

# **Insect Pests of Cotton and their Management**

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## **Insect Pests of Cotton and their Management**

Cotton crop is infested by several pests right from germination to harvest and the pest spectrum of cotton is quite complex. As many as 1326 species of insect and mite pests have been reported to attack cotton at various stages of crop growth, across the globe. However, in India the number is limited to 130 species. Among them the boll worms viz., American boll worm, *Helicoverpa armigera* (Hubner), spotted boll worm, *Earias vittella* (Fabricius), spiny boll worm, *Earias insulana* (Boisduval) and pink boll worm, *Pectinophora gossypiella* (Saunders) pose greater threat to cotton production. Besides, a complex of sucking pests viz., Green leaf hopper, *Amrasca biguttula biguttula* (Ishida), thrips, *Thrips tabaci* (Linnman), aphid, *Aphis gossypii* (Glover) and whitefly, *Bemisia tabaci* (Gennadius), are known to have occupied major pest status.

**Sucking pests :** Sucking pests have become quite serious from seedling stage, their heavy infestation at times reduces the crop yield to a great extent. Sucking pests are deleterious during early season of the cotton plant growth and development. Jassids, aphids, whiteflies and thrips continue in the absence of cotton with continuous production of vegetables.

**Leaf hopper :** *Amrasca biguttula biguttula* Ishida (Cicadellidae: Hemiptera)

**Distribution:** All cotton growing region of India.

**Host of plants:** Cotton, potato, brinjal, castor, bhendi, tomato, hollyhock and sunflower.

**Nature and symptoms of Damage:** Leaf hopper also referred, as leafhoppers are important sucking pests of cotton. Infestation starts from 15-20 DAS. Both nymphs and adults suck the plant sap and apparently introduce salivary toxins that impair photosynthesis in proportion to the amount of feeding. The affected leaves curl downwards, turn yellowish, reddening along the leaf margin then to brownish before drying and shedding. Severe "hopper burn" stunts young plants and reduce yields.



**Description and lifecycle:** Adults are elongate and wedge shaped with pale green body; about 3 mm long, greenish yellow during summer whereas they develop reddish tinge during winter. The hind portion of the forewings has two black spots on the vertex, very active with sideways walk but quick to hop and fly when disturbed. Eggs laid into the parenchymatous tissue of the leaves, curved and deeply embedded in the midribs of large veins on the undersurface of the leaves. Nymphs are flattened, pale yellowish green and wedge shaped with sideway movements and remain confined to the lower surface of leaves during day time. There are a total of 7-8 generations in a year. Yield loss from jassids can be reduced by growing hairy varieties. Nymph and adult stages last for 7-21 days and 35-50 days respectively.

**Aphids :** *Aphis gossypii*: (Aphididae: Hemiptera)

**Distribution:** India

**Host plants:** Cotton, bhendi, brinjal, chillies, guava

**Nature and symptoms of Damage:** Aphids are phloem feeders, greenish brown soft bodied small adults and nymphs feed on the underside of leaves or on the growing tips of shoots, sucking juices from the plant. Severe infestation results in curling of leaves, stunted growth and gradual drying and death of young plants. Black sooty mould develops on the honey dew of the aphids which falls on the lower leaves affecting photosynthetic activity is often evidence of aphid infestation. Heavily infested seedlings become stunted and die. Infestation indirectly decreases cotton fibre quality as a result of sticky cotton due to deposits of honeydew on open bolls.

**Description and lifecycle:** Females either lay eggs or directly produce young ones which mature in about 7 days, hence population increases very fast. Nymphs are light yellowish green, or greenish black or brownish. Nymphal period lasts for 7-9 days and adults live for 12-20 days. They have a large range of host plants with varying duration of development and reproductive rate. Outbreaks are common on seedlings and young plants during spells of dry weather.



The aphids are a vector of crinkle, mosaic, rosette, CTV and other virus diseases.

