petal fall, there is no sign of it until the fruit mature. Symptoms on the fruit begin usually at flowering where the flower buds dry up and wither. Fruit lesions are the most economically important aspect of this disease. Fruit symptoms initially begin as soft, water-soaked lesions, slightly sunken, that become tan. The lesions can cover most of the fruit surface and multiple lesions occur. The surface of the lesion becomes covered with the wet, gelatinous spores from salmon-colored fungal fruiting bodies (acervuli) with

numerous black spines (setae). Concentric rings of the spores are common within the fruit spots. In some cases, the lesions are brown, not orange, and then black from the fungal growth. The fungus survives in and on seeds. Anthracnose is introduced into the field on infected transplants or it can survive between seasons in plant debris or on weed hosts. Alternative hosts include weeds and other plants in Solanaceae. Fruit are infected when spores of the fungus or infested debris is rain splashed onto chilli plants. New spores are produced within the infected tissue and then are dispersed to other fruit. Workers may also move spores with tools or during handling of infected plants. Infection usually occurs during warm, wet weather. Temperatures around 27° C are optimum temperatures for disease development, although infection occurs at both higher and lower temperatures. Severe losses occur during rainy weather because the spores are washed or splashed to other fruit resulting in more infections. The disease is more likely to develop on mature fruit that is present for a long period on the plant, although it can occur on both immature and mature fruit.

Control

- Disease free seed
- Crop rotation after 2-3 years without solanaceous crops
- Wounds in fruit from insects or other means should be reduced to the extent possible because they provide entry points for the fungus and other pathogens like bacteria that cause soft rot
- Transplants should be kept clean by controlling weeds and solanaceous volunteers around the nursery area
- The field should have good drainage
- Removal of unharvested plant residue
- Removal of weeds and volunteer peppers plants from the field
- Fungicides mancozeb or chlorothalonil

8. Insect pests

Cutworms and armyworms *Spodoptera* spp.

Cutworms and armyworms are soil insects that breed on grasses but have wide host ranges. The moths are capable of dispersing long distances and enter the fields at night to lay large masses of eggs. These masses are covered with body hair from the female moth and can be located in the field. The young larvae hatch and feed in a group until they are half grown at which time they are more solitary. The larvae hide in cracks in the soil by day and generally feed at night. A sign of their presence is the defoliation damage. Larvae can be located in the soil at the base of the plants. They are most damaging when they attack young seedlings.

Control

Hand pick the egg masses and larvae from the field

Spray a neem product when the defoliation is above 15% leaf loss

Thrips *Haplothrips ganglgaueris, Franklinella schultzei, Scirtothrips dorsalis*
Thrips feed on a wide variety of vegetable crops. Some species are host-specific and some are not. Symptoms are that areas near the mid-vein are brown and dried up. The major damage occurs on the undersides of new or old leaves. They remove plant sap from very young leaves and their saliva causes leaves to grow in a distorted manner. Leaves tend to curl upward like the shell of a boat. Fruit is scarred or netted with cork-like steaks. The adults are minute delicate insects, less than 1 mm long and are dark and brownish with or without stripes on their backs. They move rapidly when disturbed. The younger stages are yellow or white and are still minuter. Inspect the upper surface of the leaves for brownish damaged areas on either side of the mid-vein. Adults lay eggs within leaf tissues and the young hatch after several days. Pupation occurs in the soil usually at the base of the plant. Insects congregate at the mid-vein or at the borders of damaged areas and feed on healthy tissue. They are favored in the dry season as they pupate in the soil and many drown in the rainy season. They have short life cycles and can multiply quickly.
Control
- Soap or neem product when injury seen on 10% of plants

Aphids *Lipaphis pseudobrassicae, Aphis gossypii, Myzus persicae*
A number of aphid species can attack chilli. They all have sucking mouthparts. These are small pear-shaped insects vary in color from yellow to green to black. Leaves are distorted, stunted, and often curled under. The plants have fewer fruits than usual. Some wilting may also be evident. Select leaves that are beginning to curl under or have signs of black sooty mold on the upper surface. Turn them over and look for groups of variable-sized insects. You will see adults with transparent wings and young living and feeding together. The aphids have continual generations and many different hosts. When populations on the host plant are high, winged forms are produced, and they fly to adjacent plants to establish new colonies. Aphid colonies are commonly visited by ants which feed on the honeydew secreted by the aphids. The aphids serve as virus vectors and have wide host ranges including many vegetables. This makes them important in virus disease transmission aside from the direct damage they cause. Their role as vectors and control methods were discussed under the virus disease section.

