

IPM SCHEDULE FOR VEGETABLES

A. INSECT MANAGEMENT

1. TOMATO

1.1 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. The larvae bore into the fruits with the posterior end out side the hole. Full-grown caterpillars show characteristic whitish and dark brown longitudinal stripes.



Borer damaged fruits



Larva



NPV infected larva



Marigold as a trap crop in IPM of tomato

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. 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.

1.3 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.

Management

- 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.
- Drench the base of the seedlings with Imidacloprid 200 SL (0.03ml/l) or Thiomethoxam 25 WP (0.3 g/l) before transplanting. If protreys are used for raising nursery, drench the protreys with the chemicals one day before transplanting.
- After transplanting give need-based sprays of Imidacloprid 200 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.

1.4 Tobacco caterpillar (*Spodoptera lituara*)

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.

1.5 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. 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 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.

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

Root-knot nematodes cause root galls on the feeder roots and some times affect the entire root system showing heavy galling. This causes stunted plants with yellow foliage resulting in yield reduction.

Management

- 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 farm yard manure enriched with *T. harizianum* 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.

2. BRINJAL

2.1 Shoot and fruit borer (*Leucinode orbonalis* Guen)

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 bud and the grown up larvae migrate and bore fruit contaminating them with excreta.



Larva inside the stem



larvae bore into fruit

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).

2.2 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.

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.

2.3 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. Affected plants wilt and dry up. Wilting is first noticed in patches in a plot. Both the roots and plant base show scraped damage.



Ash weevil damage on brinjal

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.

2.4 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.



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.

2.5 Red spidermites (*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.



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.

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

The root-knot nematodes cause root galls on the feeder roots which some times affect the entire root system showing heavy galling. 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. harizianum* @ 50 g/sq.m.
- Apply 2 tons of farm yard manure enriched with *T.harizianum* 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.

3. CHILLI AND CAPSICUM

3.1 Thrips (*Scirtothrips dorsalis*)

Thrips are minute insects with fringed wings, serious during dry periods 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.



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).

3.2 White or yellow mite (*Polyphagotarsonemus latus*)

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.



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.

3.3 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.

3.4 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.



Tobacco caterpillar damage on capsicum

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 + 1kg 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.

3.5 Root knot nematodes (*Meloidogyne incognita*)

Root-knot nematodes cause root galls on the feeder roots which some times affect the entire root system showing heavy galling. 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.

4. OKRA

4.1 Leaf hopper (*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. 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.

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

Spotted bollworms are active through out the year reaching peaks during March-May and August-October. Female lays green colored eggs with longitudinal ridges on buds, flowers and fruits.



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.

4.3 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.

4.4 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.

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 Thiometoxam 0.3 gm/l (should not be sprayed after flowering stage)

4.5 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.

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

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 farm yard 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.

5. CRUCIFEROUS VEGETABLES (Cabbage, Cauliflower etc.)

5.1 Diamond back moth (DBM) (*Plutella xylostella* L.)

This is a major pest of cruciferous crops, particularly cabbage and cauliflower during January-June and also during dry periods in monsoon. The first instar larvae mine the epidermal surface of the leaves. Second instars onwards the larvae feed externally by making holes in the leaves.



Damage on cabbage



Larvae



Mustard as a trap crop in cauliflower and cabbage IPM

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 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.

5.2 Leaf webber (*Crociodolomia binotalis* Zeller)

Young larvae feed gregariously and later web the leaves together and feed within. This results in rotting of cabbage head and cauliflower curds.



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%.

5.3 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%.

5.4 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. *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

5.5 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.



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.

6. LEGUMENOUS VEGETABLES

6.1 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.

6.1.1 Lycaenid borer (*Lampides boeticus* L.)

This is a butterfly pest and commonly known as pea blue. In peas, the larvae bore into young pods. The entry hole gets blocked after some time. However, in lablab, the larvae bore into flower buds. The pest can be monitored by the presence of the bored holes.

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.

6.1.2 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.

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 @ 0.5ml/l or Chlorpriphos 20 EC @ 2.5 ml/l or Indoxacarb 14.5 SC @ 0.5 ml/l.