**Thrips:** *Thrips tabaci* Lindeman (Thripidae: Thysanoptera)

**Nature and symptoms of Damage:** Thrips damages young cotton seedlings, flowers and stems. The incidence is severe in the beginning of the season during the periods of low relative humidity. Rolling of margins and shriveling of leaves due to scuffing of epidermis, upper side of the older leaves turn brown while silvery white patches are seen in the lower side of leaves and leaves show crinkling, wrinkling and drying of leaves. Infested foliage becomes distorted and curls upward, terminal buds are sometimes killed and the vegetative phase is delayed leading to late harvest.

**Description and lifecycle:** Nymphs are smaller in size and blackish in colour. The adults are slender, yellowish brown, 1 mm long with pair of fringed wings. The eggs are laid in slits in leaf tissues; eggs hatch in 5 days time, nymphal and pupal period lasts for 5 and 4-6 days, respectively. Pupation is in the soil.

They are vectors of leaf streak virus in cotton.

**Whiteflies:** *Bemisia tabaci* (Aleyrodidae:Hemiptera)

**Distribution:** India, Sri Lanka, Nigeria, Congo, West Africa, Japan and Europe

**Host Plants:** Cotton, tomato, tobacco, sweet potato, cassava, cabbage, cauliflower, melon, brinjal and bhendi.

**Nature and symptoms of Damage:** Both nymphs and adults are sap feeders. Heavy infestations of adults and their progeny can cause seedling death, or reduction in vigor and yield of older plants, due simply to sap removal. Feeding of adult and immatures results in excretion of honeydew, which is composed largely of plant sugars. Sooty mold grows on honeydew-covered substrates, obscuring the leaf and reducing photosynthesis, There may be one or a combination of the following symptoms: chlorotic spotting, vein yellowing, intervein yellowing, leaf yellowing, yellow blotching of leaves, yellow mosaic of leaves, leaf curling, leaf crumpling, leaf



vein thickening, leaf enations, leaf cupping, stem twisting, plant stunting, wilting and leaf loss. On shaking of the plants the whiteflies fly and resettle quickly.

It is very important as a vector of leaf curl virus disease of crops like tobacco, cotton, etc. and vein clearing disease of lady's finger. It also breeds on a variety of plants such as hollyhock, lady's finger, tobacco, safflower, *Achyranthes aspera*, Lab – lab niger, topioca.

**Description and lifecycle:** Nymphs and adults are sluggish creatures, clustered together on the under surface of the leaves. Nymphs are pale yellow and adults are yellowish with white waxy coating on the body. Whitefly adults can be seen on all plant surfaces, and ovipositing on the under surfaces of leaves. Whiteflies have an interesting biology (called arrhenotoky) in which females can lay eggs that have not been fertilized and these eggs will result in male offspring. Fertilized eggs will result in female offspring. Eggs are laid singly on the under surface of the leaves and Hatches after 5 to 10 days. On hatching, the first instar or crawler, moves to a suitable feeding location on the lower leaf surface. There are three nymphal instars and the last nymphal instar develops red eye spots, and is commonly called the "red-eyed nymph."the nymphal varies from 9-14 days. Pupal period is 2-8 days. The total lfie cycle lasts for 14-017 days depending upon the temperature. There are twelve overlapping generations per year.

**Mirid bugs: *Creontiades biseratense* (Miridae: Hemiptera)**

#### **Nature and symptoms of Damage**

Both nymphs and adults cause damage. Feeds on terminal growth , squares, flowers and bolls of cotton plant and causes excessive shedding of flowers, small squares and immature bolls. Circular discoloration due to piercing injury can be seen at the base of flowers and squares. During feeding, mirids pierce the plant tissue with their stylet and the affected area blackens that are seen as scars. Feeding by mirid bugs results in heavy shedding of squares and tiny bolls. Feeding in the bolls result in deformation, which is referred to as "parrot beaking". If the



infestation is severe in older bolls, the damaged locules may not develop properly and have stained lint.

**Description and life cycle:** Females lay eggs singly preferentially on the leaf petioles, eggs are cylindrical, slightly recurved and laterally compressed shining white in colour later turning to yellow as it matures, Nymphs are greenish in colour with dark brown wing pads. There are five nymphal instars. Adults of *Creontiades biseratense* are elongate, brownish in colour with dark brown T-shaped band on pronotum.

