



INTEGRATED **PEST** MANAGEMENT

SCHEDULE FOR VEGETABLES



National Horticulture Mission
Department of Agriculture & Cooperation
Ministry of Agriculture

Technical Bulletin No. 6

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MESSAGE

I am very happy to learn that the Horticulture Division has prepared a technical bulletin on Integrated Pest Management (IPM) Schedule for Vegetables, which provides illustrative details of IPM measures for a variety of vegetables being grown in India.

Even though India is a large producer and consumer of vegetables, many of them are highly vulnerable to frequent attacks of pests and diseases. At the time of such pest attack, farmers have a tendency to resort to indiscriminate use of chemicals and pesticides, which may be harmful to human health as well as to ecology. IPM is an alternative to such a scenario, which is being promoted under the National Horticulture Mission (NHM) and Horticulture Mission for North East & Himalayan States (HMNEH). This publication is expected to serve as a ready reference for field functionaries and extension workers involved in promoting IPM measures in the country.

I compliment Horticulture Division for bringing out this publication as part of 'Year of Horticulture' celebrations.

(Sharad Pawar)

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INTRODUCTION

Integrated Pest Management (IPM) is a component of the agroecosystem management technology for sustainable crop production. It is a knowledge intensive system and background information regarding the pest, abiotic and biotic factors, agroecosystem and management tactics required for execution of IPM programmes. List indicating fungal diseases, Bacterial diseases, viral and phytoplasmal diseases in vegetable crops are given in Annexure I, Annexure II and Annexure III, respectively. Similarly, details of Fungicides/Insecticides and Biopesticides, Phermones used in IPM of vegetables are given in Annexure IV, and Annexure V, respectively. The First and foremost tool in IPM programme is to determine the level of pest population, which is going to cause economic damage. In this context, Economic Threshold Level (ETL) and Economic Injury Level (EIL) are to be followed as index for initiating economically viable control measures. ETL for some vegetable crops is given in Annexure VI. Need based control strategy not only helps in reducing the pesticide consumption and environmental abuse, but also helps in maintaining minimum pest population for survival of natural enemies. Insecticides of plant origin, growth regulators, attractants/repellants, bioagents, biopesticides, entomopathogenic bacteria, fungi and Nuclear Polyhedrosis Virus (NPV), besides pheromone traps, sticky traps, and trap crops can fit well in the IPM. Botanicals, being non-persistent and safe to mammals, possess good promise in pest management. A list of Pesticides/Pesticide Formulations which are banned in India is given in Annexure VII.

INSECT MANAGEMENT

TOMATO

Fruit Borer (*Helicoverpa armigera* Hubner)

The adult is stout and medium-sized moth and has a dark circular spot in the centre on the forewing. They lay small, single, and whitish round eggs on the trifoliate leaves beneath the topmost flower cluster.

Eggs hatch in about 3-4 days and the first instars larvae initially feed on the leaves and migrate to the developing green fruit later. The larvae bore into the fruits with the posterior end outside the hole. Full-grown caterpillars show characteristic whitish and dark brown longitudinal stripes.



Management

Under Open Conditions:

- ❖ Effective management can be done by adopting marigold as trap crop.
- ❖ Giving sprays of *Ha* NPV @ 250 LE /ha at 28,35 and 42 days after transplanting.
- ❖ Mechanical collection and destruction of bored fruit at periodic intervals (3-4 times) brings down the borer incidence to less than 2 per cent.

Under Protected Conditions:

- ❖ Spray *Ha* NPV at 250 LE/ha + 1% jaggery along with sticker (0.5 ml/litre) during evenings when the larvae are young.
- ❖ For grown up larvae spray Indoxacarb 14.5 SC @ 0.5 ml/l or Thiodicarb 75 WP @ 1g/l.

Serpentine Leaf Miner (*Liomyza trifolii* Burgess)

The tiny, metallic fly punctures the leaf lamina and feeds on the oozing sap. It lays eggs on the outer margin of leaves. Within 2-3 days, whitish maggots hatch out of these eggs and start mining the leaves and pupate in 6-10 days. Pupation takes place in the soil and occasionally on the leaf surface itself. Typical serpentine shaped tunnels are formed in the leaf lamina indicating the path of feeding by the maggots.



Leaf miner damage on tomato leaves

Management

- ❖ Often the incidence starts from nursery itself. Hence, remove infected leaves at the time of planting or within a week of transplanting.

- ❖ Apply neem cake to furrows (open)/beds (polyhouse) @ 250 kg/ha at planting and repeat after 25 days.
- ❖ Spray neem seed powder extract 4% or neem soap 1% at 15-20 DAPS.
- ❖ In open conditions, if the incidence is high, remove infected leaves and spray Triazophos 40 EC (1ml) mixed with 7.5 g neem/l.
- ❖ Under protected conditions avoid frequent spraying of synthetic pesticides. At the most, one spray of Deltamethrin 2.8 EC @ 1ml/l or Cypermethrin 25 EC @ 0.5 ml/l or Triazophos 40 EC @ 2ml/l may be given, if required.

Whiteflies (*Bemisia tabaci*)

Whitefly is a well-known vector, which transmits tomato leaf curl virus. It has piercing and sucking mouthpart and both nymphs and adults feed on lower surface of the leaves causing deformation of young leaves. Whiteflies also excrete honeydew, causing sooty mold. Under protected conditions whiteflies become more persistent, which require extensive management practices as mentioned below.

Management

- ❖ Use virus resistant hybrids.
- ❖ Raise nurseries in seedling trays under nylon nets or polyhouses.
- ❖ Spray Imidacloprid 200 SL (0.3ml/l) or Thiomethoxam 25 WP (0.3 g/l) in nursery at 15 days after sowing.
- ❖ Remove the leaf curl infested plants as soon as disease symptoms are expressed. This helps in reducing source of inoculum of the disease.
- ❖ Drench the base of the seedlings with Imidacloprid 200 SL (0.03ml/l) or Thiomethoxam 25 WP (0.3 g/l) before transplanting. If proteyres are used for raising nursery, drench the proteyres with the chemicals one day before transplanting.
- ❖ After transplanting give need-based sprays of Imidacloprid 20 SL (0.3ml/l) or Thiomethoxam 25 WP (0.3 g/l) at 15 days after planting and do not repeat after fruiting stage as this may leave harmful residues in fruits.

- ❖ Install yellow sticky traps coated with adhesive or sticky glue at crop canopy level for monitoring adult whitefly population.
- ❖ If the traps indicate the whitefly activity, spray Dimethoate 30EC @ 2ml/l or neem seed kernel extract 4% (NSKE) or pongamia or neem oil (8-10 ml/l) or neem soap (10g/l).
- ❖ Rogue out the virus affected plants as soon as the symptoms are observed.

Tobacco Caterpillar (*Spodoptera lituara*)

This is a minor pest under open conditions and assumes severe form under protected cultivation particularly in ill managed playhouses. Eggs are laid in clusters on foliage. Young larvae feed gregariously on leaves. Mature larvae, migrate and cause extensive damage to leaves and fruits. They hide in soil and crop debris during the day time.

Management

- ❖ Collection and destruction of egg masses and gregarious larvae.
- ❖ Spray *Spodoptera* NPV 250 LE/ha + 1% jaggery along with sticker (0.5 ml/litre) during evenings.
- ❖ Use poison baiting. Mix 10 kg of rice bran or wheat bran with 2 kg jaggery by adding a little water in the morning. In the evening add 250 gm of Methomyl or Thiodicarb formulation and sprinkle over the bed. Caterpillars get attracted to fermenting jaggery, feed and get killed.

Red Spider Mites (*Tetranychus urticae*)

Red spider mites thrive under high temperature, dry weather and are more serious under protected conditions. They are generally found on the lower surface of older leaves. However, when the infestation is very high they attack all parts of the plant and are observed in colonies covered by white-silky webs. Adults and nymphs lacerate the leaves causing yellowing and discoloration.

Management

- ❖ Remove and destroy the affected leaves.
- ❖ Under open conditions, spray Dicofol 18.5 EC @ 2.5 ml or wettable sulphur 80 WP @ 3g/l. Spray lower

leaves and lower leaf surface thoroughly as mites are generally observed there.

- ❖ As an alternative to the chemical acaricides spray neem oil/neem soap/ pongamia soap 1%.
- ❖ Under polyhouse conditions spray need-based application of acaricides like Abamectin 1.9 EC @ 0.5 ml/l or Dicofol 18.5 EC @ 2.5 ml/l or Fenazaquin 10 EC @ 1 ml/l in rotation with plant products like pongamia oil or neem oil (8-10 ml/l) or neem soap (10 g/l).
- ❖ When incidence is severe, remove and destroy all severely infected leaves followed by a spray of mixture of an acaricide with botanicals mentioned above.

Root-knot Nematodes (*Meloidogyne incognita*, *M. javanica*)

Root-knot nematodes cause root galls on the feeder roots and sometimes affect the entire root system showing heavy galling. This affects the uptake of nutrition and water and the plants show wilting during warmer part of the day. This causes stunted plants with yellow foliage resulting in yield reduction.

Management

- ❖ Use nematode resistant variety/hybrid if available.
- ❖ Follow crop rotation with marigold, wherever possible.
- ❖ Seed treatment with bio-pesticides- *Pseudomonas fluorescens* @ 10g/kg seed.
- ❖ Nursery bed treatment with *T. harzianum* @ 50 g/ sq. m.
- ❖ For the management of nematodes in the main field apply 2 tons of farmyard manure enriched with *T. harzianum* and *Paecilomyces lilacinus* per acre before planting, along with 100-200 kg of neem or pongamia cake.
- ❖ Apply Carbofuran 3G @ 1 kg ai/ha at transplanting.

Under polyhouses the following pest management practices depicted as a flow chart may be followed.

IPM package in tomato under polyhouse

Raise seedlings in protreys in polyhouse ▼	
15 DAS (Days after seed sowing) ▼	Spray the plants with Imidacloprid or Thiomethoam.
One day before transplanting ▼	Drench the base of seedlings with Imidacloprid or Thiomethoxam
At transplanting ▼	Apply neem cake 250 kg/ha.
15 DAP (days after planting) ▼	Spray the seedlings with Imidacloprid or Thiomethoxam
25 DAP (days after planting) ▼	Apply neem cake 250 kg/ha
Post flowering and fruiting stage	Monitor for pest like fruit borer, tobacco caterpillar, leaf miner, whitefly and red spider mite.
	Erect yellow sticky traps to monitor whitefly.
	Spray NPV according to the pest.
	Remove leaves severely infected with leaf miner/red spider mite
	Spray neem seed powder/neem soap for leaf miner.
	Spray synthetic acaricide/botanical in rotation to control red spider mite, spray systemic insecticide/botanical to control whitefly.

BRINJAL

Shoot and Fruit Borer (*Leucinode orbonalis* Guen)

This pest has developed resistance against all groups of insecticides and management is very difficult. The

adult moths lay tiny white eggs singly on flower buds and other plant parts. Eggs hatch into small light brown larvae. Caterpillars feed inside the tender shoots before flowering and cause wilting of the affected shoots. Later, the larvae bore into flowers; flower



Larva inside the stem



larvae bore into fruit

bud and the grown up larvae migrate and bore fruit contaminating them with excreta. When the incidence is high, unopened flower buds swell and harbour the borer. Just before pupation, the grown up larvae come out of the fruits and flower buds to pupate in silky cocoons on plant parts or debris.

Management

- ❖ Use nylon net barrier for raising nurseries to eliminate pest incidence coming from nursery to main field.
- ❖ Cut and destroy wilted insect damaged shoot tips during pre-flowering and flowering period at weekly intervals.
- ❖ Regularly destruction of larvae in swollen damaged flower buds and fruits after each harvest is compulsory.
- ❖ Grow all round barrier crops like maize.
- ❖ Practice clean cultivation.

Pheromone Trap

Use of water traps loaded with pheromone @ 30 /Acre can reduce the pest incidence to minimum level.

Botanical and Bioagents

- ❖ Apply neem or pongamia cake @ 250-500 kg/ha to ridges at flowering and repeat 2 more times at 30-45 days interval.
- ❖ Spray NSPE 4% or neem oil 2% at 10 days interval. Mix Cypermethrin 25 EC (0.75 ml/l) with neem soap @ 7.5g/l and spray.
- ❖ Spray *Bacillus thuringiensis* formulation (1%) at weekly interval followed by release of *Trichogramma chilonis* @ 2,50,000 /ha (50,000 / release -5 times at weekly intervals, starting from flowering).

Leafhopper (*Amrasca biguttula biguttula* Ishida)

Both adults and nymphs suck the sap from leaves. The eggs are inserted into the midrib or veins. On hatching the nymphs move along the veins and nymphs suck the leaf sap. On the older leaves, the damage is seen as yellowish-green mosaic patches followed by brown necrosis and curling along the leaf margin.

Management

- ❖ Soil application of neem cake 250 kg/ha followed by sprays of NSPE 4% or neem soap 1% at 10 days interval.
- ❖ Spray of systemic insecticides like Dimethoate 30 EC @ 2ml/l or Imidacloprid 200 SL @ 0.3ml/l or Acephate 75 SP (1 g/l) at pre-flowering stage.

Ash Weevil (*Myloccerus subfasciatus* Guerin)

Ash weevil is an endemic pest feed on the foliage and cause saw teeth like damage along the leaf margin. The adults lay eggs in and around base of the plants in soil and the hatching grubs feed on roots. Affected plants wilt and dry up. Wilting is first noticed in patches in a plot. One can notice very few roots in such wilting plants when uprooted. Both the roots and plant base show scraped damage. Grubs pupate in the soil encrustation.



Management

- ❖ Soil application of neem cake at the time of transplanting (@ 250 kg/ha) and repeat the neem cake application for 1 or 2 times at 30 and 60 DAP.

Epilachna Beetle (*Epilachna vigintioctopunctata*, Fab.)

Both the grubs and the adult beetles scrape the leaves in semi-circular or half moon shaped fashion. Females lay torpedo shaped, 15-50 yellowish eggs on the ventral surface of leaves. Heavy infestation result in leaf skeletonization. Pupation takes place on the plant itself.



Adult beetle

Management

- ❖ Collect and destroy adult beetles.
- ❖ Spray any contact insecticide like Carbaryl 50 WP @ 3g/l or 40 EC @ 1.5 ml/l if required.

Red Spider Mites (*Tetranychus urticae* Koch)

Tiny mites feed mainly on the lower surface of the leaves by scrapping the epidermis causing yellowing of leaves followed by foliage drying. Practices detailed under tomato can be adopted for its control.



Red spider mites damage on brinjal

Management

- ❖ Spray of Dicofol 18.5 EC @ 2.5 ml or any other acaricide like wettable sulphur 75 WP @ 3 g/l.
- ❖ As an alternative to the chemical acaricides, spray of neem soap/pongamia soap 1% on the under surface of the leaves.

Other Pests

Gall midge (*Asphondylia* sp), stem borer (*Euzophera perticella*), leaf roller, (*Eublemma olivacea* (Walker)), lace wing bug, (*Urentius echinus*) and thrips, (*Sericothrips solanifolii*) also attack the crop.

Management

- ❖ Raise the nurseries with the nylon net barrier.
- ❖ Most of these pest can be managed by application of neem cake @ 250 kg/ha and repeating the same treatment 2-3 times at 30 days interval for 2-3 times.

Reniform Nematode (*Rotylenchulus reniformis*)

The infected plants show yellowing and reduced size of the leaves and fruits and thus affecting the yield potential.

Root-knot Nematodes (*Meloidogyne incognita*, *M. javanica*)

The root-knot nematodes cause root galls on the feeder roots which sometimes affect the entire root system showing heavy galling. This affects the uptake of nutrition and water and the plant show wilting during warmer part of the day. Later, stunting of plants with yellow foliage and reduction in yield is very common.



Root-knot infected plant

Management

- ❖ Seed treatment with bio-pesticide-*Pseudomonas fluorescens* @ 10 g/kg seed.
- ❖ Nursery bed treatment with *T. harzianum* @ 50 g/ sq.m.
- ❖ Apply 2 tons of farmyard manure enriched with *T.harzianum* and *Paecilomyces lilacinus* per acre before planting, along with 100-200 kg of neem or pongamia cake.
- ❖ Apply Carbofuran 1G @ 1kg ai/ha at transplanting.

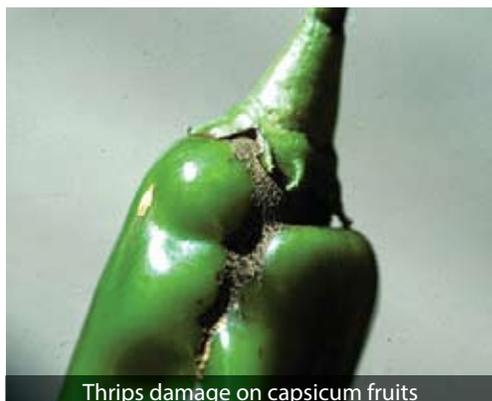
CHILLI AND CAPSICUM

Thrips (*Scirtothrips dorsalis*)

Thrips are minute insects with fringed wings, serious during dry periods of high temperature. Both adult and nymphs suck the sap from young developing leaves. Affected leaves curl upwards along the margin and get crinkled and reduced in size. They also feed on floral parts and fruits. Fruit damage result in rough brown patches affecting their quality and drastically reducing the market value.



Leaf damage due to thrips in capsicum



Thrips damage on capsicum fruits

Management

- ❖ Apply neem cake @ 250 kg/ha to plant beds while planting and repeat after 30 days.
- ❖ Spray Acephate 75 SP@ 1.0g/l or Fipronil 5 SC @ 1ml/l or ethofenprox 10 EC @ 1ml/l in rotation.
- ❖ Spray Acephate 75 SP (0.5 gm) + pongamia oil (2ml) +1 ml sticker in one litre water after emulsifying (shaking thoroughly in a bottle).

White or Yellow Mites

(*Polyphagotarsonemus latus*)

These are very minute mites and cannot be seen by naked eyes. Damage is more in hot and humid conditions. Adults and nymphs scrape terminal leaves and auxiliary shoots. As a result, leaves become narrow, twisted with elongated petiole. The damage is characterized by downward curling of leaves and stunted growth of plants and dropping of flowers.



Yellow mite damage on capsicum



Fruit discolouration

Management

- ❖ Apply wettable sulphur 80 WP @ 3g/l or any acaricide (directing the spray on the ventral surface of leaves).
- ❖ Spray pongamia oil (2ml/l) mixed with acaricides.
- ❖ Spray neem seed powder extract 4% at 10 days interval when the pest incidence is low. As and when the pest incidence increases, spray with synthetic acaricides like Dicofol 18.5 EC @ 2.5ml/l and repeat the spray after 10 days, if required.
- ❖ Under protected conditions spray acaricides like Abamectin 1.9 EC @ 0.5ml/l or Dicofol 18.5 EC @ 2.5 ml/l or Fenazaquin 10 EC@ 1ml/l in rotation with plant products like pongamia oil or neem oil (8-10 ml/l) or neem soap (10g/l) when the leaves start curling down with all the precautions.

Aphids (*Aphis gossypi* and *Myzus persicae*)

These are small green insects and suck the sap from tender leaves and flower buds. Excretion of honeydew by aphids promotes sooty mould growth, thereby reducing photosynthesis and fruit quality. Aphids also act as vectors for transmitting mosaic virus disease.

Management

- ❖ Spray Acephate 75 SP @ 1g/l or Dimethoate 30 EC @ 2 ml/l in rotation when required.
- ❖ Remove all the virus affected plants and destroy.

Borers

Tobacco caterpillar, *Spodoptera litura* and tomato fruit borer, *H. armigera* are also serious pest in chilli and capsicum. These affect the market value of the chilli crop to a great extent, if proper care is not taken.



Management

- ❖ Spray specific NPV of the borer species.
- ❖ Inundative release of *Trichogramma* sp.
- ❖ Use marigold as trap crop (one row of marigold for every 18 rows of chilli) for managing *H. armigera*.
- ❖ Collect and destroy eggs masses and immature larvae of *S. litura*.
- ❖ Use poison baiting (10 kg rice flour + 1 kg of jaggery + 250 g of Methomyl 40 SP) for *S. litura* and repeat the baiting 2-3 times if necessary.
- ❖ For *S. exigua*, spray Indoxacarb 14.5 SC @ 0.75 ml/l or Spinosad @ 0.75 ml/l or Thiodicarb 75 WP @ 0.75 g/l.
- ❖ Sometimes tomato fruit borer and tobacco caterpillar may also attack capsicum under polyhouse. Follow the management practices given under tomato.

Root-knot Nematodes (*Meloidogyne incognita*)

Root-knot nematodes cause root galls on the feeder roots which sometimes affect the entire root system showing heavy galling. This affects the uptake of nutrition and water and the plants also show wilting during warmer part of the day. Later, stunting of plants with yellow foliage and reduction in yield is very common.

Management

- ❖ Management practices given under tomato and brinjal are also effective on chillies.

IPM package in capsicum under polyhouse

Raise seedlings in proteys in polyhouse	
At transplanting	Apply neem cake 250 kg/ha.
15 DAP	Spray Acephate for thrips
30 DAP	Apply neem cake 250 kg/ha
	Post flowering and fruiting stage monitor for pest like fruit borer, tobacco caterpillar, thrips and yellow mite.
	Spray NPV according to the pest.
	Spray Acephate / Fipronil / Ethofenprox / Acephate + pongamia oil in rotation for thrips control.
Post flowering and fruiting stage	Spray synthetic acaricide / botanical in rotation to control yellow mite.

OKRA

Leafhoppers (*Amrasca biguttula biguttula*)

Hoppers lay pear shaped, elongated and yellowish white eggs in the veins on the under surface of leaves. Both the adults and nymphs suck the cell sap. Nymphs move diagonally when disturbed. There are 10 to 12 overlapping generations in a year. Plants lose their vitality and affected leaves turn yellow and curl upwards. When the infestation is high during summer, leaves turn brick red and show large necrotic spots, which is often confused with fungal infection.

Management

- ❖ Apply neem cake @ 250 Kg/ha to soil immediately after germination and repeat after 30 days.
- ❖ In the initial stages of crop before flowering spray systemic insecticide like Acephate 75 SP (1ml/l) or Imidacloprid (0.3 ml/l). Once the fruit harvest starts avoid systemic insecticides.
- ❖ Spray neem or pongamia soaps @ 0.5% or pulverized neem seed powder extract (NSPE) 4% at the lower surface of the leaves.

