Validated Integrated Pest Management Strategies for Major Vegetable Crops

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India’s wide diversity in climate and soil provides much scope for growing a wide variety of vegetable crops than in most of the countries in the world. Currently India is the second largest producer of vegetables, next to China. However, inspite of large scale production, India’s vegetable produce has not made major dent in export oriented international market.

High economic losses in vegetables, due to several insect pests, diseases, nematodes and mites have been the major bottleneck in realizing the full potential of horticultural crops. It is estimated that 25-30 per cent yield is lost due to pest attack in vegetable crops which may be worth several crores a year. With a view to prevent the losses and to manage these pests, farmers usually tend to spray chemical pesticides indiscriminately leading to pesticide residues, greater environmental and health hazards. The integrated approach to manage the pest problems with a view to reduce pesticide load in vegetables has often been found lacking.

The present document entitled ‘Validated Integrated Pest Management Strategies for major vegetable crops’ provides comprehensive information on pests identification, damage symptoms along with pictures and their management in eight selected vegetable crops viz; tomato, cabbage / cauliflower, egg plant, okra, bell pepper / hot pepper, cucurbits, onion and ginger which consume bulk of pesticides used in horticultural crops. Attempts have also been made to provide adaptable management strategies updated at farmers fields for different pests & diseases at various stages of crop growth. Need based application of chemical pesticides majorly based on economic threshold levels will help in reducing the number of needless chemical sprays, which in turn will further help to conserve the common natural enemies associated with major vegetable crops.

Attempts have also been made to give elaborate pictures, but they should not be used as the sole basis for making a decision on management. Hence users are advised to collect and preserve pest / plant samples for correct identification from taxonomist. The document has basically been designed to help farming community, extension personnel, research workers and vegetable growers and serves as a guide and inspiration for those concerned with management of horticultural crop pests.

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KEY PESTS

**Insect pests**

**Fruit borer:** This pest is widely distributed and is polyphagous. It is responsible for major yield loss in tomato. Eggs are yellowish-white, ribbed and dome shaped. Full grown caterpillars are apple green with whitish and dark grey broken longitudinal stripes. On hatching, young larvae scrap and feed on tender foliage while advanced stage larvae bore circular holes and thrust part of their body inside the fruit and eat the contents. The larvae move from one fruit to another and single caterpillar may eat and destroy 2 to 8 fruits.

**White fly:** Adults are white tiny scale like covered with a white waxy bloom. Nymphs and adults suck the sap on the ventral surface of leaves. The affected parts become yellowish, leaves wrinkle and curl downwards and are shed ultimately. Besides the feeding damage, these insects also exude honeydew which favour the development of sooty mold. This hampers photosynthetic activity of the plant resulting in stunted growth.

**Aphids:** Cool, dry and humid conditions are favourable for multiplication of aphids while heavy rains wash away the aphid colonies. Winged aphids on tomato usually migrate from one field to another especially from potato crop. Aphids suck the sap from lower leaves and tender shoots and reduce the vigour of the plant. Secrete honey dew which attracts ants and develops sooty mold. The yields are also reduced directly by sucking sap and more through the spread of virus diseases acting as vectors indirectly.

**Diseases**

**Damping off:** Damping off occurs in pre-emergence and post-emergence stage, usually noticed in patches. In pre-emergence, seeds become soft, turn brown, and decompose and in post-emergence, roots, hypocotyls and the crown of the seedling turn pale brown, soft, water soaked, and thinner. Infected seedlings topple and collapse.
Early blight: On leaves, small, dark, circular lesions develop which turn distinctly zonate. Spots rapidly enlarge, coalesce and turn into complete blight. On the main stem and side branches, small, dark, slightly sunken lesions form which enlarge and form dark brown, elongated spots. On green or semi ripe fruits, dark, velvety, sunken spots having distinct concentric rings develop at the stem end.

Late blight: It appears on the leaves, stems and fruits. On the leaves, symptoms appear as pale green and water-soaked spots. Under favorable conditions, lesions enlarge rapidly, turn dark brown to purplish-black. High humidity and leaf wetness, favours the growth of a cottony, white mould on the lower side at the edges of lesions. On stem, brown to black lesions develop which enlarge rapidly under moist conditions. On fruits, the fungus produces grey-green water-soaked spots, which enlarge, coalesce, and darken, resulting in large, firm, brown, leathery-appearing lesions.

Bacterial spot: Small water soaked spots appear with a pronounced yellowish green halo. Later spots turn brown with cankered appearance. On ripe fruits, dark brown to blackish brown water soaked spots appear which later develop cracks in these spots.

Buck eye rot: Infection first appear on lower immature green fruits touching the soil with lesions having dark brown centre surrounded by water soaked zonations. As the spot enlarge, lesions assume a pattern of concentric rings of narrow, dark brown and wide light brown bands.

Leaf curl: Symptoms include mosaic, interveinal yellowing, vein clearing, crinkling and puckering of leaves accompanied by inward rolling of leaf margins. The older leaves become leathery and brittle. The disease also induces severe stunting, bushy growth and partial or complete sterility depending on the stage of the crop. Infected plants bear few or no fruit.

Nematodes

Root knot nematode: They are microscopic, soil borne, vermiform pests that feed vigorously on roots and cause galling of roots which hampers uptake of nutrients and water. Affected plants are weak, stunted with yellow leaves and reduced fruit production. Poor development of root system makes the plant highly susceptible to drought.
VALIDATED INTEGRATED PEST MANAGEMENT INTERVENTIONS FOR TOMATO CROP

Nursery

- Prepare raised nursery beds about 10 cm above ground level for good drainage to avoid damping off etc.
- Follow soil solarisation for 2-3 weeks using 0.45 mm thick polythene sheet tightening sides of sheet to enable avoid escape of heat. Sufficient moisture should be present in the soil for solarisation.
- Mix 50 g of effective strain of fungal antagonist *Trichoderma* from reliable source in 3 kg FYM and leave for 7 -14 days for enrichment followed by mixing of *Trichoderma* enriched FYM in the soil nursery in 3 m² bed.
- Use of nylon net (40-50 gauge) to avoid vectors like white fly.
- Seed treatment with effective strain of *Trichoderma* @ 10 g / kg or captan 75 % WP @ 0.25 % a.i. and need based soil drenching with captan 75 WP @ 0.25 %.
- Raise marigold nursery 20 days before tomato nursery.

Main Crop

- Before transplanting, dip the roots of seedlings for 15 minutes in imidacloprid 17.8 SL @ 7.0 ml / litre to protect against sucking pests including white fly.
- Transplant 45 day marigold seedlings in a pattern of one row of marigold for every 16 rows of tomato for flowering synchronization. First and last row of field should be marigold and it should be sprayed with *HaNPV* @ 250 LE / ha.
- Adopt wide spacing of 60 x 45 cm (for varieties) and 90 x 60 cm (for hybrids) to reduce the chance of spread of diseases.
- Apply neem cake @ 250 kg / ha at 20 days after transplanting (DAP) to reduce fruit borer, leaf miner and nematode incidence.
- 2-3 sprays of 5% NSKE are also effective against leaf-miner, aphids and mites.
- Need based spray of imidacloprid 17.8 SL @ 150-175 ml or thiamethoxam 25 WG @ 200 g or spiromesifen 22.9 SC @ 625 ml or dimethoate 30 EC @ 990 ml / ha in 500 lit water for white fly control.
Spraying of fenazaquin 10 EC @ 1250 ml or spiromesifen 22.9 SC @ 625 ml / ha in 500 lit water against mites.