**Mealy bug:** *Phenacoccus solenopsis* Tinsley, *Paracoccus marginatus* Williams and Granara de Willink, *Maconellicoccus hirsutus*, (Green)) (Hemiptera: Pseudococcidae)

#### **Nature and symptoms of Damage**

Mealybugs are small sap-sucking insects cause severe economic damage to cotton. Mealybugs attacks cotton growing parts viz., main stem, branches and fruit, underdeveloped flowers produced bolls of smaller size; boll opening adversely affected resulting in serious reduction in yield. Plants infested by mealybugs during vegetative phase exhibit symptoms of white fluffy mass on underside of leaves, near growing tips, along leaf veins and on stem, distorted or bushy shoots, crinkled and/or twisted bunchy leaves and stunted plants that dry completely in severe cases. Late season infestations during reproductive crop stage result in deformed bolls, fewer and smaller in size bolls in affected plants, reduced plant vigour and early crop senescence. While feeding mealybugs injects a toxic substance into the plant parts resulting in chlorosis, stunting, deformation and death of plants. Excretion of honeydew attracts ants and also contributes to the development of black sooty mould. Plants severely affected with sooty mould have the appearance of burn symptoms.

**Description and life cycle:** Mealy bugs measure about 5-6mm in length and 3-4mm in breadth. The insect body is yellowish green in colour with short to medium sized waxy filaments with two short anal filaments and two dark strips on either side of the middle ridge of the body. Reproduction in mealy bugs is mostly parthenogenetic. Mature female lays eggs in ovisacs. Each ovisac



contains 150- 600 eggs, majority of which are female. Eggs hatch in 3 to 9 days into nymphs called 'crawlers', which are very mobile. The nymphal stage lasts for 22-25 days. Individual mealy bugs take 25- 30 days to grow into adults under normal conditions. There are 12- 15 generations in a year. The mealybugs survive cold conditions as eggs in ovisac or other stages, both on the host plant or in the soil. In warm climates, the insects remain active and reproduce round the year.

### **Mode of transport**

- Crawlers crawl from an infected to healthy plant.
- Small crawlers are readily transported by wind, rain, birds, clothing and vehicle on new plants.
- The waxy coating facilitates passive transport of the insect by their sticking/clinging to equipments, animals or people moving during field operations.
- Long-distance movement is through transport of infested cotton sticks or seed cotton.
- Crawlers are also carried through irrigated water, when the mealy bug infested plants are thrown in water channel.
- Ants, attracted by the honeydew, carry crawlers of mealy bugs from plant to plant.
- Mealybugs possess a waxy coating on the dorsal side that protects them from insecticides and natural mortality factors
- Have a high reproductive rate
- Have the ability to hide in cracks and crevices in soil and corners of plant parts

**Spider mites:** *Tetranychus urticae* Koch, (Tetranychidae: Acari)

### **Nature and symptoms of Damage**

Generally, mites feed on the undersides of leaves. They use their sucking mouthparts to remove plant saps. The upper leaf surface has a speckled or mottled appearance while the underneath appears tan or yellow and has a crusty texture. Feeding on the underside of the leaf, this mite extracts sap, causing the upper leaf surface to have a whitish or bronze cast. Infested leaves may turn yellow, dry up, and drop in a few weeks.



Mites produce large amount of webbing. In heavy infestations a fine web may cover the leaves. Plants may die when infestation is severe, particularly in hot dry conditions.

**Description and life cycle:** The adult is also very tiny, maybe yellowish, greenish, pinkish, or reddish depending on the species. It has an oval body with 8 legs and with 2 red eyespots near the head. The male is smaller than the female with a more pointed abdomen. A female usually has a large, dark blotch on each side with numerous bristles covering her legs and body. The eggs are tiny, spherical, pale-white, and are laid on the undersides of leaves often under the webbings. Eggs hatch in 4 or 5 days. Nymph looks similar to the adult but is only the size of an egg. It has only 6 legs. It molts 3 times before becoming an adult.

### **Cotton Stainers**

Stainers are the only insects that attacks previously undamaged cotton seeds in the field, on any scale. There are two stainer bugs, viz. the common stainer bugs *Dysdercus* and the cotton seed bugs *Oxycarenus*. All the active stages of these bugs feed on the seed in open bolls and reduce the germinating capacity and the seed oil content.

