

IPM - SCHEDULE ON FRUIT CROPS

IPM - SCHEDULE ON MANGO

1. Powdery mildew (*Oidium mangiferae*)

Symptoms: Pathogen attacks the inflorescence, leaves, stalk of inflorescence and young fruits with white superficial powdery growth of fungus resulting in its shedding (Fig 1). When fruit grows further, epidermis of the infected fruits cracks and corky tissues are formed. (Fig 2, 3 & 4).



Fig 1. Mildew on flowers



Fig 2. Mildew on fruits / pedicel



Fig 3. Necrotic lesions on shoulder and dropping from stalk end



Fig 4. Mildew on Lower Surface of Leaf

Management

- Prune diseased leaves and malformed panicles harbouring the pathogen to reduce primary inoculum load.
- Spray wettable sulphur (0.2%) when panicles are 3-4" in size.
- Spray dinocap (0.1%) 15-20 days after first spray.
- Spray tridemorph (0.1%) 15-20 days after second spray.
- Spraying at full bloom needs to be avoided.

2. Anthracnose (*Colletotrichum gloeosporioides*)

Symptoms: The pathogen causes leaf spot/leaf blight, wither tip, blossom blight and fruit rots. On leaves characteristic symptoms appear as oval or irregular vinaceous brown to deep brown spots of various sizes scattered all over the leaf surface and show, 'shot hole' symptom (Fig. 5 & 6)



Fig 5. Anthracnose on leaf



Fig 6. Wither tip Phase



Fig 7. Blossom blight phase



Fig. 8. Typical Anthracnose on cultivar Hushan-e-ara

On blossom small black spots appear on panicles and open flowers, which gradually enlarge and coalesce to cause death of flowers. (Fig 7). On fruits, it is more common during transit and storage (Fig 8).

Management

- Diseased leaves, twigs, gall midge infected leaves and fruits, should be collected and burnt.
- Blossom infection can be controlled effectively by spraying of Bavistin (0.1%) at 15 days interval.
- The foliar infection can be controlled by spraying of copper oxychloride (0.3%)
- Pre-harvest sprays of hexaconazole (0.01%) or Carbendazim (0.1%) at 15 days interval should be done in such a way that the last spray falls 15 days prior to harvest.
- Hot water treatment at 52⁰ C for 30 minutes.
- Covering the fruits on tree, 15 days prior to harvest with news or brown paper bags.
- Use bio control agent viz *Streptosporangium pseudovulgare*.

3. Die back (*Lasiodiplodia theobromae*)

Symptoms: It is characterized by drying back of twigs from top downwards, particularly in older trees followed by drying of leaves which gives an appearance of fire scorch (Fig.9 to 12).



Fig 9. Partially Die back infected tree



Fig 10. Die back on young seedling



Fig 11. Old tree showing die back



Fig 12. Darkening of pith due to die back

Management

- Scion wood selected for propagation should be free from infection
- Every care should be taken to prevent introduction of disease in newly planted orchards.
- Any infected portion should immediately be pruned, followed by spraying/pasting of copper oxychloride or pasting with cow dung at the cut ends.
- Pruning should be done in such a way that some healthy portion is also removed, to ensure complete eradication of pathogen (3 “below the infection site).
- The affected branches should be collected and burnt.

4. Sooty mould (*Capnodium mangiferae*)

Symptoms: Black velvety thin membranous covering on leaves, stems and fruits are its symptoms, wherever, honey dew secreting insects, viz. mango hopper, scales, coccids and mealy bugs are found. (Fig 13 & 14).



Fig. 13 Sooty Mould on Leaves



Fig. 14 Sooty Mould on Fruit

Management

- If honey dew secreting insects are controlled by suitable insecticides, the mould dies out for want of a suitable growth medium.
- Spraying of starch @2% is effective.
- Spray wettable sulphur +Imidacloprid +gum acacia (0.2+0.25+0.3%) or Indian oil formulation No. 1 & 2 (4%) at 15 days interval.
- Application of pesticides should cover both sides of leaves.

5. *Phoma blight (Phoma glomerata)*

Symptoms: The disease is noticed on matured / old leaves only. Fully developed spots are characterized by dark margin and dull grey necrotic centre. (Fig 15 & 16).



Fig. 15 Phoma infected leaves



Fig. 16 Close up

Management

- Spray copper oxychloride (0.3%).
- Balanced nutrition provides resistance to phoma blight.

6. Mango bacterial canker disease (*Xanthomonas campestris pv. mangiferaeindicae*)

Symptoms: The disease is noticed on leaves, leaf stalks, stems, twigs, branches and fruits, initially producing water soaked lesions, later turning into typical canker. Lesions are light yellow in colour, initially with yellow halo but with age enlarge or coalesce to form irregular necrotic cankerous patches with dark brown colour. On fruits, water-soaked, dark brown to black coloured lesions are observed which gradually developed into cankerous, raised or flat (Fig 17 to 21).



Fig. 17 Bacterial Canker infected Leaves



Fig. 18 Infection on Leaf Stalks



Fig. 19 Canker on Twig



Fig. 20 Cankerous fruit



Fig. 21 Black streaks showing canker in fruit

Management

- Regular inspection of orchards, sanitation and seedling certification are recommended as preventive measures.
- Mango stones for raising seedlings (root stock) should always be taken from healthy fruits.
- Use of wind-breaks helps in reducing brushing/ wounding and thus reduces chance of infection.
- Three sprays of Streptocycline (200 ppm) at 10 days intervals reduce fruit infection.
- In severe infection, spraying of Streptocycline (300 ppm) or copper oxychloride (0.3%) is more effective.
- An antagonistic phytoplane bacterium, *Bacillus coagulans*, is found effective.

7. Mango Malformation [*Fusarium subglutinans*]

Symptoms: Vegetative / Floral malformation/: Vegetative malformation is pronounced in young seedlings. The affected seedlings develop vegetative growths which are abnormal growth, swollen and have very short internodes. The flower buds are transformed into vegetative buds and a large number of small leaves and stems, which are characterized by appreciably reduced internodes. (Fig 22 & 23).



Fig. 22 Vegetative Malformation



Fig 23. Floral Malformation

Management

- The floral malformed panicles/ vegetative malformed shoots should be pruned and burnt which reduces the incidence of malformation.
- Application of NAA (200 ppm) in the first week of October (Before bud differentiation stages) followed by deblossoming in the late December or January reduces the incidence of malformation.

8. Gummosis

[*Lasiodiplodia theobromae* (Pat.) Griffon and Mauble (Synonyms: *Botryodiplodia theobromae* Pat.)] [*Physalospora rhodina* Cooke, perfect stage of *Botryodiplodia theobromae* Pat.]

Symptoms: Presence of profuse oozing of gum on the surface of the affected wood, bark of the trunk and also on larger braches but more common on the cracked branches. Droplets of gum trickle down on stem, bark turn dark brown with longitudinal cracks, rots completely and the tree dries up. (Fig 24).



Fig 24. Oozing of gum



Fig 25. Treated with Copper and cow dung paste

Management

- The diseased bark / portion should be removed or cleaned and pasted with Bordeaux paste or copper oxychloride paste or cow dung paste or cow dung paste (Fig 25).
- Application of Copper sulphate 500 gm/ tree (depending upon the age of the tree) in soil around the tree trunk is recommended. Gummosis is very less in the orchards receiving regular copper oxychloride sprays for control of leaf spot diseases.

9. Scab

[*Elsinoe mangiferae* Bitancourt and Jenkins = anamorph: *Sphaceloma mangiferae* (Bitancourt and Jenkins)].

Symptoms: The scab fungus attack leaves, panicles, blossoms, twigs, bark of stems and mango fruits. Spots are circular, slightly angular, brown but during rainy season, lesions differ in size, shape and colour. On young fruits, the infection is grey to grayish brown with dark irregular margins (Fig 26 & 27).



Fig 26. Scab infected leaves



Fig 27. Fruit infected with Scab

Management

- Frequent sprays of copper oxychloride (0.3%) to protect new flushes of growth are effective for scab control in nurseries.

10. Black Banded

[*Rhinocladium corticolum* Masee, perfect stage *Pezizotrichum corticolum* (Masee) Subramanian]

Symptoms: The disease is noticed on the midribs/ veins of the leaves, twigs and branches as black velvety raise fungal out growth in the form of spots which gradually increase in size and encircle the trunk limbs, branches and twigs. (Fig 28 & 29).



Fig. 28 Black Banded disease on leaf



Fig. 29 Black Banded disease on twigs

Management

- Gunny rubbing on twigs/ branches to remove the black growth.
- Spraying of Bordeaux mixture 5:5:50 or copper oxychloride (0.3%).

11. Ganoderma root-rot (*Ganoderma lucidum*)

Symptoms: The leaves of affected tree area lusterless and sparse. Diseased tree wilts and dies. Infected roots are very light in weight and get easily crumbled and powdered with fingers. The fruiting bodies of the fungus (brackets) appear at the base of the tree in rainy season.

Management

- Collection of *brackets* and destruction.
- Exposure of roots and drenching with dinocap 2 ml/l and covering with soil and incorporation of green leaves in the tree basin effectively reduce disease.

12. Root Rot & Damping off (*Rhizoctonia solani kuhn*)

Symptoms: During prolonged rainy and humid weather, infection occurs at / or below the ground level with circular to irregular water soaked patches. These patches enlarge and ultimately girdle the entire base of the seedlings. (Fig 30 & 31).



Fig. 30 Damping off phase of disease



Fig. 31 Root Rot phase of disease

Management

- Care should be taken that water should not stagnate near the root zone.
- Nursery should be raised on elevated beds.
- Nursery beds should be fumigated.
- Application of Trichoderma in the affected nursery is effective.
- During the growing season, Bordeaux mixture (1.5%) should be sprayed on the plants and the soil at weekly intervals.

13. Red rust

(*Cephaleuros virescens* Kunze)

Symptoms: Presence of the rusty red fructification of the alga on the surface of the leaves, veins, petiole and young twigs and fruit, spots are greenish grey in colour and velvety in texture which finally turn into reddish brown in colour. (Fig 32, 33 & 34).



Fig. 32 Plant infected with Red rust

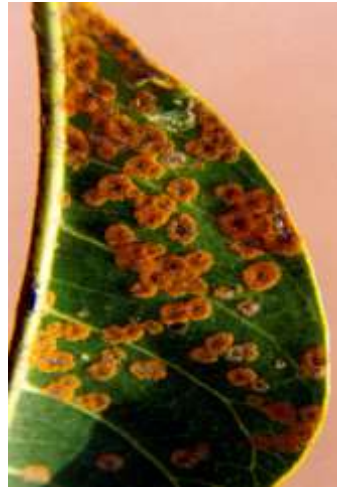


Fig. 33 Leaf infection of Red rust

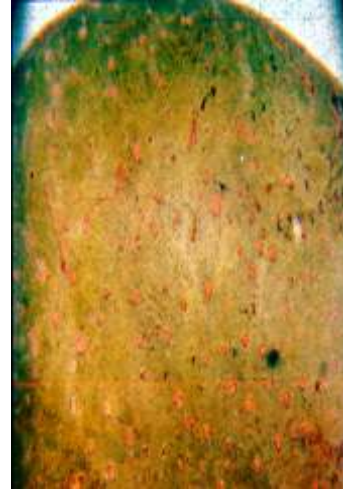


Fig. 34 Fruit showing Symptom of Red rust

Management

- If vigour of plant is maintained by balanced nutrients, the disease is less.
- Spray Bordeaux mixture (5:5:50) or copper oxychloride (0.3%).
- As the disease starts on the onset of rain, it is desired to spray fungicide twice during the month of July/ August at 15 days intervals.

14. Lichens

[*Strigula elegans* (Free.) Mull Arg.]

Symptoms: Lichens are found on full grown trees of mango, mainly on trunks, branches and twigs in the areas of high humidity, heavy rainfall and poorly managed orchards. It

is seen in the form of whitish, pinkish, superficial patches of different shapes on the main trunk, branches, leaves and twigs of the trees(Fig)



Fig. 35 Mix infection of Red rusts and lichens **Fig. 36 Lichen on trunk**

Management

- Field sanitation and balanced nutrition help in checking the disease.
- The lichens can be managed by gunny rubbing followed by spraying the trunk, branches, twigs with commercial caustic soda (1.0%)

PHYSIOLOGICAL DISORDER

15. Black Tip (Chimney disease)

Symptoms: Small etiolated area develops near the distal end of the fruit which gradually spreads, turns nearly black and covers the tip of the fruit completely. The black area remains hard and the growth of the fruit is checked (Fig 37).



Fig. 37 Black Tip on cultivar Dussehri

Management

- It can be minimized by the spray of borax (1%). The first spray should be done positively at pea stage followed by two more sprays at 15 days interval.
- Planting of mango orchard in north-south direction and 5-6 km away from the brick kilns reduce the incidence.

16. Internal Necrosis (Boron deficiency)

Symptoms: First, water soaked grayish spots develop on the lower side of the fruit. Late, the spots enlarge and develop into dark brown necrotic area. The internal tissue starts disintegrating. The pericarp and mesocarp is disintegrated exposing the flesh. (Fig. 38).



Fig. 38 Internal Necrosis on Hanging fruits **Close up of affected fruits**

Management

- Foliar spray of borax (1%) at pea stage followed by two more sprays at 15 days interval.
- Application of 250 gm. boron per tree (10-15 year old) around the tree basin.