9. Mites

Broad mite *Polyphagotarsonemus latus*
Individuals are extremely small, about the size of a small grain of sand, and not clearly visible to the naked eye. They are found in groups hidden around the mid-vein on the undersides of the leaves. They are yellow or white. Locate leaves with a brownish cast, preferably young leaves that are beginning to curl under. With close

inspection look around the mid-vein for signs of movement. Often only a few will be noted. Damage can be severe from just a few as they inject saliva into the plant while feeding. The leaves react to the saliva by shrinking in size and wrinkling giving them a protective habitat. Young leaves are cupped downward and are narrower than normal. Such damage stunts plant growth and reduces yield. Fruits develop a cork-like distorted surface similar to damage caused by thrips.

Control

- Soap or neem product

Spider mites *Tetranychus* sp.

Spider mites look like small spiders as they spin webs on the undersides of leaves. They are red in color and very tiny. They live in colonies and their feeding damage is distinguished as small yellow dots called stippling on the leaves. They are favored by long periods of dry weather as heavy rains wash them from plants. They can complete a generation in less than a week, thus can multiply quickly. They are normally controlled by natural enemies (usually other kinds of mites) and occur in large numbers if highly toxic insecticides are repeatedly used. They will not be a problem if soap or neem are used in the control of other pests but can appear in damaging numbers if broad-spectrum chemicals such as cypermethrin and dimecron are used.

VII. GARLIC

Crop monitoring

Monitor the crop on a weekly basis by walking through the field examining plants (look on undersides of leaves) to note the presence of diseases and insect pests.

1. Varietal selection

Select varieties that may have resistant or tolerant to fungal diseases and nematodes.

2. Damping-off fungi (*Pythium, Sclerotium, Rhizoctonia, Phytophthora, Fusarium)* and root knot nematode (*Meloidogyne* spp.) control. Follow the preventative guidelines outlined in section I. Incidence is less in garlic than onion but it is recommended to follow the same practices.

Control

- Crop rotation
- Use of soil amendments (mustard oil cake, neem oil cake, poultry waste, or burning sawdust)
- Clean seed for seedbed and field
- Fungicide seed treatment

3. Root knot nematode and fungal disease control

- Select the most adapted disease and nematode resistant or tolerant variety

4. Soil insect pests

Cutworms and armyworms (*Agrotis* and *Spodoptera*)

Cutworms are soil inhabiting stout larvae which feed at night on the leaves and soft stems. Most commonly the plants are defoliated but small plants can be completely severed.

Garlic can tolerate 25% defoliation until six weeks after planting before yield loss, but after six weeks the tolerance is much less.

Control methods

- Hand removal of larvae from the soil. Locate plants that have been recently damaged. At the base of these plants dig around in the soil or plant debris with your fingers to find the larvae. They hide there during the day.
- Make insecticide bait (1 liter chlorpyrifos (Dursban) + 100 kg wheat or rice bran + molasses) in the form of flakes applied to base of plants along the row

5. Thrips *Thrips tabaci*

Thrips are very small, just barely visible to the naked eye and begin attacking the crop within the first several weeks in the field. They are more prevalent in the absence of rain. Immatures are either yellow or white. Older individuals are yellowish-brown and move quickly. Feeding is the act of scraping the epidermis of leaves or stems and suck the plant sap resulting in white blotches. Severe infestations result in leaf wilting and bulbs become distorted and undersized.

Maintaining moisture in the soil reduces thrips damage. Moist soils develop fungi that kill pupae in the soil. Sprinkler irrigation will seal pests in soil while pupating. Heavy rains drown thrips in plant crevices and soil. Mulching with straw may provide shelter for thrips predators, thereby reducing thrips populations.

When 15% of plants show damage apply one of the following:

- Spray soap solution (10 g of Wheel detergent powder per 10 liter sprayer)
- Neem based insecticide (neem oil or Nimbecidine)

6. Fungal leaf diseases

Purple blotch fungal disease (*Alternaria porri*)

Stemphylium blight *Stemphylium vesicarium*

Purple blotch and Stemphylium leaf blight have identical damage symptoms that begin on the leaves and leaf sheaths as small light yellow to brown water-soaked infections beginning at the leaf tips. As the lesions expand, they coalesce into oval-shaped tan and deep purple blight or blotch lesions. Concentric zones may develop within

them. Yellow streaks, which turn brown, extend along the blade in both directions from the lesion. In advanced stages lesions may girdle and kill leaves and seed stems. Bulbs get infected and decay. Wet and warm conditions favor the disease spread. The pathogens survive on infected bulbs, seeds, and plant debris. Control measures are to obtain disease free seed and fungicides on the standing crop. Neem is effective against these diseases as determined by trials in Bangladesh.