**Red cotton bugs :** *Dysdercus cingulatus* Fabricius (Hemiptera: Pyrrhocoridae)

**Distribution:** Uttar Pradesh, Bihar, Bombay, Andhra Pradesh and Tropical Africa, Tropical Asia, Australia, U.S.A., Central and South America and India.

**Host Plants:** Cotton, Bhendi, Maize, Pearly millet, Holly hock, Clovers, Sorghum and Kapok.

**Nature and symptoms of Damage:** *Dysdercus singulatus* nymph and adults feed on developing or mature seeds. Young bolls are affected, which turn dark brown and fail to burst, Lint stained red. Seeds shrivel. Penetration of developing cotton bolls leads to occasional transmission of fungi which develop on the immature lint and seed, rendering the latter unviable and staining the lint to the typical yellow colour.



**Description and life cycle:** Nymphs and adults are brightly coloured with red head with a white prothoracic collar. Membrane of the hemi-elytron is dark and on the broadest part of the forewing is a black mark as a spot. Eggs are laid in shallow depression in soil or under debris in batches. The nymphal instars are gregarious and feeding is in congregation. Third and subsequent instars can penetrate unopened fruit to feed on developing seeds. Rate of development of egg and five nymphal instars is temperature and nutrition dependent.

**Dusky Cotton Bug :** *Oxycarenus hyalipennis*, Costa (Lygaeidae :Hemiptera)

**Nature and Symptom of damage:** They are lygus bugs associated with ripe seeds of cotton. Presence of nymphs and adults on the bursted bolls, lint gets discoloured, seeds shrivel and fail to germinate. Nymphs and adults suck the sap from the bursted / open bolls.

**Description and life cycle:** Adults are small-elongated bugs with pointed heads, dull black to very dark brown. The hemielytra has a translucent dusky appearance. All stages are characterized by a powerful smell when crushed. They feed on seeds and large numbers can reduce weight and viability of seeds. Bugs can discolour the lint if crushed and so are sometimes referred as dusky cotton stainers. Early harvesting minimizes damage.

**Scales :** Black scale or black bug *Parasaissetia nigra* Nietn. Yellow scale of cotton *Cerococcus hibisci* Green White scale, *Pulvinaria maxima* (Hemiptera: Coccidae)

**Nature and symptoms of damage:** scales remain attached to the twigs, shoots, stems and leaves of the plant and suck the plant sap which results in stunting of the plants and bears only few bolls and yellowing of leaves with sooty Movement of ants seen.

**Description and life cycle:** Most scale insects are female. Mature females are wingless and often secrete a hard shell-like covering for protection. The males are rare, small, non-feeding, and short-lived but look more like other insects as they have wings. With a few notable exceptions, the first immature stage, or



the first "instar" females are generally the only stage that disperses on plant material. All other stages remain attached to the plant surface, sessile. Females lay eggs or crawlers under their secreted scale covering or in a cavity under their bodies.

### **Stinkbug**

**Nature and symptoms of damage:** Adults and nymphs suck plant sap from leaves, flowers, bolls, and the seeds. Feeding on bolls prevents bolls to open or causes bolls to drop, and stains the lint.

**Description and life cycle:** The eggs are yellow and barrel shaped. These are laid on the lower surface of the leaves in clusters of 20-130 in 5-8 parallel rows. The nymph has varied colors (green, tan, brown or gray). It is oval-shaped, wingless but looks similar to an adult counterpart. The first nymphal instars do not feed. The nymphs form clusters at the natal site. The second and third instars are also found in clusters but they disperse when disturbed. The fifth nymphal instars are sensitive to day length, which also causes the adults to begin diapauses. The nymphal development lasts for about 8 weeks. The adult is shield-shaped and green, tan, brown or gray in color. Most of the adults are shiny, but other species are spiny and rough-textured. The female starts mating one week after emergence and lives for about 30 days. Stinkbug emits a foul odor when disturbed, hence the name.