Install pheromone traps @ 2 / acre for monitoring fruit borer activity. Replace the lures with fresh lures at every 20-25 days interval.

Monitor top three leaves for fruit borer eggs.

Release of egg parasite, *Trichogramma chilonis* @ 1.0 lakh / ha 4-5 times at weekly interval.

Spray *Ha*NPV (250 LE) on marigold flowers and buds to kill the fruit borer in them.

Spray good quality *Ha*NPV (250 LE / ha) (2 x 10⁹ POB) @ 28 DAP and repeat two more times at weekly interval. Mix 2% jaggery and spray in the evening to prevent fast degradation due to UV light.

Collection and destruction of leaf curl affected plants in the initial stages and tomato fruits infested at regular intervals.

If high incidence of fruit borer is noticed, spray chlorantraniliprole 18.5 SC @ 150 ml or novaluron 10 EC @ 750 ml or indoxacarb 14.5 SC @ 400 ml / ha in 500 lit water.

Give prophylactic or protective spray with captan 50 WP @ 2.5 kg or captan 75 WP @ 1667 g or zineb 1.5-2 kg / ha in 1000 lit water or mancozeb 35 SC @ 2.5 lit / ha in 500 lit water or mancozeb 75 WP @ 1.5-2 kg / ha in 750 lit water against early and late blight and need based application of azoxystrobin 23% SC, or azoxystrobin 18.2% w / w + difenoconazole 11.4% w / w SC or famoxadone 16.6 % + cymoxanil 22.1 % SC @ 500 ml / ha in 500 lit water or metalaxyl 3.3 % + chlorotholanil 33.1 % SC @ 1000 ml / ha in 500 lit water depending on weather, severity and stage of the crop. Cyazafamid 34.5 % SC @ 200 ml or cymoxanil 8 % + mancozeb 64 % WP @ 1.5 kg or metiram 55 % + pyraclostrobin 5 % WG @ 1.5 kg or tebucunazole 50 % + trifloxystrobin 25 % WG @ 350 g / ha in 500 lit water can also be used as need based spray against late blight and early blight, respectively.

Spray seedlings with streptocycline 40 to 100 ppm solution and in main field to manage bacterial spot.

Stake plants to reduces buck eye rot and need based application of mancozeb 75 WP @ 1.5-2.0 kg, or propineb @ 1.5 kg / ha in 500 lit water.
Conservation of natural enemies

The commonly seen natural enemies of pests in tomato cropping system should be protected from unwanted and excessive sprays of chemical pesticides.
CABBAGE/CAULIFLOWER

KEY PESTS

Insect pests

Diamond back moth: The caterpillars are pale yellowish green while adult is a small greyish moth. A patch of three diamond shaped yellowish white spots is visible by joining both the forewings, hence the name ‘diamond back’. Young larvae feed by scrapping leaf tissues causing typical whitish patches on under side of leaves. Grown up larvae bite holes in the leaves. Damage to the crop is more in the main and late winter season as compared to rainy season crop in Northern region.

Tobacco caterpillar: Causes maximum damage from July to November to rainy season crop. The adult moth is stout, brown coloured, with wavy white markings on the forewings. Eggs are laid on leaves in masses and are covered with brown hairs. Neonate larvae scrap the green matter in the leaf. Late instars feed voraciously on tender leaves and fresh growth. The larvae are blackish gray to dark green with dark longitudinal bands on the side of the body.

Stem borer: Moths are pale greyish-brown, suffused with reddish colour. Adult female lays eggs on the growing point or on the older leaves. Pale whitish brown with longitudinal stripes caterpillars initially mine the leaves and make it a white papery structure filled with their excreta. Later these caterpillars bore into stem and multiple shoots are formed. As a result infested plants are killed forming side shoots which don’t form heads. Entrance hole is covered with excreta.

Cabbage aphid: Aphids are serious during February – March months. Aphids disappear due to good rain fall. As a result of sucking of vital sap from the tissues, plants remain stunted resulting in poor head formation. Aphids also produce honey dew which makes the plant sticky and favour the growth of sooty mold with black coating thus hindering the photosynthesis and plant growth.
Diseases

**Damping-off and wire stem:** Damage results from the reduced plant stand and sometimes it is so serious that resowing becomes inevitable. Major symptoms are the failure of the seedlings to emerge as a result of seed or seedling decay or sudden death of the emerged seedlings. In wire stem, light to dark brown areas appear on the stem extending 1-2 cm below the soil line. Affected region is relatively thinner than the stems of the healthy plants.

**Downy mildew:** Downy mildew is a serious problem in cauliflower, cabbage and broccoli during cool moist weather which favor sporulation, dissemination and infection. In nursery, the disease appears as irregular yellow patches on leaves with white fungal growth on the underside of the lesions. Severe infection leads to death of seedlings. On mature cabbage, downy mildew appears as dark sunken spots on the head or wrapper leaves resulting in purplish tinge.

**Alternaria leaf spot:** They cause serious damage at all stages causing heavy loss in yield and seed quality. On seedlings, minute dark spots appear on the cotyledons and seedling stem, causing severe damping off or stunting of young plants. In older plants, all above ground parts are attacked. The bottom leaves are infected first where brown circular spots with characteristic concentric rings (target spots) are seen. Infected leaves soon turn yellow and drop. Disease gets enhanced in a warm humid weather with temperature between 25 to 30°C.

**Bacterial black rot:** This disease is more severe in cauliflower than cabbage. Plants can be infected during any crop stage. Seedlings drop lower leaves and may die. In grown up plants, infection occurs at margins. Infected tissue turns yellow and the chlorosis advances towards the centre of the leaf forming a wilted ‘V’ shape notch. Severely infected leaves may drop off. The head formation gets affected and heads of infected plants remain small and its quality is reduced. Head may rot if the disease occurs late.
VALIDATED INTEGRATED PEST MANAGEMENT STRATEGIES FOR CABBAGE / CAULIFLOWER

Nursery Stage

- Prepare raised nursery beds about 10 cm above ground level for good drainage to avoid damping off etc.
- Follow soil solarisation for 2-3 weeks using 0.45 mm thick polythene sheet. Sufficient moisture should be present in the soil for solarisation.
- Treat the soil with neem cake at 50 g / m² impregnated with 10-15 g effective strain of *Trichoderma*.
- Seed treatment with effective strain of *Trichoderma* @ 4 g / kg seed to manage rots. Seedling dip for 30 min with *Trichoderma viride* 1 % WP @ 10 g / lit water to manage collar rot in cabbage can also be followed.
- Need based soil drenching with captan 75 WP @ 0.25 % or captan 75 WS @ 0.3 % to manage damping off.
- Seed treatment with imidacloprid 70 WS with 5 g / kg for management of painted bug in rainy season and aphids in late rabi season.
- Spray *Bacillus thuringiensis* kurstaki 5 WP (Bt) @ 3 g / litre if DBM is present @ 1 larva / leaf (South India).
- Spray NSKE 5% or carbaryl 50 WP @ 0.3 % for management of *H. undallis* which appears in rainy season nursery sometimes.