6.1.3 Field bean pod borer (*Adisura atkinsoni*, Lethierry)

This is the major pod borer in field bean and the larva resembles *H. armigera*. The young larvae bore into these pods and develop inside and come out after attaining fourth instar, which is a migratory stage.

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 chlorpyriphos 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.

6.1.4 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.

6.2 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



Damaged leaves and flowers

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.

6.3 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.

6.4 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.

6.4.1 Bean fly (*O. phaseoli*)

This species is serious in French beans and peas but also can be noticed on dolichos beans. The larvae mine the leaf lamina, veins, midrib, and petiole and enter the stem resulting in mortality.

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 Endosulfan 35 EC @ 2ml/l or 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.

6.4.2 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.

7. CUCURBITACEOUS VEGETABLES

7.1 Red pumpkin beetle (*Aulacophora foveicollis* Lucas & *A. lewisii* Baly)



Beetle feeding on cucurbit leaf



Red pumpkin beetle

The adults are small, elongated yellow 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 EC2.5ml/l.

7.2 Serpentine leaf miner (*Liriomyza trifolii* Burgess)

Heavy incidence is noticed in watermelon, pumpkin, cucumber etc. However, bitter gourd seems to be resistant.

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.

7.3 Fruit fly (*Bactocera cucurbitae* Coquillett).

The damage by maggots results in rotting of young and ripened fruits or drying and shriveling of fruits before maturity. Some times even the base of the plant gets attacked and plant start wilting.

Management

- Use resistant varieties viz Arka Suryamukhi (Pumpkin).
- 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 a 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.

7.4 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.

7.5 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.

7.6 Leaf eating caterpillar (*Dipahania* (=Margaronia) *indica* Saund)

Long shining caterpillars feed on leaves and fruits.

Management

- 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.

7.7 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.

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.

8. ONION AND GARLIC

8.1 Thrips (*Thrips tabaci* Lindeman)

Thrips are pestiferous in diverse ways. They cause direct damage to leaves and bulbs, aggravate fungal diseases and even vector virus.



Thrip damages onion



Thrips hide deep inside flowers



Damage of bulb leaves



Thrip damage during bulb development



Congregation of thrips in tender leaves

Management

Monitoring: Sticky traps are commonly used for detecting thrips populations. 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 color-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.

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^o C and 75% RH.

Botanicals: Neem was found effective when mixed with insecticides.

Chemical: Many insecticide 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 are 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 sites 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.

8.2. Maggot (*Delia antiqua*)

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 does not cause economic damage to garlic.

Pest Management

Cultural

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

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

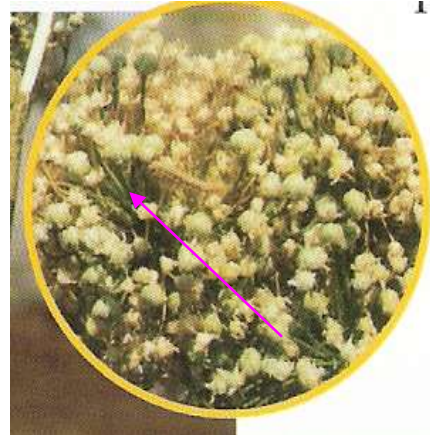
- Application of pirimiphos methyl or deltamethrin at 2ml/lit.
- Fipronil 80WG (Regent @25 g ai/kg) and cyromazine (Governor 75 WP @ 50 g ai/kg), an insect growth regulator as seed treatment were recommended.

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

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



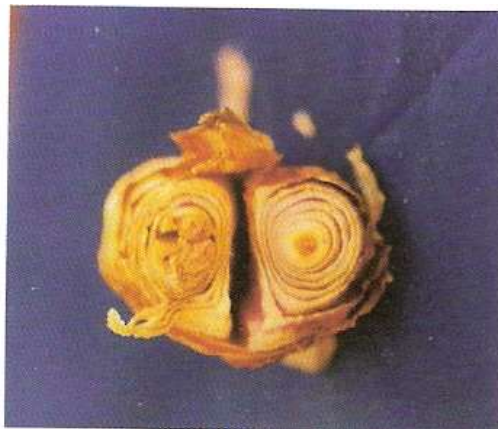
Close up of pest

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.