Shoot and fruit borer (*Earias vittella* and *E. insulana*)

Spotted bollworms are active throughout the year reaching peaks during March-May and August-October. Female lays green coloured eggs with longitudinal ridges on buds, flowers and fruits. Like brinjal shoot and fruit borer, the infestation is seen on shoots before and after flowering, feed exclusively on fruits. Infested shoots wither and wilt.



Fruit borer damage on okra

Management

- ❖ Collect and destroy the affected fruits and stems.
- ❖ Apply neem cake @ 250 kg/ha after germination and repeat two more times at 30 days interval and spray neem soap 1% or NSPE 4%. Spray at 10 days interval.
- ❖ During rainy season, spray effective contact insecticides like Indoxacarb 14.5 SC @ 0.75 ml/l. A waiting period of minimum one week to be maintained.
- ❖ Avoid staggered planting.

Aphids (*Aphis gossypii*)

This is a polyphagous pest, feeding in colonies and completely covers the shoot tips, buds and lower surface of leaves. Both nymphs and adults suck the sap. They also excrete honeydew on which sooty mould develops.

Management

- ❖ Clip and destroy infested shoots
- ❖ Thoroughly spray neem or pongamia soap (1%) or pulverized neem seed powder extract (NSPE) 4%. During pre-flowering period spray systemic insecticides like Dimethoate 30 EC (2ml/l) or Acephate 75 SP or Acetamiprid.

Petiole Maggot (*Melanagromyza hibisci* Spencer)

This is a dipteran fly and attacks the crop throughout the growth period. Generally drying of leaves is noticed. If petioles of such leaves are opened, yellow maggot and pupae can be noticed. Pest attacks immediately after germination and may cause mortality, or cracking of main stem.

Management

- ❖ Apply neem cake @ 250 kg/ha immediately after germination and repeat after 30 days followed by sprays of NSPE 4% or neem soap 1% at 10 days interval after flowering.

Whitefly (*Bemesia tabaci*)

It is a polyphagous vector transmitting yellow vein mosaic disease (YVM). It lays eggs on the lower surface of leaves. Both the adult and the nymph feed by sucking leaf sap. They excrete honeydew, which results in sooty mould. At present many varieties and hybrids resistant to YVM are available in market and hence, disease management is very easy.

Management

- ❖ Grow YVM resistant varieties/hybrids
- ❖ Apply neem cake @ 250 kg/ha at germination and again at 30 DAP followed by sprays of pulverized neem seed powder extract 4% or neem oil 1%.
- ❖ Spray Imidacloprid 200 SL @ 0.3ml/l or Thiomethoxam 0.3 gm/l (should not be sprayed after flowering stage)

Mites (*Tetranychus cinnobarinus*, *Oligonychus coffeae*)

The infestation of mites is mostly observed during the warm and dry periods of the season. Nymphs and adults lacerate the leaves resulting in whitish grey patches and affected leaves become mottled, turn brown and fall.

Management

- ❖ Spray Dicofol 18.5 EC @ 2.5 ml or any other acaricide like wettable sulphur 50 WP @ 3g/l.
- ❖ As an alternative to synthetic acaricides, spray neem soap/pongamia soap 1%.
- ❖ Thoroughly spray on the under surface of the leaves for good control.

Root-knot Nematodes (*Meloidogyne incognita*, *M. javanica*)

The root-knot nematodes typically cause root galls on the feeder roots, affecting the uptake of nutrition and water. The above ground symptoms are, stunting of the plant with yellow foliage often mistaken for nutrient deficiency symptoms. The reduction in size of fruits is often accompanied by fresh flower drop.

Management

- ❖ Seed treatment with bio-pesticide *Pseudomonas fluorescens* @ 10g/kg seed.

- ❖ Apply 2 tons of farmyard manure enriched with *Pochonia chlamydosporia* and *Paecilomyces lilacinus* per acre before sowing, along with 100-200 kg of neem or pongamia cake.
- ❖ In case of severe incidence, apply Carbofuran 1.5 kg ai/ha.

CRUCIFEROUS VEGETABLES (Cabbage, Cauliflower, etc.)

Diamond Back Moths (DBM) (*Plutella xylostella* L.)

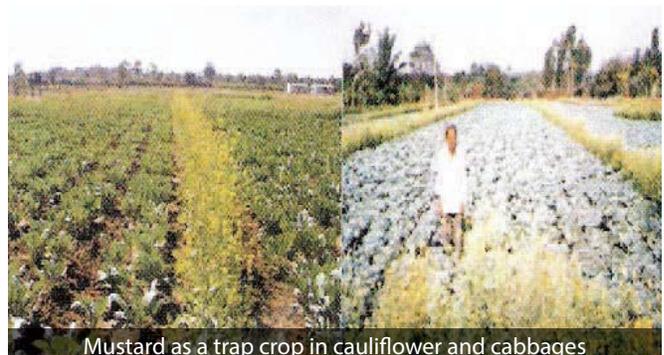
Diamond back moths are small grayish brown insects bearing whitish triangular spots on posterior margins of the forewings and while resting the wings come together and form a diamond pattern. This is a major pest of cruciferous crops, particularly cabbage and cauliflower during January-June and also during dry periods in monsoon. Eggs are yellowish white, and are laid singly on tender leaves. A single female may lay about 40-60 eggs. Incubation period is 3-6 days. The first instar larvae mine the epidermal surface of the leaves. Second instars onwards the larvae feed externally by making holes in the leaves. Pupation occurs inside silken cocoon on the plants, which last for 4-6 days. The complete life cycle from egg to egg takes place in about 20-25 days.



Damage on cabbage



Larvae



Mustard as a trap crop in cauliflower and cabbages

Management

- ❖ Sow Indian mustard as a trap crop.
- ❖ Spray neem seed powder extract @ 4% or neem soap 1% or pongamia soap 1% thoroughly coverage to the crop canopy.
- ❖ Install light traps (3-4 with 60 or 100 Watt bulbs / acre) to control adults. For one acre plot use 3-4 light traps (60 or 100 Watt bulbs) by hanging above a bucket half filled with water. Alternatively, hang the bulb above a gunny bag (slating below) smeared with grease or oil. Illuminate the bulbs for full night. Adults of DBM will get attracted to light and get trapped in the water/oil. Use the light traps for 3-4 days for effective control of DBM adults.
- ❖ As this pest has developed resistance against many insecticides, use of effective insecticide currently available in market is essential.
- ❖ Follow the detailed IPM package as given at the end of the section of pests of cruciferous vegetables.
- ❖ The adults migrating from neighbouring plots are to be controlled by using light traps spraying an affective insecticide.

Leaf Webbers (*Crocidolomia binotalis* Zeller)

The moths lays eggs in clusters of 40-100 on leaf surface, which hatch in 5-7 days. Young larvae feed gregariously and later web the leaves together and feed within. This results in rotting of cabbage head and cauliflower curds. The larval period lasts for 25-20 days while pupation occurs in soil, which varies from 15-40 days.



Leaf webber damage on cabbage

Management

- ❖ Collect and destroy egg masses and gregarious larvae.
- ❖ Spray any contact insecticide on the foliage when the larvae are observed.
- ❖ Spray neem seed kernel extract 4% or pulverized neem seed powder extract (NSPE) 4%.

Stem Borer (*Hellula undalis* Zeller)

The adult moths lays eggs singly on leaves, the hatched larvae mine the leaves along side veins. The grown up larvae bore into stems preventing head initiation, which results in multiple shoots and multiple head formation.

Management

- ❖ Spray the seedlings with an effective contact insecticide before planting followed by one more spray at 10 DAP, particularly for summer and kharif crop (March-July).
- ❖ Spray pulverized Neem Seed Powder Extract (NSPE) 4%.

Aphids (*Brevicoryne brassicae* Linn, *Myzus persicae* Sulzer)

Aphids suck the sap, devitalize the plants affecting the quality of head or curds and become severe when contact insecticides are sprayed regularly. Direct feeding on young growth leads to wilting of plants. Early attack may lead to stunted growth. Symptoms of viruses transmitted by *B. brassicae* include mosaic, chlorotic and necrotic lesion on leaves. *M. persicae* is the most important aphid virus vector.



Myzus persicae



Brevicoryne brassicae

Management

- ❖ Spray any systemic insecticide like Dimethoate 3 EC @ 2ml/l when the aphids are observed.
- ❖ Spray pulverized neem seed powder extract (NSPE) 4%.
- ❖ Follow mustard trap crop IPM as mustard will attract all aphids after flowering and main crop will be spared of the pest incidence.

MINOR PEST

Tobacco Caterpillar (*Spodoptera lituara* Fab.)

The moths lay eggs in groups and young larvae upto third instar feed gregariously and skeletonise the leaves. Grown up larvae completely devour the leaves and other plant parts in case of severe incidence. During high incidence, attain cutworm status, hide during daytime, come out during night and devastate the crop.



Tobacco caterpillar damage on cabbage head

Management

- ❖ Collect and destroy egg masses and gregarious feeding larvae.
- ❖ Scouting regularly helps to locate egg masses and skeletonised leaves.
- ❖ Poison baiting (10 kg rice/wheat flour + 1 kg of jaggery + 500 g of Methomyl formulation per acre)- Mix the flour with jaggery, leave for 6-8 hrs, in the morning. In the evening add insecticide and mix carefully by wearing gloves with a stick. Sprinkle the mixture in furrows. The fermenting jaggery attracts the caterpillars and will be killed

due to poison baiting. Repeat the baiting 2-3 days for total control.

Other Minor Pests

Gram caterpillar, *Helicoverpa armigera* (Hubner), Mustard saw fly *Athalia lugens proxima* (Klug) are some of the minor pests of cruciferous vegetables which feed on the foliage deteriorating the market quality of heads and curds.

Management

- ❖ Mechanical control is very effective for gram caterpillar as the grown up caterpillars hide inside the hole and insecticide spray is not useful.
- ❖ Spray Chlorpyrifos 20 EC @ 2.5 ml/l for mustard saw fly.

LEGUMINOUS VEGETABLES

Pod Borers

A complex of pod borers viz., *Lampides boeticus* L., *Maruca testulalis* Geyer, *Adisura atkinsoni* (Lethierry), *L. boeticus*, *Helicoverpa armigera* affects the leguminous crops by feeding floral parts and pods resulting in reducing their marketable quality.

Lycaenid Borer (*Lampides boeticus* L.)

This is a butterfly pest and commonly known as pea blue. The eggs are laid singly in flowers and flower buds. In peas, the larvae bore into young pods. The entry hole gets blocked after sometime. However, in lablab, the larvae bore into flower buds. The pest can be monitored by the presence of the bored holes. When the larvae attains fourth instars, they migrate and cause extensive damage to flower buds and pods. Hence, control measures need attention in the early stages of pest incidence.

Management

- ❖ In peas, spray at flowering as soon as eggs are noticed with Cypermethrin 25 EC @ 2.5 ml/l or Indoxacarb 14.5 SC @ 0.5 ml/l.
- ❖ In lablab, spray at flower bud stage, when on an average about 1 flower bud is damaged per inflorescence.

Spotted Pod Borer (*Maruca testulalis* Geyer)

The pyralid moth lays eggs on small flower buds as soon as flowering starts. Flower buds can be examined for holes caused by young larvae. Control measures are to be followed at flower bud stage itself to prevent the larvae from developing and feeding on pods.

Management

- ❖ Apply neem cake 250 kg/ha at flowering and first spray at flower bud formation with pulverized neem seed powder extract (PNSPE) 4% or neem soap 1%. Repeat after one week.
- ❖ Spray Cypermethrin 25 EC @ 0.5 ml/l or Chlorpyrifos 20 EC @ 2.5 ml/l or Indoxacarb 14.5 SC @ 0.5 ml/l.

Field Bean Pod Borer (*Adisura atkinsoni*, Lethierry)

This is the major pod borer in field bean and the larva resembles *H. armigera*. The eggs are laid on tender pods. The young larvae bore into these pods and develop inside and come out after attaining fourth instar, which is a migratory stage. Hence, control measures at tender pod stage and again at flat pod stage of the crop are essential.

Management

- ❖ Apply neem cake 250 kg/ha at flowering and repeat after 20 days. Spray pulverized neem seed powder extract (NSPE) 4% of neem soap 1% at tender pod formation. Repeat sprays at 10 days intervals.
- ❖ Spray Cypermethrin 25 EC @ 0.5 ml/l or Chlorpyrifos 20 EC @ 2.5 ml/l or Indoxacarb 14.5 SC @ 0.5 ml/l at peak egg laying period at tender pod stage and repeat after 15 days.

Gram Pod Borer (*Helicoverpa armigera* Hubner)

This polyphagous pest attacks peas occasionally along with *L. boeticus*. The habit of egg laying and larval feeding are the same as pea blue butterfly.

Management

- ❖ As soon as eggs are noticed give the first spray at flowering with Indoxacarb 14.5 SC @ 0.5 ml/l or Novaluron 10 EC @ 0.75 ml/l.

Aphids (*Aphis craccivora* Koch & *Acrythosiphon pisum* Harris)

Both nymphs and adults suck the sap from young plant parts like shoot tips and inflorescence. *A. craccivora* is greenish black and *A. pisum* is greenish in colour. *A. pisum* generally occurs on peas.



Management

- ❖ Clip infected shoots and spray neem soap or pongamia soap @ 1%.
- ❖ Spray Acephate 75 WP @ 0.75 ml/l or Dimethoate 30 EC 2ml/l.

Bugs

Many bugs are known to attack leguminous crops. Of these, *Nezara viridula* and *Coptosoma cribraria* are often serious, mostly on cowpeas and lablab. Eggs are laid on tender plant parts. Nymphs and adults suck the sap from foliage, flower parts and pods and emit characteristic bad smell.

Management

- ❖ Apply neem cake 250 kg per ha immediately after germination and repeat at flowering. Spray neem soap 1% or pulverized neem seed powder extract (NSPE) 4% at 10 days interval.
- ❖ Spray with Indoxacarb 0.5 ml/l if the incidence is high.

Bean Fly (*Ophiomyia phaseoli* Tryon & *O. centrocematis* de Majore)

Bean flies are the major pest attacking several legumes. While the first species attacks mostly beans and cowpeas, the second species attacks peas.

Bean Fly (*O. phaseoli*)

This species is serious in French beans and peas but can also be noticed on dolichos beans. This pest is

serious during dry periods of Kharif (June- August) and after January-February when temperature increases above 30°C and can cause more than 70% mortality of the plants. The adults are small flies and lay eggs in the unifoliate leaves that come immediately after germination. It punctures the leaf, lays eggs under the leaf epidermis which turn into white spots, often confused with disease. These dried ovipositional cavities are observed within 2-3 days of germination of seeds. The larvae mine the leaf lamina, veins, midrib, and petiole and enter the stem resulting in mortality. The incidence is high during prolonged dry spells between rains, particularly in June-July months. When the incidence is early and high, plants invariably die. This mortality is noticed only after 25-30 days, when the plants are about to flower. Any control measures taken at that time is not useful.

Management

- ❖ Apply neem cake 250 kg/ha immediately after germination. Do not delay, particularly during kharif period.
- ❖ Monitor the plants for adult activities, puncture marks and petiole mining soon after germination.
- ❖ As soon as a few adults are noticed hovering over the crop, spray Acephate 75 WP @ 0.75 g/l or PNSPE 4% or neem soap 1% or neem formulation with 10000 ppm Azadirachtin 2 ml/l. The botanicals get washed away by rain and become ineffective if it rains within 1-2 days of spray.
- ❖ Give second spray after 12-20 days of sowing if 5 leaves show petiole mining symptoms per 10 leaves.

Bean Fly (*O. centrocematis*)

This species is specific to peas and lays eggs in the base of the stem resulting in drying of the leaves, from the base. Hence, the first symptom is drying of the first primitive leaf at the base, which occurs after about 20 days of sowing.

Management

- ❖ Apply neem cake 250 kg per hectare to the ridges immediately after germination followed by sprays of pulverized neem seed powder extract 4% or

neem soap 1% or neem formulation with more than 10000 ppm Azadirachtin 2-3 ml/l at 20 and 30 DAP.

- ❖ Spray Acephate 0.75 ml/l or Dimethoate 30 EC @ 2ml per litre at 20 and 30 DAP.

Leafhoppers (*Empoasca kerri Pruthi*)

The greenish yellow nymphs and adults suck the sap. During September-October after onset of north-east monsoon, the pest becomes very serious causing withering of the foliage and plants.

Management

It can easily be controlled by any systemic insecticide or neem soap sprays as given under okra and brinjal.



Beetle feeding on cucurbit leaf



Red pumpkin beetle

CUCURBITACEOUS VEGETABLES

Red Pumpkin Beetle (*Aulacophora foveicollis* Lucas & *A. lewisii* Baly)

The adults are small, elongated yellow and defoliate the leaves immediately after germination. The larvae feed on roots and plant parts.

Management

- ❖ Mechanically collect and destroy the pest if incidence is low.
- ❖ If the pest incidence is very severe, spray Indoxacarb 14.5 SC @ 0.5 ml/l or Cabaryl 50 WP 4g/l or 25 EC @ 2ml/l or Chlorpyrifos 20 EC 2.5ml/l.

Serpentine Leaf Miner (*Liriomyza trifolii* Burgess)

This is an introduced pest occurring on many cucurbit vegetables. Heavy incidence is noticed in watermelon, pumpkin, cucumber, etc. However, bitter melon seems to be resistant. A native larval parasitoid, *Hemiptarsenus vericornis* is the major parasitoid on this pest.

Management

- ❖ Soil application of neem cake @ 250 kg/ha immediately after germination.
- ❖ Destroy cotyledon leaves with leaf mining at 7 days after germination.
- ❖ Spray PNSPE @ 4% or neem soap 1% or neem formulation with 10000 ppm or more (2ml/l) after 15 days sowing and repeat after 15 days, if necessary.
- ❖ If the incidence is high first remove all severely infected leaves and destroy. Then mix neem soap 5 gm and hostothion 1 ml/l and spray. After one week, spray neem soap 1% or PNSPE or neem formulation with 10000 ppm or more (2ml/l).
- ❖ Never spray the same insecticide repeatedly.

Fruit Fly (*Bactocera cucurbitae* Coquillett).

This is the major pest of cucurbits. The damage by maggots results in rotting of young and ripened fruits or drying and shriveling of fruits before maturity.

Sometimes even the base of the plant gets attacked and plant start wilting. The incidence is more in wet climate.

Management

- ❖ Use resistant varieties.
- ❖ Soil application of neem cake @ 250 kg/ha immediately after germination and repeat at flowering followed by sprays of neem soap 1% or PNSPE 4% at 10 days interval after flowering.
- ❖ Crush pumpkin 1 kg and add 100 gm jaggery and 10 ml Malathion and keep in the plot (4-6 places per acre). Adults are attracted to the fermenting pumpkin and lay eggs and get killed. Repeat the process 2-3 times in the cropping season.
- ❖ Erect cue lure (para pheromone trap) 3 per acre to attract and trap male fruit flies.
- ❖ Spray Carbaryl 50 WP @ 3 gm/l or Indoxacarb 0.5 ml/l.

Red Spider Mite (*Tetranychus neocaledonicus* Andre)

This pest is serious on cucurbits during warmer climate. Colonies of mites with in silk web can be observed on ventral leaf surface when incidence is high.

Management

- ❖ Spray neem or pongamia soap at 1% on lower surface thoroughly.
- ❖ Alternately, spray Dimethoate 30 EC @ 2ml/l or Ethion 50 EC @ 1ml/l or Wettable Sulphur 80 WP @ 3g/l.

Thrips (*Thrips palmi* Karny)

Both nymphs and adults feed on the young shoot tips and floral parts and is suspected vector of Tospo virus. They are serious during summer months.

Management

- ❖ Soil application of neem cake (once immediately after germination and again at flowering) followed by NSPE @ 4% and neem soap 1% alternately at 10-15 days interval.

- ❖ Spray any systemic insecticides like Acephate 75 SP @ 1g/l or Dimethoate 30 EC @ 2ml/l.

Leaf Eating Caterpillar (*Dipahania* (=Margaronia) *indica* Saund)

Long shining caterpillars feed on leaves and fruits. Apply neem cake to soil immediately after germination. Spray any contact insecticides like Carbaryl 50 WP @ 3g/l. Neem or pongamia soap @ 0.75% also effectively manages this pest.

- ❖ Soil application of neem cake (once immediately after germination and again at flowering) followed by NSPE @ 4% and neem soap 1% alternately at 10-15 days interval.
- ❖ Spray Carbaryl 50 WP @ 3g/l or Indoxacarb 0.5 ml/l.

Root-knot Nematodes (*Meloidogyne incognita*)

The root-knot nematodes cause root galls from the initial stages of the crop growth. The larvae feed on the roots, which show typical galls, and later the entire root system shows heavy galling. The foliage becomes light yellowish; the plants become stunted and results in flower and fruit drop. In spite of irrigation the plants appear sick and drooping during daytime.

Management

- ❖ Seed treatment with bio-pesticide *Pseudomonas fluorescens* @ 10g/kg seed.
- ❖ Apply Carbofuran 3 G @ 1kg ai/ha at sowing and repeat after 45 days.
- ❖ Apply 2 tons of FYM enriched with *Pochonia chlamydosporia* and *Paecilomyces lilacinus* per acre before sowing, along with 100-200 kg of neem or pongamia cake.

ONION AND GARLIC

Thrips (*Thrips tabaci* Lindeman)

Thrips feed on a wide range of cultivated plants and weeds. Some of the principal alternate hosts include cabbage, cotton, tomato, cucumber, melons, pumpkins, strawberries and many flowering plants. Thrips are pestiferous in diverse ways. They cause

direct damage to leaves and bulbs, aggravate fungal diseases and even vector virus.



Management

Monitoring: Sticky traps are commonly used for detecting thrips population. Various colours were found attracting different species of thrips in various geographical areas; widely used ones are yellow and bright blue traps.