17. Fruit Clustering (Jhumka)

Symptoms: This abnormality is characterized by formation of several fruit lets at the tip of panicle. The fruitlets are darker green in colour and their shape is slightly curved than the normal fruits. The fruitlets do not grow more and later drop and do not have formation of seeds (Fig. 39)



Fig. 39 Clustering (Jhumka) in Dushehri

Management

- During flower opening stage spray of insecticides and fungicides should be avoided.
- Population of pollinators should be kept more during flowering season.
- Pollinizing cultivars should be planted in the orchard.

18. Woody Stem gall (Cause not known)

Symptoms: Woody galls of 10-15 inches diameter are formed on limbs and branches. The galls are abundant on CVS. Chinnasuvarnakha, Langra and moderate in Neelam (Fig 40 & 41).



Fig. 40 Large woody galls on branches

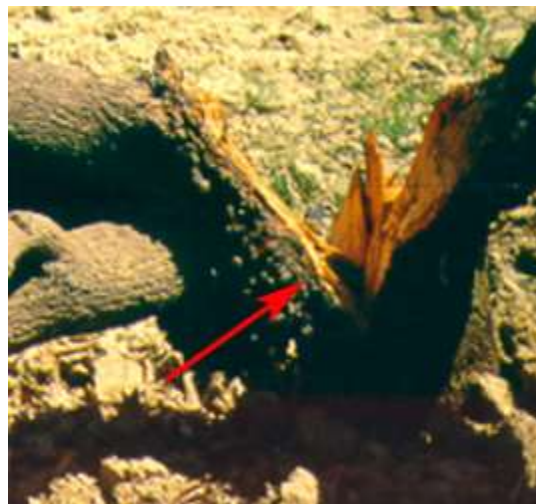


Fig. 41 Breaking of tree near galls

Management

- Remedy lies in removal of galls using saw and applying Bordeaux paste to cut surface.

19. Fruit tumors (Cause not known)

Symptoms: Tumors of pea to marble size develop on fruit and are very ugly to look at. The styler end part is much affected while stem end is practically free from tumors (Fig 42).



Fig. 42 Fruit showing tumors

Management

- Removal of affected fruits from the tree and buried in the soil.

INSECT PEST

20. Hopper (*Idioscopus clypealis*, *I. nitidulus* and *Amritodus atkinsoni*)

Symptoms: The wedges shaped Nymphs and adult insects puncture and suck sap of tender parts, reducing vigour of plants and particularly destroying the inflorescence and causing fruit drop. They also damage the crop by excreting a sweet sticky substance facilitates the development of sooty mould (Fig 43 & 44).



Fig 43. Hoppers damaging inflorescence



Fig 44. Fruit drop by hoppers

Management

- Avoid dense plantings, prune overcrowded overlapping branches after rainy season.
- Orchards should be kept clean by regular ploughing and removal of weeds.
- Conservation of bio control agents like predator, *Mallada boninensis*, *Chrysopa lacciperda*, egg parasite, *Polynema* spp. *Gonatocerus* sp. *Tetrastichus* sp. and fungus, *Verticillium lecanii*.
- Spraying of 0.2% Nimbecidin or Azadirachtin 3000 ppm@2m/l at initial stage of hopper population.
- Spray Lambda cyhalothrin 5% EC@ 0.5 ml or imidacloprid 200 SL @ 0.25 ml/l. First spray should be done at early stage of panicle formation if hopper population, is more than 5-10 panicle, second spray at full length stage of panicle and the third spray after fruit setting (at pea size).
- Chemical spray is to be minimized and should be need based.
- A rational rotation of insecticide is desirable to counteract the tendency of pest to develop field resistance.

21. Mealy bug (*Drosicha mangiferae*)

Symptoms: The adult bugs are covered with whitish powder and colonize between bark of tree trunk, young shoots and panicles (Fig45). The nymphs' ascent the trees and settle on inflorescence causing flower drop, affecting fruit set, excrete honey dew, a sticky substance, which facilitates development of sooty mould. (Fig. 46).



Fig 45. Shoot infested with Mealy bug



Fig 46. Fruits infected with Mealy bug



Fig 47. Alkathene banding on tree trunk to check migration



Fig 48. Coccinellid predators of mealy bug

Management

- Flooding of orchard with water in the month of October kill the eggs.
- Ploughing of orchard in November.
- Raking of soil around tree trunk to expose the eggs to natural enemies and sun, removal of weeds and releasing 10-15 grubs and mixing with chlorpyrifos dust 1.5% @250 g/ tree during January.
- After mud plastering, banding of tree trunk with alkathene (400 gauge g), 25 cm wide sheets should be fastened to the free trunk with the help of sutli, 30 cm above ground level and application of *Beauveria bassiana* product (2g/litre) or 5% NSKE in last week of January around tree trunk (Fig 47).
- Conservation of bio control agents, *Beauveria bassiana*, predators, *Menochilus sexmaculatus*, *Rodolia fumida* and *Sumnius renardi*.
- Releasing 10-15 grubs of coccinellid predator, *C. montrozieri* per tree (Fig 48).
- If nymphs ascended on tree spray Monocrotophos or Dimethoate (0.04%)

22. Inflorescence / leaf/ twig midge (*Erosomyia indica*), *Dasineura amraramanjarae*, *Procytiphovra mangiferae* and *Procontarinia matteriana*)

Symptoms: Damage by *E. indica* causes bending and drying of the inflorescences. Second attacks starts at fruit setting as young maggots bore into these tender fruits which slowly turn yellow and finally drop. The most damaging one is first attack in which the entire inflorescence is destroyed. (Fig 49 & 50).



Fig 49 Panicle damaged by midge



Fig. 50. Twig damaged by midge

Management

- Deep ploughing of orchard in October- November to expose pupae and diapausing larvae to sun's heat which kills them.
- Monitoring of larval population on white paper and apply control measures based on population.
- Spray monocrotophos (0.04%) or dimethoate (0.05%) at bud burst stage.

23. Fruit flies (*Bactrocera dorsalis*, *B. correctus* and *B. zonatus*)

Symptoms: The female punctures outer wall of mature fruits with the help of its pointed ovipositor and insert eggs in small clusters inside mesocarp of mature fruits. On hatching, the maggots feed on fruit pulp and the infested fruits start rotting due to further secondary infection (Figs. 51 to 54).



Fig. 51 Adult fruit fly Fig 52 trapped flies Fig 53 Maggots in pulp Fig 54. Infested fruit

Management

- Prior to harvest (30-40 days) collect and disposed off infested and fallen fruits to prevent further, multiplication and carry over of population.
- Ploughing of orchard during November-December to expose pupae to sun's heat which kills them.
- Hanging of methyl eugenol wooden block traps soaked in ethanol, methyl eugenol and malathion (6:4:1) during fruiting period from April to August @10 traps/ ha tie them tightly of 3-5 feet above ground level.
- To control adult flies during severe infestation placing poison bait viz Protein hydrolysate +malathion 50 ml +200 ml molasses in 2 litres of water be sprayed adding an additional 18 liters of water to bait poison. Commencing at pre oviposition period and repeat at 15 days interval. Addition of 10 ml methyl eugenol in place of molasses is also recommended.
- Hot water treatment of fruit at $48 \pm 1^{\circ}\text{C}$ for 60 min.

- Three weeks before harvesting, spray Deltamethrin 2.8 EC @ 0.5 ml/l + Azadiractin (3000 ppm) or 2 ml/l.
- Irradiation of fruits 0.25-0.75 KGY to control fruit fly.
- If infestation is heavy, bait splash on the trunk only, once or twice at weekly interval is recommended. To prepare bait splash, mix 100 gm of jaggery in one litre of water and add 1 ml of Deltamethrin by using an old broom.
- Managing fruit flies also reduces anthracnose disease and prevents late fruit fall.

24. Leaf webber (*Orthaga euadrusalis*)

Symptoms: Initially caterpillars feed on leaf surface gregariously by scrapping/Later they make web of tender shoots and leaves together and feed within. Several caterpillars may be found in a single webbed up cluster of leaves (Figs. 55 to 58).



Fig 55. Webber infested plant



Fig 56. Close up of web with caterpillars



Fig 57. Infection of *Aspergillus flavus*



Fig 58. Adult fly, pupae and caterpillar of webber (*Orthaga Sp.*)

Management

- Pruning of overcrowded and overlapping branches.
- Mechanical removal of infested webs by leaf web removing device and burning them.
- Ploughing of orchard done earlier for mealy bug control checks its population.
- Two to three sprays commencing from last week of July with monocrotophos (0.05%) or quinalphos (0.05%). This spray will also take care of mango psylla (*Apsylla cistellata*).
- The use of same chemical for every spray should be avoided.

25. Shoot gall psylla (*Apsylla cistellata*)

Symptoms: Nymphs emerge during August September and suck cell sap from adjacent buds. As a result of feeding, buds develop into hard conical green galls (Fig 59 & 60).



Fig 59. Infestation of shoot gall psylla



Fig 60. Nymphs of *Apsylla cistellata*

Management

- Galls with nymphs should be collected and destroyed.
- Spray Dimethoate (0.06%) or quinalphos (0.05%) at fortnightly interval starting from August.
- Spray 2, 4-D (150 ppm, i, e 150 mg/liter of water) during October which opens the galls and nymphs come out and are killed with cold.
- New mango orchard in humid region need to be discouraged.

26. Stem-borer (*Batocera rufomaculata*)

Symptoms: The damage is caused by grubs either to roots or stems. The grubs after hatching from eggs first feed on bark and make irregular cavities. It makes tunnels which may either be in boring upward, resulting in drying of branches (Fig 61).



Fig 61. Infestation of borer on tree trunk

Management

- Keep orchard clean and healthy.
- Cut and destroy affected branches with grubs and pupae.
- Clean hole and insert cotton wool soaked in emulsion of monocrotophos (0.05%) or kerosene or petrol in each hole and plug them with mud.
- Use of green muscardine fungi, *Metarhizium anisopliae* or *Beauveria bassiana*.

27. Shoot-borer (*Chlumetia transversa*)

Symptoms: Larvae bore into young tender leaves during August and freshly hatched caterpillar bore into mid rib. After a couple of days, they bore into tender shoots near the growing point tunneling downward, throwing their excreta resulting in dropping of leaves and wilting of terminal shoots (Fig.62)



Fig. 62 Infestation of shoot borer on young leaves

Management

- Attacked shoots should be clipped off and destroyed.

28. Scale (*Chloropulvinaria polygonata*, *Aspidiotus destructor*)

Symptoms: The nymphs and adult scale suck the sap of leaves and other tender parts reducing vigor of plants. They also excrete honeydew which helps in the development of sooty mould on leaves and other tender parts (Fig 63.)



Fig. 63 Scale infested leaves and twigs

Management

- Prune heavily infested plant parts to open the tree canopy and destroy' them immediately.
- Spray quinalphos 2 times or dimethoate (0.06%) at 21 days interval.
- Removal of attendant ants may permit natural enemies to control the insect.

29. Stone weevil (*Sternochetus mangiferae*)

Symptoms: Adult weevils (5-8 mm) are stout and dark brown, grubs are white legless and stumpy Eggs are laid singly on the pericarp of tender marble sized fruits. On hatching grubs bore through the pulp, feed on seed coat and later damage the cotyledons. Pupation is inside the seed (Fig. 64).



Fig. 64 Mango infested with Stone Weevil

Management

Cultural:

- Collection and destruction of infested and fallen fruits at weekly interval till harvest fruit.
- Ploughing of orchard after harvest to expose hibernating adults, reduce, infestation levels.
- Destroy all left over seeds in the orchard and also in the processing industries.
- Spraying Dimethoate (0.1%) twice at 15 days interval when fruits are of marble size.

Chemical:

- Spray main trunk, primary branches and junction of branches prior to flowering (November, December) with quinalphos @ 2.5 ml to control beetles hiding in the bark.
- Spray Acephate 75 SP @ 1.5 g/l when fruits are of lime size (2.5-4 cm diameter) followed by Deltamethrin 2.8 EC @ 1ml/l after two or three weeks.
- Vapour heat treatment of fruits.
- Irradiation of fruits with 0.25-0.75 KGY to control stone weevil.

Biological:

- Parasitoids are unknown on stone weevil. The natural enemies recorded on *S. gravis* include a mite *Rhizoglyphus* sp, ants (*Camponatus* sp., *Monomorium* sp. and *oecophylla smaragdina*) and fungus *Aspergillus* sp, *Beauveria bassiana* was found to be pathogenic on mango weevil.

30. Thrips: (*Coliothrips indicus*, *Rhipiphorothris cruentatus*, *Scirtothrips dorsalis*)

Symptoms: Nymphs and adults lacerate the tissues and suck the oozing cell sap. *C. indicus* and *R. cruentatus* feed on leaves and *S. dorsalis* on in florescence, and young fruits. Leaf feeding species feed on mesophyll near leaf tips. Affected leaves show silvery sheen and bear small spots of faecal matter (Fig 65).



Fig 65. Thrips infested leaves

Management

- If the infestation is severe, can be controlled by either dimethoate (0.1.5%) or Monocrotophos (0.1%)

31. Tea –Mosquito bug: (*Helopeltis antonii*)

Symptoms: Major pest of cashew, occasionally damages mango and other fruit crops. Adult is a reddish brown bug with black head, red thorax, and black and white abdomen. Eggs are inserted into epidermis of tender shoots and axis of inflorescence. Adult and nymphs feed on petioles, tender shoots and leaf veins causing necrotic lesions.

Management

- Spray Dimethoate (0.05) or quinalphos (25 EC) 2 ml/ liter.

32. Fruit borer: (*Deanolis albizonalis*)

Symptoms: Fully grown caterpillars (25 mm) have red bands on body alternating with white bands caterpillars bore into the fruit at the bottom (beak region) and feed inside reaching Kernels. Entrance hole is plugged with excreta. Affected fruits rot and fall prematurely (Fig 66).