Main Crop

- Adopt wide spacing of 60 x 50 cm to reduce the spread of diseases.
- Growing of Indian mustard as trap crop after every 25 rows of cabbage. (One row of mustard is sown 15 days before cabbage planting and second 25 days after planting of cabbage). First and last row should be of mustard.
- Mustard traps 80-90% of diamond back moth (DBM) population and other pests like aphids. Mustard be sprayed with dimethoate 30 EC @ 660 ml in 500-1000 lit or dichlorvos 76 EC / ha @ 627 ml water. Spray fenvalerate 5 % EC @ 300 ml / ha in 600 lit water to manage DBM in trap crop mustard.
Spraying of *B. thuringiensis var. kurstaki* 5 WP @ @ 50 g a.i./ha or 3 gm / litre at 10 DAP for DBM

Installation of light traps / bulb @ 3 / acre for DBM. Adults are attracted to light trap and fall in water bucket. Within 3-4 days most of the adults get killed.

Release egg parasitoid *Trichogrammatoidea bactrae* at 1.0 lakh / ha 3-4 times at weekly interval (optional).

Spray mancozeb 75 WP or zineb 75 WP @ 1.5-2 kg / ha in 750-1000 lit water to manage leaf spot.

Removal of basal and infected leaves to reduce *Alternaria* leaf spot and bacterial black rot of early stage.

Spray NSKE 5% or carbaryl 50 WP @ 1600 g or malathion 50 EC @ 1500 ml / ha in 1000 lit water for stem / head borer.

Spray NSKE 5% at primordia formation (18-25 DAP-head initiation stage - most critical stage) for DBM control. 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. Use sticker with spray. This will control aphids as well as tobacco caterpillar. 40 kg / ha of NSKE powder is required.

Need based spray of cypermethrin 10 EC @ 650 -760 ml in 100-400 lit water, or spinosad 2.5 SC @ 600 ml or emmamectin benzoate 5 SG @ 150-200 g or chlorantraniliprole 18.5 SC @ 50 ml / ha in 500 lit water or novaluron 10 EC @ 750 ml or indoxacarb 15.8 SC @ 266 ml / ha in 500-1000 lit water for DBM control.

Spray acetamiprid 20 SP @ 75 g ha in 500-600 lit water or dimethoate 30 EC @ 660 ml ha in 500-1000 lit water for aphids in late cauliflower.

Installation of yellow sticky traps for trapping winged aphids

Collection of egg masses and larvae of tobacco caterpillar as they are gregarious in nature. Scout for papery patches & apply baits.

Set up sex pheromone traps @ 5 / ha for mass trapping and to monitor the activity of adult moths.

Spray *S*NPV @ 250 LE / ha (2x10⁹ POB) 2-3 times in evening with jiggery 2% when larvae are young.

Need-based spray of cyantraniliprole 10.26 OD @ 600 g or trichlorfon 50 EC @ 1.5 kg / ha in appr. 500 lit water for tobacco caterpillar

Need based spray of dimethoate 30 EC @ 660 ml / ha in 500-1000 lit water for the control of painted bug.
KEY PESTS

Insect pests

**Hadda beetle:** Adult beetles are spherical, pale brown and mottled with several black spots. Grubs are yellowish in colour, stout and have spines all over their body. Eggs are cigar-shaped, yellowish in colour and laid in groups generally on the lower surface of leaves with their tips pointing. Grubs and adults scrape the leaves chlorophyll, feed on the green matter and totally skeletonise the leaves leaving veins and veinlets and forming ladder-like windows.

**Aphids:** Nymphs and adults suck the sap from the leaves and the affected plants turn yellow, get deformed and dry away. Aphids also secrete copious quantity of honeydew on which sooty mould grows, covering the affected parts with a thick black coating which hampers the photosynthetic activity.

**Leaf roller:** Full grown caterpillars (20 mm) are stout, purple brown and ornamented with yellow spots and hairs. Pupation is in folded leaves. The larvae also roll up the leaves and feed on the green matter while remaining inside the folds and thus lead a concealed life. Ultimately the folded leaves wither and dry up.

**Leaf hopper:** The adult is wedge-shaped about 2 mm long and pale green in colour. They are found between the veins of leaves on the undersurface and suck the sap. The infested leaves curl upward along the margin, which may later turn yellowish, crinkle and show burnt up patches. Plants become stunted and may be killed in severe cases and fruit set is adversely affected by the infestation.

**Shoot and fruit borer:** It is the most destructive pest. Moths have conspicuous black and brown patches and dots on white forewings. Eggs are laid singly on leaves, shoots, flower buds and occasionally on fruits. Light pink larvae initially bore into shoots and the growing point is killed. Fecal pellets are seen at entrance hole. Appearance of wilted, drooping shoots is the typical symptom. The larvae also attack the fruits making their entry under the calyx when they are young. Later larvae bore into fruits which show exit holes and become partially unfit for human consumption, lose their market value.
Diseases

**Damping off**: It appears in two stages as pre-emergence and post emergence. In pre-emergence, seeds rot before emergence while in post emergence, seedlings topple down at the soil surface.

**Phomopsis blight and fruit rot**: Pathogen attacks seedlings soon after emergence. Leaf spots first appear as small gray to brown lesions with light centers which become numerous and cover large areas of leaves. Lesions may also develop on petiole and stem, causing blighting of affected portion. Symptoms on the infected fruits appear as minute, sunken dull and dusky spots. Fruit lesions are sunken, discoloured with margin of black fruit bodies.

**Little leaf**: The characteristic symptom is the small or little leaves. The petioles are so short that the leaves appear to be sticking to the stem. Internodes of the stem are also shortened. Petioles and leaves remain shortened giving the plant a bushy appearance. Mostly there is no flowering and fruiting is rare. The mycoplasma is transmitted by the plant hopper *Hishimonas phycitis*.

Mites

**Red spider mite**: Usually the infestation is noticed following indiscriminate use of insecticides, especially pyrethroids. Adults are reddish brown with four pairs of legs. Larvae are pink in colour while nymphs are greenish red in colour. Colonies of larvae, nymphs and adults feed on the under surfaces of leaves, make webs. As mite numbers increase these white speckles will increase in number, the leaf will take on a bleached appearance and die. Affected leaves gradually start curling and finally get shrunken, wrinkled and crumpled.

Nematodes

**Root-knot nematode**: The most characteristic symptom of nematode damage is the formation of knots or galls on the root system. Galls may occur singly or several galls may coalesce to form very massive galls. Plants show stunted growth, leaves show chlorotic and wilting symptoms. Fruiting is adversely affected. Affected fields give patchy look with poorly grown, stunted plants.
VALIDATED INTEGRATED PEST MANAGEMENT INTERVENTIONS FOR BRINJAL CROP

Nursery Stage

- Green manuring with sunhemp / Dhaincha in July-August.
- Raised seed bed about 10 cm 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.
- Seed (5 g / kg seed), nursery (250 g in 50 lit water drenched over 400 sq. mt area) and seedling root dip (1% for 15 min) treatment with *Trichoderma viride* 1 % to manage damping off or root rot etc and need based soil drenching with captan 75 WP @ 0.25 %.
- Selection of fruit borer resistant varieties / hybrids.