8.4. Bulb Mite (*Rhizoglyphus robini* Claparede)

This pest infests the bulbs by penetrating the outer layer of tissue.



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/l 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.

8.5. 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.



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 60⁰ C for 10 minutes was also effective but affects clove sprouting capacity.
- Fumigation with methyl bromide at 32 g/m³ for 2 h at 80⁰ 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.

8.6. Red Spider Mite (*Tetranychus cinnabarinus*)

Symptoms: Tetranychid mites are an important that 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.

B. DISEASES

1. TOMATO

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

Symptoms:

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.

1.2 Late Blight (*Phytophthora infestans*)

Symptoms

Blight appears on foliage as light-pale green water soaked dead area. 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.



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.

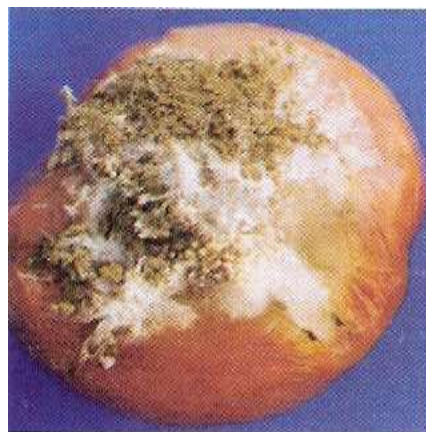
1.3 Collar Rot (*Sclerotium rolfsii*)

Symptoms:

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.



Wilting by collar rot



Sclerotia on fruits

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.

1.4 *Pseudocercospora* Leaf Blight (*Pseudocercospora fuligena*)

Olivaceous black sooty growth of fungus was observed on the lower surface of the leaves.



Black moldy growth on foliage

Management

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

1.5 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.



Sclerotinia on fruits rot

Management

- Cut the infected plants 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.

1.6 Fruit Rots *Pythium* and *Phytophthora* affect green fruits while *Rhizoctonia*, *Myrothecium*, *Colletotrichum*, *Phomopsis*, *Alternaria* and *Cladosporium* affect matured fruits.



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 inoculums.

1.7 Grey Leaf Spot (*Stemphyllium solani*)

Symptoms:

Small circular dark brown necrotic, numerous spots appeared all over the leaf lamina that is uniformly distributed on entire foliage.

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 used of exotic hybrids.
- Removal and burning of all crop debris after senescence of the crop.

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

Symptoms:

Small, dark spots appear on leaflets and stems of seedlings transplanted crop. Numerous spots coalesced and cause severe burning of the leaves. Prominent yellow halo is observed around the spot.



Bacterial leaf blight



Bacterial canker on fruits

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 dipping in streptomycin solution @ 100 ppm.
- Adopt inter cropping 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 antibiotics application.

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

Symptoms:

It is characterized by absence of chlorotic halo around spot, crusty and comparatively larger spots. Some time yellow halo is observed in this *Pseudomonas* species.



Bacterial speck on leaves

Management

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

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

Symptoms:

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.



Tomato leaf curl complex

Management

- Removal of weed host from field near surrounding areas.
- Root dipping in imidacloprid solution @ 4-5 ml per liter 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 crop 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.

2. BRINJAL

2.1 *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 color.



Phomopsis stem blight



Fruit rot & infected seed

2.2 *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 observed.



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 once 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 costly control measure and moreover ensures the status of previously applied *Trichoderma* during use of carbendazim.

2.3 Sclerotinia Rot (*Sclerotinia sclerotiorum*)

Symptoms:

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 leads to rotting of adjoining plant parts. These sclerotia become black after drying.



White rot on twig



Stem rotting by *Sclerotinia*

Management

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

2.4 Collar Rot (*Sclerotium rolfsii*)

Symptoms:

White, cotton like and silvery mycelium growth is clearly visible on the affected portion. Later on white to light brown mustard like sclerotia is observed on the same portion. Progressive drooping and yellowing or wilting of the entire plant is observed.