Fig. 66 Fruit borer on mango

Management

- Collection of fruits and dead wood after fruit harvest.
- Destroy all fallen fruits.
- Spray Monocrotophos 1.5 ml/l at marble size onwards and repeat with Deltamethrin 28 EC @ 1ml/l after two weeks in case of heavy infection
- No spray should be given in fortnight before harvest.

33. Leaf miner: (*Acrocercops syngramma*)

Symptoms: Tiny caterpillars mine under the dorsal epidemics of tender leaves and feed within; as a result grayish white blisters appear on leaves (Fig 67).



Fig. 67 Leaves miner infestation

Management

- Clipped off destroy the affected shoots.
- Spray quinalphos (0.05%) from the emergence of new flush.

34. Red tree ant (*Oecophylla smaragdina*)

Symptoms: The ants web and stitch together a few leaves, usually at the top of the branches and build their nests. However, indirect damage is caused by protecting insects like aphids and scales, which excrete honey dew (Fig. 68).



Fig. 68 Red tree ants

Management

- Nests should be removed and destroyed mechanically by web cutting device.
- Spraying any contact insecticides, Dimethoate 1.5 ml/l after disturbing the nest.

35. Termites (*Odontotermes sp.*)

Symptoms: Termites are white in colour, shy to light and remain underground. They feed on root or move upward making the tunnels. They construct mud galleries on tree trunk and under the protection of these galleries, feed on the bark of the trunks (Fig 69).



Fig 69. Termitorium along with mango tree

Management

- Remove the mud galleris on trunk and swab or spray the trunk with Malathion (1.5 ml/l).
- After two month, drench the soil at the base of the tree with Deltamethrin (1ml/l).

IPM of Guava

A. DISEASES

1. Wilt: The pathogens, viz. *Fusarium oxysporum f.sp. psidii*, *F. solani*, *Macrophomina phaseoli*, *Rhizoctonia bataticola*, *Cephalosporium sp.* and *Gliocladium roseum* are reported to cause wilting.

Symptoms

First external symptom of the disease is the appearance of yellow colouration with slight curling of the leaves of the terminal branches. Plants, at a later stage, show unthriftiness with yellow to reddish discoloration of leaves. Later, the entire plant is defoliated and eventually dies (Fig. 1).



Fig 1. Wilted plants

Disease management:

- Disease can be kept under check by proper sanitation in the orchard. Wilted trees should be uprooted, burnt and trench should be dug around the tree trunk.
- While transplanting, roots of plants should not be damaged severely. Maintenance of proper tree vigour by timely and adequately manuring, interculture and irrigation enable them to withstand infection. The pits may be treated with formalin and kept covered for about 3 days and transplanting should be done after two weeks.
- Symptoms of the disease are less under green manuring and when organic sources of nitrogen are used.
- Organic manures, oil cakes and lime also check the disease.
- Spread of wilt could be checked by judicious amendments of N and Zn.

- Use of rootstocks resistant to wilt could be an alternative effective method for the control of disease. Cross of *Psidium malle* X *P. guajava* has been found free from wilt and this material can be used as resistant root stock.
- Though different fungicides are effective for the control of wilt pathogens in lab, but these pathogens increase its aggressiveness, once the effect of these fungicides diminishes in soil.
- Biological control by *Aspergillus niger* strain AN17 is found effective. *Aspergillus niger* multiplied in FYM @ 5 kg pit -1) can be applied in the pits while planting new plants. In older plants *Aspergillus niger* enriched FYM can be applied @ 10 kg plant¹.

2. Anthracnose: [*Gloeosporium psidii* (Delacroix Sacc. = *Glomerella psidii* (Del.) Sheld./ *Colletotrichum psidii* Curzi.]

Symptoms: Fruit and leaf infection phase: Fruit and leaf infection is generally seen in rainy season crop. Pin-head spots are first seen on unripe fruits, which gradually enlarge. On ripe fruits, the infection causes softening of tissues and lesions attain a diameter of 10 to 20 mm.



Fig. 2 Disease on young fruits



Fig. 3. Disease on mature fruit

Disease Management:

- Effective control of anthracnose can be achieved by sprays of Bordeaux mixture (3:3:50) or Copper oxychloride 0.3 per cent at 7 days interval.
- Monthly sprays of difolatan (0.3%) and dithane Z-78 (0.2%) are also effective in controlling the disease.
- For post harvest treatment 20 min. dip in 500 ppm tetracycline is effective. Application of bio agent viz *Streptosporangium pseudovulgare* on fruits could be able to control anthracnose disease (Fig.4)



Fig. 4. Bio control

3. Canker [*Pestalotia psidii* Pat.]

Symptoms: The first evidence of infection on fruit is the appearance of minute, brown or rust coloured, unbroken, circular, necrotic areas, which in advanced stage of infection; tears open the epidermis in a circinate manner. The margin of lesion is elevated and a depressed area is noticeable inside (Fig 5).



Fig. 5. Canker on fruit

Disease Management: The spread of disease (in early stage of infection) is controlled by 3 to 4 sprays of 1 per cent Bordeaux mixture or lime sulphur at 15 days interval.

4. Algal leaf and Fruit Spot [*Cephaleuros virescens* Kuntze (= *C. mycoideae* Karst.), *C. parasiticus*]

Symptoms: *Cephaleuros* infects immature guava leaves during early spring flush. Minute, shallow brown velvety lesions appear on leaves. On immature fruits the lesions are nearly black. (Fig. 6). As fruits enlarge, lesions get sunken. The pathogen speculates

readily during the period of high rainfall (July-September) and the disease incidence is greatest during September. In winter, symptoms are not available.



Fig. 6 Algal spots on leaves

Disease management: The control of alga can be achieved by sprays of Copper oxychloride (0.3%) 3-4 times at an interval of 15 days.

5. Cercospora Leaf spot (*Cercospora sawadae* Yamamoto)

Symptoms: The disease appears as water soaked, brown irregular patches on the lower surface and yellowish colour on the upper surface of the leaf. Older leaves are mostly affected and the severely affected leaves curl and subsequently drop off (Fig. 7).



Fig. 7 Cercospora Leaf spot

Disease Management: Spray copper oxychloride (0.2%) or Mancozeb (0.2%) before onset of rains.

6. Sooty mould [*Phragmocapnias betle*, *Scorias philippensis*, *Tichomerium grandisporum*, *Limacinula musicola*, *Aithaloderma clavatisporum*, *Tripaspermum* sp., *Polychaeton* sp., *Leptoxyphium* sp. and *Conidiocarpus* sp.]

Symptoms: Symptoms consist of blackish brown velvety thin membranous covering on the leaves. In severe cases, the foliage appears black due to heavy infection. The affected leaves curl and shrivel under dry conditions (Fig 8)



Fig. 8 Sooty Mould

Control: The control of disease consists in removing the cause by destroying the insects. The mould will die out for want of suitable growth medium if honeydew-secreting insects are killed by suitable insecticides. Foliar spraying of wettasul + Metacid +Gum Accecia (0.2+ 0.1 +0.3%) at 15 days interval has been found very effective in minimizing the sooty mould incidence.

7. Damping off of Seedlings (*Rhizoctonia solani* Kuhn).

Symptoms:

Both pre emergence and post emergence phases of the disease are observed. In pre emergence phase the infected seeds and seedlings show water soaked discoloration, the seed becomes soft and ultimately rots. In post emergence phase, hypocotyle at ground level or upper leaves are discolored into yellowish to brown colour, which spreads downwards and later turn soft and finally rot and constrict (Fig.9)



Fig. 9. Damping off guava seedlings

Control:

1. Diseased seedlings and weeds should be removed and burnt.
2. Excessive use of water and close planting should be avoided as the organism is moisture loving. Seedbeds should be prepared with proper drainage arrangement.
3. As the fungus survives on several hosts, planting of susceptible hosts should be avoided.
4. Two minute dipping of guava seeds in captan / thiram (0.2%) is advocated before seed sowing.
5. Drenching of soil with Copper oxychloride (0.3%) helps in reducing the diseases intensity in nursery.

8. Phytophthora fruit rot [*Phytophthora parasitica* Dastur/ *P. nicotianae* var. *parasitica*, *P. citricola*]**Symptoms:**

The symptom starts at calyx disc of the fruit during rainy season. Affected area becomes covered with whitish cottony growth develops very fast as the fruit matures. (Fig 10 & 11).



Fig. 10 Phytophthora on foliage



Fig. 11 Phytophthora fruit rot on green fruits

Control:

- Dithane Z-78 (0.2%) or Aureofungin (10ppm) are found effective to control foliar infection and drenching the soil with Copper oxychloride has also been found very effective.
- Plant spacing and fertilizer régimes should be managed to avoid unnecessarily dense plant canopies.

9. Stylar end rot [*Phomopsis psidii* De camara and *P. destructim*]

Symptoms:

The visible disease symptom is the discoloration in the region lying just below and adjoining the persistent calyx. Such area gradually increases in size and turn dark brown. Later the affected area becomes soft. (Fig. 12)



Fig.12. Stilar end rot

Control: Spray copper oxychloride (0.3%) or bavistin or topsin M(0.1%) at 15 days interval during fruiting. However care should be taken that no spraying is done 15 days prior to harvesting.

10. Soft watery rot (*Botryodiplodia theobromae* Pat)

Symptoms

The infection starts as a brownish discoloration mostly at the stem end and it gradually proceeds downwards in an irregular wavy manner. Finally the whole fruit may get involved. (Fig 13.)



Fig. 13 Soft watery rot

Control

- (i) Ensure careful handling in order to reduce the incidence of wounding
- (ii) Captan and homeopathic drug arsenic oxide are found effective against the fungus
- (iii) Applications of *Bacillus subtilis* and *Streptosporangium pseudovulgare* on guava fruits have been found effective.

11. Botryosphaeria rot (*Botryosphaeria ribis* Gross. & Duggar)

Symptoms

The infection usually occurs at or near the distal end in the region of persistent calyx. The rot begins with a translucent zone around the distal end that becomes brown in colour. (Fig. 14)



Fig. 14. Botryosphaeria rot

Control: Orchard sprays with copper oxychloride (0.3%)/ or dithane M 45 (0.2%) at 15 days interval.

12. Hyaloderma leaf spot (*Hyaloderma* sp.)

Symptoms:

The fungus preferentially infects mature leaves during wet weather. In the more advanced stage, when the conditions are highly favourable, the disease can cause a severe spot on the leaves around the middle lamina. Under humid conditions, it is common to see the brick red colour spots (Fig. 15 & 16).



Fig. 15. Hyaloderma leaf spot (lower surface)

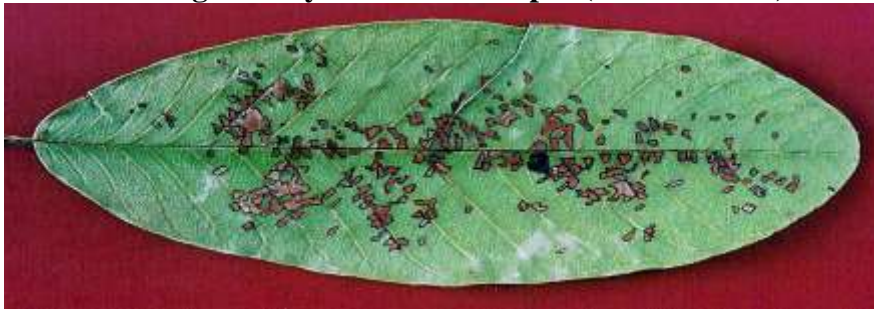


Fig. 16 Hyaloderma leaf spot (upper surface)

Control: The diseases could be managed with copper oxychloride (0.3%) spray during rainy season.

B. INSECT PESTS

13. Fruit Fly: *Bactrocera cucurbitae*, *B. correcta*, *B. diversus*, *B. dorsalis*, and *B. zonata*.

The fruit fly is the most destructive insect in the production of guava, particularly during rainy season. Guava fruits are attacked by a number of fruit flies. The main species, infesting guava in north India, have been identified as *B. correctus* and *B. Zonatus*. (Fig.17 to 18).



Fig. 17. Fruit fly with ovipositional damage



Fig 18. Fruit flies attracted to drop of pheromone



Fig. 19. Fruit fly pheromone trap larvae.



Fig. 20. Fruit infested with fruit fly

Management

- To check the carryover of the pest, collect and destroy fallen and infested fruits along with fruit fly maggots.
- Tillage of tree basin also helps in checking the pest population as the pupae and hibernating larvae are destroyed by natural enemies.
- Hanging of methyl eugenol bottle traps (containing 100 ml solution of 0.1% methyl eugenol & 0.1% malathion) is highly effective in controlling the pests (Fig.19 & 20). It is also helpful in early detection of this pests and monitoring of its population. Ten such traps may be hanged in a hectare at a height of 5-6 ft, well before the ripening of fruits. If mango orchard is in the vicinity, traps should

be hanged form the second week of April. The solution may be changed at weekly intervals.

14. Bark- Eating Caterpillar [*Indarbela tetraonis* Moore and *I. quadrinotata* (Walker)]

Symptoms: The presence of irregular tunnels and patches covered with silken web consisting of excreta and chewed up wood particles on the shoots, branches, stem and main trunk (Fig.21). Shelter holes may also be seen particularly at the joints of shoots and branches. (Fig.22).



Fig. 21 Damage of bark eating caterpillar on trunk



Fig. 22. Infestation of bark eating caterpillar on twigs.