Main Field

- Setting up of yellow sticky / Delta traps @ 2-3 / acre for white fly.
- Give 2-3 sprays of NSKE 5% at weekly interval for the control of sucking pests and leaf folder.
- If incidence of white fly and other sucking insect pests is still above ETL, apply fenpropathrin 30 EC @ 250 -340 ml / ha in 1000 litres water or diafenathiouron 50 WP @ 600 g / ha in 500-750 litres water or phosphamidon 40 SL @ 750 ml / ha in 500 litres water or carbaryl 50 WP @ 2.0 kg / ha (hoppers) in 1000 litres of water or spiromesifen 22.9 SC @ 400 ml / ha (mites) in 500 lit water.
- Pheromone traps @ 100 / ha should be installed for monitoring and mass trapping of shoot & fruit borer moths. Replace the lures with fresh lures after every 15-20 days interval.
- Clipping of damaged shoots from time to time in initial stages.
- Bird perches @ 10 / acre should be erected.
- Sprays of NSKE also brings down the borer incidence significantly. Neem oil (Azadirachtin based 1%) application is also helpful in reducing borer infestation, though marginally.
- Release egg parasitoid *T. brasiliensis* @ 1-1.5 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 DAT for reducing nematodes and borer damage. Don’t apply neem cake when there is heavy wind velocity or temperature is above 30°C.

- Need-based alternate sprays of chlorantraniliprole 18.5 SC @ 200 ml / ha in 500-750 lit water or emamectin benzoate 5 SG @ 200 g or trichlorfon 50 EC @ 1.0 kg or phosalone 35 EC @ 1428 ml / ha in 500 lit water or Lambda cyhalothrin 5 EC @ 300 ml ha in 600 lit water at 15 day interval effectively controls shoot & fruit borer.

- Collection & destruction of little leaf affected plants, phomopsis blight affected fruits & field sanitation

- Spray zineb 75 WP @ 1.5-2 kg / ha in 750-1000 lit water or carbendazim 50 WP @ 300 g / ha in 600 lit water to manage Phomopsis blight and leaf spot diseases.

- Continuous cropping of brinjal leads to more borer and bacterial wilt infestation. Therefore, crop rotation with non-solanaceous crops may be followed.

**Conservation of natural enemies**

The commonly seen natural enemies of pests in brinjal cropping system should be protected from unwanted and excessive sprays of chemical pesticides.
KEY PESTS

Insect pests

**Thrips:** Thrips are minute and slender insects, appear in nursery as well as main field and affect the crop through out its life period. Both adults and nymphs damage the crop and lacerate the leaf tissue and suck the sap. Tender shoots, buds and flowers are attacked as a result they become twisted and deformed, upward curling of leaves is seen. Pest infestation increases at high temperature.

**Aphids:** Occurs mainly in dry, cloudy, cool and humid weather conditions during February –April while heavy rains wash away the aphid colonies. Aphids are small, succulent, pear-shaped insects that vary in color from yellow to green to black. Appear on the tender shoots and on the lower surface of the leaves. Suck the sap and reduce the vigour of the plants. Secrete sweet substances which attract ants and develops sooty mold.

Borers

**Tobacco caterpillar:** Tobacco caterpillar adult is brown in colour. The larvae of second and third instar enter chilli pods by making a hole near calyx and feed on chilli seed. The affected pods drop off or develop white colour on drying. It is nocturnal in habit but can be seen during day time as well.
**Fruit borer:** Insect is very active in post - rainy season, (October to March) which coincides with reproductive phase of chilli crop. Larvae damages by boring into fruits and feeds on inner contents of the pods. On bell pepper, fruits are attacked during April-June period.

**Diseases**

**Damping off:** Damping off is serious in warm and moist heavy soils having poor drainage. Seed may rot before emergence or the seedlings may be toppled before they emerge from the soil. Young seedlings die in patches due to decay of tissues in the collar.

**Cercospora Leaf spot:** Appears as brown, circular spots with small light grey centres and dark brown margins. Severely infected leaves may drop off prematurely resulting in reduced yield.

**Die-back & Anthracnose:** The spots on fruits are usually circular, water-soaked and sunken with black margins. As the disease advances the spots spread, forming concentric markings with dark fructifications. The fruits with many spots drop off prematurely resulting in heavy loss of yield. Fungus may also attack the fruit stalk and spread along the stem causing dieback symptoms.

**Fusarium wilt:** Disease is most likely to occur in poorly drained soils and is characterised by yellowing, upward and inward rolling of the leaves and wilting of the plant. Initially wilt appears in patches in water stagnating / low lying areas and quickly spreads through irrigation along the water channel. By the time above - ground symptoms are evident, the vascular system of the plant is discoloured, particularly in the lower stem and roots.
**Powdery mildew:** It is more common in hot pepper. It occurs during warm periods under both dry and humid weather conditions. Initially, chlorotic blotches or spots appear on the upper leaf surface with white to gray powdery growth on the corresponding lower surface. It proceeds from the older to younger leaves and shedding of foliage is very prominent.

**Begomo virus:** Leaves are greatly reduced in size and plant gives stunted look due to leaf curl infection caused by begomo virus. In advanced stages, the whole plant appears bushy, with stunted growth and fewer flowers. Small sized fruits are produced with deformed seeds. In case of severe infection, complete crop failure is not uncommon.

**Mites**

**Broad mite:** It spreads during the month of November. Nymphs and adults suck sap from leaves. Affected leaves curl downward along the margins of the leaf and attain an inverted boat shape. Leaf petioles get elongated and small leaves are serrated giving bunchy appearance. Leaves turn dark grey in colour with reduced leaf sheath, plants stop flowering and result in considerable yield reduction.

**Disorders**

**Sun scald:** It is a physiological disorder of bell pepper and fruits facing direct sun rays are affected more by sun scald. Symptoms include a whitish necrotic area on the side of the fruit exposed to a fierce, usually afternoon, sun. The flesh becomes light, dry and papery on areas that had direct sunlight on them. Poor foliage cover allows the defect to occur.
VALIDATED INTEGRATED PEST MANAGEMENT INTERVENTIONS FOR HOT PEPPER / BELL PEPPER CROP

Nursery stage

- 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 for soil solarisation for soil borne pests. Sufficient moisture should be present in the soil for solarisation.
- Mix 50 g of effective strain of *Trichoderma* from reliable source in 3 kg of FYM and leave for 7-14 days for enrichment followed by mixing of *Trichoderma* enriched FYM in the soil of a 3 m² bed.
- Seed treatment with effective strain of *Trichoderma* from reliable source @ 10 g / kg and imidacloprid 70 WS @ 10 g / kg seed to manage damping off and sucking pests in the initial stage in direct seeded chilli 1 WP.
- *Pseudomonas fluorescens* (TNAU Strain, ITCC BE 0005 @ 10 g / kg seed or *Trichoderma viride* (TNAU Strain ITCC 6914 @ 4g / kg seed can also be used as seed treatment.
- Need based soil drenching with captan 75 WP @ 0.25 % or captan 75 WS @ 0.2-0.3 % or mancozeb 75 WP @ 0.3 % or metalaxyl + mancozeb @ 0.3 % to manage damping off / rots
- Erect *Khaskhas* shading / support on one side of nursery beds of bell pepper 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 ten minutes.
- Erect bird perches @ 10 / acre for facilitating visits of predatory birds.
- Install delta traps @ 2 / acre for hoppers, aphids and white fly etc.
- Spray with *P fluorescens* @10 g / l twice (at vegetative and flowering stage) at evening time for overall health and growth of plants.
Spray of neem products / NSKE 5% against aphids, thrips, hoppers and white fly. Spray NSKE 5% 2-3 times against thrips at 15-20 days after transplanting (DAT) when rating is between 1-2. If the population of thrips & white fly is still high, then spray fenpropathrin 30 EC @ 250 -340 ml / ha in 750-1000 lit water or pyriproxyfen 10 EC @ 500 ml or spinosad 45 SC @ 160 g / ha in 500 lit water (thrips) or fipronil 5 SC @ 800-1000ml / ha in 1000 lit water (thrips only).