Wilting and fungal structures

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 within a week of ploughing.
- Seedlings dip 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 oxychloride @ 0.3% near the collar region followed by carbendazim @ 0.1% for immediate control.
- Fungicide drenching should be done preferably in evening.

2.5 Pseudocercospora Leaf Blight (*Pseudocercospora sp.*)

Symptoms:

Olivaceous black sooty growth of fungus was observed on the lower surface of the leaves.



Black mold

Management

- Collect and burn the infected leaves.
- Spray hexaconazole or triademephon or bitertanol @ 0.05% when disease appears.
- Restricted use of exotic susceptible hybrids and varieties is advocated.

2.6 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.

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.

2.7 Little Leaf (Phytoplasma)

Symptoms:

Characteristics symptoms are excessive shortening of the leaves. Numerous leaves aggregated in each branch giving bushy appearance, shortening of internodes.



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.

3. CHILLI / CAPSICUM

3.1 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. Symptoms on red fruits are more commonly observed than green fruits. Small, irregular, sunken, light brown lesions were observed on mature fruit. 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.

3.2 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 mostly observed in leaves. Affected lower leaves become yellow and fall down.



Bacterial leaf spot in chilli

Management

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

3.3 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.



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%.

3.4 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.
- Selections 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.

3.5 Phytophthora leaf blight/ Fruit rot

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.



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.

3.6 Leaf Curl Complex (*CMV* and *Gemini Virus*)

Symptoms:

Chilli leaf curl complex is mainly due to CMV and gemini virus as well as mite 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.



Leaf curl symptoms

Management

- Root dipping of the seedlings in imidacloprid solution @ 4-5 ml per liter 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 50⁰ C or 10% tri sodium phosphate solution for 25 minutes.
- Barrier crop of taller non-host crop like maize, bajra, 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.

3.7 Sun scald: It is a common physiological disorder and fruits facing direct sun rays are affected by sun scald. 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 & proper water management will help to develop the canopy of leaves & 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.

4. OKRA

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

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.



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 burnt in field itself to reduce the inoculum at source.

4.2 Yellow Vein Mosaic (YVMV- Gemini virus)

Symptoms:

Characteristic symptoms appears as prominent yellow vein and veinlets having green tissue interveinal area. Severely infected leaves some time become completely golden yellow.



Yellow Vein Mosaic

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.

4.3 Enation Leaf Curl (ELCV)

Symptoms:

The plant becomes unable to bear its weight after viral infection. The stem and leaf petiole are bent. Apical portion of plant developed into full of small, curl and aggregated leaves. Floral part does not set the fruit. Fruit if sets then seeds are unfertile and aborted.



Apical leaf curling



Twig bending by ELCV

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.

4.4 Root Knot Nematode (*Meloidogyne incognita*)

Symptoms:

Disease appears as stunting of the plants, yellowish green of the plant, some time drooping of the leaves. Clear symptoms are observed after uprooting of the plant where roots are full of knots.

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.

5. LEGUMENOUS, VEGETABLES (PEA AND BEANS)

5.1 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. *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. Symptoms appear on stem near the soil level and extend downward into the roots and

upward also. 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.

Management

- Long crop rotation with wheat and bajara.
- Field sanitation by uprooting and burning of all infected plants.
- Summer fallowing, ploughing accompanied with once 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.

5.2 Collar Rot (*Sclerotium rolfsii*)

Symptoms:

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 once 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.

5.3 Powdery Mildew (*Erysiphe pisi*)

Symptoms:

This 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 pods remain smaller in size. The outer skin of infected pods becomes gray in colour and rough.



Powdery mildew on foliage

Management

- Avoid delay in sowing and must complete up to first fortnight of October.
- Always use tolerant cultivar like Pant P-9, NDVP-250, KS-245 and PMR-17 of pea.
- Foliar spray of penconazole @ 0.025% of tridemorph @ 0.1% of dinocap @ 0.1% at 5-7 days interval.
- Infected crop debris must be burnt after harvesting of pods.