Management:

- Keep the orchard clean and healthy to prevent the infestation of this pest.
- Detect early infestation by periodically looking out for drying young shoots.
- Kill the caterpillars mechanically by inserting the iron spike in shelter holes made by these borers at early stages of infestation.
- In case of severe infestation, remove the webs and insert the swab of cotton wool soaked in 0.05 per cent dichlorovos or inject water emulsion of 0.05 per cent chlorpyriphos and plug the holes with mud.

15. Fruit borers

(i) **Pomegranate butterfly:** [*Deudorix (Virachola) isocrates* (Fab)] & (ii) **Castor capsule borer:** [*D. punctiferalis* (Guenee)]

Symptoms: The affected fruits are generally deformed at the point of entry of larvae. Larval faeces may be seen exuding out of the borer hole (Fig. 23 to 27). Such fruits weaken, rot and drop down.



Fig.23 Fruits damaged by *D. isocrates*



Fig 24. Larva (*D. isocrates*) inside the damaged fruits



Fig. 25 Mature larvae of *D. isocrates*



Fig. 26. Mature larvae of *D. punctiferalis*



Fig. 27. Fruits damaged by *D. punctiferalis*

Management:

- Cultivation of pomegranate should be discouraged close to guava as this is the most preferred host of this pest.
- Regular collection of infested fruits and their destruction to check the further spread and carryover the population.
- To prevent the infestation of pest, spray carbaryl (0.2%) or ethopropox (0.05%) at the beginning of fruiting season and before ripening of fruits. At least 15 days waiting period should be observed before beginning of harvest. The spray may be repeated at fortnightly intervals depending on severity of attack.

16. Coccids (*Chloropulvinaria psidii*, *Drosicha mangiferae*, *Ferisia virgata*, *Hemiaspidioproctus cineris* and *Nipaecoccus viridis*, *Planococcus citrii*, *Saisetia oleae*, *S. coffeae*).

F. virgata occasionally appears in large numbers particularly on young plants. The adults are conspicuous, secreting white, glossy threads of wax encircling the body. Body is covered with waxy powder. (Fig. 28).

Symptoms:

Excessive de sapping results in yellowing, withering, drying and shedding of leaves; drying of young shoots and dropping of affected fruits. Secondary infection of sooty mould takes place on honeydew, excreted by these insects, hindering the photosynthetic activity of the plant.



Fig. 28. Infestation of mealy bug *D. mangiferae* on leaf



Fig. 29. Infestation of mango mealy bug on fruits

Management:

- The affected leaves and young shoots may be pruned and destroyed along with the pest in early fruiting of non-fruiting season. It helps in bringing down the initial pest population and prevents further spread.
- Overlapping and overcrowding branches may also be pruned to check spread of these pests in the orchards.
- In case of heavy infestation of *F. virgata*, spray of 0.045 per cent dimethoate in early fruiting season or non-fruiting season is suggested. Spray may be repeated at fortnightly intervals depending on the severity of attack.
- For prevention and control of mango mealy bug, (*D. mangiferae*) alkathene banding (400 gauge 25 cm wide) may be tied with the help of thread on tree trunk. In case of heavy infestation, 1.5 per cent chlorpyrifos dust @ 250 gm/tree may be applied by raking the soil round the tree trunk. This may be done particularly when guava orchards are located in the vicinity of mango orchards.

IPM ON AONLA PESTS

A. DISEASES

1. Rust (*Ravenelia emblicae* Syd, *Phakopsora phyllanthi* Diet)

Symptoms

Black pustules appear which later develop in a ring. The pustules join together and cover big area of the fruit. On leaves, pinkish brown pustules develop which may be arranged in group or scattered as infection of fruit does not go on leaves and vice-versa.(Fig 1 & 2).



Fig. 1 Rust on fruits

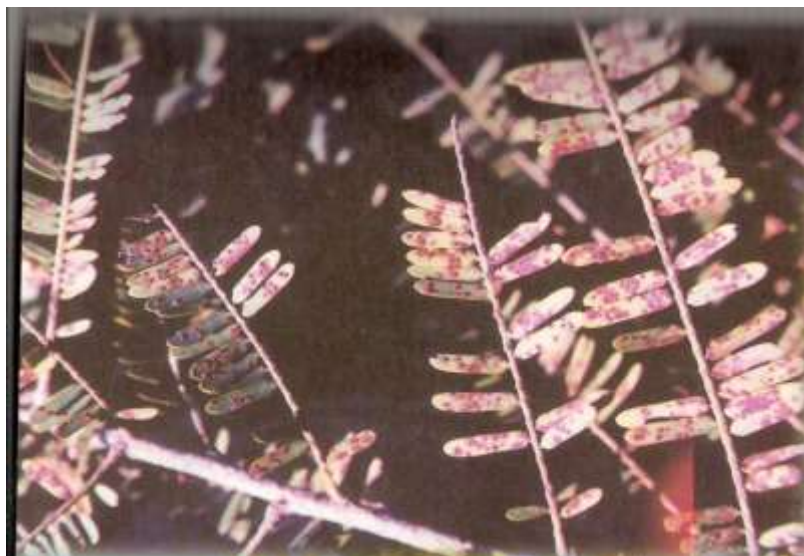


Fig 2. Rust on leaves

Management

- Three sprays of wettable sulphur (0.4%) of Dithane- Z-78 (0.2%) at an interval of one month from July.

2. Wilt / (Frost injury)

Symptoms

Large number of plants shows cracking, bark splitting, defoliation and wilting symptoms. The main reason for wilting though was attributed due to frost injury, but association of *Fusarium* sp. was also found. (Fig 3 & 4)



Fig. 3 Wilted remnant part of aonla tree



Fig 4. Bark cracking and splitting in wilting plants

Management

- During winter (November to January) young plants should be covered with sufficient irrigation which protects plants from the frost injury.
- Mulching with available organic waste/black polythene.
- Cow dung pasting on tree trunk have been found quite effective in minimizing the frost injury.

3. Sooty mould (*Capnodium* sp.)

Symptoms

Sooty mould causes velvety covering of black fungal growth on the surface of leaves, twigs and flower. These are restricted only to the surface and do not penetrate into leaves (Fig 5).

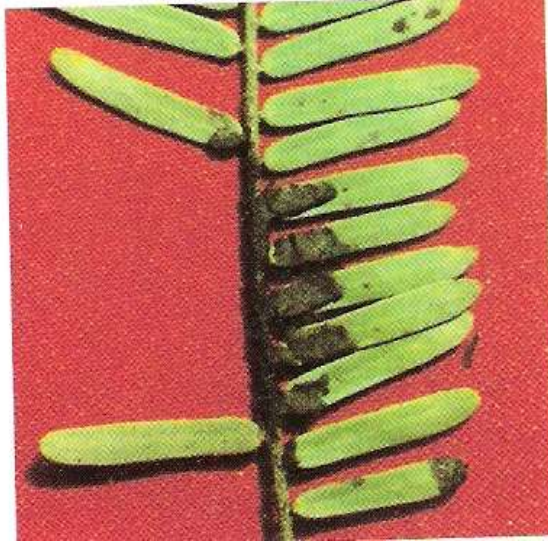


Fig 5. Sooty mould infection on leaves

Management

- Spray starch @2%, monocrotophos @0.05% and wettable sulphur @0.2% can be mixed in starch if infection is more.

4. Lichen: [*Strigula elegans* (Fee.) Mull. Arg.]

Lichens are found on the surface of trunk of the grown up trees. It is seen in the form of whitish, pinkish, superficial patches of different shapes on the main trunk and branches of the tree (Fig 6).



Fig. 6. Lichen on tree trunk

Management

- Gunny rubbing, followed by spraying of trunk and branches with commercial caustic soda (1%) before on set of rains.

5. Blue mould [*Penicillium citrinum*]

Symptoms

It causes brown patches and water-soaked areas on the fruit surface. As the disease progresses, three different types of colours develop in succession, i.e., first bright yellow, then purple-brown and finally bluish green. There is exudation of drops of yellowish liquid on the fruit surface. (Fig 7 & 8).



Fig 7. Blue mould infection on transit fruits of aonla



Fig. 8. Blue mould infected fruit

Management

- Careful handling of fruits. Any injury on the fruit surface during harvesting and storage make the aonla fruits prone to blue mould
- Avoid bruising or injury to fruits while harvesting.
- Sanitary conditions in storage should be maintained.
- Treatment of fruits with borax or sodium chloride checks the blue mould infection.
- Treatment with carbendazim or thiophanate methyl 0.1% after harvest.
- Fruits smeared with mentha oil, checks the rot.

6. Anthracnose: [*Colletotrichum gloeosporioides* state of *Glomerella cingulata* (Ston.) Spauld and Schrenk.]

Symptoms

Initial symptom of the disease is in the form of minute, circular, brown to grey spots with yellowish margin on leaflets. On fruits, the depressed lesions are formed, which later turn dark in the centre (Fig 9 & 10).



Fig. 9. Anthracnose on leaves

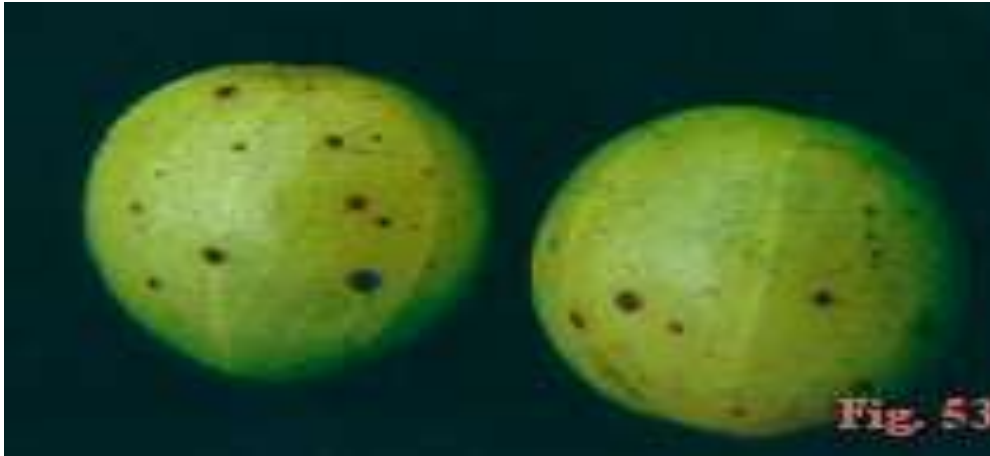


Fig. 10. Anthracnose on fruits

Management

- Sanitation of orchard
- Discard affected fruits from the orchard
- Spray carbendazim (0.1%) before harvesting of fruits.

7. Soft rot: [*Phomopsis phyllanthi* Punith]

Symptoms

Smoke brown to black round lesions develop within 2-3 days of infection. The diseased parts later show olive brown discoloration with water soaked areas and cover the whole fruit within 8 days. (Fig 11 & 12).



Fig. 11. Soft rot disease on fruits



Fig. 12. Close up of soft rot disease on fruits

Management

- Spray Difolatan (0.15%) or Dithane M-45 or Bavistin (0.1%) just before the harvest are found effective in controlling the rot.
- Avoid injury to fruits while harvesting.

8. Black Soft Rot (*Syncephalastrum racemosum*)

Symptoms:

Black Soft rot was noticed on harvested and stored ($20 \pm 5^{\circ}\text{C}$ and $65 \pm 5\%$ relative humidity) fruits. These fruits had numerous, minute brown necrotic lesions showing white mycelial growth. The rotted surface was covered with a black, powdery layer of spores (Fig.13)



Fig. 13. Black Soft Rot

Management

- Avoid fruit injury, during harvesting.
- Discard affected fruits from the orchard.
- Spray Dithane M-45 (0.2%) or carbendazim (0.1%) during fruiting season.

9. Internal necrosis (Physiological)

Symptoms

The symptom starts with the browning of the innermost part of mesocarpic tissue at the time of endocarp hardening and extends towards the epicarp resulting into brownish black appearance of the flesh. In case of severe incidence, these black spots become corky and gummy pockets develop (Fig 14).

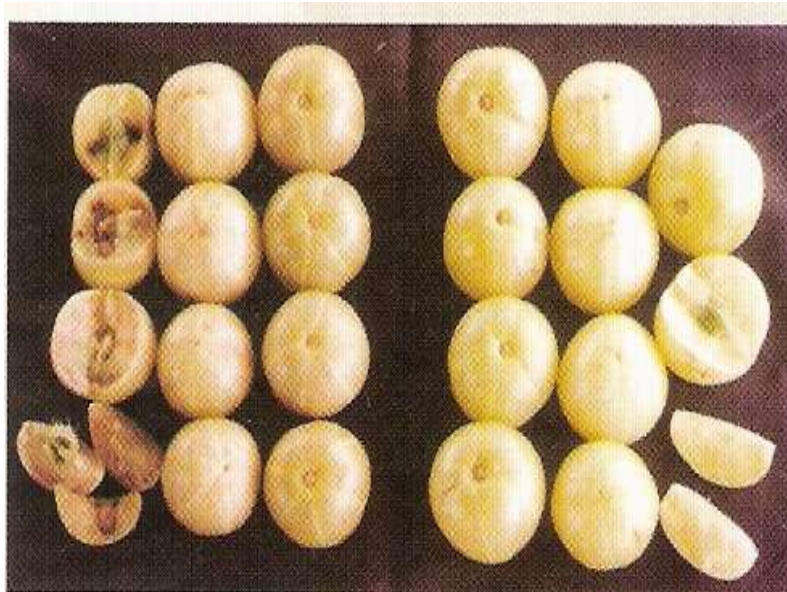


Fig. 14. Internal necrosis

Management

- Combined spray of zinc sulphate (0.4%) + copper sulphate (0.4%) and borax (0.4%) during September-October has been found effective.
- Spray of 0.5 to 0.6% borax in the month of September-October.
- Resistant cvs like Chakaiya, NA6 & NA-7 should be planted.