Apply either

- iprodione (Rovral 50WP)
- mancozeb + metaxyl (Ridomil Gold),
- difenoconazole (Score)
- neem (neem oil or Nimbecidine)

7. Fungal bulb rot diseases

Fusarium basal rot

This disease attacks the basal plate region and the roots. The fungus is present in all soils and is usually considered a secondary invader because it attacks plants already weakened by insects, mechanical damage, or other diseases. Fusarium is most active at high temperatures. The soil-borne pathogen invades the roots, resulting in empty, tan-colored, non-functional roots. The basal plate region may develop a pinkish growth of mycelium. First visual symptoms are often the yellowing of the tip and dieback of the shoot during the spring. Warm soil temperatures and high soil moisture promote disease development. Bulbs infected with Fusarium may decay further in storage. Since the Fusarium inoculum remains as dormant spores in the soil or on plant residue, crop rotation with crops not belonging to the Allium genus (eg., garlic, onions, shallots, leeks, chives) is recommended.

Control

- Crop rotation
- Remove plant residue
- Select disease free planting material

White rot *Sclerotium rolfsii*

Symptoms include premature yellowing and dying of older leaves, stunting, and leaf tipburn, followed by destruction of the root system, shoot dieback, and rotting of the bulb. Leaf decay begins at the base, with older leaves being the first to collapse. A semi-watery decay of the bulb scales results. Roots also rot, and the plant can be easily pulled from the ground. Associated with the rot is a fluffy white growth, the fungal mycelium, which develops around the base of the bulb. As the disease progresses, the mycelium becomes more compacted, less conspicuous, with numerous small spherical black bodies sclerotia forming on this mycelial mat. These sclerotia, the resting bodies of the pathogen, are approximately the size of a pin head or poppy seed. Plants can become infected at any

stage of growth. The pathogen persists as small, dormant structures, called sclerotia, in soil. Sclerotia can survive for over 20 years, even in the absence of a host plant. Disease severity depends on sclerotia levels in the soil at planting. As few as one sclerotium per 10 kilograms of soil can initiate disease. Only one sclerotium per kilogram of soil can cause measurable disease loss, and 10-20 sclerotia per kilogram result in infection of essentially all plants.

Sclerotia can be spread throughout a field or from field to field by flood water, equipment, or on plant material. Sclerotia remain dormant in the absence of garlic or other *Allium* crops. Their germination is stimulated by *Allium* root extracts and exudates that extend into the soil about 1.5 cm from the root. Disease development is favored by cool, moist soil conditions.

Control

- Plant only clean stock from known origins that have no history of white rot
- Crop rotation is effective in slowing disease buildup
- Do not move cull bulbs, litter, and soil from infested to non-infested fields
- Always clean tools before moving from one field to another
- Garlic seed is not likely to carry sclerotia, but transplants and sets can

Black mold *Aspergillus niger*

Black mold is first evident at the top or sides of the bulb where disease or injury has caused an opening in the skin. The fungus develops between dry, dead outer scales and the first inner fleshy scales of the bulb. Invaded scales initially become water soaked. Under dry conditions diseased scales dry and shrivel, and black masses of spores are visible between outer scales. Diseased scales may also be invaded by soft rot bacteria, causing the whole bulb to deteriorate into a watery soft rot.

Black mold occurs most commonly where onions or garlic are grown under warm dry conditions. It is more of a concern in onion crops than in garlic. The fungus survives on decaying organic matter such as plant debris.

Control

- There are no chemicals for the direct control of black mold.
- Handling of bulbs to avoid bruising also reduces injury and invasion sites for the fungus.

Blue mold *Penicillium* spp.

Penicillium is both a field and storage disease. Plants from infected cloves planted in the fall will often emerge in the spring, turn yellow, and then die. A blue-green color is observed on cloves in soil and in storage. When conditions are optimum for rapid emergence, the plant may outgrow the disease. Air-borne spores

spread the disease. Initial symptoms include water soaked areas on the outer surface of scales. Later, a green to blue green, powdery mold may develop on the surface of the lesions. Infected areas of fleshy scales are tan or gray when cut. In advanced stages, infected bulbs may disintegrate into a watery rot.