5.4 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 sori consist of numerous uredospores.



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 cultivar of pea.
- Avoid delay in sowing of pea and must complete up to first fortnight of October.
- Fungicidal sprays should be done in critical period if an average of two pustules per leaf 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.

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

Symptoms:

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 severe disease of cowpea, French bean and pea. *Aschochyta paseolorum* infects cowpea producing large, circular to irregular brown spots with reddish margin on leaves.



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.

5.6 Sclerotinia Blight (*Sclerotinia sclerotiorum*)

Symptoms:

Very soon white fungus growth is observed on the rotted portion. Later on embedded sclerotia in white mycelium 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.



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.

5.7 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. Small spots appear on pods of different ages. 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.
- Field sanitation by burning of all the infected leaves and crop debris.

- Use of clean, disease free seed and tolerant varieties.
- Seed soaking in streptomycin 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.

5.8 Cowpea 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.



Yellow mosaic of cowpea

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.

6. CUCURBITS

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

Symptoms:

Disease on leaf 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.



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.

6.2 Downy Mildew (*Pseudoperonospora cubensis*)

Symptoms:

It appears as irregular, numerous, small, yellow areas surrounded by green tissues scattered all over the leaf lamina. The yellow areas are angular and bounded by veins. Symptoms on bitter gourd are light brown while grayish brown on pointed gourd 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.

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

Symptoms:

Disease appears on all foliar part as white to dull white, powdery growth quickly covers most of the leaf surface and leads to heavy reduction in photosynthesis area.



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.

6.4 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 are most severe in muskmelon, while *Phomopsis* fruit rot an ash gourd.



Pythium & *Phytophthora* rot on Bottle & pointed gourds



Sclerotium rot & *Sclerotinia* rot of bottle gourd vine (photo)



Phomopsis rot in ash gourd



Sclerotium rot in ash gourd

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.

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

Symptoms:

This disease is now becoming severe in muskmelon, bottle gourd and sponge gourd. 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 it.



Gummy stem lesions on muskmelon

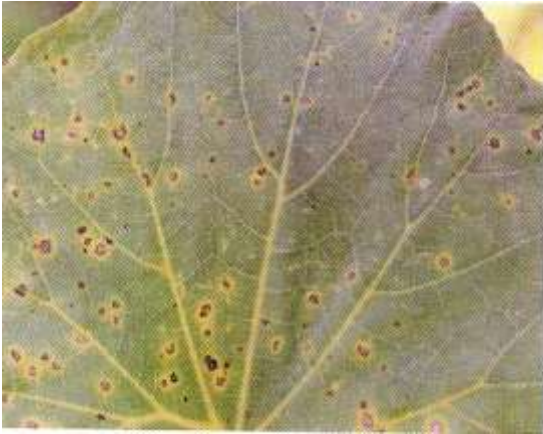
Management

- 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.

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

Symptoms:

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. .



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.

6.7 Bacterial Wilt (*Erwinia tracheiphila*)

Symptoms:

Wilt is a common 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.



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.

7. COLE CROPS

7.1 Downy Mildew (*Peronospora parasitica*)

Symptoms:

Fine hair like downy growth of fungus is observed on the lower surface of leaves.



Necrosis with downy growth

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.

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

Symptoms:

Alternaria leaf spot is usually appeared in early stage of plant growth in cauliflower while in later stage in cabbage. Alternaria leaf spots are restricted to lower leaves. Symptoms appear as circular light brown spots on leaves. Concentric rings are clearly visible on the spots.



Lesions on leaf



Spots on cabbage & concentric ring

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 siliqua formation.

7.3 White Rot (*Sclerotinia sclerotiorum*)

Symptoms:

Disease appears as water soaked rotting of curd, petiole, stalk and stump region of the leaves. Cauliflower grown for seed production is severely effected by the disease and entire inflorescence collapsed.



White rot in cabbage

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.

7.4 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.