INSECTS

10. Bark-eating caterpillar: [*Indarbela tetraonis* (Moore)]

Symptoms

It is identified by the presence of irregular tunnels and patches covered with silken-web consisting of excreta and chewed up wood particles, on the shoots, branches, and trunk. (Fig 15.).

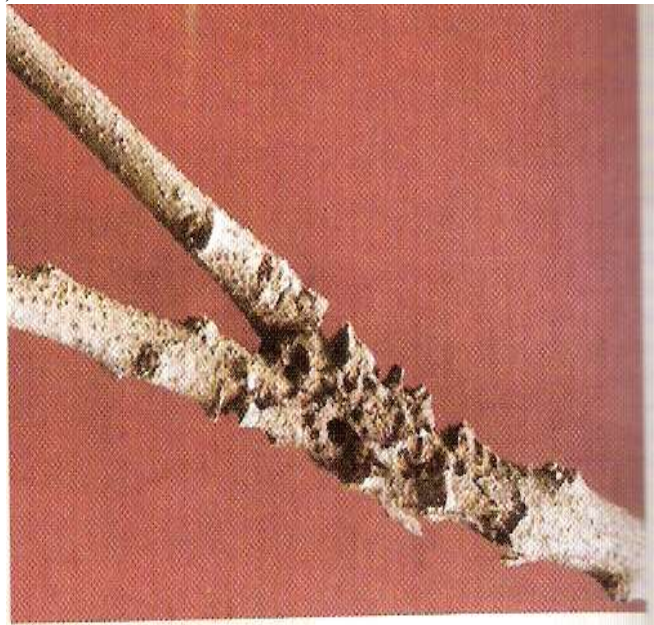


Fig. 15. Shoot damaged by bark eating caterpillar

Management

- Keep the orchards clean and healthy to prevent the infestation of this pest.
- Detect early infestation by periodically looking out for drying young shoots.
- Kill the caterpillars mechanically by inserting the iron spike in shelter holes made by these borers at early stage of infestation.
- In case of severe infestation, remove webs and insert swab of cotton wool soaked in 0.025% dichlorvos or inject water emulsion of or chlorpyrifos (0.05%) and plug the holes.
- The larvae are parasitized by entomogenous fungus *Beauveria bassiana* in nature. It can be used as a potential bio-control agent.

11. Shoot gall maker: [*Betousa stylophora* (Swinhoe)]

Symptoms

In the beginning of the infestation terminal shoots swell, which increases in size with the passage of time. Full size galls can be seen in the month of October-November (Fig 16).



Fig. 16. Nursery plants infested with shoot gall maker

Management

- Over crowding of branches should be discouraged. Galled shoots should be pruned and destroyed along with the pest after harvest.
- In case of regular occurrence of this pest, spray Dimethoate (0.05%) in the beginning of the season. It may be repeated at fortnightly intervals, if needed.

12. Pomegranate butterfly: [*Deudorix (Virachola) isocrates* (Fabr.)]

Symptoms

Affected fruits are generally deformed at the point of entry of larvae. Frass may be seen exuding out of the borer hole. Such fruits weaken, rot and the fell down before maturation. (Fig. 17.)



Fig 17. Damaged by Pomegranate butterfly

Management

- Cultivation of pomegranate and guava should be discouraged close to aonla plantation as these are major host plants of this pest.
- Infested fruits should be identified, collected and destroyed to prevent further spread of infestation.
- Spray Dimethoate (0.04%) or carbaryl (0.2%) at pea size stage of aonla fruits. The spray may be repeated after two weeks, depending upon the intensity of attack.
- Release of *T. chilonis* @2.5 lakhs/ha four times at 10 days interval.

13. Mealy bug: [*Nipaecoccus viridis* (Newstead), *N. vestator* (Newstead)]

Symptoms

The attacked new shoots are found bending and twisting with yellowing of leaves. In case of severe infestation, twigs become leafless and dry. Excessive excretion of honeydew is noticed. Flowers dry up and drop (Fig.18)



Fig 18. Infestation of mealy bug on inflorescences.

Management

- Clean cultivation and maintenance of health and vigour of the tree.
- Prune affected parts and destroy them at early stages of infestation.
- In case of severe infestation spray monocrotophos (0.05%) or quinalphos (0.05%).

14. Aonla aphids: [*Cerciaphis emblica* (Patel & Kulkarny), *Schoutedonia emblica* (Patel & Kulkarny) and *Setaphis bougainvillea*. (Thunberg)].

Symptoms

The infested leaves turn yellow and dry up. Infested shoots appear bended and twisted at the growing points. Presence of ants also indicates the infestation of aphids. The new shoots are infested at growing points. (Fig. 19)



Fig 19. Foliage infested by aphid

Management

- Clipping off and destruction of affected leaf and shoot and spray dimethoate (0.06%).

15. Leaf rollers: [*Garcillaria acidula* and *Tonica (Psorosticha) zizophy* Stainton]

Symptoms

The infestation may be identified by webbing of leaves, their withering and dropping. The adults of these insects are miniature moths. Larvae of these moths bind the leaves together and feed therein. In case of heavy incidence leaves dry and drop leading to drying of twig also (Fig 20).



Fig. 20. Damage by leaf roller

Management

- Avoid overcrowding of branches and maintain sanitation in the orchard.
- Rolled leaves may be clipped off and destroyed along with the larvae in the beginning of infestation.
- In case of heavy incidence, spray carbaryl (0.2%) or quinalphos (0.05%) or endosulfan (0.07%)

16. Stone borer: [*Curculio* sp.]

Symptoms

Externally the ovipositional site appears as small brown patch on the fruit. The infested fruits may also be identified by the presence of exit hole. Larva after hatching travels through the mesocarp, reaches to stone, enters inside it and feed there on seeds, destroying them completely (Fig 21 & 22).



Fig. 21. Fruit damage by stone weevil



Fig. 22. Seed damage by weevil

Management

- Deep ploughing of the orchards after harvesting exposes the diapausing larvae and is effective in brining down the pest population.
- First spray of 0.2% carbaryl or 0.05% quinalphos or 0.07% endosulfan at pea size of fruit. Second spray may be done at fortnightly interval with changed insecticide, if needed.

17. Fruit midge: [*Clinodiplosis* sp.]

Symptoms

Incidence of this pest occurs in the fruiting season in aonla from September to January. Adults are seen on wings in the months of September-October and are miniature flies. The eggs are laid inside the fruits. Larvae after hatching feed on the content of the fruits. (Fig 23).



Fig. 23. Infestation by fruit midge

Management

- Deep ploughing of the orchards after harvesting exposes the diapausing larvae and is effective in bringing down the pest population.
- Spray of carbaryl (0.2%) or monocrotophos (0.04%) or qinalphos (0.05%) at the beginning of the fruiting.

IPM ON BANANA

1. Rhizome (corm) weevil (*Cosmopolites sordidus* Germar)

The grubs feed on rhizome while the adult weevils feed on the pseudo-stem. The eggs are laid singly at the collar region (above ground or on rhizomes under ground). After hatching, the grubs bore into the rhizome by making tunnels where pupation occurs. The plants become weak, eventually rot and collapse in monsoon (Fig 1 & 2).



Fig. 1 Weevil infested banana pseudo stem



Fig. 2 Banana suckers infested by weevil

Management

- Weed free cultivation is essential to avoid the spread of corm weevils.
- Use healthy, uninfected sucker or rhizomes for planting. Wash the suckers and dip in a solution of Chlorpyrifos 20 EC @ 2.5 ml/l before planting. Follow clean cultural practices and maintain sanitation in the orchard.
- Soil application of carbofuron @ 20g/plant during 3rd, 5th & 7th month after planting.
- In case of post-planting infestation, spray the pseudostem and drench around the base of the tree with Chlorpyrifos 20 EC @ 2.5 ml/l. After one week spray and drench with Malathion 50 EC @ 2 ml/l.
- Cut the banana plant after harvest at the ground level and treat it with carbaryl (1g/liter) or chlorpyrifos (2.5 ml/lit) at the cut surface.
- Monitor the weevil activity in a garden by keeping longitudinal banana pseudostem traps @ 25-40/ ha. If any weevil is attracted to the laid traps, place longitudinal split banana traps @ 100 ha with bio control agents like entomopathogenic fungus *Beauveria bassiana* or entomopathogenic nematode, *Heterorhabditis indica* @ 20 g/trap. These bio control agents have to be swabbed on the cut surface of the stem traps and keep the cut surface facing the ground.

- Keep pheromone (cosmolure) trap @ 5 traps / ha. The position of traps should be changed once in a month.

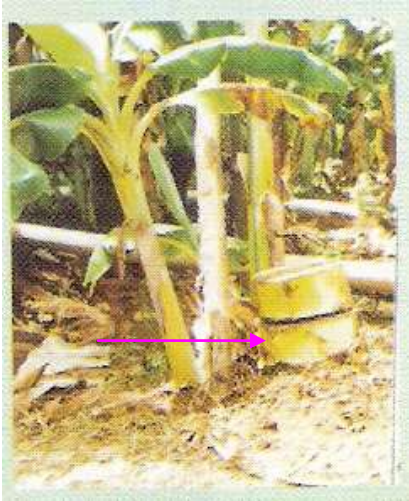


Fig. 3 & 4 Monitoring of weevil on cut pseudo stem

Fig. 5. Dead weevil due to Beauveria bassiana

2. Pseudo stem borer (*Odoiporus longicollis* Olivier)

Jelly exudation on the banana stem indicates the weevil and grub activity inside the stem. This is the early symptoms of the weevil attack. Due to grub feeding the pseudo stem becomes hollow and break at the apical region due to gush of wind (Fig 6 & 7)



Fig. 6 Weevil and grubs in leaf sheath



Fig. 7. Weevil infested banana plant

Management

- Follow clean cultivation practices. In case of severe infestation uproot and burn the plants.
- Swab the cut surface of the longitudinal split traps with 20 g of the formulation either entomopathogenic fungus, *Beauveria bassiana*, *Matarhizium anisopliae* or

- entomopathogenic nematode, *Heterorhabditis indica* and keep the split traps near the banana plant facing cut surface to soil(Fig. 8 & 9)
- Spray Chlorpyrifos 20 EC 2.5 ml/l + 1 ml wetting agent or Azadirachtin (5 ml/litre) for two or three times at three weekly intervals.
 - If infestation is noticed after 7 months of planting, stem injection is the only way to control. Inject Monocrotophos (150 ml/350 ml water) solution @ 2ml/plant or Dichlorvos (0.25%) in the opposite direction one at two feet height and other one at 4 feet above ground level at 30 degree angle on either side of the plant.
 - No injection should be given after flowering.
 - Injection needle should reach only to 2 or 3 leaf sheath depth without touching the central core into the bored hole.
 - After the harvest of banana bunch, cut the tree at the base and treat it with 100 ml carbaryl (2 g/ litre).
 - Monitor the banana weevil activity in a garden by keeping banana stem traps
 - i) Longitudinal split trap (30 cm),
 - ii) Disc-on-stump trap at the rate of 10-15 traps /ha.
 - Avoid matocking (Leaving the plant after bunch harvest for recycling of nutrients) in weevil endemic area.
 - After harvesting, the pseudo stem has to be cut into 30 cm length bits and use it as a trap for weevil collection, instead of keeping it in heaps.



Fig. 8 B. bassiana on split banana stem for control of weevil



Fig. 9. Entomopathogenic nematode controlling weevil

3. Banana aphid (*Pentalonia nigronervosa*)

The aphids are persistent vectors of bunchy top disease. The aphids congregate below the leaf base and their direct damage is fairly less. Severe infestation results in progressive leaf dwarfing and curling reduced bunch size and distorted fruits.

Management

- Rogue out the virus-affected plants before spraying.
- Spray Dimethoate 30 EC@ 2ml/l or Oxy-demeton methyl 25 EC @ 2ml/l at fortnightly intervals.

4. Leaf eating caterpillars

Hairy caterpillar, *Pericallia ricini* (Fabricius), *Asuraila* Moore, *Cretonotus gangis* Linn, *Diacrisia oblique* (Walker), *Euproctis fraterna* Moore, *Eupterote geminata* Walker cause considerable injury to the leaves. Leaf rollers, bag worms, slug caterpillars and tobacco caterpillar (*Spodoptera litura* Fab.) are some of the minor lepidopterous pest feeding on banana leaves.

Management

- Hand picking and mechanical destruction of caterpillars in early stage of attack.
- In case of sever infestation; spray Endosulfan 35 EC @ 2ml/l or Carbaryl 50 WP @ 4g/l.
- Remove and destroy the rolled leaves with larvae and pupae of leaf rollers.

5. Flea beetles (Fruit / leaf scaring beetle): *Nodostoma sabcostatum*, *N. viridipennis*, *Colapis hypochlora*

The beetles feed on tender unfolded leaves and fruits and remain hidden under unfolded leaves. The leaves of central whirl are worst affected. The beetles scratch epicarp of the tender fruits, blemish them and render unmarketable.

- Follow clean cultivation and sanitation in the orchards.
- Spray Endosulfan (0.05%) or carbaryl (0.1%) during April-September coinciding with emergence of new growth.
- Repeat spray at fortnightly interval if required.
- Stop spraying 15 days before bunch harvesting.