Many species of *Penicillium* can cause blue mold. These fungi are common saprophytes on plant debris and senescent plant tissue. Invasion of garlic is usually through wounds, bruises, or uncured neck tissue. Once inside the bulb, the mycelium grows through the fleshy scales, eventually sporulating profusely on the surface of lesions and wounds. Optimum conditions include moderate temperatures (21° to 25°C) and high relative humidity.

Control

- Harvest and handle garlic bulbs with a minimum of bruising or wounding
- Promptly cure the bulbs so the necks are dry. Store bulbs at temperatures of 5°C or less with low relative humidity.

8. Viruses

Because garlic is clonally propagated, almost all planting stock is infected with some type of virus. The viruses are usually mild and do not seriously affect yield, and may even impart desirable characteristics in some varieties. Fortunately, most of these viruses in garlic are latent. Latent garlic viruses may not become visible or reduce yields until the garlic plant is stressed or growth interrupted. The most common symptoms of virus infection are color changes of the leaves. These include mosaics, flecking, streaking and mottling. Leaf shape distortion may also occur. Aphids are one vector capable of transmitting some viruses from infected to healthy plants.

Control

- Planting healthy cloves,
- Reducing aphid populations,
- Proper fertility and water management during the growing season.

VIII. GINGER

Crop monitoring

Monitor the crop on a weekly basis by walking through the field examining plants (look on undersides of leaves) to note the presence of diseases and insect pests.

1. Nursery management

First establish a nursery and procure healthy disease free seed rhizomes from a disease free crop. Rhizomes should be well matured,

plump and hard when pressed. Before planting, cut the sprouted rhizomes into pieces, weighing about 10-25 g each and immerse them in a solution of 0.3 % mancozeb (Penncozeb, Dithane M-45, etc) for half an hour and let them dry before planting.

2. Nematodes (*Meloidogyne* spp., *Pratylenchus* spp. and *Radopholus similis*)

Nematode damage to roots causes stunting, chlorosis, poor tillering and necrosis of leaves. Characteristic root galls and lesions that lead to rotting are generally seen in roots. The infested rhizomes have brown, water-soaked areas in the outer tissues and wilt if damage is heavy. Nematode infestation also aggravates rhizome rot diseases.

Control

- The nematodes can be controlled by treating infested rhizomes with hot water (50°C) for 10 minutes
- Using nematode free seed rhizomes
- Applying soil amendments into the nursery beds and field that kill bacterial wilt and root knot nematodes in particular but less so for damping-off fungi: select among:
  - ✓ Mustard oil cake (@ 300 kg/ha) (should be 15 days old) Price about Tk 10/kg (best)
  - ✓ Neem oil cake (@ 200 kg/ha) (best)
  - ✓ Poultry waste (manure) (@ 3 t/ha) (should be at least 6 months to 2 years old (next best)
  - ✓ Burning sawdust (@ 6 cm thick) (next best) (particularly good for seedbeds and after burning incorporate the ashes into the soil) Price about Tk 700/t)
  - ✓ If the seedbed is a raised bed cover with polyethylene sheet (solarization or the sun’s heat sterilizes the soil, however 3-4 weeks of sunny days is required for the sterilization effect to work)

3. Soil borne diseases

Bacterial wilt *Pseudomonas* (*Ralstonia*) *solanacearum*

Bacterial wilt is also a soil and seed-rhizome borne disease that occurs during the wet season when the crop is young. Water soaked spots appear at the collar region of the pseudostem and progress upwards and downwards. The first conspicuous symptom is mild drooping and curling of leaf margins of the lower leaves which spreads upwards. Yellowing starts from the lower-most leaves and gradually progresses to the upper leaves. In the advanced stage, the plants exhibit severe yellowing and wilting symptoms. The vascular tissues of the affected pseudostems show dark streaks. The affected pseudostem and rhizome when pressed gently extrude milky ooze from the vascular strands.