If both thrips & mites are seen together, spray of fenpropathrin 30 EC @ 250 -340 ml / ha in 750 – 1000 lit water or ethion 50 EC @ 1.5 -2.0 litre / ha in 500-1000 lit water is very useful.

Rouging out and destroying of leaf-curl disease / mosaic complex affected plants periodically.

Erection of pheromone traps @ 5 / ha for H. armigera / S. litura for monitoring of adults for egg laying.

Periodic releases of egg parasitoid, Trichogramma sp @ 1.5 lakh / ha for fruit borer (H. armigera)

2-3 sprays of HaNPV / SnPV (250 LE / ha) (2 x 10⁹ POB) / ha in initial stages or as and when needed.

Only need based spray of insecticides viz; spinosad 45 SC @ 160 ml or emmamectin benzoate 5 SG @ 200 or indoxacarb 14.5 SC @ 333-400 ml / ha in 500 lit water during initiation of flowering & fruiting stage for fruit borer, H. armigera is highly effective. Apply these pesticides preferably during evenings.

Periodic removal and destruction of damaged fruits due to borer.

Protective spray with mancozeb 75 WP or zineb 75 WP @ 1.5-2.0 kg / ha in 750-1000 lit water or propineb 70 WP @ 0.5 % and need based application of difenconazole @ 0.05 % or myclobutanil 10 WP @ 0.04 %, or captan 70 % + hexaconazole 5 WP @ 500-1000 g / ha in 500 lit water to manage fruit rot and die back.

Spray sulphur 52 SC @ 2 lit / ha in 400 lit water or sulphur 80 WP @ 3.13 kg / ha in 750-1000 lit water and need based application of flusilazole 40 EC @ 100-150 ml / ha in 500 lit water against powdery mildew.

Need based spray of either hexaconazole 2 SC @ 3 lit / ha or tebuconazole 25.9 % m / m EC @ 500-750 ml or tebuconazole 10 WP + sulphur 65 WG @ 1250 ml / ha in 500 lit water or azoxystrobin 11 % + tebuconazole 18.3 % SC W / W @ 600-700 ml / ha in 500-700 lit water, against powdery mildew and fruit rot.

At the time of planting, apply effective strain of Trichoderma from reliable source @ 5 kg / ha along with well rotten FYM to manage fungal wilts.

Crop rotation be followed if wilt occurs regularly every year.
Conservation of natural enemies

The commonly seen natural enemies of pests in bell pepper cropping system should be protected from unwanted and excessive sprays of chemical pesticides.

*Illis cinta*  
*Spider*

*Coccinellids*

*Damsel fly*  
*Yellow wasp*  
*Preying mantis*
KEY PESTS

Insect pests

Leaf hopper: This pest attacks the crop at its early stage of the crop. Nymphs and adults of leaf hopper are pale greenish, wedge shaped with a pair of black spots on vertex and a black spot on posterior portion of each of the forewings and move in a peculiar fashion diagonally. Both nymphs and adult suck cell sap from the undersurface of leaves and inject toxins. The affected leaves turn yellowish and curl upwards along the margins. In case of heavy infestation the leaves turn dark brick red ‘hopper burn’.

Shoot and fruit borer: The incidence of shoot & fruit borer usually occurs during humid conditions after rain fall. Larva bores into terminal shoots of young plants leading to death of the shoots. With the formation of the buds, flowers and fruits, the caterpillars bore inside these and feed on inner tissues. Infected buds & flowers will shed. Entrance hole is plugged with excreta. Fruits become deformed in shape with no market value.

White fly: Female lays stalked yellow spindle shaped eggs singly on the lower surface of the leaf. Nymphs are oval, scale like and remain attached to the leaf surface. Adults are tiny, with yellowish body and wings coated with milky white waxy powder. Nymphs and adults suck the sap usually from the under surface of the leaves and excrete honeydew. Leaves appear sickly and get coated with sooty mold. Plant shows stunted growth. It also transmits the vein mosaic virus.

Aphid: These are polyphagous pests. Nymphs are light yellowish black or brownish. Adults are mostly wingless but few winged forms also seen. Cool and humid conditions are favourable for multiplication while it disappears due to good rain fall. Colonies of these nymphs and adults are found often on tender shoots and as a result of sucking of vital sap from the tissues crinkling and curling of leaves takes place. Leaves appear shiny and sticky due to honeydew excreted by the aphids. Later sooty mould grows on honeydew and leaves have a black coating.
Diseases

Yellow vein mosaic: There is a presence of characteristic symptom of interwoven network of yellow veins encompassing with islands of green tissues on leaves. Later, entire leaves turn yellow. The plants remain stunted or yellowish green in colour. Infection restricts flowering and fruits, if formed, may be smaller, yellowish and harder. This disease, spread by white fly, is economically most important disease of okra. Sometimes the losses exceed more than 80%.

Powdery mildew: White floury spots or patches appear on the undersurface of the leaves which later spread to both the leaf surfaces. Initially white superficial spots appear on leaves, but entire surface may be covered with powdery mass. Severely affected leaves turn yellow and shriveled. Severe infection will cause the leaves to roll upward and scorch. It may result in heavy leaf shed.

Mites

Red spider mite: The infestation of mites is mostly observed during the warm and dry period of the season. Larvae & nymphs are pink, greenish red in colour while adults are oval, reddish brown in colour. Mites feed on the under surface of leaves and as a result of feeding whitish grey patches appear on the leaves. The affected leaves gradually start curling and finally get wrinkled, mottled, crumpled, turn brown and fall.

Nematodes

Root knot nematode: Second stage larvae infect the plant by entering the roots. There they feed and moult to reach adult hood. They feed vigorously on roots and cause characteristic knots or galling of roots. Galls may occur singly or several galls may coalesce to form very massive galls. Affected plants are weak, stunted with yellow leaves.
VALIDATED INTEGRATED PEST MANAGEMENT INTERVENTIONS FOR OKRA CROP

- Sow YVM resistant varieties
- Sowing of sorghum or maize all around okra field as a barrier crop for shoot & fruit borer adult moths and white flies.
- Spray NSKE @ 5 % (Azadirachtin based) 2-3 times at weekly interval for sucking pests
- Setting up of yellow sticky traps / delta traps @ 2 per acre
- Spray of propargite 57 EC or dicofol 18.5 EC @ 2ml / litre for red spider mite management
- Erection of bird perches @ 10 / acre in the field for facilitating bird predation.
- Need–based spray of imidacloprid 17.8 SL @ 100 ml or thiamethoxam 25 WG @ 100 g / ha in 500 lit water for hoppers, aphids and other sucking pests. Give another spray after two weeks.
- Removal and destruction of YVM affected plants, borer affected shoots and flower beetles time to time.
- Spray fenpropathrin 30 EC @ 250 -340 ml or oxydemeton methyl 25 EC @ 1.0 litre / ha in 1000 lit water to manage white fly.
- Installation of pheromone traps @ 2 / acre for monitoring the activity of shoot & fruit borer. Change lures after every 15-20 days.
- Spray neem oil based azadirachtin 0.03% @ 2-2.5 lit / ha in 500 lit water or spray sulphur 80 WP @ 3.13 kg / ha in 750-1000 lit water to manage powdery mildew.
- Release of egg parasitoid, Trichogramma chilonis @ 1.0 lakh / ha 4-5 times at weekly interval.
- Shoot & fruit borer infestation, if crosses ETL (5.3 %), spray emmamectin benzoate 5 WG @ 135-170 g or chlorantraniliprole 18.5 SC @ 125 ml or quinalphos 25 EC @ 800 ml / ha in 500 lit water.
- Removal and destruction of crop residues, stubbles of okra plants and deep ploughing after harvest.
- Use reflective mulches of silver black colour of 7 µ thickness to deter white flies in early stages.
Conservation of natural enemies

The commonly seen natural enemies of pests in okra cropping system should be protected from unwanted and excessive sprays of chemical pesticides.