6. Burrowing nematode (*Radopholus similis*)

Symptom

The infected banana plants show yellowing initially which later on appear stunted as the populations increase. Later, the nematodes enter into the rhizomes also and are transmitted to healthy field. Severe infestation cause root decay and at the time of fruit bearing, the plants collapse even with slight winds.

Management:

A: Cultural methods:

1. Fallowing for three months after banana harvest effectively suppressed the burrowing nematode population, while flood fallowing for five months destroyed not only burrowing nematode but also *Fusarium* sp.
2. Oil cakes of Neem, Mahua, Castor, Karanji etc. have shown special potential in reducing the nematodes.
3. Application of neem cake @ 400 g/plant one at planting and second after four months reduced the population of *R. similes* and increased the bunch weight.

4. Crop rotation with paddy, sugarcane, green gram, cotton or turmeric suppressed the nematode population and increased the yield.
5. Leaf extracts of *Glyricidia maculate*, *Ricinus communis*, *Crotalaria juncea*, *Glycosmis pentaphylla*, *Azadiracta indica*, *Kalanchoe pinnata*, *Piper betle* and *Moringa oleifera* were lethal to *R. similes*.
6. Inter-cropping of banana with *Crotalaria juncea* was found to reduce *R. similes* with better growth and yield of banana in India.

B. Physical methods

1. Paring the planting material by trimming away necrotic lesions and immersing it in hot water at 50-55⁰ C for 30 minutes were effective to render the planting material nematode free.

C. Biocontrol methods

1. The promising biological agents such as *Paecilomyces lilacinus*, VA mycorrhiza, *Glomus fasciculatum* and bacterium, *Pasteuria penetrans* are effective in reducing nematode population in soil and root.
2. Application of neem cake @ 500 g with *G. mosseae* per plant was found to be most effective in reducing the nematode population both in soil and roots of banana.

6. Root-knot nematode (*Meloidogyne incognita* & *M. Javanica*)

Symptoms: The root-knot nematodes are root parasites typically cause root galls on the feeder roots, affecting the uptake of nutrition and water. The above ground symptoms are stunting of the plant with yellow foliage often mistaken for nutrient deficiency symptoms.

Management

- Use of nematode free suckers at planting.
- Apply 2 kg of farm yard manure enriched with biopesticide *T. harzianum* and *P. lilacinus* at the time of planting and afterward apply 6 more times the same dosage of bio-agent enriched manure at 6 months interval.
- For a standing crop also apply 2 kg of farmyard manure enriched with biopesticide. *T. harzianum* and *P. lilacinus* to be repeated 6 monthly intervals.
- Apply Carbofuran 3G @ 25 g/pit in the field at the start of the monsoon rains.
- The treatment of suckers either by using hot water or chemical before planting as suggested for the control of *R. similes*.

7. Root Lesion Nematode: (*Pratylenchus coffeae*)

Symptom: It is commonly associated with plantain and cooking bananas. The uprooting, root lesions and rhizome discolouration in caused by *Pratylenchus* spp. are indistinguishable from those caused by *R. similes*.

Management

1. Since both *P. coffeae* and *R. similes* have similar life cycles, feeding habits as well as symptoms produced on roots, control measures suggested for *R. similes* may be followed for *P. coffeae* except in varietal resistance.
2. Application of carbofuran @ 50 g/plant one at the time of planting and two applications at 3 months intervals in cv. Nendran was found to be very effective in reducing the nematode population.

8. Spiral Nematode (*Helicotylenchus multincinctus* & *H. dihystra*)

Symptom: It causes lesions on root surfaces and destruction of small feeder roots. Since the nematode penetrates only the first few layers of cortical cells, a longitudinal section of an infected root will reveal mainly superficial damage. In contrast to *R. similes*, which cause deep lesions, *H. multincinctus* does not enter corms, although it may be transmitted in bits of root material attached to planting pieces.

Management

- Nematode-free sites and planting materials are required for control of *H. multincinctus* and many control measure mentioned for *R. similes* apply to spiral nematode as well.
- Since it is confined to roots, planting pieces may be cleaned by paring off any root stubble attached to the corms.
- Hot water treatment of planting pieces to control *H. multincinctus* (50-55⁰ C for 7-8 min.) is less severe than that recommended for *R. similes*, because the spiral nematodes does not penetrated the corms.

9. Sigatoka Leaf Spot Disease (*Mycosphaella fijiensis*, *M. musicola* & *M. eumusae*)

Symptoms: Initially pale yellow specks appears on the upper leaf surface, these streaks lengthen to yellow streaks and enlarge into mature spots. The centre of the spots becomes brown with a yellow halo. Spotting is common along the margins and at the apex of the leaf with elliptical in shape (Fig 10). Normally 15-18 (functional) leaves are necessary at the time of flowering for bunch development, but due to Sigatoka leaf spot it is difficult to maintain even 10 leaves.



Fig. 10. Sigatoka leaf spot

Management

- Banana orchard must be kept weed free.
- Suckers should be removed in time.
- The drainage system should be proper; water logging will increase the humidity which favours infection.
- Dried hanging leaves with spots, fallen leaves, and leaves with more than 75 percent spots should be removed and buried in the soil or destroyed by burning or dumped in manure pits.
- Fungicides can be sprayed to control Sigatoka disease. The type of fungicides and interval of spray may vary depending upon variety and locations. The spray schedule should be adjusted accordingly.
- Spray should be taken up when minute yellow specks are visible on the leaf. The field should be clean, dried affected leaves should be removed before spraying. Contact fungicides such as Mancozeb (0.25%) and chlorothalonil (0.2%) or Carbendazim (0.1%) or Propiconazole (0.1%) or Hexaconazole (0.1%) can be sprayed with teepol (sticking agent).
- Continuous use of same systemic fungicide will cause resistance or tolerance in pathogenic population. Hence alternate spray of systemic and contact fungicides at 7-10 days intervals can minimize the risk of development of resistance in pathogens.
- Other minor leaf spots such as Cordana, Septoria, freckle and eyespot are not found to cause economic damage. The fungicide sprayed for Sigatoka can control other minor leaf spot pathogens too.

9. Panama wilt (*Fusarium oxysporum* f.sp.*cubense*)

Symptom: The earliest signs of the disease are faint yellow streaks in the petioles of oldest lower most leaf. Two types of symptoms follow this stage. In the yellowing type there is progressive yellowing of the old leaves and eventual collapse at the petiole. In

the non yellowing type, the leaf collapses at the petiole without leaf chlorosis. The pseudostem often shows more or less conspicuous longitudinal splitting of the outer leaf sheath from its outer covering.

Management

- Restricting the movement of infected suckers to clean or non infested areas.
- Growing of paddy or sugarcane once or twice followed by banana for 2-3 cycles.
- Sanitation by immediate removal of diseased plants with surrounding soil from the field.
- Cleaning of implements used in after planting the infested field before using it in other non infested field to prevent the spread of inoculums to other areas.
- Planting of healthy suckers extracted from healthy plantation.
- Care during cultivation to avoid root injury and control of nematodes.
- Application of powder formulation of bioagents such as *Trichoderma spp.*, *Pseudomonas fluorescens* and *Bacillus subtilis* @ 15 gms for 4 times once at time of planting in the planting pits and remaining doses at 3rd 5th and 7th months after planting around the plants.
- Pairing (removal of roots and outer skin of corms) and dipping the suckers for 30 minutes in Solution containing carbendazim (2g/litre) and 0.05% monocrotophos (14 ml/lit.) prior to planting followed by drenching at bimonthly intervals starting from 5 months after planting or injection of corm with 3 ml of 2% carbendazim solution (20 g/lit) or embedding 50 mg of carbendazim in a capsule in corm at 5th, 7th and 9th month after planting is useful.
- Among the organic amendments tested neem cake (*Azadirachta indica*) at 250 kg/ha was the most effective treatment.
- Providing good draining facilities during rainy season.

10. Anthracnose (*Colletotrichum musae* (Berk. & Curt.) v. Arx)

Symptoms: Infection appears as small black circular streaks on the flowers, skin and distal ends of banana heads. On ripening, the fruit develop typical numerous small dark circular spots which enlarge, coalesce and become sunken.

Management

- Sanitation of plantation and packing house to minimize the inoculum load is necessary in order to check the disease.
- Correct stage of harvest and minimizing the injuries to fruit during harvest is also necessary.
- Adopting good cultural practices including removal of dead leaves from plants, refrigeration of fruits and transporting fruits in polyethylene bags.
- Pre harvest field spraying of Prochloraz (0.15%) or Chlorothalonil (0.2%) or carbendazim / Bitertanol/ Thiophenate methyl / Calixin// Rovral (2g/litre) in humid weather was found to be quite effective at 15 days interval.

11. Rhizome rot/ head rot/ tipover: Bacterial soft rot (*Erwinia carotovora*)

Symptoms: Generally the disease attack the young plants and causes rotting leading to poor establishment mostly in Cavandish (AA) and diploid (AA) group of banana. It occurs in severe form in high rainfall areas and also in alluvial soils. Decayed rhizome develops dark brown water soaked cavities like root borer tunnels.

Management:

- Good drainage, adequate phytosanitary measures, use of disease free planting stocks, good soil aeration and cultural operations help in controlling the disease.
- Drenching the soil around the plant with either bleaching powder @ 2 gm/ lit at an interval of 10-15 days found effective.

12. Banana Bract Mosaic Virus

It is known as Kokkan disease identified Banana Bract Mosaic Virus (BBMV).

Cultivars affected: Nendran, Robusta, Poovan, Ney Poovan, Rasthali, Red Banana, Monthan and Karpuravalli are affected.

Transmission: Virus is transmitted through *Aphis craccivora*, *Aphis gossypii* and *Pentalonia nigronervosa* in a non-persistent manner. The virus primarily spreads through infected suckers and tissue culture plants.

Symptoms: Presence of spindle shaped pinkish to reddish streaks on pseudostem, midrib and peduncle (Fig. 12). Typical mosaic and spindle shaped mild mosaic streaks appear on bracts, peduncle and fruits. In Nendran, the leaf orientation changes in such a way giving the appearance of ‘Travelers palm’ plants (Fig.13 & Fig.14).



Fig. 12. Reddish streaks on pseudostem and suckers (Inset)



Fig. 13. Leaf orientation like “Traveller’s palm” in Nendran



Fig 14. Typical mosaic on bract

Management

- Banana bract mosaic virus (BBMV) is wider spread in Southern States. Quarantining of this disease may play a major role in limiting the spread to other states.
- The symptom expression is more and prominent in winter period when the temperature is below 30⁰C, during this period the mother plants can be selected based on visual diagnosis for tissue culture.
- Farmers must be aware of the external symptoms and the infected plants should be cut and burnt as and when noticed.
- Detection or indexing the mother plants becomes important for tissue culture companies to assure TC plants free of virus. It is necessary to use appropriate techniques like ELISA or DIBA using highly reliable antiserum.
- Aphid Vector, *Pentalonia nigronervosa* transmits this virus. It can be controlled using systemic insecticide. Spray Neemkosol 2.5 ml per litre or monocrotophos 2 ml per litre to control the aphid vector.
- Do virus indexing before and during tissue culturing.

13. Banana streak viral

Streak virus disease has become a major threat to Poovan and other important commercial cultivars of banana. The disease was first noticed on variety “Poyo” belong to Cavendish sub group (AAA) of banana.

Transmission: Transmitted by mealy bugs, *Planococcus citri* and *Ferrisia virgata* from banana to banana (Fig.15). The primary mode of transmission is through infected suckers.

Symptoms:

Initially small dots, with golden yellow colour develop which later it extends to form long streaks. The chlorotic streaks become necrotic giving a blackish appearance on lamina (Fig. 16, 17 & 18).



Fig. 15.Mealy bug feed on the
On the base of pseudostem



Fig.16 Chlorotic gold
yellow streaks



Fig. 17. Necrotic streaks



Fig. 18. Severe Streak symptom of BSD in cv. Grand Nain

Management

- This virus disease can be effectively managed by assuring the plants free of infection by indexing plants with appropriate techniques before mass multiplication.
- The symptom expression varies with the climate and other factors. Plants maintained at 22⁰ C in a glass house will show the symptoms. Hence mother plants can be maintained in temperature controlled glass houses for two to three months to assure the virus freeness.
- Tissue culturing also triggers formation of virus from integral sequences and causes disease.

17. Bunchy Top

Causal organism: The virus is transmitted by the banana aphid, *Pentalonia nigronervosa*.

Symptoms

The leaves arise in clusters, giving a rosette appearance (Fig. 19 & 20). They are brittle with numerous dark green dots or patches with the margins rolled upward. The plants do not usually grow taller than two to three feet and they fail to put forth any fruit. Fruits of infected plants are malformed (Fig 21 &22)



Fig. 19. Bunchy top in banana



Fig. 20 Dark green dots and streaks on petiole



Fig 21. Healthy bunch of banana



Fig.22. Bunchy top infected bunch

Control:

- The only method for controlling the disease is by exclusion. Thus, strict quarantine regulations in disease-free areas may be the best means to prevent its entry.
- Systematic eradication of the diseased plants, suckers and the clumps is very essential.
- All species of banana, including edible, seedless and seeded ones are susceptible.
- Where the disease is already present, measures to check the insect vector and to plant new areas with healthy suckers may provide some control.
- The use of insecticides / biopesticides to control the aphid vector does not control effectively.
- Injection of systemic chemicals like Methyl demeton @ 0.05-0.2 ml/plant at 3-4 weeks intervals also helps in reducing the vector population considerably.
- Integrated control measures recommended against this virus disease include early detection, rouging of diseased plants after spraying to eliminate vector (aphids), replanting with virus-free material and careful cultivation.