Control

- The cultural practices adopted for managing soft rot (below) are also to be adopted for bacterial wilt

- The seed rhizomes may be treated with Streptocycline 200 ppm for 30 minutes and shade dried before planting
- Once the disease is noticed in the field all beds should be drenched with Bordeaux mixture 1% or copper oxychloride 0.2%
- Select healthy seed rhizomes

Soft rot *Pythium aphanidermatum* (often with *P. myriotylum* and *P. vexans*)

Soft rot is the most destructive disease of ginger which can result in total loss of infected clumps. The disease is caused by a fungus which is both seed-rhizome borne and soil borne. Feeding by root flies and nematodes open wounds through which the fungus gains entry into the rhizome. The fungus multiplies in the presence of saturated soils in the rainy season. Waterlogging favors the disease. Younger sprouts are the most susceptible to the pathogens. The infection starts at the collar region of the pseudostems and progresses both upwards and downwards. In early stages of the disease, the middle portion of the leaves remains green while the margins become yellow. The yellowing is followed by drooping, withering, and drying of pseudostems. The bases of the aerial shoots become soft, watery and rot (soft rot) and the plant can be easily pulled out. The shoots fall and cease to produce rhizomes. The infection extends to the rhizomes that become soft and pulpy and on pressing they easily collapse. In more serious cases the inner tissues are reduced to a soft and black, putrefying mass. Losses can be high.

Control

- Rotate the ginger crop to avoid repeated planting of ginger or turmeric on the same land
- Treatment of seed rhizomes with mancozeb 0.3% for 30 minutes before storage and once again before planting reduces the incidence of the disease
- Select well drained soils for planting, since stagnation of water predisposes the plant to infection
- Use of soil amendments such as mustard oil cake, neem oil cake, poultry waste, and burning sawdust at planting
- Seed rhizomes are to be selected from disease free gardens, since the disease is also seed borne
- Application of the beneficial fungus *Trichoderma harzionum* along with neem oil cake @ 1 kg/ bed helps in preventing the disease at planting time
- Once the disease is located in the field, removal of affected clumps and drenching the affected and surrounding beds with mancozeb 0.3% checks the spread of the disease
- Choose a well drained location

4. Foliar diseases

Leaf spot *Phyllosticta zingiberi*

Leaf spot is more common during the wet season. The disease starts as water soaked spot and later turns into a white spot surrounded by dark brown margins and yellow halo. The lesions enlarge and adjacent

lesions coalesce to form necrotic areas or blotches. The disease spreads through rain splashes during intermittent showers. The incidence of the disease is most severe in ginger grown under exposed conditions.

Control

- The disease can be controlled by spraying Bordeaux mixture 1% or mancozeb 0.2% or chlorothalonil
- Grow in the shade

5. Rhizome insects

Ginger root flies *Chalcidomyia atrocornis and Formosina flavipes*
The larvae of these mosquito-like flies cause wounds in the rhizome providing entry for soft rot and secondary infection which can destroy the rhizome. The adult fly lays cigar-shaped white eggs in between the leaf sheath and rhizome on the top whorl, either singly or in rows of 4 to 6 eggs. Maggots enter into the rhizome by a minute hole made on unopened leaf bud and reach down the base of the tiller where they pupate. The maggots feed on the central core which later decays. The terminal unopened leaf wilts and dries up. Infestation is more on plants under too little shade. The pest activity starts during November and is at its peak in March-April. The life cycle is completed in 49-52 days.

Control

- Removal and destruction of affected shoots at ground level combined with spraying of neem will control the pest
- Adequate shade also must be provided

6. Defoliating insects

Skipper butterfly *Udaspes folus*
The bright green larvae of leaf roller cut and roll leaves into tubes that allow them to feed on leaves from the protection offered from within. The adults are medium sized butterflies with brownish black wings with white spots. Usually natural enemies control them and populations are low. If leaf area loss is more than 10% then control is warranted, particularly if leaf spot is also prevalent.

Control

- Handpicking

7. Preservation of seed rhizomes

It is necessary to store seed-rhizomes in order to plant in the coming season. The seed-rhizome is to be stored from the time of harvesting (December) to the time of sowing (April-May) to protect if from rotting and to maintain its vigor for 4-5 months during the off-season period. One of two methods is used for storage:

a. Field Storage: In this method a small part of ginger crop is left (according to requirement) unharvested. To protect the seed-rhizome from drying up, a thick layer of dry leaves is spread over the entire area. The ginger is then harvested when required for

plantation in April. Sometimes the harvested rhizomes are heaped under the shade of a tree over a layer of sand. The heap is covered with ginger leaves then plastered with mud and cow dung.