Cultural

- ❖ Good crop management practices can be readily manipulated to the disadvantage of thrips.
- ❖ Field sanitation techniques such as removing alternate weed host on bunds and destruction of culls of onion and garlic are helpful to some extent in bringing down thrips population.
- ❖ Avoid successive planting of onion and garlic or other preferred host. Therefore, planting in upwind direction could be helpful in escaping infestation from old planting to some extent in the initial stages.

Planting Date

By making adjustments in transplanting dates, onions can be made tolerant to early thrips attack and satisfactory yields can be obtained with minimum chemical intervention.

Mulching

- ❖ Thrips being colour-sensitive, coloured mulches may be employed for their control.
- ❖ Reflective plastic silver colour and aluminium painted black mulches were effective in repelling the thrips in seed crop.

Irrigation

Sprinkler irrigation reduces thrips population considerably compared to drip and surface irrigation. Insects would be washed off or drowned in the water accumulated in the leaf bases. Due to continuous retention of moisture in the soil, the pupae get rotten. In case of garlic, sprinklers are not that effective as in case of onion mainly due to the closer inner leaf alignment that protects the thrips from splashes of water.

Barriers

Two rows of maize or inner row of wheat and outer row of maize surrounding the onion plots.

Biological Control

- ❖ These include lady beetles, minute pirate bugs, ground beetles, big-eyed bugs, lacewings, hover flies, predatory mites and spiders. So far limited success has been achieved in biological control of *T. tabaci* in many parts of the world.
- ❖ A predator, minute pirate bug, *Orius tantillus* and anthocorid bug, found effectively feeding on thrips on garlic.
- ❖ *Metarhizium ansopliae*, *Paecilomyces fumosoroseus*, *Verticillium lecani* and *Frankliniella* also killed *T. tabaci* sp. Mortality of thrips was highest with *B. bassiana* at 26°C and 75% RH.

Plant Resistance

Commercial varieties, N-2-4-1 and Pusa Ratnar were found resistant to *T. tabaci* in Punjab but the former was susceptible to thrips in Maharashtra. The variety B-780 is moderately resistant to thrips. In Bihar, Pusa Red and N-53 had lowest thrips population while Arka Niketan had highest infestations.

Botanicals

Neem was found effective when mixed with insecticides.

Chemical

Many insecticides like dimethoate (0.06%) and Methyl Demeton (0.05%) are recommended for thrips control. Cypermethrin at 60 g ai/ ha offers good control of this pest. Carbosulfan (0.05%) and Lambda cyhalothrin also effectively suppress thrips population.

- ❖ The secret of thrips control in onion lies in the placement of the insecticide. It is necessary for the product to reach the base of the leaves where the majority of the thrips area is located. Unlike other crops, onion and garlic require higher pressure and spray volume for good coverage of foliage. Addition of a spreader or sticker (0.05-1.0%) is useful for retention and spread of spray fluid on erect leaves of onion. Avoid repeated use of the same insecticide to minimise development of insecticide resistance.
- ❖ In seed crop, control of thrips is often difficult. The umbels will provide excellent hiding site and it is difficult to reach them with insecticide.
- ❖ From the beginning, seed crop should be monitored regularly for thrips and should be controlled well before flowers open.
- ❖ Avoid sprays after flower opening.
- ❖ If necessary, safer insecticide should be used late in the evening when no bees are foraging.

Maggot (*Delia antique*)

Symptoms: Onion maggot is more restricted to cooler coastal climates where onions are grown on organic and muck soils. Maggot is primarily a pest of onions and do not cause economic damage to garlic. This pest occurs in some parts of north India.

Pest Management

Cultural

- ❖ Avoid planting in soils that are high in undecomposed organic matter.
- ❖ Avoid close spacing while planting.
- ❖ Control of *D. antique* is exceptional in areas where crop rotation was followed in the previous year.

Host Plant Resistance: No resistant varieties are available against maggot.

Biological: Ground beetle is a good predator and establishing grassy refuse strips in onion crop will enhance the beetle population and reduce the maggot population.

Chemical control

- ❖ Application of Pirimiphos Methyl or Deltamethrin at 2ml/lit.
- ❖ Fipronil 80WG (@25 g ai/kg) and Cyromazine (75 WP @ 50 g ai/kg), an insect growth regulator as seed treatment were recommended.

Army Worms (*Spodoptera exigua*, *S.litura*) and *Helicoverpa armigera* Hubner

This pest occurs sporadically on onion grown for seed. Larvae feed inside the stem and move upward to reach the base of the umbel at early stages of flowering. Subsequently it invades the umbel and feeds on seeds. Arka Niketan was least attacked.



Infestation of pest on umbel

Close up of pest

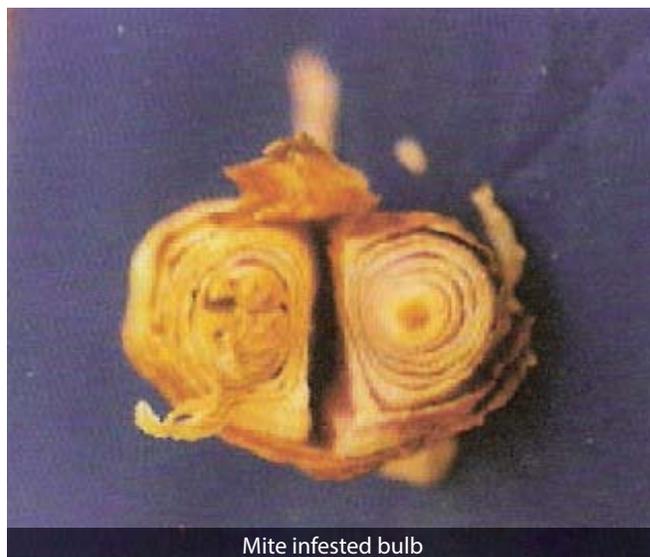
Pest Management

- ❖ Pheromone traps can be placed at 125 cm height and dispenser should be regularly replaced for effective trapping.
- ❖ NPV and Bt can also be employed for control of the pest.
- ❖ Insecticides like Cypermethrin, Quinolphos, Acephate, etc. can be used if infestation is more.

Bulb Mite (*Rhizoglyphus robini* Claparede)

This pest infests the bulbs by penetrating the outer layer of tissue. The plants wilt and rot as opportunistic fungi and bacteria gain entry inside the bulbs. Bulb mites can reduce plant stands, stunt plant growth, and promote rot of bulbs in storage. On seeded onions,

they can cut off the radical before the plants become established.



Mite infested bulb

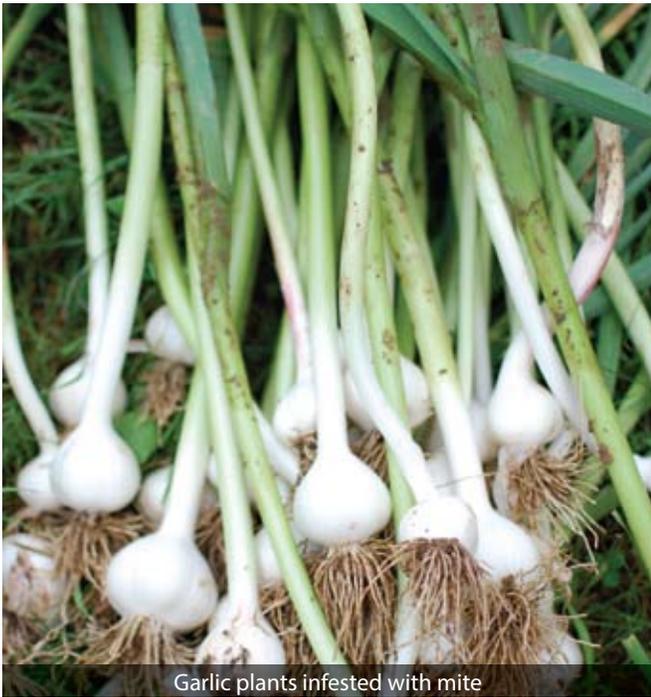
Management

- ❖ Decaying cole crops, especially cauliflower, may harbour very high bulb mite populations in the field.
- ❖ Avoid planting successive onion or garlic crops.
- ❖ Flood irrigation or heavy rains may reduce mite levels in the soil.
- ❖ In garlic, sow clean seed cloves.
- ❖ Hot water treatment of seed garlic before planting may reduce mite infestation
- ❖ Soil drenching with Dicofol at 2 ml/1 or soil application of powdered sulfur effectively reduce the mite population considerably. Fumigation with Methyl Bromide @16 g/m³ for 3 h or 10 g/m³ for 6 h is recommended for control of mobile phases of the mite in stored garlic.

Eriophyid Mite (*Aceria tulipae* Keifer)

Garlic plants infested with mite show symptoms like stunting, twisting, curling and yellow mottling and reduce the plant stand as well as yield. Mites also attack the stored garlic bulbs. Most of the mites are located at the basal portion of cloves and make them dry and desiccated.

Mite is capable of transmitting viruses such as wheat yellow streak mosaic virus in wheat, garlic mosaic virus and onion mosaic caused by Allium 1 virus.



Garlic plants infested with mite

Management

- ❖ Flood irrigation or heavy rains may reduce field populations.
- ❖ Avoid planting successive onion or garlic crops.
- ❖ Wettable Sulfur 0.3% + Dimethoate (0.03%) as pre-sowing and post-sowing treatment is recommended.
- ❖ Seed dressing and plant stand treatments with 0.5% Sulfur and 0.1% Dimethoate are also effective in controlling mites.

- ❖ Hot water treatment of seed garlic at 55 and 60° C for 10 minutes was also effective but affects clove sprouting capacity.
- ❖ Fumigation with Methyl Bromide at 32 g/m³ for 2 h at 80° F or 3 g/m³ Aluminium Phosphide for 72 h in airtight plastic box has been recommended for the control of mite in stored garlic.

Red Spider Mite (*Tetranychus cinnabarinus*)

Symptoms: Tetranychid mites are found through out the world on major vegetable crops. This is emerging as a regular mite pest in onion and garlic.



Red spider mites



Attack of red mite on leaves

Management

- ❖ Spraying miticides like Dicofol and Ethion.
- ❖ Even a thorough water spray also washes off the mites from the plant.

DISEASE MANAGEMENT

TOMATO

Alternaria Blight (*Alternaria solani*,
A. alternata f.sp. lycopersici)

Symptoms

Irregular leaf spots mostly appear from marginal portion of leaves. In many tomato cultivars, symptoms are V shaped and progress towards midrib. These lesions are having prominent yellowing on their outer margin due to host specific toxin produced by the pathogen. Mostly disease appears in vegetative phase of plant growth before flowering. Symptoms of early blight appear on all above ground parts of the plant. Pre and post emergence damping off in seedbeds also occurs.



Elongated & concentric on stem/
fruit lesions/ foliage due to alternaria

Management

- ❖ Crop rotation with non-solanaceous host is essential for effective reduction of inoculum.
- ❖ Healthy seeds should be collected only from disease-free fruits.

- ❖ Field sanitation by plucking the lower leaves and burning of infected crop debris.
- ❖ Summer ploughing to increase the desiccation of pathogen and infected plant parts.
- ❖ Minimize relative humidity in plant canopy for preventing the infection.
- ❖ Two spray of Chlorothalonil @0.2% at 8 days interval is effective against the disease but spray must be started soon after infection on floral part.

Late Blight (*Phytophthora infestans*)

Symptoms

Blight appears on foliage as light-pale green water soaked dead area. The lesions are wet in morning and dried, shriveled in daylight. It enlarges rapidly until entire leaves are killed and exposing all the fruits for infection. In moist and cloudy weather a downy white fungus develops near the outer margin of lesion on underside of the leaves. Green and ripe fruit affected by the blight appear as greenish brown and internal tissues become spongy with bad odour.



Phytophthora blight on green fruits

Management

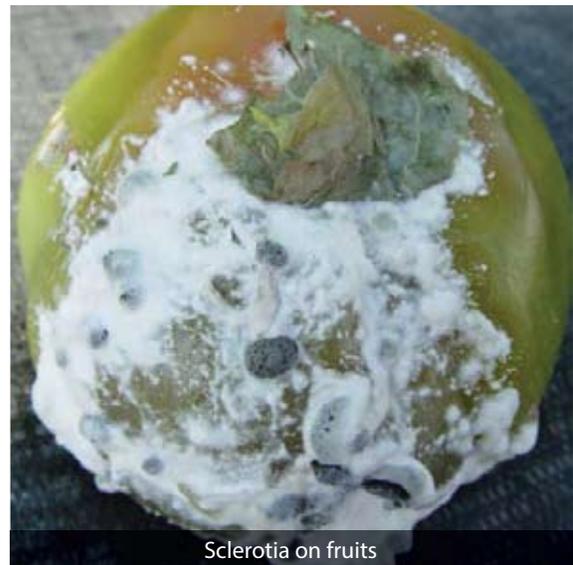
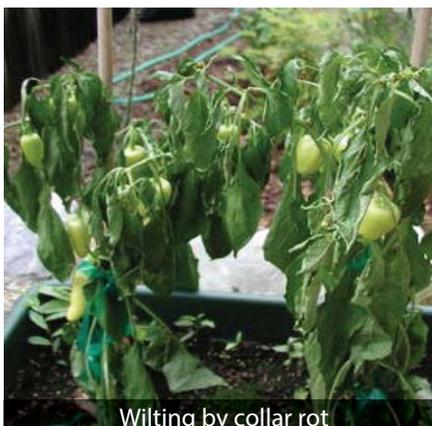
- ❖ Always use healthy and certified seeds collected from disease-free area.
- ❖ Infected crop debris and fruits must be collected from the field and burnt.
- ❖ Preventive sprays of Mancozeb@ 0.25% provide good control in cloudy, cold and drizzling weather but spray interval should be 5 to 7 days.
- ❖ One spray of Metalaxyl+ Mancozeb@0.2% is very effective when applied within two days of infection but repetitive sprays should not be given.
- ❖ Staking of plant reduces all phytophthora diseases of tomato.

Collar Rot (*Sclerotium rolfsii*)

Symptoms

The first symptom of disease is observed as soft tissue necrosis of bark of the stem near soil line. White, cottony and silvery mycelial growth is clearly visible on the affected portion. Fungal growth is also found just below the soil surface. Later on white to light brown mustard like sclerotium is observed on the same portion. Progressive drooping and yellowing followed by wilting of the entire plant is observed. Sometime plants collapse soon after infection. The disease is soil borne where pathogen survives in the form of sclerotia.

It has wide host range and causes severe problem on tomato, brinjal, chilli, cowpea, French bean, bottle gourd, sponge gourd, ash gourd, ridge gourd and elephant foot yam. The incidence in tomato alone is 15-20% every year with 20-25% yield loss in farmers field.



Management

- ❖ Use crop rotation with cereals, corn, sorghum and millets.
- ❖ Remove all the weeds from field.
- ❖ Avoid use of infested farmyard manure, soil crop debris and compost in the field.
- ❖ Irrigate the soil in summer and plough the field to destroy germinating sclerotia.
- ❖ Green manuring followed by application of *Trichoderma* @ 5 kg/ha within a week of ploughing.
- ❖ Seedlings dip in *Trichoderma*@ 1% for 10 minutes.
- ❖ Avoid dense planting and maintain proper aeration near collar region.
- ❖ Use Ammonium Nitrate as a fertilizer for nitrogen source.
- ❖ Drench Copper Oxychloride @ 0.3% near the collar region followed by carbendazim @ 0.1% for immediate control.
- ❖ Fungicide drenching should be done preferably in evening.

Pseudocercospora Leaf Blight (*Pseudocercospora fuligena*)

Olivaceous black sooty growth of fungus was observed on the lower surface of the leaves. Symptoms are only observed on the leaves. Leaf defoliate soon after infection. No discoloration was observed on the corresponding upper side of the leaves.



Black moldy growth on foliage

Management

- ❖ Collect and burn the infected leaves.
- ❖ One spray of hexaconazole or triademefon or bitertanol @ 0.05% at 7-10 days interval.
- ❖ Be careful for selecting exotic hybrids and varieties.

White Rot (*Sclerotinia sclerotiorum*)

Symptoms

Infection starts during flowering stage. Soft, wet, water soaked rotting of stem, leaves, fruits, and flowers are observed followed by white fungal growth over it. This mycelium develops honeydew stage soon after colonization. Later on after drying, the entire portion is converted into compact mycelial mat followed by hard sclerotial body. Fruits are severely affected where sclerotia formed inside and outside of the fruits. The disease is observed in December to January during low temperature, cloudy weather and high atmospheric humidity accompanied by soil moisture.



Sclerotinia on fruits rot

Management

- ❖ Cut the infected plant parts along with some healthy portion in morning and carefully collect in polythene to avoid falling of sclerotia in the field. Burn all these materials away from field.
- ❖ Foliar spray of Carbendazim @ 0.1% at flowering stage followed by spray of mancozeb @ 0.25% in cool, cloudy and humid weather.

Fruit Rots

Several fruit rotting pathogens viz. *Pythium* and *Phytophthora* affect green fruits while *Rhizoctonia*, *Myrothecium*, *Colletotrichum*, *Phomopsis*, *Alternaria* and *Cladosporium* affect matured fruits. Average 40% yield loss is recorded every year due to fruit rot pathogen.

Symptoms

Myrothecium fruit rot on green as well as ripe fruit appeared as water soaked rotting with prominent concentric zonation. White to black numerous bodies were observed on each rings of rotting. *Rhizoctonia* fruit rot is most serious disease of kharif tomato. Symptoms appear as rhythmic rotting of fruits coming with the soil contact. Rotting is immediately followed by cracking and fungal growth over it. Buckeye fruit rot caused by *Phytophthora parasitica* was observed mostly in green fruits. Symptoms of ripe fruit rot caused by *Colletotrichum coccodes* were also observed, as black, dry and corky rotting with acervuli over it. Sclerotium fruit rot is very clear due to white fungal mycelium and mustard grain like sclerotia over fruits. *Sclerotinia* fruit rot is having bigger and irregular sclerotia over it. Generally lower portion of fruits are infected which are coming in soil contact.



Rhizoctonia fruit rot



Myrothecium fruit rot

Management

- ❖ Avoid the contact of fruit from soil by staking of plant.
- ❖ Provide proper drainage in the field.
- ❖ Green manuring followed by soil application of Trichoderma @ 5 kg/ha in soil is very effective in checking most of the fruit rotting.
- ❖ Collect affected fruit and bury them to reduce primary inoculum.

Grey Leaf Spot (*Stemphylium solani*)

Symptoms

Small circular dark brown necrotic, numerous spots appear all over the leaf lamina that is uniformly distributed on entire foliage. Sometimes clear narrow yellow halo is visible around the spots. Usually these spots are isolated but in later stage they coalesce to each other. Severely infected older leaves blight and fall down. Small elongated to circular lesions appear on stem after brightening of leaves.

Management

- ❖ Periodical monitoring of the crop for initiation of disease from last fortnight of December to first week of January.
- ❖ Foliar spray of either Mancozeb @ 0.25% or Chlorothalonil @ 0.2% two to three times at 7-10 days interval.
- ❖ Restricted use of exotic hybrids.
- ❖ Removal and burning of all crop debris after senescence of the crop.

Bacterial Spot (*Xanthomonas campestris* pv. *vesicatoria*)

Symptoms

Small, dark spots appear on leaflets and stems of seedlings transplanted crop. Numerous spots coalesce and cause severe burning of the leaves. Prominent yellow halo is observed around the spot. The most conspicuous and damaging phase is infection of immature fruits. Small water soaked spots appear on exposed surfaces of the green and turning red fruits. These are slightly raised and corky in appearance. Disease appears in rainy season and continues up

to fruit initiation stage. The disease is prevalent in warm humid weather when RH is more than 90% and temperature is between 25 and 35°C.



Management

- ❖ Summer ploughing to desiccate the bacteria and host.
- ❖ Soil solarization in nursery bed to avoid seedling infection.
- ❖ Rotation of nursery seedbed and main field.
- ❖ Seed should be collected from disease free plants.
- ❖ Seed dipped in streptomycin solution @ 100 ppm.
- ❖ Adopt intercropping of urd and mung as mulches to prevent rain splash.
- ❖ One spray of Streptomycin @ 150-200 ppm followed by one spray of Copper Oxychloride @ 0.2% in afternoon.
- ❖ Use tolerant line of tomato like LE-415.
- ❖ One spray of copper oxychloride @ 0.3% after fifteen days of antibiotic application.

Bacterial Speck (*Pseudomonas syringae* pv. *tomato*)

Symptoms

It is characterized by absence of chlorotic halo around spot, crusty and comparatively larger spots. Sometime yellow halo is observed in this *Pseudomonas* species. The spots are necrotic, circular to roughly circular. As the fruit approaches the pink stage, the tissue around the spot retains its green colour longer than normal. Small black spots appear on leaf, petiole, pedicel, and peduncle while irregular, elongated lesions appear on stem. Bacterial speck is favoured by cool, moist, weather and temperature range between 15 and 25° C. Generally, disease is observed in winter season when fruit starts ripening.



Management

- ❖ Seed dipping in Streptomycin solution @ 100 ppm.
- ❖ Summer ploughing to desiccate the bacteria and host.
- ❖ Seed should be collected from disease free plants.
- ❖ One spray of Streptomycin @ 150-200 ppm in afternoon.
- ❖ One spray of Copper Oxychloride @ 0.3% after 10 days of antibiotic application.

Leaf Curl Complex (Virus-transmitted by white fly as well as by mechanical injury)

Symptoms

Disease appear in severe forms during the month of September to November. Leaves show downward rolling, curling, twisting and chlorosis. Plants show stunting, shortening of internodes, bushy appearance, no flowering and fruiting at later stage of virus infection. Sometimes leaves show light and dark mottle symptoms. Since geminivirus and TMV both viruses are involved in most of the infection, therefore it gives mixed infection of leaf curl complex in kharif tomato.



Management

- ❖ Removal of weed host from field near surrounding areas.
- ❖ Root dipping in Imidacloprid solution @ 4-5 ml per litre of water for one hour during transplanting of the seedlings.