Natural enemies in okra
KEY PESTS

Insect pests

Thrips: Thrips are the most serious pests of onion all over the country. Sometimes 50-60% losses in bulb crop are observed due to thrips attack. Thrips are found in the axil of green leaves where these sucks juice of early-emerging leaves. Small white silvery patches are seen all over the leaves. The infested plants show stunted growth with twisted leaves. If the infestation comes in early stage of growth, bulb formation stops completely.

Diseases

Damping off: In pre-emergence damping off, seedlings are killed before they reach the soil surface. Post emergence is characterised by the toppling of seedlings anytime after they emerge from the soil. It is more common during kharif season with temperature and humidity are high.

Stemphyllium blight: It is common in Northern and Eastern India. Its severity varies from 5 to 50 % and is more severe in rabi than kharif crop during March and April. Small yellow to pale orange spots or streaks develop on middle of leaves stalk on one side. The spots frequently coalesce into extended patches to cover the entire foliage. In seed crop, inflorescence stalk is severely damaged.

Purple blotch: It is common during kharif season. Hot and humid climate with temperature of 25-30°C and relative humidity of 80-90 % favour development and spread of the diseases. Disease appears as small whitish sunken lesions which enlarge and coalesce covering the entire leaf. Concentric zones may develop within the lesions.

Nematodes

Rice root-knot nematode: Usually young seedlings are infected and thus may result in complete destruction of crop. Infection by nematode causes abnormal swelling of roots known as root knot or galls, yellowing, wilting and stunting of plants.
VALIDATED INTEGRATED PEST MANAGEMENT INTERVENTIONS FOR ONION CROP

Nursery Stage
- Raised nursery beds up to 10 cm above ground level with good drainage and rice bran ash.
- Mix entire nursery bed with effective strains of *Trichoderma* spp. @ 50 g / 3 sq. m with FYM / vermicompost
- Need based spray of urea @ 0.2% to reduce yellowing caused due to unprecedented rains during January-February

Main Crop
- Planting outer row maize as barrier crop against onion thrips.
- Seedling dip in *Pseudomonas inflorescence* before transplanting @ 5 ml / litre.
- Give adequate irrigation during crop season as thrips pupae get rotten in soil with continuous retention of moisture.
- Irrigating fields through sprinkler wash off the thrips.
- Install blue coloured sticky traps @ 20 / acre for thrips management.
- Need based application of sulphur 80 WP @ 0.2% or for sulphur deficiency.
- Spray the crop with dimethoate 30 EC @ 660 ml or fipronil 80 WG @ 75 g or oxydemeton methyl 25 EC @ 1.2 litre / ha in 500 lit water for protection against thrips. Thrips control is critical during bulb initiation stage i.e. seventh week or 50 days after transplanting (DAT). These are effective even at higher temperature against thrips when population crosses ETL of 30 thrips / plant. Addition of sticker (0.1%) is essential for retention of spray fluid on leaves.
- Need based application of neem cake @ 250 kg / ha for nematode management.
- Spray zineb 75 WP @ 1.5-2 kg / ha in 750-1000 lit water against downy mildew and blight.
- Need based spray with difenconazole @ 0.1 % or tebuchinazole 25.9 % m / m EC @ 625-750 ml / ha in 500 lit water or metiram 55 % + pyraclostrobin 5 WG @ 1500-1750 g / ha in 750 lit water against purple blotch.
Conservation of natural enemies

The commonly seen natural enemies of pests in onion cropping system should be protected from unwanted and excessive sprays of chemical pesticides.
KEY PESTS

Insect pests

**Fruit fly**: Very serious pest causing losses up to 80%. Maximum damage occurs during July-August. Gravid female inserts the white, cigar shaped eggs into the flowers and/or tender fruits. The newly hatched maggots bore into the fruit pulp by forming serpentine galleries and feed inside, contaminating them with its frass and providing entry points for saprophytic fungi and bacteria, which cause rotting of the fruits. Due to feeding, there is pre-mature dropping of fruits.

**Cucumber Moth**: The larvae are pale to dark green with a white stripe running along both sides of the body. Caterpillars scrape the chlorophyll portion of the leaves by webbing them together. It also bores into flowers and after the fruit starts to develop, the larvae can chew shallow holes in the surface.

**Red Pumpkin Beetle**: It is a serious pest of bottle gourd. Adult beetles are mainly responsible for the damage of the plant above ground, attacking on the leaves, flowers and fruits. Making holes and causing death or retardation of growth. In case of heavy infestation, re-sowing is required to be done. Larvae live in the soil and feed on the roots and stem of the plant.

**White fly**: Both the nymphs and adults suck the plant sap mainly from underside of the leaves and secrete honeydew on which black sooty-moulds develop which in turn reduces photosynthesis by the plants. Apart from causing direct damage by their feeding, they also act as vector of viral diseases.
**Leaf Miner:** Serpentine mines are made by larvae in leaves. Drying and dropping of leaves due to severe infestation. Adults are pale yellow in colour. Pupates within mines.

**Diseases:**

**Downey mildew:** It is one of the serious diseases which initiates as water soaked angular lesions under conditions of high humidity and moderate temperature, soon turning chlorotic and finally on the corresponding lower surface purplish during growth is seen.

**Cercospora leaf spot:** The disease occurs on almost all cucurbits but is more common on cucumber, bitter gourd and bottle gourd and is usually found on foliage. Small block circular spots with grey centre with yellow hold appear on leaves. These sports enlarge and later encircle the leaves. Severely infected leaves fall off. The fruit size is reduced. More prevalent during rainy season.

**Fusarium wilt:** The symptoms are expressed at flowering & fruiting stage in bottle gourd and water melon. Replacement of tap root by a number of lateral roots. Yellowing, dropping of leaves and wilting and druing of whole plant are the major symptoms. Caused by seed borne and soil borne fungus. Vascular bundles in the collar region become discolored / brown.

**Powdery mildew:** The characteristic white, powdery fungal growth is readily recognizable on leaves, stems and vines. It is observed on almost all cucurbits and causes considerable loss. Affected leaves wither and dry. Powdery mildew affects fruit quality and reduces yield by reducing number and size of fruit.

**Anthracnose:** Yellowish water soaked spots appear which enlarge and turn dry brownish black with centre giving shot hole appearance. On fruits spots are circular sunken with dark borders containing numerous pin head size fruiting bodies.