b. Pit storage: In this method, the freshly harvested rhizomes are cut into seed-rhizome size pieces, each having at least 2-3 buds. In order to obtain good germination, the seed-rhizomes are to be stored properly in pits under shade. For seed material, robust and healthy rhizomes from disease-free plants are selected immediately after harvest. For this purpose, healthy and disease-free clumps are marked in the field when the crop is 6-8 months old and still green. The uprooted seed-rhizomes are immersed with a solution containing quinalphos 0.075% and mancozeb 0.3% for 30 minutes, removed, and dried under shade. Pits are dug in a cool place with a depth of 80-100 cm covered by sheds. The walls of the pits may be coated with cow dung paste. The seed-rhizomes are placed in pits in layers along with well-dried sand/saw dust (put one layer of seed rhizomes, then put 2 cm thick layer of sand/saw dust). Sufficient gap is to be left at the top of the pits for adequate aeration. The pits can be covered with wooden planks with one or two small openings for aeration. The seed-rhizomes in the pits may be checked once every three weeks and any shriveled or disease affected rhizome are to be removed. The seed-rhizomes can also be stored in pits dug in the ground under shade. Farmers also preserve seed-rhizomes using leaves of *Glycosmis pentaphylla* (panal).

IX. TURMERIC

Crop monitoring

Monitor the crop on a weekly basis by walking through the field examining plants (look on undersides of leaves) to note the presence of diseases and insect and mite pests.

1. Nematodes

Nematodes feed within the root system blocking the flow of nutrients and water reducing plant growth. Among the nematode pests, root knot nematodes (*Meloidogyne* spp.), burrowing nematodes (*Radopholus similis*), and lesion nematodes (*Pratylenchus* spp.) are prominent. These are common in all soils each having many hosts. These species develop and reproduce inside plant tissues of host roots. They are spread by movement of the roots.

Control

- Select planting material from areas with less history of nematode
- Use mustard oil cake or neem oil cake soil amendment at planting

2. Soil borne diseases

Rhizome rot *Pythium* sp.

The symptoms from this soil-borne fungus start from the leaf margins, which dry up. The collar region of the pseudostem becomes soft and water soaked, and the plant eventually collapses.

Control

- At planting time use soil amendments such as mustard oil cake, neem oil cake, poultry waste, or burning sawdust
- Dip the rhizomes in 0.3% mancozeb (Dithane M45) solution for 30 minutes prior to storage and at the time of sowing prevents the disease.
- When the disease is noticed in the field, the beds should be drenched with 0.3% mancozeb (Dithane M45)

Erwinia soft rot*

3. Foliar diseases

Leaf blotch *Taphrina maculans*

The disease appears as small, oval, rectangular or irregular brown spots on either side of the leaves. They soon become dirty yellow or dark brown and the leaves turn yellow causing the yield to go down considerably. In severe cases the plants become scorched.

Control

- The disease can be controlled by spraying mancozeb 0.2% (Dithane M45, Penncozeb, etc).

Leaf spot *Phyllosticta*

Leaf spot is common during the wet season. The disease starts as small rectangular or irregular water soaked brown spots which later turn into white spots surrounded by dark brown margins and yellow halo. The lesions enlarge and adjacent lesions coalesce to form necrotic areas or blotches and eventually wilting. The disease spreads through rain splashes during intermittent showers. The incidence of the disease is most severe in turmeric grown under exposed conditions.

Control

- The disease can be controlled by spraying Bordeaux mixture 1% or mancozeb 0.2% (Dithane M45, Penncozeb, etc).

Alternaria porri*

4. Insects

Leaf roller *Udaspes folus*

The larvae of this skipper butterfly cut and roll leaves into tubes. The tubes offer them protection from natural enemies and they feed from within by scraping off leaf tissue. The bright green larvae are about 35 mm in length when full grown. The adults are medium sized butterflies with brownish-black wings with large white spots. Damage is the defoliation caused and butterflies but as they have many natural enemies, it is unlikely that high populations would occur.

But larvae are large and a single larva can defoliate an entire leaf.

Control

- Handpicking

Turmeric thrips *Panchaetothrips indicus*

This black thrips remove photosynthetic tissue with their piercing sucking mouthparts. The damage causes stippling or chlorotic spots on the leaves. When severe the leaves eventually roll up, turn pale, and gradually wither. As thrips are very small they would have to be very abundant to cause this type of economic injury. Their numbers are higher in the dry season as they pupate in the soil.

Control

- If leaf damage causes yellowing spray soap or neem

5. Stored product beetle

A small beetle causes damage on cured produce in storage by making small holes in rhizomes and feeding on the central portion. Secondary pathogens gain entry furthering the deterioration of the rhizome making them unmarketable.

Control

- Fumigation
- Keep storage area well aerated