- ❖ Nursery should be grown in nylon net to check the white fly infection.
- ❖ Seed treatment with hot water at 50° C or 10% trisodium phosphate solution for 25 minutes.
- ❖ Use barrier crop of taller non-host crops like maize, bajra and sorghum.
- ❖ Collect healthy seeds from disease free plants.
- ❖ Periodical sprays of systemic insecticides up to flower setting.
- ❖ Avoid mechanical injury during intercultural operations.
- ❖ Use tolerant varieties.
- ❖ Roughing of infected plants soon after infection at initial stage of growth.
- ❖ Avoid transplanting before September to check the twig blight phase.
- ❖ Crop rotation is required with cereals at least three-year.
- ❖ Use tolerant cultivars.
- ❖ Infected crop residue and fallend mummified fruits should be collected and burnt.
- ❖ Spray carbendazim @ 0.1% after 10 to 15 days of transplanting and during flower setting.

BRINJAL

Phomopsis Blight (*Phomopsis vexans*)

Symptoms

Leaves show clearly defined circular, light brown spots mostly in lower leaves. Center of the spots is slightly lighter in colour. These spots are papery, often crack and some time shot hole. Sometime irregular, big lesions are also observed on leaves particularly in cool and humid weather. Stem lesions are started form basal part near nodal region as gray dry rot with constriction. Bark partially dries but later on entire twig dries. This leads to drying of few twigs or partial wilting of some portions of plants. Pale to light brown sunken spots develop on the old fruits. Individual spots expand and coalesce to cover most part of the fruit.



Phomopsis stem blight



Fruit rot & infected seed

Management

- ❖ Treatment of seed with carbendazim @ 0.25% is essential to eliminate seed inoculum.

Rhizoctonia Root Rot (*Rhizoctonia solani*)

Symptoms

Lesions start on stem near collar region at or below the soil level and move downward into the roots. Later on drooping and wilting of the plant is observed. Disease is more common in poorly drained soil and the fields having prolonged excessive moisture.



Rhizoctonia root rot & wilting

Management

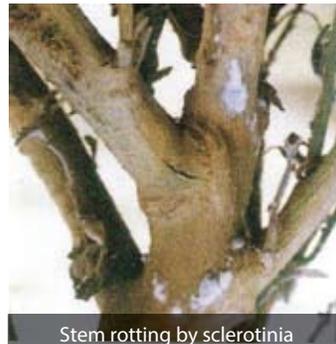
- ❖ Crop rotation with sugarcane and wheat is important for inoculum reduction of this soil pathogen.
- ❖ All infected plants must be uprooted and burnt along with field sanitation by removing all the weeds.
- ❖ Summer ploughing followed by irrigation in between April to June and then again ploughing to reduce the activated soil inoculum.
- ❖ Green manuring in June and July followed by soil application of *Trichoderma* @ 5 kg/ha soon after ploughing of the sunhemp.

- ❖ Seedlings dip in *Trichoderma* @1% suspension for 10 minutes before transplanting.
- ❖ Drenching of *Trichoderma* @ 1% suspension after 15 days of transplanting and repeat at 15 days intervals if required.
- ❖ Maintain proper drainage and aeration in the field.
- ❖ Balanced dose of fertilizers including micronutrients is effective for reducing the disease.
- ❖ Drenching of Carbendazim @ 0.1% near collar region is a costly control measure and moreover ensures the status of previously applied *Trichoderma* during use of Carbendazim.
- ❖ Green manuring in June and July followed by soil application of *Trichoderma* @ 5 kg/ha soon after ploughing of the sunhemp.
- ❖ Crop debris and infected plant parts should be carefully cut along with some healthy part and collected from the field in the morning. These should be burnt without shattering and falling of sclerotia in the field.
- ❖ Spray Carbendazim @ 0.1% soon after flowering.
- ❖ Alternate spray of Mancozeb @ 0.25% at 8-10 days interval of Carbendazim spray.
- ❖ Dense planting should be avoided to reduce the shade and humidity in plant canopy.

Sclerotinia Rot (*Sclerotinia sclerotiorum*)

Symptoms

Infection takes place on leaves, twigs, flowers and fruits. Water soaked lesions develop and the infected tissue macerated by the pathogen. Plants start dying from apical portion because primary infection always takes place on flowers leading to rotting of adjoining plant parts. Soft, wet, water soaked rotting of stem, leaves, fruits and flowers are observed followed by white fungal growth over it. Later on after drying of the entire portion of pith and fruits it is converted in to compact mycelial mat followed by hard sclerotial body. These sclerotia become black after drying. Infection on lower portion of main stem results in complete wilting of brinjal plant.



Management

- ❖ Crop rotation with flooded rice is beneficial for reducing the soil inoculums.
- ❖ Summer ploughing in such a way that surface is buried deep.

Collar Rot (*Sclerotium rolfsii*)

Symptoms

The first symptom of disease is observed as soft tissue necrosis of bark of the stem near soil line. White, cotton like and silvery mycelium growth is clearly visible on the affected portion. Fungal growth was also found just below the soil surface. Later on white to light brown mustard like sclerotia is observed on the same portion. Progressive dropping and yellowing or wilting of the entire plant is observed. Sometime plants collapse soon after infection. The disease is soil borne where pathogen survives in the form of sclerotia.



Management

- ❖ Carefully select crop rotation with cereals, corn, sorghum and millets because the pathogen is having broad host range.
- ❖ Remove all the weeds particularly dicot from field.
- ❖ Avoid use of infected farmyard manure, soil, compost, etc. in the field.

- ❖ Irrigate the soil in summer and plough the field to destroy germinating sclerotia.
- ❖ Green manuring followed by application of Trichoderma @ 5 kg/ha withings a week of ploughing.
- ❖ Seedlings dipped in Trichoderma @ 1% for 10 minutes.
- ❖ Avoid dense planting and maintain proper aeration near collar region.
- ❖ Always use ammonium nitrate as a fertilizer for nitrogen source.
- ❖ Drench Copper Oxchloride @ 0.3% near the collar region followed by Carbendazim @ 0.1% for immediate control.
- ❖ Fungicide drenching should be done preferably in evening.

Pseudocercospora Leaf Blight (*Pseudocercospora* sp.)

Symptoms

During winter olivaceous black sooty growth of fungus was observed on the lower surface of the leaves. Symptoms are only observed on the corresponding upper side of the leaves.



Management

- ❖ Collect and burn the infected leaves.
- ❖ Spray Hexaconazole or Triademefon or Bitertanol @ 0.05% when disease appears.
- ❖ Restricted use of exotic susceptible hybrids and varieties is advocated.

Bacterial Wilt (*Ralstonia solanacearum*)

Symptoms

The lower leaves droop before wilting occurs. The vascular systems become light brown. Root and rootlets are rotted leaving only corky portion of main root. Wilt and sudden death are seldom accompanied by the chlorosis of the leaves.

The pathogen is soil inhabitant, persisting for long period in same soils. Bacteria enters in the plant through inter cultural wounds, nematode injury usually under ground surface. Relatively high soil moisture, soil temperature and acidic soil pH favour the disease. The disease is prevalent in warmer climates having high humidity under tropical and sub-tropical conditions.

Management

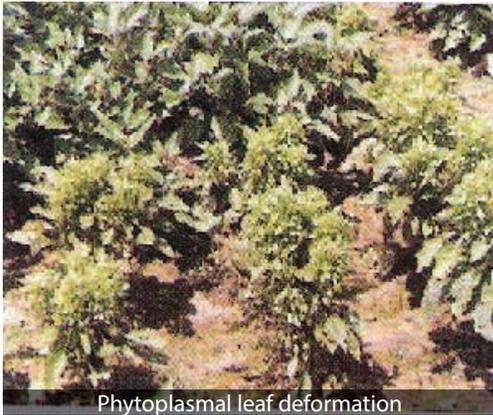
- ❖ When the pathogen is established in soil, satisfactory control is very difficult.
- ❖ Always prefer to grow tolerant varieties because chemical control is neither feasible nor economic.
- ❖ Infested soil should be kept fallow for about a year and frequently disked during the summer season to accelerate desiccation of plant debris and death of bacteria.
- ❖ Use of antagonistic bacteria, neem cake, and organic matter as soil application.
- ❖ Maintain soil pH to neutral by liming.
- ❖ Avoid water stagnation and anaerobic conditions in the field.
- ❖ Light texture of soil and well-drained field reduces the disease incidence.
- ❖ Follow long crop rotation with cereals and non-solanaceous host.

Little Leaf (Phytoplasma)

Symptoms

Characteristic symptoms are excessive shortening of the leaves. Numerous leaves aggregate in each branch giving bushy appearance and shortening of internodes. Auxiliary buds enlarge but petioles and leaves remain small, narrow, pale green and soft. Purple coloured fruits characteristically become white after infection. Later stage of infection leads to complete sterility of

the plant. The disease is caused by phytoplasma like organism and transmitted by leafhoppers.



Phytoplasmal leaf deformation

Management

- ❖ Periodical spray of systemic insecticides is necessary to control vector.
- ❖ Uproot the severely infected plants and burn just before starting of spray schedule.
- ❖ Avoid early transplanting before third week of August to escape leafhopper population.
- ❖ During first sign of initial infection, spray Tetracycline @ 100 ppm twice at 10-12 days interval to check the multiplication of phytoplasma in the host tissue.

CHILLI/CAPSICUM

Dieback and Anthracnose (*Choanephora capsici*, *Colletotrichum capsici*)

Symptoms

Disease initiate on tender twigs from the apical top of the plant as necrosis and withering. It progresses from tip to downward. *Choanephora capsici* rotted leaves and twigs clearly show black sporangial structure over it. The twigs are water soaked, brown and dieback as the infection spreads downward. Later on infected twigs developed several minute acervuli. Symptoms on red fruits are more commonly observed than green fruits. Small, irregular, sunken, light brown lesions were observed on mature fruit. Most often they are coalesced and become papery on green fruits. Apparently fruits looking healthy during harvest may show the symptoms of diseases during drying. Maximum infection was

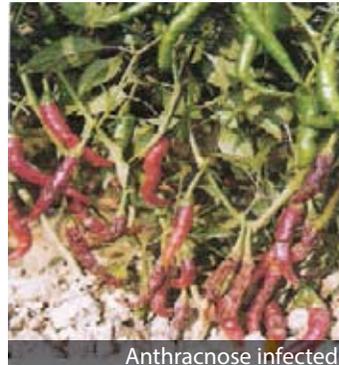
observed in first fruiting. Fruit rot extends to the seed cavity making it internally seed borne pathogen.



Die back in chilli



Choanephora on stem & leaf rot



Anthracnose infected chillies and close up



Management

- ❖ Disease free seeds should be collected from healthy fruits.
- ❖ Screening of diseased fruits must be done after drying of the fruits.
- ❖ Seeds should be treated with Carbendazim @ 0.25% during sowing.
- ❖ Seedling should be sprayed by Carbendazim @ 0.1% before transplanting.
- ❖ Cut the rotting twigs along with healthy part and burn it.
- ❖ Foliar spray of Copper Oxychloride @ 0.3% followed by Carbendazim @ 0.1% at flowering stage.
- ❖ Avoid apical injury during transplanting and also at flowering stage.
- ❖ Collect all the green fruits of first setting and consume it. Do not keep these fruits for seed purpose.

Bacterial Leaf Spot

Symptoms

The disease is common from nursery stage to vegetative stage of plant growth. Symptoms may appear any time up to first flowering. Very small,

circular spot surrounded by yellow halo is mostly observed in leaves. Affected lower leaves become yellow and fall down. Bacterial spots remain green and appear as spot bending symptoms on completely yellow leaves.



Bacterial leaf spot in chilli

Management

- ❖ One spray of Streptocycline @ 150 ppm alternated with Kasugamycin @ 0.2%.
- ❖ Seed dipping in Streptocycline solution @ 100 ppm for 30 minutes.

White Rot (*Sclerotinia sclerotiorum*)

Symptoms

Soft, wet, water soaked rotting is observed on stem followed by white fungal growth over it. Infected stem turns white after drying. This mycelium develops honeydew stage soon after colonization. Later on, the entire pith of stem dried and converted into compact mycelial mat followed by hard sclerotical body.



Sclerotinia rot of capsicum

Management

- ❖ Cut the infected plant parts along with some healthy portion in morning and carefully collect in polythene to avoid falling of sclerotia in the field. Burn all these materials away from field.
- ❖ Foliar spray of Carbendazim @ 0.1% at flowering stage followed by Mancozeb @ 0.25%.

Leaf Blight (*Alternaria alternata* and *Cercospora capsici*)

Symptoms

Disease is observed as circular to oblong spots with light gray to white gray centers and dark brown margins. Small spots coalesce to each other in severe case and leads to defoliation. *Alternaria* spots are dark brown, irregular and covered with a grayish brown to black spores of the pathogens. In moist conditions, sporulation of both pathogens was observed on the spots.



Cercospora leaf spots

Management

- ❖ One foliar spray of Chlorothalonil @ 0.2% alternated by thiophenate-methyl @ 0.1% after 8-10 days.
- ❖ Selection of disease free and certified seeds to check the primary infection.
- ❖ Foliar spray of Tricel @ 0.2% to maintain crop vigour at 10-12 days interval.
- ❖ Field sanitation by burning of infected crops debris followed by summer ploughing.

Phytophthora Leaf blight/Fruit Rot

Symptoms

Phytophthora can attack leaves, roots and fruits. Sometimes sudden wilting and death of plants occur mid-season at fruiting stage. Often a number of plants in a row show these symptoms. Commonly the disease strikes older plants. Stem lesions can occur at any level on stem and an irreversible wilt of the foliage occurs. Leaves first show small dark green spots that enlarge & become bleached. Infected fruits initially develop dark, water soaked patches that become coated with white mold and spores of the fungus and eventually rot. Fruits wither but remain attached to the plant. It is very difficult to manage this disease once the pathogen becomes established in a field. Pathogen infects fruits during prolonged period of rainfall, high humidity, over-crowded plants and high nitrogen.



Phytophthora leaf blight and fruit rot

Management

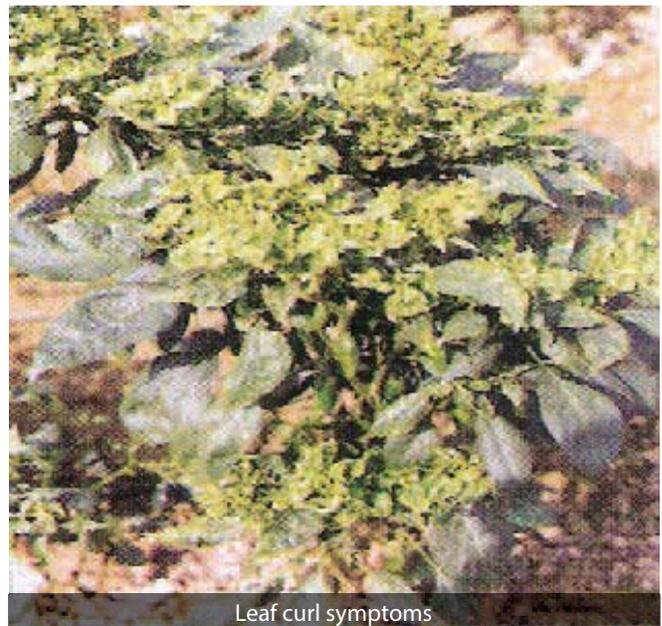
- ❖ Always use healthy and certified seeds collected from disease-free area.
- ❖ Infected crop debris and fruits must be collected from the field and burnt.
- ❖ Preventive sprays of Mancozeb @ 0.25% provide good control in cloudy, cold and drizzling weather.
- ❖ One spray of Metalaxyl+ Mancozeb @ 0.2% is very effective when applied within two days of infection but repetitive sprays should not be given.

- ❖ Staking of plant reduces the disease infection..
- ❖ Rotation, water management and drainage are the cultural methods.
- ❖ Avoid over cropping and high nitrogen.

Leaf Curl Complex (CMV and Gemini Virus)

Symptoms

Chilli leaf curl complex is mainly due to CMV and gemini virus as well as mites and thrips. Reduction in size of leaves, shortening of veins, puckering, mottling of the leaves, stunting and bushy appearance of the plant are symptoms of viral infection. Conspicuous outgrowth and prominent veins are visible on lower side of the leaves. Downward rolling, narrowing and shortening of leaves due to mite infestation were observed.



Leaf curl symptoms

Management

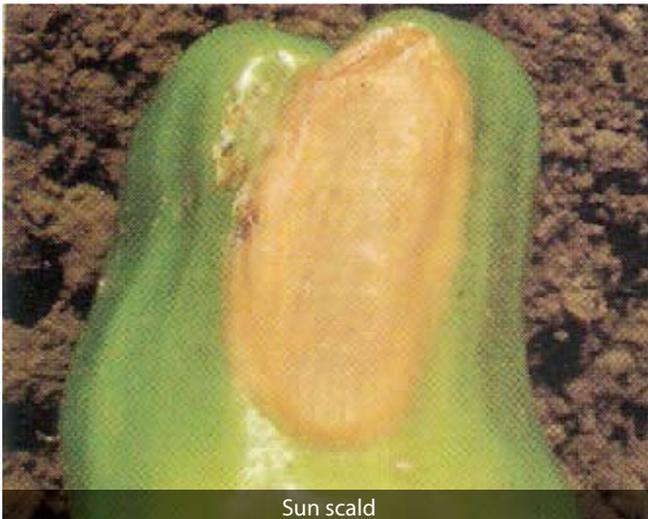
- ❖ Root dipping of the seedlings in Imidacloprid solution @ 4-5 ml per litre of water for one hour during transplanting.
- ❖ Nursery should be grown in nylon net to check the vector infestation.
- ❖ Seed treatment with hot water at 50°C or 10% tri sodium phosphate solution for 25 minutes.
- ❖ Barrier crop of taller non-host crops like maize, bajra and sorghum.
- ❖ Collect healthy seeds from disease-free plants.

- ❖ Periodical alternate spray of Dicofal @ 0.25% with wettable sulphur @ 0.2% and one to two spray of systemic insecticide.
- ❖ Use tolerant varieties
- ❖ Initial rouging of infected plants soon after infection and burn it.

Sun Scald

Symptoms

It is a common physiological disorder and fruits facing direct sun rays are affected by sun scald. Symptoms include a whitish necrotic area on the side of the fruit exposed to a fierce, usually afternoon, sun. The flesh becomes light, dry and papery on areas that had direct sunlight on them and can cover up to one-third of the fruit.



Sun scald

Management

- ❖ Adequate fertility and proper water management will help to develop the canopy of leaves and foliage required to protect the fruit from sun scald.
- ❖ Shade crop like Dhaincha can also be grown on border to protect the crop from hot winds during summer.
- ❖ Poor foliage cover allows the defect to occur.
- ❖ Variety selection may play a role; compact plants may not provide cover as well as more vigorous plants.

OKRA

Leaf Blight (*Cercospora abelmoschi* and *C. hibisina*)

Symptoms

The fungus causes no definite leaf spot but grow as sooty to dark olivaceous, ectoparasite covering entire leaf lamina. Disease initiated as small isolated fungal growth on lower side of leaf but very soon it spreads on both sides. Infected leaves fall down very quickly after drooping and rolling. It causes severe loss in seed production crop as well as the late sown crop grown for green fruits. Sometimes light brown lesions are observed after washing out of spores from leaves due to rainfall.



Black mould fungus on leaves

Management

- ❖ Two to three foliar spray of Bitertanol @ 0.05% or Difenconazole @ 0.025% or Hexaconazole or Triadimefon @ 0.05% at 6 days interval.
- ❖ Spray should be started immediately after disease initiation; delay in spray schedule will not give proper control due to very fast secondary infection rate.
- ❖ Okra sowing should be completed latest by first week of July.
- ❖ Collect the defoliated leaves and burn in field itself to reduce the inoculums at source.

Yellow Vein Mosaic (YVMV- Gemini virus)

Symptoms

The viral disease is transmitted by whitefly. Early infection causes 20-30% yield loss. Characteristic symptoms appears as prominent yellow vein and vein lets having green tissue interveinal area. Severely infected leaves some-time become completely golden yellow. Fruits develop green to yellow colour and become hard in early stage of growth.



Management

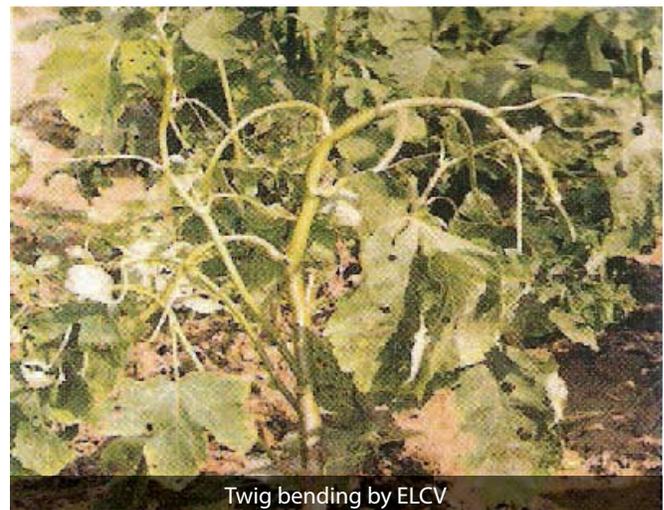
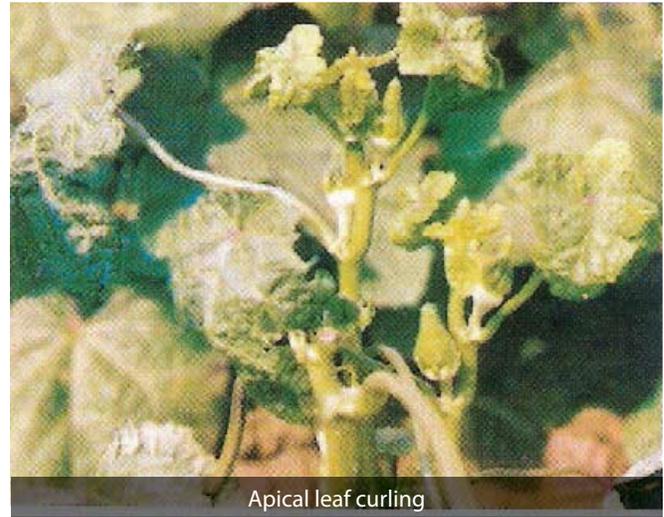
- ❖ Seed treatment with Imidacloprid @ 5 ml per kg of seed.
- ❖ Use resistant variety
- ❖ Early sowing in last month of June to first week of July.
- ❖ Once or twice rouging of infected plants at initial stage of plant growth.
- ❖ Periodical spray of any safe systemic insecticide up to flowering stage.
- ❖ Removal of malvaceous hosts around the field.