Preventive strategies for viral diseases

- Selection and planting of disease free vigorous suckers.
- Explants used for propagation should be indexed.
- Production and supply of virus free plants to banana growers. Removal and destruction of virus-infected plants as soon as the symptoms are noticed.
- Keeping the banana field and surrounding areas weed free, as certain weeds normally harbour the viruses.
- Spraying of banana field with systematic insecticides of regular intervals to control the insect vectors.
- It is necessary to enforce legal restriction on intra state movement in order to avoid spread of new banana bract mosaic disease as it is widely prevalent in Southern States but in other States, the incidence is very minimal.

IPM/INM ON BANANA

- Application of 10kg Rice husk ash with 25g phosphobacteria/plant could save 20% NPK fertilizers, produce 29% more yield and generate additional net profit of Rs.39,250/ha., in Rasthali banana.
- Application of 0.5kg cement kiln flue dust per plant and 75 kg of alcohol distillery effluent/hectare could supplement 40% of recommended potassium and increase the yield by 25% in Ney Poovan banana with an additional net profit of Rs.31450/- per hectare.
- Longitudinal split banana stem traps (at the rate of 100/ha) swabbed with 20g of rice chaffy grains formulation of entomopathogenic fungus, *Beauveria bassiana* controls the banana stem and corm weevil infesting on banana plants.
- The technology by using 50 per cent N applied through neem cake have exhibited significant reduction in root-lesion-nematode population with increased yield in six commercial cultivars of banana.
- The technology by applying Carbofuran granules @ 40 g/plant one at planting and two applications at 3 monthly intervals after planting successfully control the *P.coffeae* population and increase the yield significantly in cvs. Nendran, Karpuravalli and Monthan.

- Identified newer nematicides Rugby 10G @ 10g / plant or Caldan 4G @ 10g / plant applied one at planting and second application after three months for the management of major nematodes infesting on banana. The cost benefit ratio worked out to be much cheaper in newer nematicide Rugby 10 G and Caldan 4G compared to Carbofuran 3G and other treatments.
- The technology by using the plant extracts of *Azadirachta indica*, *Calotropis procera*, *Datura stramonium*, *Vitex negundo* and *Crotolaria juncea* extracts showed higher nematicidal properties which found very effective in reducing the nematode population with increased yield in cvs.Rasthali and Nendran.
- The technology by using biocontrol agents *P.lilacinus* with neem cake or any one of the botanicals namely viz., *Tagetes* spp., (leaf or flower extracts) or *Solanum torvum* was developed for the management of root-knot nematode in banana.
- The technology by using distillery sludge @ 2.5 kg + vermicompost @ 1 kg + neem cake @ 1 kg + poultry manure @ 2.5 kg at 3, 5, 7 MAP in cv.Karpuravalli resulted significant reduction in nematode population with increased yield.
- The technology by using neem formulations such as nimbecidine or juerken or neewin as sucker dip treatment @ 15 ml/litre water for 30 minutes was developed for the successful management of nematodes in banana.
- Marigold (*Tagetes* spp.) plants grown as an intercrop in banana field proved to be very good to manage the banana nematodes as a trap crop and to provide an additional income to the growers.
- Soil application of *Trichoderma viride* as chaffy grain formulation @ 20g/plant at planting and two applications at two monthly interval after planting reduces up to 80% of *Fusarium* wilt disease in tissue cultured as well as sucker derived plants of banana in cv.Rasthali (Silk-AAB).
- Spraying Petroleum oil (Banole ®) @ 1% with the half the dose of any one of the fungicides (ie. propiconazole 0.05 %, companion (0.05 %) carbendazim 0.05 % + calixin 0.05%, carbendazim 0.05 and mancozeb 0.12% in order of preference) effectively reduced the Sigatoka leaf spot incidence (85% to 97%) in all the phases of banana growth.

- Dipping of fruits in water extract of *Solanum torvum* sp. @ 50% concentration effectively reduces the Anthracnose disease of banana (more than 90%) and also increases the shelf life up to 26 days.

IPM SCHEDULE FOR CITRUS PESTS

DISEASES

VIRUS AND VIRUS-LIKE DISEASES

1. Tristeza (CTV): It is caused by a phloem limited, 2000 nm long filamentous virus.

Symptoms: Five different strains of tristeza are known to exist viz. mild, seedling yellows, decline on sour orange, stem pitting on grapefruit and stem pitting on sweet orange. Sudden collapse or abrupt wilting that justifies the name 'quick decline' followed by defoliation in sweet orange, grape fruit and mandarin, on sour orange rootstocks are indicative of tristeza infection.(Fig 1-6).



Fig. 1. CTV induced quick decline of sweet orange



Fig. 2 . CTV induced mosambi leaves showing chlorosis of mid vein and lateral veins and leaf yellowing



Fig. 3. CTV induced declined mosambi plant



Fig. 4. Vein corking in mosambi



Fig 5. Leaf cupping in acidlime



Fig. 6 Stem pitting



Fig. 7 Black and brown Aphid-vector of CTV

Transmission: Tristeza can be transmitted by grafting, budding, dodder and by aphid vectors. *Toxoptera citricidus*, *T. aurantii*, *Myzus persicae* and *Aphis craccivora* are the common aphid vectors and the most efficient among these is *T. citricidus*(Fig 7).

2. Ring Spot (CRSV)

The field symptoms appear on mature leaves that include loss of pigmentation in the form of distinct rings with green tissue in the middle. The number varies from one to several per leaf. These symptoms are prominent on Kinnow mandarin, Malta orange and Kagzi lime (Fig. 8 & Fig. 9 &10).



Fig. 8. Ring spot on kinnow



Fig. 9. Malta orange



Fig. 10. Kagzilime

3. Mosaic: Yellow mosaic disease of citrus is common especially on sweet orange. The causal virus has been named as citrus yellow mosaic badnavirus group.

Symptoms: Bright yellow mottling or mosaics on the leaves of sweet orange are characteristic symptoms of infection under field conditions (Fig 11 & Fig. 13). Similar type of symptoms was also found in pummelo (Fig. 13). In acid lime, citrus mosaic virus infected leaves show light green irregular areas.



Fig. 11. Mosaic on Mosambi



Fig. 12 Yellow mottling on sathgudi orange



Fig. 13. Mosaic/ golden yellowing (Plummelo)

4. Exocortis:

Citrus trees are known to be naturally infected by 5 distinct groups of viroids. Among these, citrus exocortis viroid (CEVd) is economically the most important viroid disease and present in almost all the citrus growing regions.

Symptoms: Field symptoms range from mild bark cracking to very severe bark scaling/splitting on trifoliate and Rangpur lime rootstock accompanied by various degrees of stunting and mild to moderate decline of the tree (Fig. 14).



Fig. 13 Exocortis induced severe bark splitting on Rangpur lime rootstock

5. Witches' broom

It is one of the most recent diseases of acid lime which is seen in isolated pockets and caused by *Candidatus Phytoplasma aurantifolia*.

Symptoms: Symptoms include small chlorotic leaves with highly proliferated shoots, and shortened internodes. Leaves drop prematurely and infected branches show distorted twigs resembling characteristic witches' broom symptoms on the canopy of the infected lime or mandarin tree. (Fig 14 & 15).



Fig. 14 Symptom on canopy of acid lime **Fig. 15 Dried broom like symptom on mandarin**

6. Greening

Symptoms: The range and severity of symptoms vary with season, type and extent of infection, age and nutritional status of the trees. Greening infected citrus leaves are generally small, upright and frequently have symptoms with green veins and chlorotic interveinal areas (Fig 16 & 17).



Fig. 16 Greening symptoms in Nagpur Mandarin



Fig. 17. Leaf chlorosis



Fig. 18. Citrus psylla, vector of greening

Casual Agent: It is now known to be caused by a phloem-limited, uncultured bacterium with a cell wall of the Gram-negative type.

Management

- The control of greening disease involves removal of affected unproductive trees and their replacement by disease-free budded plants developed on improved rootstock.
- Through proper indexing programme, greening-free parent trees should be selected for bud wood.
- Regulatory (quarantine) measures should be strengthened to limit movement, sale and use of infected bud wood or nursery stock.
- Strict control of nurseries through registered disease-free certification scheme is essential to prevent the spread of disease.
- Since the disease also spreads through the vector, citrus psylla, suitable insecticide quinalphos @ 1.0 ml/litre of water should be sprayed to control its spread.
- Spraying should be done at bud burst stage of when infestation is noticed on sprouts in June-July, January-February and October-November.
- Although tetracyclines have been reported to suppress greening symptoms when applied as trunk injection, complete elimination of the pathogen is not possible by this method.

- In brief, an intensive and integrated management approach is most effective against greening disease. This includes quarantine measures, use of disease-free planting material, and reduction of inoculums by pruning of infected branches, removal of heavily infected trees and control of psylla.

INTEGRATED MANAGEMENT OF VIRAL DISEASES

The virus disease of crop plants, particularly of perennial horticultural plants, can be best managed through an integrated approach of using virus-free planting material, use of host resistance, sanitation, cultural practices, vector control and regulatory measures.

a) Use of virus-free certified planting material/Bud wood certification:

b) Sanitation:

c) Vector control

- Collecting tools like knives, secateurs etc. to be sterilized by dipping in 1-2% sodium hypochlorite solution.
- Different virus/virus like pathogens of citrus are being transmitted by various insect vector. These insect vectors should be controlled by using biological and non biological methods in order to prevent the spread of virus diseases. The non-biological methods include the use of suitable insecticidal sprays, insect traps, reflective mulches etc.
- For controlling aphids, psylla, mealybug and leaf hopper acephate @ 1.5 g/litre or monocrotophos @ 1.5 ml/litre or dimethoate @ 2 ml/litre of water should be sprayed.
- Time of application of these insecticides is also very important. For aphids spraying should be done during January-February. For psylla during March-April and for leaf hopper and mealybug spraying should be done as and when these insects are seen.
- Different biocontrol agents include parasitoids, predators and microbes. Parasitoids are host (insect) specific. The genera *Aphelinus*, *Mesidia* and *Mesidiopsis* of Aphelinidae (superfamily: Chalcidoidea) are of parasitoids of aphids, and *Tamarixia radiata* is an effective parasitoid of citrus psylla.
- Similarly different coccinellids are useful predators of aphids. Entopathogenic fungi like *verticillium lecanii* and *Paecilomyces farinosus* etc are being used commercially against *T. citricidus*, *Aphis gossypii*.

d) Cultural Practices

- Crop hygiene is a neglected area which is a major cause of mechanically transmitted disease like ring spot, mosaic and exocortis through field implements during intercultural operations, harvesting etc.
- All pruning and grafting tools should be adequately disinfected with 1-2% sodium hypochlorite, prior to any fruit picking, grafting or cutting of any tree or nursery plant to avoid spread of mechanically transmitted diseases.

e) Cross Protection

- Cross protection is the phenomenon of development of resistance against severe strain of a virus when a particular plant is previously inoculated with mild strain of the same virus.
- The most extensive use of cross protection has been in the citrus industry.
- Efforts may be taken to identify effective stable mild strain virus that can protect trees under field condition.

f) Quarantine / Regulation

- Quarantine remains the most important means of preventing the introduction of new, exotic and potentially destructive viral pathogens.
- One of the main problems of quarantine is the introduction of diseases for which indexing methods do not exist or can not be taken up due to infrastructural deficiencies.
- Importation of bud wood should be restricted to the bare minimum essential and multiple steps of therapy be undertaken before introduction.
- Strict quarantine measures and restricted movement of citrus bud wood will limit the spread of viral diseases.

7. Bacterial disease

Canker- *Xanthomonas campestris* pv. *citri* (Hasse) Dye

Symptoms: The characteristic symptom of the disease on leaves is the yellow halo that surrounds lesion. Young lesions are raised or pustular, particularly on the lower leaf surface. The pustules later became corky and crateriform, with a raised margin and a sunken centre (Fig. 19, 20 & 21).



Fig. 19. Canker on leaves

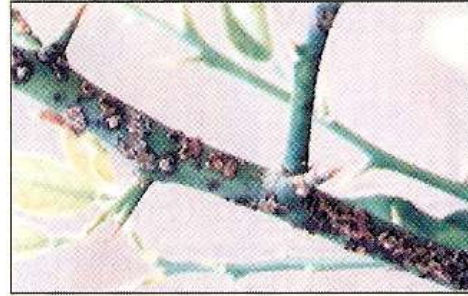


Fig. 20. Canker on twig



Fig. 21. Canker on fruit



Fig. 22. Canker spread through leaf minor

Management:

- Prevention is the only affective means of reducing the canker disease.
- Avoid leaf injury form wind blown and soil.
- Reduce wind speeds by planting of wind breaks.
- Avoid working in infected orchard when the trees are wet from dew or rain.
- Control leaf miner caused injury facilitates infection (Fig. 22).
- Thorough inspection of nursery and orchards quarantines and on-site burning of infected / pruned debris before monsoon.
- Three to four sprays of copper oxychloride (COC) 0.3% in combination with streptocycline 100 ppm at monthly interval just after the onset of monsoon.

FUNGAL DISEASES:

8. Phytophthora Diseases (*P. citrophthora*, *P.nicotianae* (= *P. parasitica*), and *P. palmivora*)

Symptoms: *Phytophthora* causes foot rot, root rot, crown rot, gummosis, leaf fall and brown rot disease in well grown orchards. Foot rot lesions develop as high as 60 cm from the ground level on the trunk. On scraping the dead bark of the lesion, a brown, discolored, slippery area can be seen. Such active lesions start oozing gum which can be seen on the trunk as brownish black oozing known as gummosis (Fig. 23 to 27).