Bacterial black rot in cabbage

Management

- Always collect seeds from disease free plants for next year use.
- Seed treatment with hot water (50⁰ C for 30 minutes) or seed clipping 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 form 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.

8. ONION AND GARLIC

8.1 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 polyethylene sheet for 30 days before sowing provides good control.
- Horticultural 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.

8.2 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.



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) proved 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), difenoconazole @ 0.8 ml/l and covering crops with transparent polythene sheets inhibited growth of the pathogen *A. portii* in the field.

iv) Chemical Methods

- Four sprays of mancozeb or chlorothalonil and 3 sprays of iprodione @ 0.25 % at 10 days intervals 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 metalzxy +mancozeb @0.25% gave good control in onion seed crop.

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

Symptoms:

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.



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 (50⁰ C for 20 minutes) proved to be the best treatment for reducing the pathogen of Stemphylium blight 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.

8.4 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.



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: The cultivars 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

8.5 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.

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.

8.6. Fusarium Basal Rot / Basal plate Rot (*Fusarium oxysporum f.sp cepae*).

Symptoms:

- . 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 oxysporium* in the field in different growing seasons.

Biological Methods

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

- Combined seed treatment of *T. viride* + *P. fluorescence* 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 decay after 5 months of storage.

8.7. 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.



Sclerotial rot in onion bulbs

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 49⁰ C gives effective control.
- Solarization of soil at high temperature i.e. 35⁰ C for 18 hours or 45⁰ 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.

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

Symptoms:

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.



Pink rot due to Phoma

Management

Host Resistance

Allium fistulosum and some garlic lines are resistance to pink root. Cultivars 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.

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

Symptoms: 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 are harvested, stored or transported.
- Onion should be stored at 1-15⁰ 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

8.10. Bacterial Rots

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

Symptoms:

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.

8.11 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.

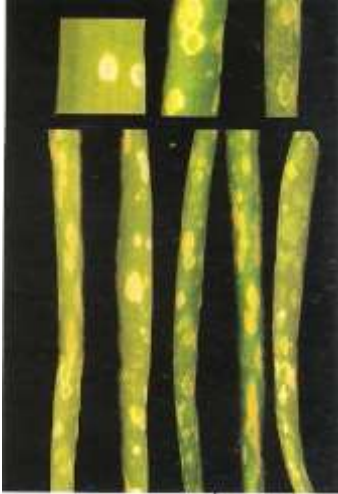
Management

- 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.



Diamond shaped viral lesions

Management

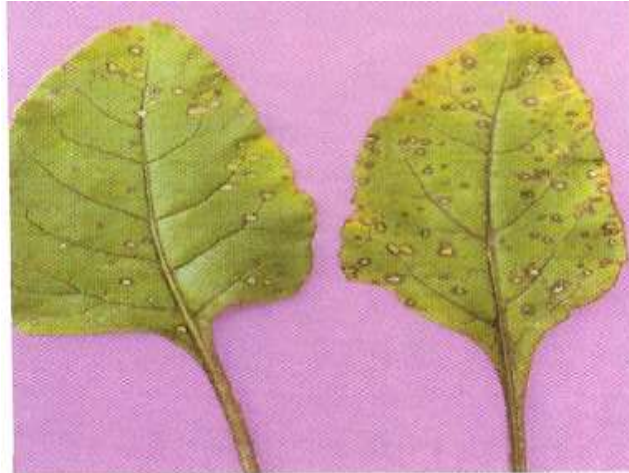
- Plant high quality transplants free from thrips and Iris yellow spot virus. Practice three year or longer rotation between onion crops.
- Eliminate volunteers, culls, and weeds in and around onion field.
- Sprinkler irrigation can provide some suppression of thrips and disease.
- Avoid thin, patchy 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.

9. LEAFY VEGETABLES

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

Symptoms:

Symptoms appear as light brown, circular spots, surrounded by red margin. The red circular halo is not prominent in many vegetables except spinach.



Cercospora spot in spinach

Management

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

9.2 White Rot (Sclerotinia sclerotiorum)

Symptoms:

Symptoms appear as water soaked rotting of petioles, stump region and cover portion of the leaves.