Enation Leaf Curl (ELCV)

Symptoms

The disease is second most destructive viral disease of okra after YVMV in kharif season. The disease is caused by geminivirus and transmitted by whitefly. The plant becomes unable to bear its weight after viral infection. The stem and leaf petiole are bent. Apical portion of plant develop into full of small, curl and aggregated leaves. Floral part does not set the fruit. Fruit if sets

then seeds are infertile and aborted. Characteristically small, green, outgrowths are observed on vein and vein-lets of the lower side of leaves.



Management

- ❖ Seed treatment with Imidacloprid @ 5 ml per kg of seed.
- ❖ Once or twice rouging of infected plants at initial stage.
- ❖ Use tolerant cultivars.
- ❖ One to two sprays of Abamectin @ 0.05% upto flowering stage.

Root-Knot Nematode (*Meloidogyne incognita*)

Symptoms

Disease appears as stunting of the plants, yellowish green of the plant and some-times drooping of the

leaves. Plant shows hunger sign. Clear symptoms are observed after uprooting of the plant where roots are full of knots. Main and lateral root bears spherical to elongated galls of variable size.

Management

- ❖ Apply neem cake @ 25 q/ha or saw dust @ 28 q/ha along with 120 kg nitrogen before transplanting.
- ❖ Phorate or Aldicarb @ 25 kg/ha should be applied if neem cake is not available.
- ❖ Crop rotation with cereals and low land paddy for at least 2 years.
- ❖ Summer ploughing for desiccation of nematode.
- ❖ Sowing of marigold is very effective for reduction in larval population.

LEGUMINOUS & VEGETABLES (PEA AND BEANS)

Root and Stem Rot (*Fusarium solani*,
Fusarium oxysporum f.sp. *pisi* and
Rhizoctonia solani)

Symptoms

Infection leads to drooping and wilting of plants at early stage of plant growth. In pea, symptoms appear as vascular discoloration of stem and reddish appearance in the pith extending towards roots. This is a characteristic symptom of *Fusarium solani* in pea. Sometimes general yellowing of entire plants is observed in cowpea due to *Fusarium* infection. *Rhizoctonia* infection in peas results dropping followed by wilting of the entire plants. The bark of collar region and root portion develops complete rots and degenerate. This is easily peeled off with slight pressure on bark leaving only pith portion. Symptoms appear on stem near the soil level and extend downward into the roots and upward also. Lesions are somewhat sunken and reddish brown. Later on as the lesions enlarge, they turn gray to ash colour at the centre and numerous minute, black dot like fruiting body developed from the centre. The inner portion of stem pith becomes hollow. Dull white mycelial growth is observed near soil line at initial stage of infection in humid weather.

Management

- ❖ Long crop rotation with wheat and bajra.
- ❖ Field sanitation by uprooting and burning of all infected plants.
- ❖ Summer fallowing, ploughing accompanied with irrigation followed by again ploughing in summer to reduce the soil inoculum.
- ❖ Green manuring in June and July followed by soil application of *Trichoderma* @ 5 kg/ha soon after ploughing of the sunhemp.
- ❖ Seed treatment with *Trichoderma* @ 0.6 to 1% depending upon soil and pathogen status.
- ❖ Drenching of *Trichoderma* @ 1% suspension after 20 days of sowing in beans only.
- ❖ Maintain proper drainage and aeration in the field.
- ❖ Balanced dose of fertilizers including micronutrients.
- ❖ Drenching of Carbendazim @ 0.1% for immediate control.

Collar Rot (*Sclerotium rolfsii*)

Symptoms

The disease become ubiquitous with broad host range. Initially wet rotting of bark is observed. Rot covers entire bark of the plant near collar region. Characteristic symptoms are observed as white, fungus growth on affected portion as well as on contact soil. Gradually the hyphal mat is converted into small, mustard like sclerotia that survives in the soil.

Management

- ❖ Crop rotation with low land paddy and other cereals.
- ❖ Field sanitation by uprooting and burning of all infected plants.
- ❖ Summer fallowing, ploughing accompanied with irrigation followed by again ploughing in summer to reduce the soil inoculums.
- ❖ Green manuring in June and July followed by soil application of *Trichoderma* @ 5 kg/ha soon after ploughing of the sunhemp.

- ❖ Seed treatment with *Trichoderma* @ 0.6 to 1% depending upon soil and pathogen status.
- ❖ Remove all weeds from field.
- ❖ Drench *Trichoderma* @ 1% suspension after 20 days of sowing to reduce early infection in beans.
- ❖ Drench Copper Oxychloride @ 0.3% near the collar region in evening for immediate disease control in beans only.

Powdery Mildew (*Erysiphe pisi*)

Symptoms

Disease appears as white to light gray, powdery fungal spores on leaves, twigs, tendrils and pods as pustules. Soon these pustules coalesce and cover all foliar part of pea. Infection of pods leads to partial filling of the grain and pod remain smaller in size. Outer skin of infected pods becomes gray in colour and rough.



Powdery mildew on foliage

Management

- ❖ Avoid delay in sowing and complete up to first fortnight of October.
- ❖ Always use tolerant varieties.
- ❖ Foliar spray of Penconazole @ 0.025% or Tridemorph @ 0.1% or Dinocap @ 0.1% at 5-7 days interval.
- ❖ Infected crop debris must be burnt after harvesting of pods.

Rust (*Uromyces fabae*, *Uromyces pisi* and *U. phaseoli*)

Symptoms

Characteristic symptoms observed as minute, slightly raised pustules on all above ground plant parts. Generally elongated pustules are seen on stem. Rust pustules are never observed on pods of pea. These pustules on pea are distinct, faint yellow, circular consisting of numerous uredospores. Later on dark red coloured teleutospores are formed on the leaves and tendrils. Early bloom stage of crop to four weeks before harvest is most critical period for rust and must be protected from the infection.



Uredo pustules on pea stem



Rust pustules on cowpea

Management

- ❖ Burning of infected crop debris is very effective for reduction of inoculum.
- ❖ Use rust tolerant variety of pea.
- ❖ Avoid delay in sowing of pea and complete up to first fortnight of October.
- ❖ Fungicidal sprays should be done in critical period if an average of two pustules per leaf is observed in the field.
- ❖ Use Flusilazole or Hexaconazole @ 0.025 % or Bitertanol @ 0.05% or Triadimephon @ 0.05% at interval of 5-7 days for effective control.

Leaf Blight (*Pseudocercospora cruenta* and *Cercospora cruenta*)

Symptoms

Disease appears as black, sooty and moldy growth of fungus on all foliar part. Initially the spore mass are olivaceous dark brown and spread very fast in the field. Quick defoliation is characteristic feature of the disease, which leads to naked stem and twigs on the plant. Symptoms of *Cercospora* are observed as small circular brown spots with reddish margin. *Aschochyta* blight is a severe disease of cowpea, French bean and pea. *Aschochyta paseolorum* infects cowpea producing large, circular to irregular brown spots with reddish margin on leaves and all other plant parts.



Pseudocercospora black leaf blight

Management

- ❖ Two to three foliar sprays of Hexaconazole @ 0.025% or Biteranol @ 0.05% or Difenconazole @ 0.025% at 6 days interval.

- ❖ Spray should be started immediately after disease initiation. Delay in spray schedule may not give proper control due to very fast secondary infection rate.
- ❖ Avoid delay in sowing of kharif cowpea and it must be completed latest by last week of June.
- ❖ Collect the defoliated leaves and burn in field itself to reduce the inoculum at source.

Sclerotinia Blight (*Sclerotinia sclerotiorum*)

Symptoms

Disease is observed as wet, soft and white rotting of the tissues. Very soon white fungus growth is observed on the rotted portion. Later on embedded sclerotia in white mycelium is formed on the infected portion as well as inner portion of pith and fruits. Primary infection on pea and cow pea always starts from floral infection followed by pods. Seeds converted into sclerotia become concomitant mixture during threshing.



Sclerotinia rot in French bean

Management

- ❖ All infected part must be carefully collected and burnt before drying of the plants.
- ❖ Seed cleaning is essential to remove the sclerotial mixture during threshing and processing.
- ❖ Deep ploughing, low land paddy with continuous stagnation of water reduces the sclerotial population.
- ❖ Close planting and dense canopy of plant should be avoided.
- ❖ Remove all weeds particularly from the field.

- ❖ Fungicidal spray must be started at early bloom stage of flowering stage.
- ❖ Alternate spray of Cabendazim @ 0.1% and Mancozeb @ 0.25% at 7-10 days interval is essential.
- ❖ Field sanitation by burning of all the infected leaves and crop debris.
- ❖ Use of clean, disease-free seed and tolerant varieties.
- ❖ Seed soaking in Streptocycline solution @ 100 ppm for 30 minutes.
- ❖ Proper drainage should be maintained in the field to avoid water stagnation.
- ❖ Sowing time should be adjusted in such a way that fruiting stage should not coincide with heavy rain period.

Bacterial Blight (*Xanthomonas campestris* pv. *phaseoli* (common blight); *X. phaseoli* var. *fuscans* (Fuscous blight), *Pseudomonas syringae* pv. *phaseolicola* (Halo blight), *P. syringae* pv. *syringae* (Brown spot blight).

Symptoms

Disease is first seen as small translucent, water soaked spots on leaves. Symptoms of common blight, fuscous blight and brown blight are difficult to differentiate on the basis of symptoms except, isolation of casual organism. However, the infected tissue may turn yellow and die to form lesions of various sizes and shapes. Bigger blotch symptoms appear on the leaves in severe cases of common blight particularly in rainy season. Small spots appear on pods of different ages. Vascular discoloration is evident in severe incidence. Halo blight has most of the symptoms of common blight along with a chlorotic halo.



Bacterial blight in cowpea

Management

- ❖ Crop rotation of about 2-3 years is sufficient to dispose off over wintering bacteria.

Cow pea Golden Mosaic (Viral disease)

Symptoms

This is an aphid borne viral disease caused by poty virus while white fly transmitted mosaic is gemini virus. Symptoms appear as yellow and green mosaic patches on the apical leaves. Later on most of the leaves become complete yellow. Infected pods turn to yellow from normal green colour. Fruit setting is also reduced in infected plants.



Management

- ❖ Soil application of Carbofuran @ 1.5 kg ai/ha during seed sowing.
- ❖ Use resistant lines like Arka Garima, Cowpea-263 and KS-10.
- ❖ Rouging of infected plants at initial stage.
- ❖ Foliar sprays of Abamectin @ 0.05% at 10 days interval up to flowering stage.

CUCURBITS

Anthracnose (*Colletotrichum orbiculare* & *C. lagenarium*)

Symptoms

Disease on leaves is observed as water soaked small yellow spots that enlarge and turn to brown. The necrotic portion dries and shatters. Elongated water soaked, sunken lesions appear on stem. Light yellow to brown discoloration of these stem lesions is due to abundant sporulation. Severe incidence resulting infection in juvenile fruits as small, sunken, light brown, cracked spots are observed. Two species are involved in cucurbits because the size of spots is distinct and appear in different weather condition.



Anthracnose on leaves



Anthracnose on fruits

Management

- ❖ Always seed should be collected from healthy fruits and disease-free area.
- ❖ Seeds must be treated with Carbendazim @ 0.25%.
- ❖ Field sanitation by burning of crop debris.
- ❖ Grow crop on bower system to avoid soil contact.
- ❖ Maintain proper drainage in the field.
- ❖ Seed production should be preferably carried out in summer season because summer crop is often free from pathogen.
- ❖ Foliar sprays of Carbendazim @ 0.1% or Chlorothalonil @ 0.2% but spray must be started soon after infection.

Downy Mildew

(*Pseudoperonospora cubensis*)

Symptoms

Disease appears as irregular, numerous, small, yellow areas surrounded by green tissues scattered all over the leaf lamina. It appears just like in definite mosaic pattern particularly in cucumber. The yellow areas are angular and bounded by veins. Symptoms on bitter melon are light brown while grayish brown on pointed melon without prominent yellowing on these hosts. In high humid weather, faint white downy growth of fungus is observed.



Yellow lesions on cucumber leaf



Brown lesions on bottle gourd

Management

- ❖ Crop should be grown with wide spacing in well-drained soil.
- ❖ Air movement and sunlight exposure helps in checking the disease initiation and development.
- ❖ Bower system of cropping reduces the disease incidence.
- ❖ Field sanitation by burning crop debris to reduce the inoculums.
- ❖ Seed production should be preferably carried out in summer season because summer crop is often free from disease.
- ❖ Use tolerant cucumber lines like Summer Prolific.
- ❖ Protective spray of Mancozeb @ 0.25% at seven days interval gives good control.
- ❖ In severe case one spray of Metalaxyl + Mancozeb @ 0.2% may be given but it should not be repeated.

Powdery Mildew (*Sphaerotheca fuliginea* and *Erysiphe cichoracearum*)

Symptoms

Disease appears on all foliar part as white to dull white, powdery growth. This white growth quickly covers most of the leaf surface and leads to heavy reduction in photosynthesis area. Plants may wither and die. Growth of plant and fruits seized. Transpiration rate is very fast from infected leaves.



Powdery mildew on bottle gourd

Management

- ❖ Foliar sprays of Penconazole @ 0.05% or Tridemorph @ 0.1% or Carbendazim @ 0.1%, give very good control of the disease.
- ❖ Use tolerant line.

Fruit Rots (*Phytophthora cinnamomi*, *Pythium*, *Rhizoctonia*, *Phomopsis cucurbitae*)

Symptoms

Disease is mostly observed on matured fruits as comparatively dry rotting with characteristic pycnidia over it. Generally lower portion of fruits touching soil surface are affected. *P. cinnamomi* is causing rotting of vines, leaves and fruits of pointed gourd, *Rhizoctonia* fruit rot is most severe in muskmelon, while *Phomopsis* fruit rot on ash gourd.



Pythium & phytophthora rot on bottle & pointed gourds



it. Black dot like pycnidia is also observed on the affected bark.



Management

- ❖ Avoid exotic hybrids and varieties due to high degree of susceptibility.
- ❖ Summer ploughing and green manuring followed by *Trichoderma* application.
- ❖ Maintain proper drainage and aeration in the field.
- ❖ Seed treatment with Carbendazim @ 0.25%.
- ❖ One drenching of Carbendazim @ 0.1% near collar region.
- ❖ Avoid injury near collar region.

Management

- ❖ Avoid soil contact of fruit by using bower system of cultivation and staking of plant.
- ❖ Provide proper drainage in the field.
- ❖ Green manuring followed by soil application of *Trichoderma* @ 5 kg/ha in soil is very effective in checking most of the fruit rotting.
- ❖ Collect affected fruits and burn them to reduce primary inoculum.

Gummy Stem Blight (*Didymella bryoniae*-teleomorph and *Phoma cucurbitacearum* anamorph)

Symptoms

This disease is now becoming severe in muskmelon, bottle gourd and sponge gourd. Most of the hybrids are susceptible to the disease. Introduction of hybrids introduced this disease in all cucurbits growing area. Initially water soaked area are observed on the stem near soil line. Later on translucent gum like exudates released from the affected portion is deposited over

Leaf Spots (*Cercospora citrullina*, *Alternaria cucumerina* and *Corynespora melonis*, *Didymella bryoniae* (teleomorph) and *Phoma cucurbitacearum* anamorph)

Symptoms

Severity of the disease is increasing every year and engulfing ridge gourd, bottle gourd, pointed gourd, pumpkin and sponge gourd. Hybrids and exotic materials of bottle gourd and ridge gourd are highly susceptible to *Didymella* leaf blight. It is spreading throughout the cucurbits growing area. Papery with rhythmic large spots followed by shot hole is observed in *Didymella*. Black small dot like fruiting structures are also observed on the old spots. White fungus growth is clearly visible on outer margins of the spots in morning periods. Several other types of leaf spots occur on different cucurbits. Often these leaf spot diseases are more pronounced at maturity stage.

Circular spots with variable size are observed on the leaf lamina. They are light brown to dark brown with white centre in *Cercospora*.



Cercospora spot on bottle gourd



Didymella blight on ash gourd

Management

- ❖ Field sanitation, selection of healthy seeds and crop rotation reduces disease incidence.
- ❖ Fungicidal sprays of Mancozeb @ 0.25% alternated with one spray of Hexaconazole @ 0.05%.
- ❖ Seed production should be preferably carried out in summer season because summer crop is often free from disease.

Bacterial Wilt (*Erwinia tracheiphila*)

Symptoms

Bacterial wilt is a common and often destructive disease on cucumber, muskmelon, squash and pumpkin. The first signs of wilt appear usually on individual leaves as drooping, which become flaccid in sunny weather.

As the disease progresses, more leaves wilt and eventually an entire plant is wilted. When wilted stems are cross-sectioned, viscid and sticky bacterial matrix exudates from the vascular bundles is observed. This feature is used as a means of diagnosis. This is vascular pathogen and differs from other *Erwinia* spp. unable to degrade middle lamella.

The bacteria lives in the bodies of adult cucumber beetles particularly red striped and spotted beetle. Primary infection is produced when beetles feed upon young leaves or cotyledons. The bacteria present in the vessels of infected plants die within 1 or 2 months after the dead plants dry up.



Sudden wilting in cucumber

Management

- ❖ Control of cucumber beetles at initial stage from the soil with neem cake or systemic granular insecticides.
- ❖ Tolerant varieties with restricted use of exotic cucumber lines should be grown.
- ❖ Summer ploughing of soil to expose all the stages of beetles.

Mosaic and Leaf Distortion

Symptoms

Most of the cucurbits grown in rainy season are affected by virus disease like cucumber mosaic, green mottle, leaf distortion, water mosaic etc. Generally alternate green and yellow patches with mottling symptoms are observed. Sometimes leaves deform

and curl downwards. Smalling and narrowing of the leaves is also observed in leaf distortion virus. Plants become small and excessive branching, proliferation of the leaves, twigs, petioles, bushy appearance of the plants are observed.



Management

- ❖ Management of the disease involves destruction of diseased hosts and weeds.
- ❖ Virus free seeds must be used to check the seed transmission.
- ❖ Initial rouging of the infected plants.
- ❖ Periodical spray of systemic insecticides up to flowering stage to control vectors.
- ❖ Seed production should be preferably carried out in summer season because summer crop is often free from virus infection.
- ❖ Restricted use of exotic hybrids and varieties in bottle gourd, bitter gourd and cucumber.

COLE CROPS

Downy Mildew (*Peronospora parasitica*)

Symptoms

Disease is observed on the leaves. Fine hair like downy growth of fungus is observed on the lower surface of leaves. Corresponding of the fungal growth there is minute pinhead brown necrotic spots visible on the upper surface of leaves, which later on coalesce to each other. It may appear from nursery to curd formation stage.

Management

- ❖ Field sanitation, disease-free seed and crop rotation reduce pathogen inoculum.

- ❖ Foliar spray of Mancozeb @ 0.25% at disease initiation stage and repeat next spray at 6-8 days interval.
- ❖ One spray for Metalaxyl + Mancozeb @ 0.2% in severe case may be given but do not repeat.
- ❖ Use sticker @ 0.1% with fungicide to avoid runoff of droplets.



Alternaria Leaf Spot (*Alternaria brassicae* and *A brassicicola*)

Symptoms

Alternaria leaf spot usually appears in early stage of plant growth in cauliflower while in later stage in cabbage. Alternaria leaf spots are restricted to lower leaves only and do not cause economic loss to the crop except when some of the hybrid varieties of cauliflower are used. Symptoms appear as circular light brown spots on leaves. Concentric rings are clearly visible on the spots. Black sporulation is observed in humid weather. Cabbage infections do not extend very far in the host tissue. Inflorescence and siliqua are severely infected during seed crop. The curd of cauliflower infected as brown discoloration of individual florets and flower clusters.





Spots on cabbage & concentric ring



White rot in cabbage

Management

- ❖ Alternaria leaf spot of cole crops is effectively managed by detaching all the infected lower leaves in morning and then burning.
- ❖ Spray of Chlorothalonil @ 0.2% along with sticker @ 0.1% in evening hour.
- ❖ Use disease-free seeds from healthy crop.
- ❖ One spray of Mancozeb @ 0.25% along with sticker during silique formation.

White Rot (*Sclerotinia sclerotiorum*)

Symptoms

Disease appears as water soaked rotting of curd, petiole, stalk and stump region of the leaves. Soon after infection, growth of white mycelium is observed all over the infected portion. Cauliflower grown for seed production is severely affected by the disease and entire inflorescence collapses. The mycelium develops honeydew stage after colonization of the tissue. Later on entire rotted portion is converted into compact mycelial mat followed by hard black sclerotial body. This is the resting structure and primary inoculum source.

Management

- ❖ Main crop of cauliflower and cabbage should be periodically observed near the stump region in cool, cloudy and moist weather for primary infection.
- ❖ Cut the infected curds, leaves along with some healthy portion in morning and carefully collect in polythene to avoid falling of sclerotia in the field. Burn all these materials away from field.

- ❖ Foliar spray of Carbendazim @ 0.1% at flowering stage, followed by spray of Mancozeb @ 0.25% along with sticker @ 0.1%.
- ❖ Spray must cover stump and lower region of leaves.

Bacterial Black Rot (*Xanthomonas campestris* pv. *campestris*)

Symptoms

The disease often appears along the margins of leaves as chlorotic lesions and chlorosis progresses in the direction of midrib usually forming V shaped area, which is the most characteristic symptom of the disease. Some of the veins and veinlets within chlorotic area turn black in severe cases. Black vascular scar is observed on any detached infected leaves, midribs and veins. Yellowing of leaves was observed from lower portion of mid vein in severe infection. Disease severity increases rapidly whenever hailstorm is taking place in cropping season. Symptom may appear from any side and centre of the leaves. Severe infection results in complete burning of crop of cauliflower before the curd formation.

The bacterium is transmitted through seed which usually enters in the cotyledons through stomata, pass to the young leaves and progress systematically throughout the plant system. The foliage infection and transmission is through water pores, insect

injury, infested soil, storm, cultural practices and seedlings.