**Virus complex:** This disease is serious constraint in cucurbits which cause leaf curl, yellow mosaic and stunting. In cucumber mosaic, typical mosaic symptoms develop on young leaves which mottle with alternating light green and dark green patches.
VALIDATED INTEGRATED PEST MANAGEMENT INTERVENTIONS FOR CUCURBITACEOUS CROPS

- Seed treatment with effective strain of *Trichoderma* @ 10 g / kg of seed
- Two to three applications of neem 300 ppm @ 10 ml / litre against hadda beetle on bitter gourd or red pumpkin beetle on bottle gourd in early stages of crop growth.
- Two sprays of *Bacillus thuriengiensis* @ 2g / litre for protection against cucumber moth on bitter gourd.
- Installation of cue lure traps for fruit flies for wider area management @ 10 / acre. Wooden plywood blocks are dipped in solution of Ethanol : Cuelure : Insecticide (DDVP)@ 8:2:1 for 48 hours.
- Raking of soil for exposing fruit fly pupae to sunlight and predatory fauna.
- Install yellow coloured sticky traps @ 10 / acre for fruit fly management.
- Collection and destruction of fruit fly infected fruits periodically.
- Preferably grow cucumber on bamboo support or tresilising or in green houses can reduce downy mildew with reduced lead wetness and free air flow.
- Need-based spray of DDVP 76 EC @ 627 ml or trichlorfon 50 EC @ 1.0 kg / ha in 500-1000 lit water in the early stage for red pumpkin beetle control.
- Need based spray of dicofol 18.5 SC @ 1350-2700 ml / ha in 500-1000 lit water is effective against red spider mites on bitter gourd and bottle gourd. Addition of sticker (0.1%) is essential for retention of spray fluid on leaves. Spray of cyantraniliprole 10.8 OD @ 900 ml / ha in 500 lit water is highly effective for white fly, leaf miner, thrips, red pumpkin beetle and white fly in cucurbits.
- Need based application of neem cake @ 250 kg / ha for nematode management
- Need based spray with carbendazim 50 WP @ 300 g / ha in 600 lit water to manage powdery mildew and anthracnose. Thiophenate methyl 70 WP @ 1430 g / ha in 750-1000 lit water can be used to manage anthracnose in bottlegourd
- Need based spray with azoxystrobin 23% SC @ 500 ml or cymoxanil 8% + mancozeb 64% @ 1.5 kg / ha in 500 lit water against downy mildew in cucumber. Zineb 75 WP @ 1.5 – 2 kg / ha in 750-1000 lit water can be used to manage downy mildew and anthracnose and need based spray of ametoctradin + dimethogromorph 20.27 % w / w SC @ 420-525 ml / ha
in 800-1000 lit water to manage downy mildew in cucurbits. Fenamidone 10 % + mancozeb 50 WG @ 1.5 kg / ha in 375-500 lit water or famoxadone 16.6 % + cymoxanil 22.1 % SC @ 500 ml / ha in 500 lit water can also be used in gherkins.

- An application of 10 kg borax per hectare to deficient soil before planting will prevent boron deficiency. Foliar sprays of borax (100 g / 100 L) may also be used.

**Conservation of Natural Enemies**

The above shown natural enemies of pests in cucurbitaceous cropping system should be protected from unwanted & excessive sprays of chemical pesticides.
KEY PESTS

Insect pests

White grubs: White grubs is severe during the *kharif* season (south-west monsoon, June to October). The female adults enter into the soil to lay eggs. The grubs after hatching start feeding on roots. Severely infested fields have large patches of dead plants; the surviving plants are often stunted, and show signs of wilt. Such plants can be easily pulled out.

Diseases

Rhizome rot: In the younger sprout infection starts at the collar region of the pseudostem and progresses upwards and downwards with characteristic foul smell. Yellowing of leaves spreads to all leaves of the plant from the lower region upwards followed by drooping, withering and drying of pseudostems.

Bacterium wilt: It is also a soil born disease. First symptoms of infection start with mild wilting / curling of lower leaves that progress upwards. As the disease progress, leaves droop down and plants exhibit severe yellowing and wilting, topples down producing petrifying smell.

Nematodes

Nematode: Occasionally infected plants show stunted growth, chlorosis with necrosis and burning / drying at the leaf tips. Infested seed rhizomes look shriveled with sunken or swollen patches on the outer surface. Root galls and lesions are seen on the roots.
VALIDATED INTEGRATED PEST MANAGEMENT INTERVENTIONS FOR GINGER CROP

- Use well decomposed FYM impregnated with *Trichoderma harzianum* at 250 g / q FYM.
- Soil solarization of the fields with transparent 0.45 mm thick polythene sheet for 15-20 days may be done before sowing.
- Seed rhizomes can also be solarized by keeping inside the polythene for two hours.
- Treat the seed rhizome with fungicides like carbendazim 50 WP @ 100 g + mancozeb 75 WP (250g) dissolved in water or with *Trichoderma harzianum* at 6-8 g / liter of water for 30 minutes.
- Control white grub adults by spraying their feeding trees like apple etc. with carbaryl 50 WP @ 2 g per liter of water. This spraying may be repeated from 3 to 4 times until mid-July, ideally using community approach.
- Give hot water treatment to seed rhizomes at 51°C for 10 minutes before planting.
- In standing crop, drench the fields with carbendazim 50 WP @ 0.2% or mancozeb 64 % + metalaxyl 8 % @ 0.25% along the roots of one month old crop or at the onset of monsoon.
- Treat the rhizomes meant for seed (75-80 kg) purpose with carbendazim 50 WP (100 g) + mancozeb 75 WP (250 g) + chlorpyriphos 20 EC (250 ml) mixed in 100 litres of water for one hour and shade dry before storage. Empty space may be filled with dry grass. The pit is covered with a wooden piece and cemented with cow dung.

** IPM technologies validated includes pesticides which may not have label claim for ginger crop.
COMMON NATURAL ENEMIES IN VEGETABLE CROPS

Coccinellids (*Coccinella septumpunctata*, *Menochilus sexmaculatus*): Lady bird beetles are very common found in vegetable crop fields. Lady bird beetles are predators of aphids, whit flies, scale insects, bollworms, other insects and mites. They feed on eggs, nymphs and adults especially these feed on large quantities of aphids. Larvae are more efficient predators than adults especially fourth instar larvae are more voracious feeders than other instars. They have a ferocious appearance, which misleads people into thinking they are harmful, which is untrue. Cannablisim is also observed in lady bird beetle. *C. septumpunctata*: Adult is half pea shaped, yellow to reddish brown with 7 black spots on elytra, both the head and ventral side are blackish in colour. Pupa is light brown marked with black dot and fixed on leaves at the posterior end. Egg is 1.2 mm long and yellowish in colour. *Menochilus sexmaculatus*: It is a black-spotted lady beetle. The long and narrow black band at the pronotal base is connected to the transverse oval black discal spot by a short and narrow longitudinal constriction or line.

Green lace wing (*Chrysoperla carnea*): Chrysopa feeds on aphids, mites, jassids, whitefly, thrips, bollworms and many other small insects. Adults are of medium size, 1-2 cm long, green, yellow green or sometimes brownish with golden eyes and delicate netted wings. The larvae, which are very active, are gray or brownish and alligator-like with well-developed legs and large pincers and grow from <1 mm to 6-8 mm. Oval shaped eggs are laid singly at the end of long silken talks and are pale green, turning gray in several days. Young larvae are susceptible to dessication. They need a source of moisture.
Spiders (Neosiana sp, Thomisus sp.): Spiders are generalist & excellent predators feeding on many insects; some spider species use webs to capture prey while other species stalk their prey. Some of the spiders feed even on ants. Orb weavers, they frequently remake their webs to catch prey, recycling - i.e. eating - the old web in the process.

Syrphid fly (Ischiodon scutellaris Fabricius): Many species of syrphid fly are predacious on aphids, and also mealy bugs, whiteflies, lepidopterous larvae and beneficial insects. Adults are usually brightly coloured, resembling bees and wasps. Syrphid larvae vary in appearance and habits. They are either obligate or facultative predators. The larvae are somewhat slug-like and are tapering towards head. Pupae are typically tear-drop shaped.