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.

10. RADISH

10.1 Alternaria blight (*Alternaria raphani*)

Symptoms:

Symptoms appear as small circular dark, black spots on the leaves while irregular, oval to elongated lesions on siliqua and inflorescence.



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 form 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.

11. CARROT

11.1 White Rot (*Sclerotinia sclerotiorum*)

Symptoms:

Disease appears as water soaked rotting of stalk, stump and collar region engulfing lower portion of the leaves.



Collar infection of Sclerotinia



Sclerotinia carrot rot

Management

- Crop rotation with low land 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.

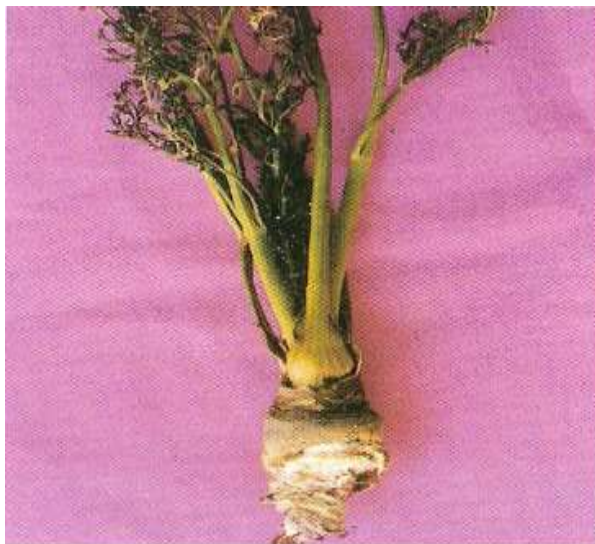
11.2 Collar Rot (*Sclerotium rolfsii*)

Symptoms:

Rotting covers entire root along with stump and leaves of the plant near collar region. Characteristics symptoms observed as white, cottony, fungal growth on root.

Management

- Crop rotation with low land 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



Sclerotium carrot rot

12. Elephant Foot Yam

12.1 Collar Rot (*Sclerotium rolfsii*)

Symptoms:

Initially yellowing of the plant was observed and later on plant toppled down before maturity of Rhizomes. Characteristics symptoms observed as white, cottony, fungal growth and sclerotia on affected portion as well as on contact soil.



Toppling of foliage by collar rot

Management

- Remove all the sclerotia from apical portion of rhizome during planting.
- Crop rotation with low land paddy and other cereals.
- Field sanitation by uprooting and burning of all infected plants.
- Summer fallowing, ploughing accompanied with once 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

1. 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 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 cultivar (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 to10 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 emamectin 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).

2. 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 mix 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.

3. 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 must.

- Release egg parasitoid *Trichogrammatoidea bactrae* at 0.5-0.75 lakh/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.

4. 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 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 emamectin benzoate (proclaim) 5% (WDG) @ 0.25 g/litre or indoxacarb 14.5 SL @ 500 ml/ha

5. 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 nights 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 insecticide 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 border line.

6. Cucurbitaceous crops

1. Collection and destruction of infected fruits/vines
2. Deep ploughing of field after the crop harvest to kill the pupae.
3. Earthing up of the soil around the vine to expose the pupae for desiccations and predation by birds.
4. Soil application of neem cake @ 250 kg/ha after germination and repeat once at flowering.
5. Plant maize as a border crop seven days before sowing.
6. 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.
7. Spray neem seed powder extract 4% or neem soap or pongamia 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.
8. 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.
9. Erect pheromone traps cue lure @ 3 traps / ac and change after 60 days.

Pheromone application technique for the management of fruit fly in cucurbits

Male Annihilation Technique (MAT)

5x5 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

7. 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 farm yard 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.

Source / Courtesy

Indian Institute of Vegetable Research, Varanasi, Indian Institute of Horticulture Research, Bangalore, NRC (O & G) , Rajgurunagar, Pune, NRC (C) Nagpur, CISH, Rehmankhera, Lucknow, NCIPM, New Delhi.