Bacterial black rot in cabbage

Management

- ❖ Always collect seeds from disease-free plants for next year use.
- ❖ Seed treatment with hot water (50° C for 30 minutes) or seed dipping in 100 ppm antibiotic solution for 30 minutes.
- ❖ Crop rotation with non-cruciferous crops.
- ❖ Use intercrop of urd and mung as mulches to reduce rain splash.
- ❖ Detach the lower infected leaves in afternoon when dew and bacterial ooze dried up from the leaves and then burn it.
- ❖ Nursery site should be changed frequently to avoid seedling infection.
- ❖ Use antagonistic bacteria in the soil.
- ❖ Spraying of antibiotic like Streptocycline @ 150-200 ppm or Kasugamycin @ 0.2% at 10-15 days interval.
- ❖ Mixture of streptocycline @ 100 ppm and copper oxychloride @ 0.3% with sticker @ 0.1% should be used if *Alternaria* infection also exists on the foliage giving good control of both the diseases.
- ❖ The cauliflower variety Pusa Snowball K-1, Super Snowball and cabbage variety Pusa Mukta possesses high degree of tolerance to black rot pathogen.

ONION AND GARLIC

Damping Off (*Phythium species*, *Rhizoctonia solani*, *F.oxysporum* and *F. oxysporum f.sp.cepae*)

Symptoms

Symptoms of this disease consist of seed rotting, pre-mergence damping-off and post-emergence damping-off.

Management

Cultural Methods

- ❖ Soil solarization of nursery beds with transparent polythylene sheet for 30 days before sowing provides good control.
- ❖ Agricultural practices that minimize periods of excessive soil moisture, crop rotation, land leveling, installing drains, sowing of clean and healthy seed on raised beds are used to reduce seedling diseases. Overcrowding of plants or dense sowing of onion seeds should be avoided
- ❖ Well decomposed farmyard manure should be used in nursery.

Biological Method

- ❖ Seed treatment with *Trichoderma viride* @ 4 g/ kg seed followed by soil application of *T.viride* @ 500 g multiplied in 50 kg farmyard manure/ ha.

Chemical Methods

- ❖ Using protectant fungicides such as thiram or captan @ 0.2% as seed dressing before sowing.
- ❖ Drenching the nursery beds with captan or thiram @ 0.2% or carbendazim @ 0.1% or Copper Oxychloride @ 0.3% in standing crop should be done.

Purple Blotch (*Alternaria porri*)

Symptoms

Initially, small white sunken spots develop on the leaves. These spots enlarge, become eye shaped under moist conditions, turn to purple and are surrounded by a broad chlorotic margin. Infection can cause a semi watery rot of necks of bulbs, which turn yellow-red, bulb tissue eventually become papery.



Badly damaged leaves of onion



Blotch infection on stem & umbel

Management

i) Cultural Methods

- ❖ Crop rotation with non-host crops; good drainage and use of recommended doses of N and fertilizers reduce the disease incidence.
- ❖ Hot water soaking of onion seed (50° C for 20 minutes) prove to be the best treatment for reducing purple blotch pathogen.

ii) Host Plant Resistance

- ❖ Onion varieties Agri found Light Red, Agrifound Dark Red, Red Globe and VL Piyaz 3 are reported to be moderately resistant.

iii) Biological Methods

- ❖ Application of *Trichoderma viride* (1000 spores/ml), Difenconazole @ 0.8 ml/Land covering crops with transparent polythene sheets inhibited growth of the pathogen.

iv) Chemical Methods

- ❖ Four sprays of Mancozeb or Chlorothalonil and 3 sprays of Iprodione @ 0.25 % at 10 days interval is effective in reducing the disease.
- ❖ A combination of Mancozeb @0.25% + Abamectin @ 0.05% is effective in controlling thrips as well as purple blotch.
- ❖ Heat treatment of onion bulbs at 35° C for 8 hours before planting and prophylactic spray of Metalzyl + Mancozeb @0.25% gave good control in onion seed crop.

Stemphylium Leaf Blight (*Stemphylium vesicarium* (Wallr.) Simmons)

The fungus causes serious damage in a complex with *A. porri*. The disease is more severe in *rabi* than in *kharif* season as higher temperatures prevail during March-April, and the area under cultivation of onion is extensive during that season.

Symptoms

The first symptoms of the disease appear on the radical leaves at 3-4 leaf stage. The disease symptoms are developed in the middle of the leaf as small yellow to orange flecks or streaks, which soon develop into elongated, spindle shaped to ovate elongate diffused spots surrounded by characteristic pinkish margin. The spots coalesce into extended patches, blighting the leaves and gradually the entire foliage.



Stemphylium leaf blight

Management

Cultural Methods

- ❖ Sanitation of field and collecting and burning of crop refuse reduces the disease incidence.
- ❖ Cultural control methods include long rotations with no-host crops.
- ❖ Good field drainage and reduced plant density.
- ❖ Hot water soaking of onion seed (50° C for 20 minutes) proved to be the best treatment for reducing the disease.

Host Plant Resistance

- ❖ Welsh onion (*Allium fistulosum*) lines are moderately resistant to Stemphylium leaf blight.

Chemical Methods

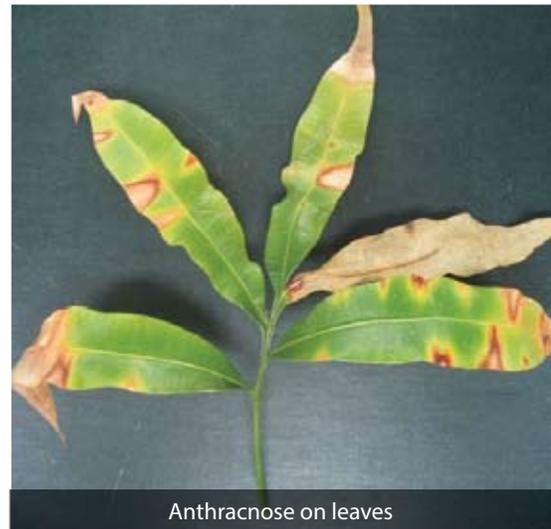
- ❖ Three to four sprays of 0.25% Mancozeb at 20 days interval starting at 60 days after transplanting.
- ❖ However, Mancozeb offers best control with higher cost benefit ratio.
- ❖ For seed production, fortnightly sprays of 0.025% Mancozeb or Iprodione is recommended.

Colletotrichum Blight/Anthracnose / Twister Disease (*Collectotrichum gloeosporioides*)

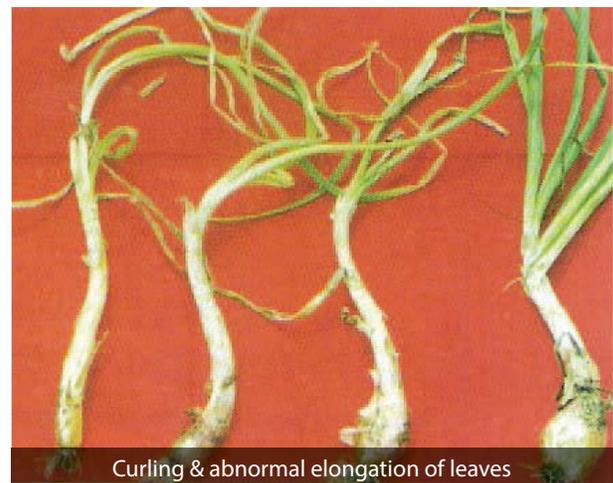
Symptoms

The characteristic symptoms are curling, twisting, chlorosis of the leaves, and abnormal elongation of neck (false stem). Initially pale yellow water soaked oval sunken lesion appears on leaf blades, which increase lengthwise covering the whole leaf. Numerous black coloured slightly raised structures are produced in the

central portion. These structures may be arranged in concentric rings. The affected leaves shrivel, droop down and finally withers. Bulbs are smaller in size; some may rot before harvest while others rot in store.



Anthracnose on leaves



Curling & abnormal elongation of leaves

Management

Cultural Methods

- ❖ Sanitation and destruction of infected plant debris helps in reducing the disease.

Host Plant Resistance

Varieties like IPA 3, Belem, IPA 9, Franciscana IPA 10 and Roxinha de Belem were found resistant.

Chemical Methods

- ❖ Application of Benomyl @ 0.02% as soil treatment is recommended.
- ❖ Spraying of Mancozeb @ 0.25% also gives good control of disease

Downy Mildew (*Peronospora destructor* (Berk). Casp.)

Symptoms

The fungus causes both systemic and local infections. Plants raised from infected bulbs are showing systemic infection, which remain stunted, distorted and pale in colour. Local infection is caused by air borne conidia, which produce oval to cylindrical spots are violet to purple in colour. Affected leaves become pale green, fold over and collapse. Older leaves are attacked first and infection spreads to the sheath.

Management

Cultural Methods

- ❖ Bulbs used for seed production should be selected from healthy field. Crop rotation for 3-4 years with no-host crop should be followed.
- ❖ Infected crop debris and refuse heaps of onion culled from storage should be disposed properly.
- ❖ Late planting, poor drainage, higher doses of fertilizers and frequent irrigation should be avoided as these practices encourage high disease incidence.

Host Plant Resistance

- ❖ Onion lines IC-48045, IC-32149, IC-49371 and DOP-2 have been reported resistant to downy mildew.

Chemical Methods

- ❖ Spraying of Mancozeb @ 0.25% and ziram @ 0.1% at 10-12 days interval is recommended.
- ❖ Bulb and seedling dip in Ridomil MZ @ 0.25% for 12 hours followed by 2 foliar sprays of the same gives effective disease control.

Fusarium Basal Rot/Basal Plate Rot (*Fusarium oxysporum f.sp cepaeae*).

Symptoms

Initially there is progressive yellowing and dying back from the tips of the leaves, the aerial part may die in 1-2 weeks or decay may extend over much longer period. When disease appears above the ground level, decay has already taken place at the base. The roots may turn pink and gradually decay until the entire root disappears.



Rotting of onion in field



Fusarial infection on bulbs

Management

Cultural Methods

- ❖ Crop rotation for 4-5 years with non-host crop has been found effective in eliminating the disease.
- ❖ Mixed cropping with tobacco and sorghum is effective in reducing the disease.
- ❖ Good drainage, deep ploughing in hot summer and avoiding injury during cultural practices reduces the disease incidence.
- ❖ Satisfactory control of basal rot can be achieved by flooding the soil in the non-growing season.

Host Plant Resistance

- ❖ Three lines viz. IIHR 141, IIHR 506 and Sel 13-1-1 consistently resistant to *Fusarium oxysporum* in the field in different growing seasons.

Biological Methods

Trichoderma spp., *Pseudomonas fluorescense* and *Bacillus subtilis* have been found effective against *F. oxysporum* under *in vitro* conditions.

- ❖ Combined seed treatment of *T. viride* + *P. fluorescense* reduced onion basal rot incidence both in pot and field conditions.

Chemical Methods

- ❖ Dipping onion sets in Benomyl, Carbendazim, Thiram and Difolatan @ 0.2% controls pink root, basal rot and neck rot of onion.
- ❖ Spraying of Carbendazim @ 0.1% at 30, 20 and 10 days before harvest gave the lowest loss of yield due to delay after 5 months of storage.

White Rot (*Sclerotium cepivorum* Berk)

Symptoms

Initial symptoms are yellowing and dying back of leaf tips. Roots are normally destroyed and there is a semi-watery decay with abundance of superficial white fluffy mycelium. Brown or black sclerotia develop on the surface or within tissue.



Management

Cultural Methods

- ❖ Production should be confined to areas known to be free from disease.
- ❖ Crop rotation should be followed.
- ❖ When white rot incidence is low, infected plant may be destroyed and the soil around these plants should be treated.
- ❖ Hot water treatment of bulbs at 49°C gives effective control.
- ❖ Solarization of soil at high temperature i.e. 35°C for 18 hours or 45°C for 6 hours reduces the disease incidence by 50-70%.

Biological Methods

- ❖ *Trichoderma viride*, *Glyocladium zeae*, *Coniothyrium minitans*, *Penicillium nigricans*, *Bacillus subtilis* and *T. harzianum* have been reported as prominent antagonists for control of white rot.

Chemical Methods

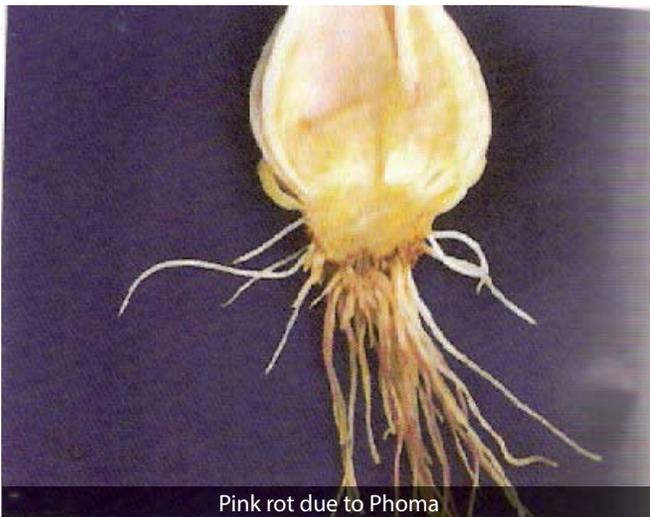
- ❖ Iprodione (Rovral) @ 0.25% was found effective. Benomyl @ 0.1% was also reported to be good in controlling the diseases.

Pink Root (*Phoma (Pyrenochaeta) terrestris*, *Fusarium solani*)

The disease occurs in onion grown for the first time and becomes increasingly damaging in successive crop particularly with short rotations. It is mainly a field disease and damaging effects are mainly on growing plants but losses also occur during transport and storage. Pink root often occurs in association with *Fusarium* basal rot.

Symptoms

The characteristic symptoms can be seen on the infected root. The affected roots turn yellow, shriveled and die, meanwhile taking on a distinct pink colour. The new roots, which grow from the infected plants, get immediately infected and become functionless. The disease is confined to the root only. The affected plants are commonly not killed but development of bulbs retarded.



Pink rot due to Phoma

Disease Cycle: The pathogen persists in soil and is distributed on onion seedlings, sets and garlic cloves. Dissemination also results from movement of spores, infested soil and plant residue by agricultural tools, wind and surface irrigation or drainage water.

Management

Host Resistance

Allium fistulosum and some garlic lines are resistance to pink root. Varieties reported to be pink root resistance may not prove resistant in all situations.

Cultural Methods

Soil solarization reduce pink root incidence. It has been observed that early sowing resulted in a higher disease incidence than late sowing. Long rotations with non-host crop should be followed.

Chemical Methods

Many workers have reported soil fumigation and use of fungicides but it is uneconomical at field level. After chemical control in field conditions pathogen population reduce early in the season but later returned to normal.

Black Mold (*Aspergillus niger* Van Tieghem, *A. fumigatus* (green mold) and *A. alliaceus*)

Symptoms

The disease occurs in the region having high temperature ranging from 35° - 45° C. It causes post harvest blemishes and rotting of onion grown and stored in hot climate.



Black mold (*Aspergillus* sp)

Management

Cultural Methods

- ❖ Storage of seed and bulb should be done after proper drying.
- ❖ Bruising should be avoided when bulbs area is harvested, stored or transported.
- ❖ Onion should be stored at 1-15°C.
- ❖ The presence of calcium in onion tissue plays an important role in resistance to the disease.

Chemical Methods

- ❖ Dusting of topped onion with Calcium Carbonate reduced post harvest bulb rotting by 16 to 17%. During transit, black mold can be reduced if the containers are fumigated with nitrogen tri chloride@430 mg / m³

Bacterial Rots

- i) Brown Rot (*Pseudomonas aeruginosa*),
- ii) Soft Rot (*Erwinia carotovora pv. carotovora* (Jones) Bergey, and
- iii) Slippery Skin (*Pseudomonas allicola*)

Symptoms

Bacterial pathogens are known to be associated with various types of rots in onion, which are usually observed during storage. Some are primary pathogens and others secondary, following fungal, insect or nematode attack. When the pathogen is of primary causal agent, it may damage the crop considerably. Bacterial decay of onion is widely distributed in warm climate and cause severe problems.

Management

- ❖ Grow the crop under optimum condition of tith, fertilizer, drainage, crop rotation and freedom from weeds.
- ❖ It is necessary to dry the crop quickly after harvest.
- ❖ During rainy season, artificial curing is required.
- ❖ Chemicals like Streptocycline were found somewhat effective in the control of bacterial diseases.

Viral Diseases (transmitted by various aphid species or mechanically to onion)

(i) Onion Yellow Dwarf Virus

Symptoms

The first symptoms appear on the youngest leaves, which turn pale and develop yellow streaks at the base of the leaves. Leaves may crinkle and flop over. Symptoms are more pronounced on leaves that develop from an infected bulb or transplant. Later there is more pronounced yellowing and leaves crinkle, flatten, twist and fall to the ground. Flower stalks are shortened, streaked with yellow and twisted.

Management

- ❖ No effective control measure is available.
- ❖ Plant virus free transplants and crop rotation of at least three years should be followed.
- ❖ Rouging of diseased plants and isolation from other susceptible crops or volunteer onions is advised.
- ❖ Spraying of insecticides to control aphids minimizes secondary spread.

(ii) Iris Yellow Spot Virus

Symptoms

It is caused by the tospovirus similar to Tomato Spotted Wilt Virus. Iris yellow spot symptoms first appear as straw-coloured, dry, tan, spindle or diamond-shaped lesions, with or without distinct green centers with yellow or tan borders on leaves. Symptoms vary greatly and are not always characteristic.



Diamond shaped viral lesions

Management

- ❖ Plant high quality transplants free from thrips and Iris yellow spot virus. Practice three year or longer rotation between onion crops.
- ❖ Eliminate volunteers, culls, and weeds in and around onion field.
- ❖ Sprinkler irrigation can provide some suppression of thrips and disease.
- ❖ Avoid thin, patchy stands and crop stress.
- ❖ Thrips control may provide some reduction in iris yellow spot, but thrips control alone is not sufficient to economically control the disease.

LEAFY VEGETABLES

Leaf Spots (*Cercospora* sp. and *Aternaria* sp.)

Symptoms

This is a common problem of all the leafy vegetables. Symptoms appear as light brown, circular spots, surrounded by red margin. The red circular halo is not prominent in many vegetables except spinach. Disease is caused by *Cercospora* sp. Lettuce, celery and Chinese cabbage are affected by *Alternaria* sp. Symptoms are light brown and circular spots can be seen all over leaf lamina.



Cercospora spot in spinach

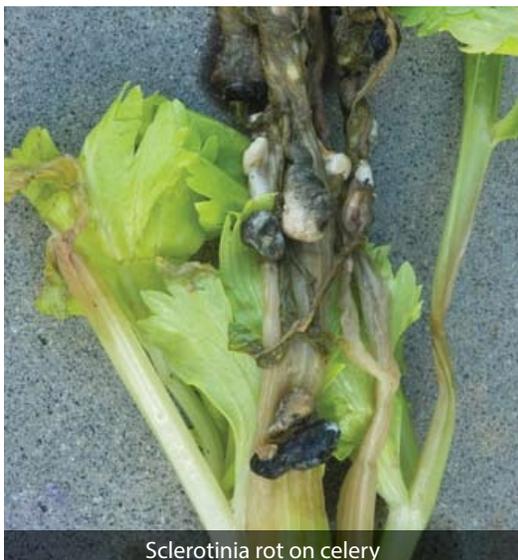
Management

- ❖ Avoid dense sowing of spinach.
- ❖ Collect lower leaves and burn it.
- ❖ Only one spray of Chlorothalonil @ 0.2%.

White Rot (*Sclerotinia sclerotiorum*)

Symptoms

This disease is more common in cool and humid weather. Symptoms appear as water soaked rotting of petioles, stump region and cover portion of the leaves. Soon after infection, white mycelium is observed all over the infected portion. This mycelium develops honeydew stage after colonization of the tissue. Later on entire rotted lower portion and stump is converted into compact mycelial mat followed by hard black sclerotial body. This is the resting structure and source of primary inoculums.



Sclerotinia rot on celery

Management

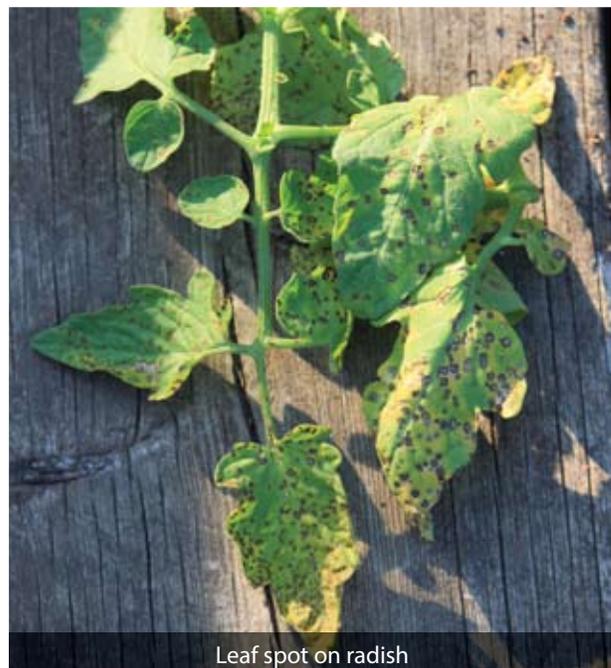
- ❖ Cut the infected curds, leaves along with some healthy portion in morning and carefully collect in polythene to avoid falling of sclerotia in the field. Burn all these materials away from field.
- ❖ Main crop should be periodically observed near the stump region in cool, cloudy and moist weather for primary infection.
- ❖ Foliar spray of Carbendazim @ 0.1% followed by spray of Mancozeb @ 0.25% along with sticker @ 0.1%.
- ❖ Spray must cover stump and lower portion of leaves.