Fig. 23. Gummosis



Fig. 24. Foot rot



Fig. 25. Root & Collar Rot



Fig. 26. Brown Rot



Fig. 27. Decline due to foot & root rot

Management

(i) Use of resistant rootstocks: Rough lemon, though highly vigorous in growth but is susceptible to *Phytophthora*. Much variability exists among the strains of rough lemon and Rangpur lime. Sour orange and Trifoliate orange are highly tolerant. However, sour orange is susceptible to tristeza virus and can be used where tristeza is not a problem.

(ii) Cultural practices: Since the pathogen is soil-borne, its complete eradication becomes difficult in field nurseries but modified cultural practices can keep diseases under control. For example:

- Seeds should be treated with fungicides before sowing.
- Seeds should be sown in trays or in raised nursery beds where water can not stand for longer period.

- Nursery site should be away from the citrus orchards and soil must be well drained.
- To avoid contamination, nursery operation equipments should be separate from the orchards equipments.
- Introduction of soil and other material infested with the pathogens should not be allowed.
- Preferably containerized nursery system should be adopted.
- Plant should be selected from *Phytophthora*-free certified nurseries and with high budding (above 9” ht.).
- The nursery soil beds should be either solarized in summer months and / or fumigated with soil fumigant like Dazomet to eliminate the chances of pathogen in it.
- While planting, care should be taken to keep bud union as high as possible so that irrigation water should not touch the scion.
- Soil should be kept well drained and flood irrigation and stagnation of water for longer period in the basin should be avoided.
- Injuries to trunk and root system by farm operation should also be avoided.
- Irrigation emitters should be placed so that the trunk is not wetted for prolonged period.
- In orchards, if old budlines or elite mother plants got infection and a considerable portion of root and collar has been destroyed by *Phytophthora*, inarching or bridge grafting with resistant rootstock can effectively rescue the affected plants. Such infected plants in the orchard can be rejuvenated for longer productive life.

(iii) Chemical control

- Copper fungicides are used as foliar spray, drenching of basins and as trunk paste to control *Phytophthora* diseases. Two sprays with drenching either by Aliette (2.5 g/l) or Ridomil MZ-72 (2.75 g/l) covering the whole plant canopy and basin of affected plant at 40 days interval after the onset of monsoon.
- Copper fungicides are effective in controlling foot and root rot and gummosis of citrus provided they should be used at correct time.
- Bordeaux paste should always be applied before onset of monsoon on tree trunk as prophylactic measure. Foot rot or gummosis affected portions should be scraped out with sharp knife taking care not to damage the wood before application of Bordeaux paste.
- Apply matalaxyl (or its isomer, mefenoxam) and fosetyl-A1
- Alternating use of both fungicides should be practiced to minimize the risk of the development of fungicide resistance.

9. Black Fly -*Aleurocanthus woglumi* Ashby (*Aleurodidae*, *Homoptera*)

Damage: Both nymphs and adults suck cell sap and secrete voluminous honeydew on which sooty mould grows wildly that leads to fungal manifestation (*Capnodium* sp.) locally called as ‘Kolshi’, covering entire plant due to which photosynthesis is affected (Fig. 28 & 29).



Fig. 28. Infested leaves



Fig. 29. Eggs and nymphs of citrus black fly

Management:

- Spray monocrotophos @ 1.5 ml or phosalone @ 1.5 ml @ of water on the lower side of leaves covering the entire tree canopy.
- After 15 days second spray should be given with any of the above insecticides or neem oil @ 10 ml/L of water.

10. Psylla (*Diaphorina citri* Kuwayama (Psyllidae; Homoptera)

Damage: Nymphs and adults in flocks of tens and hundreds suck the cell sap from young twigs, leaf and flower buds that results into heavy drop of young flush and fruits and drying of twigs. Nymph secretes honeydew on which sooty mould grows (Fig. 30 & 31).



Fig. 30 Infestation of psylla nymphs



Fig. 31. Nymphs parasitized by *T. radiate*

Management:

- Control of psylla during March-April and June-July flush is must as the pest causes severe damage.
- Collateral host like Curry leaf (*Murraya koengi*) plant should not be grown in the vicinity of citrus orchards as it may act as a breeding ground for psylla. However, the possibility of using this plant as a “trap crop” may be used.
- Spray Dimethoate 2ml/l or Imidacloprid 0.05% or quinalphos 1 ml/l of water at bud burst stage or when infestation is noticed on sprouts in Jun-Jul, Jan-Feb and Oct-Nov. If required, second spray of any of the above insecticides should be given after 15 days.
- A hymenopteran nymphal parasitoid *Tamarixia radiate* has been quite effective causing as high as 30 to 40% and even upto 90% parasitism at certain locations particularly during March-April.
- Among predators, the chrysopid *Apertochrysa crassinervis*, *Brumus suturalis* and the *Coccinellids*, *Coccinella rependox* prey upon nymphal psylla to be used for biological control.
- Release of *Mallada boninensis* in the month of February and Oct.-November.

11. Leaf Miner (*Phyllocnistis citrella* Stainton (Phyllocnistidae, Lepidoptera)

Damage: Newly emerged larva mines the under surface of the leaf in a zigzag way. Serpentine mines on the underside of leaf which are silvery in colour due to entrapped air are the characteristic symptoms (Fig. 32 and 33).



Fig. 32. Mandarin leaf having larval mines Fig. 33. Shoot affected by citrus leaf miner

Management

- i. Spray monocrotophos @ 1.5 ml or quinalphos 2 ml water at bud burst stage or as soon as infestation is noticed. Second spray should follow after 10 days.
- ii. Prune heavily infested branches destroy them and spray should be aimed at young flush only.
- iii. Parasitoids such as *Tetrastichus phyllocnistoides*, *Cirrospillus quadristriatus*, *Simpieses purpurea* and black chalcid, *Ageniaspis* sp. larvae cause about 30 to 45 and even upto 80% parasitism.

12. Lemon Butterfly (*Papilio demoleus* Linn. (Papilionidae, Lepidoptera))

Damage: The pest attacks Nagpur mandarin and acid lime plantations almost throughout the year but is serious during July-August. Larvae being the voracious feeder cause severe defoliation of plants (Fig. 34 & 35).



Fig. 34 Defoliation of shoots



Fig. 35. Egg and larval instars

Management:

- The pest can be controlled by foliar spray of any of the contact or systemic insecticides viz., dimethoate @ 1.5 ml, fenitrothion 1ml, or quinalphas 2ml/l at an early larval stage.
- Dipel (*Bacillus thuringiensis* Berl.) spray at 0.05% gives good control of the pest. Entomopathogens like bacterium *Serratia marcescens* and fungus *Fusarium* sp. also kill the pest population substantially.
- A braconid *Apanteles flavipes* and ichneumonid *Melalophacharops* sp. are the predominant larval parasitoids and a chalcid *Pteromalus puparium* and a ichneumonid *Holcojoppa coelopyga* are the major pupal parasitoids which could be utilized for effective control of the pest biologically.

13. Bark Eating Caterpillar (*Inderbela quadrinotata*, *T. tetraonis* Moore (Melarbelidae, Lepidoptera))

Damage: Infestation is seen in neglected orchards. Grubs feed on the bark portion during evenings and nights by coming out of tunnels bored at the joints of two branches. Infested plants have shortened life span and low productivity. As many as 17 tunnels were recorded on a single 8 year old tree (Fig. 36).



Fig. 36. Larvae feeding on bark

Management: Inserting a cotton wad soaked in petrol or kerosene or monocrotophos or 3-5 ml dichlorvos (1%) in tunnel and plugging it by mud and also spraying the affected portion with the same solution after clearing the larval excreta and wooden frass.

14. Mealy Bug (*Planococcus citri* Risso (Pseudococcidae, Homoptera)

Damage: The leaves and tender shoots get deformed and twisted into knots and loops. It feeds at stem ends of fruits and often causes heavy fruit drop. Clusters of white formations of bug are found at the joints of twigs (Fig. 37). It also excretes honeydew which invites sooty mould.



Fig. 37 Twig and fruit infested by mealy bug



Fig. 38. Mealy bug attacked by *M. boninensis*



Fig. 39. Citrus mealy bug

Management:

- Chemical control of the pest includes spraying of dimethoate 150 ml+ kerosene oil 250 ml in 100 litres of water or malathion 20 ml in 10 litres of water.
- Use of nymphal and adult parasitoid *Leptomastix dactylopii* and the predators the coccinellid *Cryptolaemus montrouzieri* and the chrysopid *Mallada boninensis* (Fig. 38 & 39).

15. Aphids (*Toxoptera citricida* Kirkaldy and *T. aurantii* (B.d.F) (Aphididae, Homoptera).

Damage: Adults and nymphs suck the sap from tender leaves and shoots devitalizing the plants. The pest secretes copious sugary solution on which sooty mould grows (Fig.40 & 41) . Brown citrus aphid, *Toxoptera citricida*, is responsible for vectoring citrus virus disease 'Tristeza (Fig. 42).



Fig. 40. Aphid infested citrus Twig / leaves



Fig. 41. Leaves affected by Aphid feeding



Fig. 42. Brown citrus aphid

Management:

- Spray quinalphos or dimethoate 0.05% at weekly intervals.
- An ichneumonid parasitoid *lipolexis scutellaris* and the predators like chrysopids, coccinellids, syrphids feed on this pest.

16. Thrips (*Scirtothrips* spp. *Heliorthrips haemorrhaeodalis* Bouche (Thripidae, Thysanoptera)

Damage: The nymphs and adults suck the sap from fully developed flower and leaf buds, young and grown-up fruits and also the leaves (Fig. 43 & 44) The leaves become cup shape and leathery. Two white line parallel to leaf midrib and a whitish silvery ring around the fruit neck are characteristics of thrip infestation.



Fig. 43 Leaves damaged by citrus thrips

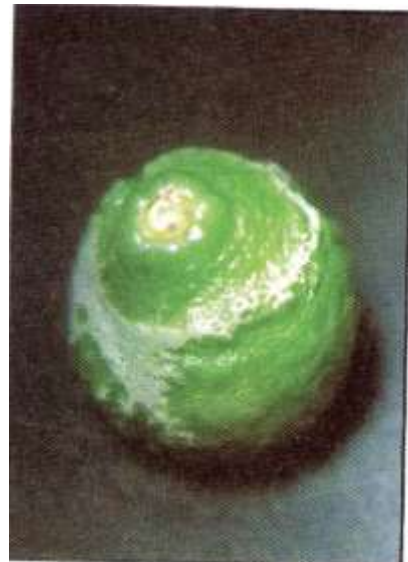


Fig. 44 Fruit damaged by citrus thrips

Management:

- Dimethoate or quinalphos or monocrotophos @ 1ml/l of water should be sprayed at bud burst stage & on berries and the surrounding vegetation should also be sprayed as the pest thrives on it.

17. Fruit Sucking Moth (*Ophederes* sp. *Achaea janata* L. (Noctuidae, Lepidoptera)

Damage: The adults puncture the ripening fruits. Such fruits drop prematurely as a result of rotting due to fungal and bacterial infections introduced through punctures causing considerable fruit loss (Fig. 45 to 46).



Fig. 45 Fruit sucking moth



Fig. 46 Punctured fruits by sucking moth

Management:

- Poison baiting with 20 g malathion (w.p) + 200 g gur with some vinegar or fruit juice in 2 litres of water (two bottles containing poison bait per 25-30 trees) has been found quite effective.
- Use light traps to collect moths.
- Sprays of malathion or endosulfan should also be given on the weeds around the orchard where the young stages of the pest survive.
- Destroy fallen fruits by burying in the ground.
- Clean cultivation of the orchard is must to avoid the pest development.

18. Fruit fly (*Dacus dorsalis* Handel (Trypetidae, Diptera)

Damage: The adult fly punctures the ripening fruits by penetrating its ovipositor and lays the eggs inside. Larva on hatching feed on the pulp inside. Fungal and bacterial infection takes place through puncture hole due to which rotting of fruit occurs.

Management:

- Keeps bait containing malathion or trichlorofon 0.05% +1 % crude sugar, about two months before fruit ripening followed by 10 days interval.
- Use male attracting fly trap baited with 0.1% methyl eugenol and 0.05% malathion @ 25 traps / ha starting form 60 days before fruit harvest and fresh solution after every 7 days.
- Fallen fruits should be collected and buried deep in the ground.

19. MITES (*Eutetranychus orientalis* Klien (Tetranychidae, Acarina)

Damage: Mite feeding causes pale stripping on the upper surface of leaves which are not seen on the lower surface. In severe infestation the stripping enlarges to dry necrotic areas(Fig. 47& 48).



Fig. 47 Affected fruits



Fig. 48. Infested leaves



Fig. 49. Adults

Management:

- Foliar spray of dicofol @ 1.5 ml or oxydemeton methyl 1.5 ml or wettable sulphur 3 g/l of water. Second spray, if required, may be given after a week.
- The most important natural enemies of citrus mite are a predacious mite *Euseius hibisci* and the predators *Agistemus* sp. and *Ambylesisus hibisci*(Fig. 49).
- Water stress often aggravates mite problem. Make sure that trees are well irrigated, particularly during the stress in late summer.

21. Trunk borer

Damage: Grub bores the trunk at ground level horizontally up to the pith and then tunnels vertically and again horizontally for exit. Attacked trees gradually dry up (Fig. 50, 51 & 52).

Management

Swabbing of tunnel either with Dichlorvos (0.1%) or Monocrotophos (0.02%) kills the grub effectively.



Fig. 50. Infested trunk



Fig. 51. Affected tree



Fig. 52. Adult