Praying mantis (Mantis religiosa): Praying mantis are predators and hunt on living insects. Large mantis feed on lizards, rodents, frogs, birds and even snakes. They wait for their prey to come close and quickly catch it. The mantis uses its two front legs to attack it’s prey. They are active during night. The adult praying mantis ranges in size from a centimeter to several inches in length. They blend themselves in surrounding and have very good eyesight; Sexual cannabilism is also seen.

Dragonfly (Libellula saturate): They act as a predator as they feed on mosquitos and other harmful small insects like bees, butterflies and flies. Their larvae are aquatic. They hold their prey tightly in legs studded with spikes. They catch their prey using extendable jaws. The life span of adult dragonfly is only few months. It’s most of the life is spent in the larval stage underneath the water surface. Female dragonfly lay eggs in or near water, often on floating or emergent plants. The larval stage of large dragonflies may last as long as five years.

Damsel fly (Agriocnemis pygmaea): They occur on aquatic vegetation and on the bottom of streams and ponds. They feed on aquatic insects and other arthropods. Damselfly adults use their hind legs which are covered with hairs to capture prey. They hold the prey in their legs and devour it by chewing. Adults are commonly found near water. Damselflies have long thin bodies that are often brightly colored with green, blue, red, yellow, black or brown.
Trichogramma sp (Trichogramma chilonis, T. japonicum, T. brasiliensis and other Trichogramma spp): Trichogramma are extremely tiny wasps. They are parasites of borers. Parasitised egg cards may be stapled to the underside of the leaves of the plant, so that the parasitoids may emerge and attack the host eggs. Each female parasitizes about 100 eggs. The short life cycle allows the wasp population to increase rapidly. Trichogramma is active at a optimum temperature of 23-25°C with 75% humidity. Conservation of parasite is important using crop management practices that protect and encourage natural enemies and increase their impact on pests. Trichogramma are readily available from commercial suppliers.

Nuclear polyhedrosis virus: NPV is a specific disease. Virus solution is sprayed on plants @ 250 LE / ha. preferably in the evening with adjuvants like jaggery solution 0.5% and 0.1% of any spreader / sticker or detergent powder. It is highly effective against tobacco caterpillar and fruit borer on all vegetable crops. The larvae get infected with NPV once they eat virus-contaminated foliage. The infected larva becomes sluggish and stops feeding. Later, the infected larva turns black. It is seen hanging on the foliage. Nuclear polyhedrosis viruses have numerous polyhedral inclusion bodies which contain rod-shaped viral particles. It is safe to honeybees, fish, mammals & natural enemies of insects & can be stored in cool place.

Predatory wasps (Vespa orientalis): Yellow wasps prey on many insects that are considered to be pests. They do also prey on bees, but unlike honey bees, these wasps colonies die out at the onset of every winter. Each social wasp colony includes a queen and a number of female workers with varying degrees of sterility relative to the queen. Size and composition of colony varies and it ranges from few dozens to many thousands. Common manifestation of wasps stings to man are related to allergy.

Cotesia (Cotesia sp): Cotesia is a parasite of caterpillars like tobacco caterpillar and gram caterpillar. Cotesia sp adults are small, dark wasps and resemble tiny flies. They have two pairs of wings, the hind wings being smaller than the forewings. The antennae are about 1.5 mm long and curved (not elbowed) upward. The abdomen of the female narrows to a downward curving extension called the ovipositor with which she lays eggs. The pupae are in an irregular mass of yellow silken cocoons attached to the host larva or to plant leaves.

Illis cinta: It feeds on powdery mildew spores.
Neem seed kernels should be pulverized using an electrical households mixer / grinder or by using a mortar and pestle. Winnowing should be done to separate the shell from the kernel. Pulverised neem seed kernel particles should pass through 18-mesh sieve. After sieving the powder should be mixed with water in the ratio of 100 g : 300 ml. The adjuvant (soap / detergent powder) should then be added to mixture in the ratio of 5 ml / gram of the adjuvant for every 100 grams of neem kernel seed powder. This mixture should be allowed to stand overnight. In the morning, it should be stirred and strained through a muslin cloth. More water must be passed through the residue left on the muslin cloth just adequate to adjust the ratio of neem kernel powder to water in the filterate becomes 100 gm powder in 2 litre water. The filterate should again be stirred to get a creamy dispersion of NSKE, ready for spraying. Spraying should preferably be carried out in the evening when the intensity of UV rays is low and while spraying thorough coverage of foliage is must.

**Graphic Presentation of NSKE Preparation**

- Neem seed kernel
- Grind
- Soak in water overnight
- Filter through muslin cloth
- Add 1% detergent
- Prepare 5% solution and spray
  - **For one ha:** 25 kg kernel
  - 500 litres water + 5 kg detergent
APPLICATION OF OTHER BIOPESTICIDES

Nuclear polyhedrosis virus (HaNPV): First spraying is to be done as soon as newly hatched larvae are seen. Repeat the spray after 7-10 days. Spray preferably in evening hours when intensity of UV rays is less and thorough coverage of foliage is must. Add sticker like Teepol or Triton X-100 while spraying. Collect the NPV infected larvae from field, crush and spray in the field.

Bacillus thuringiensis: Prepare a homogenous paste first, then dilute 1 kg of B.t.k. in 500 litres of water. Apply preferably during evening hours.

Trichoderma mixing: Mix 250 gm of effective strain of fungal antagonist Trichoderma in 3 kg of FYM and leave for about seven days for enrichment of culture. FYM should have sufficient (10%) moisture in it. After 7 days, mix in the soil in a nursery bed of 3 sq.m. (3mx1m). Solution of 4% of T.harzianum can be prepared for seedling dip.
SAFETY PRECAUTIONS IN THE USE OF PESTICIDES

A. Purchase
1. Always purchase only required quantity of pesticides and not in bulk
2. Never purchase loose or unsealed containers. Purchase pesticides before the expiry date ends
3. Don’t purchase pesticides without proper label

B. Storage
1. Avoid storage of pesticides in house premises or near grain storage
2. Never keep any pesticide near food
3. Keep all pesticides away from reach of children and livestock
4. Don’t expose them to sunlight for longer period
5. Keep all pesticides in original container in intact seal

C. Handling
1. Never transport any pesticides along with food material

D. While preparing solution
1. Always use clean water
2. Always protect your nose, eyes, mouth, ears and hands with clothes
3. Use hand gloves.
4. Don’t eat, drink, smoke or chew while filling the spray tank. Don’t smell pesticides
5. Never mix granules with water except those wettable granules
6. Avoid spilling of pesticides solution while filling the spray tank.

E. Equipment
1. Select right kind of equipment and nozzle.
2. Don’t blow nozzle with mouth.
3. Don’t use unwashed sprayer for weedicide or insecticide

F. While applying pesticides
1. Apply only recommended dose and spray solution
2. Apply insecticides preferably in the evening. Avoid rainy or hot sunny or windy days.
3. Don’t apply pesticides against the wind direction
4. Thoroughly wash the sprayers & buckets with soap water after spraying.
5. Buckets used for spraying should not be used for domestic purpose
6. Avoid entry of animals & workers in the field immediately after spraying

G. Disposal
1. Left over spray solution should not be drained in ponds
2. Used empty containers should be crushed and buried deep in soil
3. Never re-use empty pesticide container for any other purpose.