RADISH

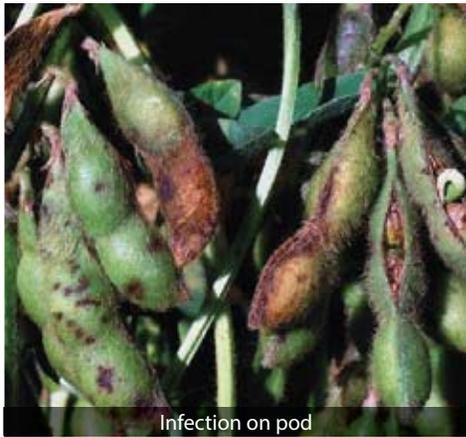
Alternaria Blight (*Alternaria raphani*)

Symptoms

All foliar part is affected by the pathogen. Symptoms appear as small circular dark, black spots on the leaves while irregular, oval to elongated lesions on siliqua and inflorescence. Infected seeds also cause pre and post emergence seed rot after sowing. Pericarp of seed is severely infected by the pathogen. Cotyledons of seed are also infected resulting internally seed borne nature of the pathogen. Infected seeds act as a primary source of infection.



Leaf spot on radish



Infection on pod

Management

- ❖ Collect disease free-seed from healthy crop.
- ❖ Seed treatment by captan @ 0.25%.
- ❖ Pluck the infected lower leaves from main root crops in February and burn it .
- ❖ One spray of Mancozeb @ 0.25% after breaking the leaves.
- ❖ One spray of Mancozeb @ 0.25% during siliqua formation.

CARROT

White Rot (*Sclerotinia sclerotiorum*)

Symptoms

Disease appears as water soaked rotting of stalk, stump and collar region engulfing lower portion of the leaves. Soon after infection, white mycelium growth is observed all over the infected portion. This mycelium is converted into compact mycelial mat. Later on entire infected crown portion of carrot including some of the edible root converted into black, hard and large sclerotium. Sclerotia are the source of primary inoculum and cause primary infection on flowers.



Collar infection of sclerotinia



Sclerotinia carrot rot

Management

- ❖ Crop rotation with lowland paddy and other cereals.
- ❖ Field sanitation by uprooting and burning of all infected plants and weeds.
- ❖ Summer fallowing, ploughing accompanied with once irrigation followed by again ploughing in summer.
- ❖ Green manuring in June and July followed by soil application of Trichoderma @ 5 kg/ha soon after ploughing of the sunhemp.
- ❖ Seed treatment with Trichoderma @ 0.6 to 1% depending.

Collar Rot (*Sclerotium rolfsii*)

Symptoms

Initially wet and soft rotting of carrot root is observed. Rooting covers entire root along with stump and leaves of the plant near collar region. Characteristic symptoms observed as white, cottony, fungal growth on root. Gradually this hyphal mat is converted into small, mustard like sclerotia that survive in the soil.

Management

- ❖ Crop rotation with lowland paddy and other cereals.
- ❖ Field sanitation by uprooting and burning of all infected plants and weeds.
- ❖ Summer fallowing, ploughing accompanied with irrigation followed by again ploughing in summer.
- ❖ Green manuring in June and July followed by soil application of Trichoderma @ 5 kg/ ha soon after ploughing of the sunhemp.
- ❖ Seed treatment with Trichoderma @ 0.6 to 1% depending



Sclerotium carrot rot

Elephant Foot Yam

Collar Rot (*Sclerotium rolfsii*)

Symptoms

Initially yellowing of the plant was observed and later on plant toppled down before maturity of rhizomes. Close observation revealed wet rotting of apical



Toppling of foliage by collar rot

portion of rhizome and base line stem. Rotting covers entire collar region of the rhizome that remain continue during storage also. Characteristic symptoms observed as white, cottony, fungal growth and sclerotia on affected portion as well as on contact soil. Gradually this hyphal mat is converted into small, mustard like sclerotia that survive in the soil.

Management

- ❖ Remove all the sclerotia from apical portion of rhizome during planting.
- ❖ Crop rotation with lowland paddy and other cereals.
- ❖ Field sanitation by uprooting and burning of all infected plants.
- ❖ Summer fallowing, ploughing accompanied with irrigation followed by again ploughing to germinate and desiccate the soil borne sclerotial inoculum.
- ❖ Green manuring in June and July followed by soil application of *Trichoderma* @ 5 kg/ha soon after ploughing of the sunhemp.
- ❖ Rhizome dipping in *Trichoderma* @ 1% solution for 20 minutes.
- ❖ Remove all the weeds from field.
- ❖ Drenching of *Trichoderma* @ 1% suspension after 25 and 40 days of sowing.
- ❖ Drench Copper Oxychloride @ 0.3% followed by Carbendazim @ 0.1% in evening near the collar region for immediate control.

RECOMMENDED IPM PRACTICES FOR IMPORTANT VEGETABLE CROPS

Tomato Nursery

- ❖ Raise marigold (tall African variety golden age bearing yellow and orange flower) nursery 15-20 days before tomato nursery.
- ❖ Prepare raised nursery beds about 10 cm above ground level for good drainage to avoid damping off.
- ❖ Cover the beds with polythene sheet of 45 gauge (0.45 mm) thickness for three weeks before sowing for soil solarisation for reducing the soil borne pests. Sufficient moisture should be present in the soil.
- ❖ Seed treatment with *Trichoderma viride* @ 4g/kg of seed in nursery to prevent infection of soil borne/seed borne fungal 1 kg of FYM. Mix in 1m². It can be applied even in main field.
- ❖ Spray nursery with it if insect is noticed.
- ❖ Spray Dithane M 45 or Ridomyl against Downy Mildew as this disease is generally seen in nursery.

Main crop

- ❖ Showing of resistant variety (Fruit borer-Avinash-2, Bacterial wilt- Arka Abha, Arka Alok, Shakti, Arka Abhijit, Arka Shreshta, Leaf Curl-Parbhani, Yeshree, H.24; Root-knot Nematodes, Hissar Anmol, SL 120, Pusa Hybrid 2; Powdery Mildew- Arka Ashish, Early Blight-Devgiri, Fusarium wilt-Pant Bahar).
- ❖ Before transplanting dip the roots of seedlings for 15 minutes in Imidacloprid @ 0.3 ml/litre for management of aphids, white fly & leaf miner.
- ❖ Transplant a row of marigold after every 16 rows of tomato as a trap crop. Marigold should be 15 days older than tomato plants so that they flower at the same time. Maximum egg laying by borer is observed on marigold flowers. First and last row of plots should be marigold and it should be sprayed with *HaNPV*.
- ❖ Adopt wide spacing of 60 x 45 cm (for varieties) and 90x 60 cm (for hybrids) to reduce the chance of spread of diseases.
- ❖ Apply neem cake @ 250 kg/ha at 20 DAP to reduce fruit borer, leaf miner and nematode.
- ❖ Bird perches @ 10/ acre should be erected for facilitating field visits of predatory birds.
- ❖ Spray of 5% NSKE at 15 DAP has also been found to be effective against leaf-miner & white fly. Spray Imidacloprid or Thiomethoxam at 15 DAP for leaf miner & white fly control, if needed.
- ❖ Pheromone traps @ 5/ ha be installed for monitoring fruit borer activity. Replace the lures with fresh lures after every 20-25 day interval. ETL for fruit borer is 8 to 10 moths /day/trap.
- ❖ Monitor top three leaves for *Helicoverpa* eggs.
- ❖ Release of *T. chilonis*, *T. braziliensis* and *T. pretiosum* @ 1.0 lakh/ha 4-5 times from flower initiation stage at weekly intervals for fruit borer.

- ❖ Spray *HaNPV* 250 LE/ha (2 x 10⁹ POB) + 1% jaggery along with sticker 0.5 ml/ liter 3 times at 28, 35 and 42 DAP during evening to reduce borer damage.
- ❖ Regular collection & destruction of damaged fruits i.e. clean cultivation helps in management of borer effectively.
- ❖ If the borer incidence crosses ETL (5% damage), apply Emmamectin Benzoate (proclaim) or Indoxacarb.
- ❖ Rouge out and destroy leaf-curl and wilt affected plants.
- ❖ Spray 0.02% Chlorothalonil/Mancozeb/Captan @ 1.25-1.5 kg a.i./ha in 700 L of water for the control of early and late blight. Repeat after 10 days if necessary.
- ❖ If red spider mite is noticed, spray neem soap or neem oil (0.1%) or any acaricide like Dicofol 18.5 EC (1.5 ml/l) or Ethion EC (1.5 ml/l) or Sulphur 80 WP (3g/l).

Brinjal Nursery

- ❖ Always prepare raised nursery beds about 10 cms above ground level for good drainage to avoid damping off, etc.
- ❖ Cover the nursery beds with polythene sheet of 45 gauge (0.45 mm) thicknesses for three weeks during June for soil solarisation which will help in reducing the soil borne insects, diseases like bacterial wilt and nematodes. However, care should be taken that sufficient moisture is present in the soil for its solarisation.
- ❖ Mix 250 gm of fungal antagonist *Trichoderma viride* in 3.00 kg of FYM and leave for about seven days for enrichment of culture. After seven days mix in the nursery soil in a bed of 3 sq. meters.
- ❖ Seed of popular high yielding hybrid like F1- 321 be sown in beds in the first week of July and properly mixed in soil for healthy nursery raising. Before sowing, seed be treated with *T. viride* @ 4 gm/ kg seed. Weeding should be done from time to time and infected seedlings should be rogued out from the nursery.

Main crop

- ❖ Bird perches @ 10/ acre should be erected for facilitating field visits of predatory birds.
- ❖ Delta traps @ 2-3/ acre should be installed for hoppers, aphids and white fly, etc.
- ❖ Give two to three sprays of 5 % NSKE against leaf hoppers, aphids and mites. Sprays of NSKE also brings down the borer incidence significantly. Neem oil (2%) application is also helpful in reducing borer infestation, though marginally. If incidence of leaf hopper and other sucking insect pests is still above ETL, then apply Imidacloprid 17.8 SL @ 150 ml/ha.
- ❖ Pheromone traps @ 5/ acre should be installed for monitoring and mass trapping of shoot & fruit borer *Leucinodes orbonalis*. Replace the lures with fresh lures after every 15-20 days.
- ❖ Release egg parasitoid *T. chilonis* @ 1.0 – 1.5 lakh/ ha for shoot & fruit borer, 4-5 times at weekly interval.
- ❖ Apply neem cake @ 250 kg/ ha (in two splits) in soil along the plant rows at 25 and 60 days after transplanting and give light covering with soil. This will be highly helpful in reducing nematodes and borer damage. Don't apply neem cake when there is heavy wind velocity or temperature is above 30°C.
- ❖ Clipping of borer damaged shoots and collection & destruction of damaged fruits i.e. clean cultivation helps in management of borer and phomosis disease effectively.
- ❖ If the borer incidence crosses ETL (5% fruit infestation), then apply Cypermethrin 25 EC @ 200 g a.i./ha (0.005%) or Carbaryl 50 WP @ 3 g/litre of water.
- ❖ Continuous cropping of brinjal leads to more borer and wilt infestation. Therefore, crop rotation with non-solanaceous crops should be followed.
- ❖ Periodically collect and destroy the egg masses, larvae and adults of beetle.
- ❖ Rogue out the little leaf affected plants from time to time. Use of green manure, mulching with polythene, soil application with bleaching powder will reduce the infection of bacterial wilt disease.

Cabbage/Cauliflower

Nursery

- ❖ Prepare raised nursery beds about 10 cm above ground level for good drainage to avoid damping off or raise seedlings in protrays in nursery under net house conditions wherever such facility is available.
- ❖ Cover the beds with polythene sheet of 45 gauge (0.45 mm) thickness for three weeks before sowing for soil solarisation for reducing the soil borne pests. Sufficient moisture should be present in the soil.
- ❖ Seed treatment with *Trichoderma viride* @ 4g/kg of seed in nursery to prevent infection of soil borne/seed borne fungal 1 kg of FYM. Mix in 1m². It can be applied even in main field.
- ❖ Spray nursery with *Bt* formulation (1ml or 1gm/l) at 10 days after sowing.
- ❖ Spray Dithane M 45 or Ridomyl against Downy Mildew as this disease is generally seen in nursery.
- ❖ Spray Indoxacarb 14.55 SC (0.5 ml/l) or Novbaluron (0.75 gm/l) or Quinalphos (1.5 ml/l) a day before transplanting seedling to control stem borer and early infestation of DMB.

Main crop

- ❖ Sowing of resistant varieties (Downy Mildew-Stone Head, Black rot-Puksa Drum Head, Pusa Mukta, K-1, Aphids-All season, Red Drum Head).
- ❖ Growing of two rows of mustard after every 25 rows of cabbage as a trap crop at the time of planting. This traps 80-90% of DBM population and other pests. Mustard be sprayed with Dichlorovos 0.1% as soon as it germinates. (One row of mustard is sown 15 days before cabbage planting and second 25 days after planting of cabbage. Ensure that first and last row of plot are also mustard.
- ❖ Adopt wide spacing of 60 x 45 cm to reduce the chance of spread of diseases.
- ❖ Use light traps for adult DBM @3 traps/acre. Hang a bulb over a bucket of water. Within 3-4 days most of the adults get killed.
- ❖ Spray *Bt* (1 g/litre) if DBM 1.0/plant is noticed early or Spray NSKE 5% at primordia formation (18-25 DAP- head initiation stage - most critical stage). Repeat if DBM is > 1/plant at 10-15 days interval. Maximum of 3-4 NSKE sprays in one crop season are required. When NSKE are sprayed, thorough coverage of the entire plant surface is a must.
- ❖ Release egg parasitoid *Trichogrammatoidea bactrae* at 0.5-0.75 lack/ha 3-4 times at weekly interval. (optional)
- ❖ For controlling *Spodoptera* mechanically collect and destroy gregarious young larvae and set up traps for mass trapping. However, to control grown up caterpillar, do baiting with Methomyl in rice grain / wheat grain (10 kg), jaggery (2 kg) and insecticide formulation 250gm/ acre.
- ❖ Periodically remove and destroy disease affected leaves.
- ❖ If required, spray Chlorothalonil/Mancozeb for *Alternaria* and Blitox + Streptomycin for black rot. Wider spacing (60 x 50 cm) will almost eliminate any disease spread.

Okra (Lady's finger)

- ❖ Deep summer ploughing to expose resting stages of the pests
- ❖ Sowing of YVMV resistant hybrids viz. Makhmali, Tulsi, Anupama-1 and Sun-40, etc. especially during *kharif* season of the crop.
- ❖ Grow maize/sorghum on borders as a barrier/trap crop for the entry of shoot & fruit borer adults.
- ❖ Set up yellow sticky and delta traps for white fly, etc.
- ❖ Erection of bird perches @ 10/acre in the field for facilitating bird predation.
- ❖ Give two to three sprays of NSKE @ 5% alternating with sprays of pesticides, if needed, for leaf hopper, white fly, mites and aphids, etc. Leaf hopper, if crosses ETL (5 hoppers/plant), spray Imidacloprid 17.8 SL @ 150 ml/ha. This will be effective in controlling other sucking pests as well.
- ❖ Install pheromone traps @ 2/ acre for monitoring of *Earias vittella* moth emergence. Replace the lures after every 15-20 day interval.

- ❖ Release egg parasitoid like, *Trichogramma chilonis* @ 1-1.5 lakh/ ha starting from 30-35 days after sowing, 4-5 times at weekly interval for shoot & fruit borer.
- ❖ Rogue out the YVMV affected plants, if any, from time to time.
- ❖ Periodically remove and destroy the borer affected shoots and fruits
- ❖ Need based application of chemical pesticides viz. Imidacloprid 17.8 SL @ 150 ml/ha or Propargite etc. 57EC @ 0.1 % for control of leaf hoppers, aphids, white flies, borers and mites. Shoot & fruit borer, if crosses ETL (5.3 per cent damaged fruits), spray cypermethrin 25 EC @ 200 g a.i/ha (0.005%) or Quinalphos 25 EC @ 0.05% or Emmamectin Benzoate (proclaim) 5% (WDG) @ 0.25 g/litre or indoxacarb 14.5 SL @ 500 ml/ha

Chilli and Capsicum

Nursery

- ❖ Prepare raised nursery beds about 10 cm above ground level for good drainage to avoid damping off, etc.
- ❖ Cover the beds with polythene sheet of 45 gauge (0.45 mm) thickness for three weeks before sowing for soil solarisation which will help in reducing the soil borne pests. Sufficient moisture should be present in the soil for solarisation.
- ❖ Mix 150 gm of fungal antagonist *T. harzianum* (c.f.u. 2×10^9 /gm) in 3 kg of FYM and leave for about seven days for enrichment. After 7 days mix in the soil in a bed of 3 sq. m.
- ❖ Treat the seeds of popular hybrids with *T. viride* @ 4 gm/ kg.
- ❖ To avoid fungal diseases like damping off in nursery, drench soil with any copper fungicide like copper oxy Chloride (Blue copper) @ 3 g/litre of water during 2nd or third week after sowing.
- ❖ Erect khaskhas shading/support on one side of nursery beds to avoid the exposure to cold/frost during winter (December-January). Cover the beds with polythene sheets at night to avoid frost injury. However, remove the sheets during day time to expose them to sun.

Main crop

- ❖ At the time of planting, dip the seedlings in *Pseudomonas fluorescens* solution @ 5 ml/litre for two minutes.
- ❖ Erect bird perches @ 10/ acre for facilitating field visits of predatory birds.
- ❖ Install delta sticky traps @ 2/acre for hoppers, aphids and white fly, etc.
- ❖ Need based spray of commercial neem product/ NSKE 5% against aphids, thrips, hoppers and white fly etc. Spray NSKE 5% 2-3 times against thrips at 15-20 days after transplanting (DAT) when rating is between 1-2. This will reduce the population substantially. If the population of thrips & white fly is still high, then spray Spinosad or Fipronil or Imidacloprid @ 0.5 ml/l or Acephate @ 2ml/l.
- ❖ Spray vertimec for mites occurrence
- ❖ Erection of pheromone traps @ 5/ ha for *Helicoverpa* sp/ *Spodoptera litura* for monitoring of adults for egg laying.
- ❖ Periodic releases of egg parasitoid, *Trichogramma* sp @ 1.5 lakh/ ha for fruit borer (*Helicoverpa* sp.)
- ❖ Spray of HaNPV 250 LE/ha 2-3 times at 60 DAP or in initial stages or as and when needed.
- ❖ Spray of biopesticide like proclaim 5% (WDG) @ 0.25 gm/litre or Spinosad @ 0.6 ml/L when larvae are small. Apply these biopesticides preferably during evenings.
- ❖ Spray of chemical insecticides like indoxacarb 14.5 SP @ 500 ml/ha or Fenvalerate @ 100 a.i /ha during initiation of flowering to podding stage for fruit borer, *Helicoverpa* sp is effective.
- ❖ Periodic removal and destruction of damaged fruits due to borer or fruit rot. Destruction of crop residues/debris will reduce the carry over load of many insect pests. After harvest crop will be immediately ploughed in the field.
- ❖ Rouging out and destroying of leaf-curl disease/ mosaic complex affected plants periodically.
- ❖ Spray 0.02% Mancozeb/Captan for managing the leaf blight & fruit rot. Proper water management & drainage reduce the incidence effectively.
- ❖ Adequate fertility & proper water management will help develop the canopy of leaves & foliage

required to protect the fruit from sun scald. Sometimes a shade crop like *Dhaincha* can also be grown as a border line.

Cucurbitaceous Crops

- ❖ Collection and destruction of infected fruits/vines
- ❖ Deep ploughing of field after the crop harvest to kill the pupae.
- ❖ Earthing up of the soil around the vine to expose the pupae for desiccations and predation by birds.
- ❖ Soil application of neem cake @ 250 kg/ha after germination and repeat once at flowering.
- ❖ Plant maize as a border crop seven days before sowing.
- ❖ Management of leaf miner by i) removal of cotyledon leaves infected with leaf miner one week after germination ii) followed by spraying of neem seed powder extract @ 4% or neem soap @ 1% reduces the incidence of leaf miner.
- ❖ Spray neem seed powder extract 4% or neem soap or pomgamia soap @ 1% or carbaryl @ 3gm/l or Indoxacarb 0.5 ml/l or Dimethoate 30 EC Sulphur @ 30 g/l after flowering at 10 days interval.
- ❖ Crush pumpkin 1 kg and add 100 gm jaggery and 10 ml malathion and keep in the plot (4-6 places per acre). Adults are attracted to the fermenting pumpkin and lay eggs and get killed. Repeat the process 2-3 times in a cropping season.
- ❖ Erect pheromone traps cuelure @ 3 traps / ac and change after 60 days.

Pheromone application technique for the management of fruit fly in cucurbits

Male Annihilation Technique (MAT)

5 x 5 cm² wooden blocks soaked in solution of 6:4:1 ethanol : methyl eugenol : malathion for 48 hours hung @ 10/ha

Bait Application technique (BAT)

Spray liquid of 0.1% insecticide and 10% jaggery or 10% ripe banana at 200 spots/ha

Onion/Garlic

- ❖ Do seed treatment with thiram (2g/kg seed) to control seed and soil borne diseases in nursery.
- ❖ Apply *Trichoderma viridae*@5 kg/ha mixed with FYM to main field as well as in nursery.
- ❖ Surround the onion plots (at least 250 sq. m.) with two rows of maize planted 30 days before planting onion to block the thrips to enter onion plants.
- ❖ Avoid planting onion during peak incidence of thrips.
- ❖ Seedling root dip with Carbosulfan for 2 ha should be done before planting to protect the plants during initial stages whenever late planting is done.
- ❖ Grow the crop on raised beds and provide proper drainage during kharif season to minimize disease incidence.
- ❖ Thrips and foliar disease can effectively controlled by spraying Carbosulfan (2ml/l) +Carbendazim (2.5 g/l) + sticker (0.7 ml/l); Profenofos (1ml/l) +Mancozeb (2.5 g/l) +sticker (0.7 ml/l); Cypermethrin (60 g ai/ha) + Chlorthaloni (2.5 g/l) + sticker (0.7 ml/l) in rotation.
- ❖ Bulbing stage (45-75 days) is crucial for thrips management and needs chemical intervention.
- ❖ Never use same pesticide repeatedly.

MANAGEMENT OF NEMATODES IN PROTECTED VEGETABLE CROPS

Nature of damage due to different nematodes under polyhouse conditions is similar to the crops grown under open conditions. Root-knot nematodes, *Meloidogyne incognita*, reniform nematodes, *Rotylenchulus reniformis* and lesion nematodes, *Pratylenchus* sp. are the major nematodes attacking horticultural crops under protected conditions. They feed on the roots devitalizing the plants ultimately affecting both qualitative and quantitative production. All of them may be managed by following the integrated management as follows.

Management

- ❖ If the beds are highly infested with the nematodes bring down the population of nematodes by applying neem/pongamia cake @ 500 g + Carbofuran @ 50 g/ sq. m.
- ❖ Treat the seeds with bio –pesticide-*Pseudomonas fluorescens* @ 10 g/kg seed.
- ❖ Raise the seedling in the coco-peat or any substrate by treating it *P. fluorescens* @ 1kg+ *T. harzianum* @ 1kg + neem or pongamia cake @ 50 kg/ton.
- ❖ Treat the bed with neem or pongamia cake @ 50g *T. harzianum* @ 25 g or *Pochonia chlamydosporia* + *Paecilomyces lilacinus* @ 25 g/sq. m at an interval of 2 months.
- ❖ Apply 2 tons of farmyard manure enriched with bio-pesticide-*Trichoderma harzianum* per acre before planting, along with 100-200 kg of neem or pongamia cake.
- ❖ Apply Carbofuran 3 G @ 1kg ai/ha at planting and repeat after 45 days.

PROCEDURE FOR ENRICHMENT OF FYM WITH **BIO-AGENTS**

Use one kg of bio-pesticide-*Trichoderma harzianum* + *Paecilomyces lilacinus* / *Pochonia chlamydosporia* / *Pseudomonas fluorescens* + 50 kg of neem or pongamia cake to enrich 1 ton of farmyard manure and leave it under shade for 15 days. Once in 5 days, mix the FYM thoroughly by maintaining optimum moisture.

Preparation of Biopesticides at farmers' level

Neem Seed Kernel Extract (NSKE 4%)

Method of preparation

- ❖ Dried neem seed kernels (400g) are grinded to coarse powder.
- ❖ Take 40 g of this powder and tie it in a fine muslin cloth, soak overnight in 400-500 ml of water in a container.
- ❖ Shake and filter the suspension with water to make 1000 ml volume.
- ❖ Add 2 g of soap to this solution (NSKE 4%) and use for spray.
- ❖ NSKE helps in the management of *Spodoptera*, *Helicoverpa*, semiloopers, leaf folders and sucking pests including mites.

Tobacco Decoction

Method of preparation

- ❖ Boil 1 kg tobacco dust in 10 liters of water for 30 minutes to attain coffee red colour.

- ❖ Add water to the boiling solution to make 10 litres volume.
- ❖ Cool and filter the decoction using a thin muslin cloth.
- ❖ Add soap @ 2 g/l and dilute to 80 to 100 litres for spray.
- ❖ This preparation is effective against whitefly, aphids, and leafhoppers.

Note: Tobacco decoction should not be used for more than once, as it is toxic to natural enemies.

Cattle-dung and Urine Extract

Method of preparation

- ❖ Mix Cattle-dung (5 kg) and urine (5 liters) thoroughly in 5 liters of water in a container and allow this mixture for 4 days by keeping a lid over the container.
- ❖ After 4 days, filter and add 100 grams of lime to this solution.
- ❖ Dilute the solution in 80 liters of water, which is sufficient for spraying an acre.
- ❖ Spraying cow dung urine solution prevents eggs laying by the moth, e.g. *Helicoverpa* and *Spodoptera*, etc.
- ❖ It is found to give protection against some diseases and the sprayed crop looks green and healthy.

Nuclear Polyhedrosis Virus (NPV)

Method of preparation

- ❖ Collect 400 NPV infected *Helicoverpa* or 200 *Spodoptera* larvae from field.
- ❖ Grind the collected larvae. Filter the solution obtained using a thin cloth.
- ❖ Dilute the NPV solution to 100 litres and add 100 g of Robin Blue to protect from UV light in the field.
- ❖ Spray this solution during evening hours.
- ❖ Insects Controlled: *Helicoverpa*, *Spodoptera*
- ❖ Virus of one insect species does not kill the other insect species.
- ❖ Virus infected dead larvae are observed hanging head down from top branches 2-5 days after spraying the solution in the case of *Helicoverpa* and split body in case of *Spodoptera*

SOME USEFUL TIPS IN PEST MANGEMENT

- ❖ Always use protective clothing while spraying.
- ❖ Avoid spraying insecticides repeatedly. Alternate them with botanicals, wherever possible to prevent development of resistance and pest resurgence.
- ❖ Add 0.5 ml of any sticking agent to the spray solution.
- ❖ Oil should be made into an emulsion before spray by shaking thoroughly in a bottle before dilution and sprayed immediately without any delay.
- ❖ Botanicals may cause phytotoxicity when the temperature is more than 32 ° C in polyhouse. Hence, it should be done with caution and only after pre-checking. It is always better to spray botanicals in the evening.
- ❖ After spraying any insecticide keep appropriate waiting period before harvesting fruits.

Do's

- ❖ Timely sowing
- ❖ Field sanitation
- ❖ Always use freshly prepared neem seed kernel extract (NSKE).
- ❖ Apply pesticides only when required.
- ❖ Wash okra & brinjal fruits before consumption.

Don'ts

- ❖ Don't apply more than the recommended dose of the pesticide.
- ❖ Don't repeat the same pesticide consecutively.
- ❖ Don't apply mixture of pesticides.
- ❖ Don't apply highly hazardous insecticides like monocrotophos in vegetables.
- ❖ Don't apply pesticides just before harvesting.
- ❖ Don't consume produce till 3-4 days after application of pesticide.

ANNEXURE-I

Occurrence of Fungal Diseases in Vegetable Crops

Crop	Disease	Pathogen	Severity (%)	Average incidence (%)
Brinjal	Phomopsis blight	<i>Phomopsis vexans</i>	10-70	32.5
	White rot	<i>Sclerotinia sclerotiorum</i>	5-22	8.7
	Collar rot	<i>Sclerotium rolfsii</i>	10-30	15.3
	Leaf blight	<i>Alternaria alternata</i>	5-35	25.2
	Root rot	<i>Rhizoctonia solani</i>	10-40	21.8
	Rhizopus fruit rot	<i>Rhizopus stolonifer</i>	2-12	5.2
	Leaf spot	<i>Corynespora cassiicola</i>	4-10	6.5
	Wilt	<i>Fusarium solani</i>	2-7	3.1
	Myrothecium leaf spot	<i>Myrothecium roridum</i>	2-16	2.4
Tomato	Alternaria blight	<i>Alternaria solani</i> , <i>A. alternata</i> <i>f.sp. lycopersici</i>	15-90 5-30	40.00 15.2
	Septoria leaf spot	<i>Septoria lycopersici</i>	3-10	4.6
	Late blight	<i>Phytophthora infestans</i>	5-80	12.5
	White rot	<i>Sclerotinia sclerotiorum</i>	5-15	7.3
	Collar rot	<i>Sclerotium rolfsii</i>	10-40	19.6
	Grey leaf spot	<i>Stemphyllium solani</i>	10-30	15.7
	Fruit rot	<i>Rhizoctonia</i> , <i>Cladosporium</i> , <i>Pythium</i>	5-20	15.2
	Black leaf mold	<i>Pseudocercospora fuligena</i>	0-3	1.4
	Wilt	<i>F. oxysporum f.sp. lycopersici</i>	2-8	3.2
Chilli/ Capsicum	Leaf spot	<i>Myrothecium roridum</i>	5-12	6.5
	Die-back	<i>Choanephora capsici</i> , <i>Colletotrichum capsici</i> ,	15-60	35.4

Crop	Disease	Pathogen	Severity (%)	Average incidence (%)
	Anthracnose	<i>Colletotrichum capsici</i>	10-40	15.2
	Phytophthora blight	<i>Phytophthora capsici</i>	5-20	6.9
	Leaf blight & fruit rot	<i>Alternaria alternata, Alternaria solani</i>	5-20	13.7
	Leaf spot	<i>Cercospora capsici</i>	10-35	20.4
	Collar rot	<i>Sclerotium rolfsii</i>	2-5	3.4
	White rot	<i>Rhizoctonia solani</i>	1-4	2.2
	Root rot	<i>Rhizoctonia solani</i>	5-12	6.9
	Myrothecium leaf spot	<i>Myrothecium roridum</i>	0-3	1.4
Cucurbits	Downy mildew	<i>Pseudoperonospora cubensis</i>	10-80	35.8
	Anthracnose	<i>Colletotrichum lagenarium</i>	35-90	55.3
	Cercospora leaf spot	<i>Cercospora citrullina</i>	20-50	32-60
	Gummy stem/leaf blight	<i>Didymella bryoniae</i>	5-20	12.5
	Vine & Fruit rot	<i>Sclerotium, Rhizoctonia, Phythium, Sclerotinia,</i>	10-25	15.7
	Powdery mildew	<i>Sphaerotheca fuliginea, Erysiphe cichoracearum</i>	15-45	18.7
	Phytophthora blight	<i>Phytophthora cruentainnamomi</i>	25-60	35.5
Legume vegetables	Leaf blight	<i>Pseudocercospora cruenta, cruenta</i>	20-90	60.9
	Ascochyta blight	<i>Ascochyta phaseolorun Rhizoctonia solani</i>	5-15 10-25	8.5 12.7
	Ashy stem blight	<i>Macrophomina bataticola</i>	5-30	15.3
	Root rot	<i>Sclerotium rolfsii</i>	5-15	9.2
	Phoma leaf blight	<i>Phoma phaseolina</i>	3-12	9.7
	Rust	<i>Uromyces phaseoli</i>	10-30	12.5
	Powdery mildew	<i>Peronospora pisi</i>	5-60	15.3
	Downy mildew	<i>Peronospora pisi</i>	5-60	15.3
	White rot	<i>Sclerotinia sclerotiorum</i>	10-35	25.1
	Wilt	<i>F. solani f.sp. pisi</i>	8-10	7.6
	Leaf spot	<i>Myrothecium roridum</i>	2-8	4.3
Cole crops	Leaf spot	<i>Alternaria brassicae, A. brassicicola</i>	5-30	16.9
	Downy mildew	<i>Peronospora parasitica</i>	5-25	10
	White rot	<i>Sclerotinia sclerotiorum</i>	5-15	8.7
	Root rot/wire stem	<i>Rhizoctonia solani</i>	10-25	12.5

Crop	Disease	Pathogen	Severity (%)	Average incidence (%)
	Black leg	<i>Phoma lingam</i>	2-5	2.2
Root crops	Leaf spot	<i>Alternaria raphani</i>	15-60	30.8
	Collar rot	<i>Sclerotium rolfsii</i>	2-8	4.9
	White rot	<i>Sclerotinia sclerotiorum</i>	1-3	2.5
	Leaf spot	<i>Cercospora dauci</i>	2-5	2.1
Okra	Leaf blight	<i>Cercospora abelmoschi</i> , <i>C. hibisina</i>	25-85	60.4
	Charcoal rot	<i>Macrophomina phaseolina</i>	5-20	11.5
	Leaf spot	<i>Myrothecium roridum</i>	3-7	3.5
Onion/Garlic	Purple blotch	<i>Alternaria porri</i>	15-70	43.8
	Leaf blight	<i>Stemphyllium vesicarium</i>	10-40	22.3
	Downy mildew	<i>Peronospora destructor</i>	5-25	8.6
Elephant foot yam	Collar rot	<i>Sclerotium rolfsii</i>	15-55	24.6
Leafy vegetables	Leaf spot	<i>Cercospora sp.</i>	10-25	14.9
Nursery crops	Damping off	<i>Rhizoctonia</i> , <i>Phythium</i> , <i>Phytophthora</i> , <i>Colletotrichum</i> , <i>Sclerotium</i> , <i>Phomopsis</i> , <i>Alternaria</i> , <i>Fusarium</i>	30-85	47.6

ANNEXURE-II

Occurrence of Bacterial Diseases in Vegetable Crops

Crop	Disease	Pathogen	Severity (%)	Average incidence (%)
Brinjal	Wilt	<i>Ralstonia solanacearum</i>	2-5	2.4
Tomato	Leaf spot	<i>Xanthomonas campestris pv. vesicatoria</i>	25-80	45.7
	Leaf speck	<i>Pseudomonas syringae pv syringae</i>	15-70	25.3
	Wilt	<i>R. solanacearum</i>	1-3	1.7
	Soft rot	<i>Erwinia carotovora pv. carotovora</i>	2-18	8.4
Chilli/Capsicum	Leaf spot	<i>X. campestris pv. vesicatoria</i>	5-38	18.8
	Soft rot	<i>E. carotovora pv. carotovora</i>	2-10	4.9
	Wilt	<i>R. solanacearum</i>	3-8	3.6
Cowpea	Common blight	<i>X. campestris pv. campestris</i>	10-45	25.6
	Halo blight	<i>P. syringae pv. phaseolicola</i>	5-12	7.3
Cole crops	Black rot	<i>X. campestris pv. campestris</i>	10-60	21.7
	Soft rot	<i>E. carotovora pv. carotovora</i>	5-15	8.2
Cururbits	Wilt	<i>E. tracheiphila</i>	0-2	1.2
Root crops	Soft rot	<i>E. carotovora pv. carotovora</i>	5-10	5.5
Leafy vegetables	Soft rot	<i>E. carotovora pv. carotovora</i>	7-16	8.9

ANNEXURE-III

Occurrence of Major Viral and Phytoplasmal Diseases of Vegetable crops

Crop	Disease	Pathogen	Severity (%)	Average incidence (%)
Brinjal	Little leaf	<i>Phytoplasma</i>	10-60	15.2
	Mild mosaic	<i>Poty virus</i>	4-10	8.6
Chilli	Mottle mosaic	<i>Poty virus / CMV</i>	5-20	8.3
	Leaf curl	<i>Gemini</i>	3-12	6.5
	Little leaf	<i>Phytoplasma</i>	1-2	<1
Tomato	Leaf curl complex	<i>Gemini, TMV, CMV</i>	30-80	65.2
Bottle gourd	Mosaic	<i>Poty</i>	5-35	9.5
Ash gourd	Yellow vein mosaic	<i>Gemini</i>	20-65	20.3
Bitter gourd	Leaf distortion	<i>Poty/ Gemini</i>	15-60	35.7
Pumpkin	Yellow mosaic	<i>Gemini</i>	15-50	8.5
Ivy gourd	Leaf distortion/ mosaic complex	<i>Poty</i>	10-30	15.9
Okra	Yellow vein mosaic	<i>Gemini</i>	30-90	42.5
	Enation leaf curl	<i>Gemini</i>	5-25	11.5
Cowpea	Golden mosaic	<i>Gemini/Como</i>	20-60	35.7

ANNEXURE-IV

Fungicides/ Insecticides used for the Control of Vegetable Diseases/Pest

Common name	Trade name	Dose
Captan	Captaf, Dhanutan	0.2-0.25
Thirum	Hexathir, Thiride	0.2-0.25
Carbendazim	Bavistin, Derosal, Dhanustin,	0.05-0.1
Thiophanate Methyl	Topsin-M, Cercobi-M, Cover	0.05-0.1
Dinocap	Karathane	0.1
Mancozeb	Dithane M-45, Indofil M-45, Dhanuka M-45	0.2-0.25
Zineb	Dithane Z-78	0.2-0.25
Ziram	Cuman-L	0.2-0.25
Copper Oxychloride	Blitox-50, Fytolon, Blue copper, Dhanucop	0.3
Wettable Sulphur	Sulfex, Dhanuksal, Kumulus	0.25-0.3
Tridemorph	Calixin	0.05-0.1
Triademophon	Baycor	0.05
Penconazole	Topas	0.025-0.05
Propineb	Antracol	0.2
Tebuconazole	Folicur	0.05
Difenconazole	Score	0.025-0.05
Bitertanol	Bayleton	0.05
Hexaconazole	Contaf	0.025-0.05
Flusilazole	Punch	0.05
Triforine	Saprol	0.05-0.1
Pencycuron	Monceren	0.05-0.1
Copper Hydroxide	Kocide	0.2-0.25
Propiconazole	Tilt	0.025-0.05

New insecticides

Common name	Trade name(s)	Formulation	Recommended conc.		Target pests
			(%)	(ml or g/l)	
Abamectin	Vertimec	1.8 EC	0.0009	0.5	Mites/thrips
Acetamiprid	Pride (for seed treatment)	20 SP	0.004	0.2	Sucking pests
Beta Cyfluthrin	Bulldock	2.5 EC	0.0035	1.5	Bores
Bt Formulations	Halt(WP), Dipel(8L), Biobit (WP), Delfin (WG)			0.5 to 1.0	DBM
Fenpropathrin	Danitol, Meothrin	10 & 30 EC	0.045	1.5	Borers
Fipronil	Regent	5 SC	0.01	2.0	Borers
Imidacloprid	Confidor, Sensor	17.8 SL	0.0045	0.25	Sucking pests
Imidacloprid	Stalone, Atom	200 SL		0.4	Sucking pests
Indoxacarb	Avaunt	14.5 SC	0.0145	1.0	Borers
Methomyl	Lannate, Dunnet, Astra	40 SP	0.06	1.5	Borers
Propargite	Omite	57 EC		3.5	Chilli mites
Spinosad	Tracer	45 SC	0.018	0.4	DBM/borers
Thiamethoxam	Actara	25 WG	0.0025	0.2	Seed treatment (for sucking pests)

ANNEXURE-V

Biopesticides, Pheromones used in IPM

S. No.	Biopesticides/Pheromone	Trade name	Target pest
1.	Azadirachtin (Neem based)	Neemarin, Azadirachtin, Multineem, Neemguard, Neemzol, margocide	Caterpillars, leafhoppers, whiteflies, aphids
2.	Bacillus thuringiensis kurstaki (Bacteria)	Halt, Biolep, Delfin, Dipel, Biovit, Thuricide	Caterpillars
3.	verticillium lecanii (Fungus)	Dispel, Boverin, Biotrol,	Caterpillars, white grubs
4.	Beauveria bassiana (Fungus)	Vertalec, Mycotal, Verticel	Aphids, thrips, whiteflies, scale insects
5.	Nuclear Polyhedrosis Virus (H-NPV)	H-NPV	Helicoverpa armigera
6.	Nuclear Polyhedrosis Virus (S-NPV)	S-NPV	Spodoptera litura
7.	(Z) 11 Heaxadecanal & (Z) Hexadecanal (97:3) (Sex pheromone)	Heli-lure	Helicoverpa armigera
8.	(Z, E), 911 Tetradecanyl Acetate & (Z, E) 9,12-Dienyl Acetate (19:1) (Sex pheromone)	Spodo-lure	Spodoptera litura
9.	(E)-11 hexadecenyl Acetate & (E)-11-Hexadecen-1-ol (100:1) (Sex pheromone)	Nomate, Leucilure	Leucinodes orbonalis
10.	(Z)- Heaxadecanal -11-enal & (Z)-hexadec-11-enyl Acetate (Sex Pheromone)	Nomate-DBM, Checkmate DBM	Plutella xylostella
11.	4-(4-Hydroxyphenyl)-2-Butanone Acetate (Sex pheromone)	Cuelure	Bactrocera cucurbitae

ANNEXURE-VI

Economic threshold level for some vegetable crop pests

Crop	Pest	Economic Threshold Level (ETL)
Cabbage	Diamondback Moth (<i>Plutella xylostella</i>)	10 larvae (3rd & 4th instar) per plant in seedling stage
Cauliflower	Aphid	30 aphids/plant
Chilli	Mites (<i>Polyphagotarsonemus latus</i>)	Single mite per leaf
Chilli	Thrips (<i>Thrips tabaci</i>)	2 thrips per leaf
Brinjal	Whitefly (<i>B. tabaci</i>)	5-10 flies / leaf
Brinjal	Shoot and Fruit Borer (<i>L. orbonalis</i>)	0.5% shoot and fruit damage
Tomato	Fruit Borer (<i>Helicoverpa armigera</i>)	8 eggs in 15 plants or single larva per plant or 2% fruit infestation.
Okra	Fruit Borer (<i>Earias vittella</i>)	5.3 % of fruit infestation
Okra	Leafhopper (<i>Amrasca biguttula biguttula</i>)	4-5 nymphs per plant
Pea	Aphids (<i>Acyrtosiphon pisum</i>)	3-4 aphids / stem tip
Onion	Thrips (<i>Thrips tabaci</i>)	13-14 thrips/ plant 15 days after transplanting.

ANNEXURE- VII

List of Pesticides / Pesticides Formulations Banned in India

A. Pesticides Banned for Manufacture, Import and Use (28 Nos.)`	
1.	Aldrin
2.	Benzene Hexachloride
3.	Calcium Cyanide
4.	Chlordane
5.	Copper Acetoarsenite
6.	Cibromochloropropane
7.	Endrin
8.	Ethyl Mercury Chloride
9.	Ethyl Parathion
10.	Heptachlor
11.	Menazone
12.	Nitrofen
13.	Paraquat Dimethyl Sulphate
14.	Pentachloro Nitrobenzene
15.	Pentachlorophenol
16.	Phenyl Mercury Acetate
17.	Sodium Methane Arsonate
18.	Tetradifon
19.	Toxafen
20.	Aldicarb
21.	Chlorobenzilate

22.	Dieldrine
23.	Maleic Hydrazide
24.	Ethylene Dibromide
25.	TCA (Trichloro acetic acid)
26.	Metoxuron
27.	Chlorofenvinphos
28.	Lindane (Banned vide Gazette Notification No S.O. 637(E) Dated 25/03/2011)-Banned for Manufacture, Import or Formulate w.e.f. 25th March, 2011 and banned for use w.e.f. 25th March, 2013.
B. Pesticides / Pesticide Formulations banned for Use but their manufacture is allowed for Export (2 Nos.)	
29.	Nicotin Sulfate
30.	Captafol 80% Powder
C. Pesticides formulations banned for Import, Manufacture and Use (4 Nos)	
1.	Methomyl 24% L
2.	Methomyl 12.5% L
3.	Phosphamidon 85% SL
4.	Carbofuron 50% SP
D. Pesticides Withdrawn (7 Nos)	
1.	Dalapon
2.	Ferbam
3.	Formothion
4.	Nickel Chloride
5.	Paradichlorobenzene (PDCB)
6.	Simazine
7.	Warfarin



National Horticulture Mission
Department of Agriculture & Cooperation
Ministry of Agriculture
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