**Stem Weevil:** *Pempherulus affinis* Faust. (Curculionidae: Coleoptera)

**Distribution:** India, Burma, Thailand and Philippines

**Host Plants:** Cotton, Bendi, Jute, *Abutilon inolicum*, *Hibiscus rosasinensis*, *Hibiscus cannabinus* and other malvaceous and tiliaceous plants.

**Nature and symptoms of damage:** The adult weevil excavates a small hole on the stem and oviposits. The grubs tunnel into the stems and branches, principally in the stem just above the ground. The stem swells and forms a round lump. Root damage by grubs kills young seedlings, gall like swelling seen on lower stem, wilting of seedlings.



**Description and life cycle:** Adult beetle is small dark coloured, with brown and white marks, the lower surface is whitish, the eggs are brown, the whole body is clothed with flat scales the adult weevil is long lived (36 days) and this would assist in to tide over a time when there is no cotton crop in the ground. On an average, single female lays eggs in the range of 50-121. The egg, larval and pupal period are 6 to 9, 35 to 57 and 9 to 12 days respectively and the average adult longevity is 50 days. About six broods were noticed and neither hibernation nor aestivation was recorded. In Tamil Nadu State three complete generations were observed from October to April.

### **Foliage Feeders**

Great majority of leaf feeders are chewing insects, mostly lepidopterous larvae, ash weevils and grasshoppers. Lepidopterans are sufficiently extensive at times causing defoliation, thus affecting the photosynthetic efficiency of the plant.

**Cotton Semiloopers:** *Anomis flava*, *Xanthodes grellsi*, *Tarache nitidula* Fabricius (Noctuidae: Lepidoptera)

**Nature and symptoms of damage:** Outbreak of *Anomis flava* are often sporadic. Defoliation results in significant loss of leaf area when the plants are young. Lopper eggs may be deposited anywhere on the cotton plant, but larvae are usually found on the lower leaf surface and are most likely to be observed on the upper third of the plant. Upon hatching these larvae drop to the older leaves, where small larvae make a window like holes by feeding on the lower leaf surface. The grown up larvae feed voraciously leaving only the mid rib and vein. The caterpillars occasionally feed on the tender shoots, squares, buds and bolls.

**Description and life cycle:** *Anomis flava*: Eggs are spherical and ribbed larvae is a green coloured semi looper with five white longitudinal lines with six pairs of black and yellow spots on the back, red prolegs.

*Xanthodes grellsi*: green coloured with horseshoe marks and black warts on the abdomen. Adult has bright lemon yellow forewing with a lunar streak.



*Tarache nitidula*: Dark brown caterpillar, Bright white wings with dark markings

**Cotton Leaf Roller:** *Syllepta derogata* Fabricius (Pyraustidae : Lepidoptera)

**Distribution:** It is commonly found in rainfed cotton growing areas, higher infestations occur in shady and weedy conditions.

**Nature and symptoms of damage:** Larvae are seen in groups during initial stages in folded leaves amidst fecal material. Leaves rolled in the form of trumpets fastened by silken threads. Marginal portions of the leaves are eaten away. Late/last instar larvae move out and pupate individually.

**Description and life cycle:** The larvae are greenish white and semi translucent. Larvae bright green (glistening) with dark head and prothoracic shield. Brown pupae is typical in having 8 short spines with hooked tips at their extremity. Moth with yellow wings transversed with brown / black wavy lines and a black border with greyish fringe. Head and thorax are dotted black and abdomen has brown rings.

**Leaf worm :** *Spodoptera litura* ( Noctuidae: Lepidoptera)

**Nature and symptoms of damage:** The larvae feed gregariously on the under surface of the leaves and skeletonize them leaving only the midrib and veins in severe cases. Leaves reduced to papery structures initially which later become reddish brown patches later riddled with irregular holes. They also attack flowers, buds, squares causing severe damage.

**Description and life cycle:** Females lay eggs in masses that are cream to golden brown in colour. Egg masses are usually covered with body hair, scales and are laid on the under surface of the leaf. Egg (3-4 days), larval (3-20 days) and pupal periods (8-10 days). The life cycle is completed in 50- 60 days. Egg masses contain 300-305 eggs which are arranged in rows up to 3 layers and are covered by scales from the body of the females.

Larva are pale greenish and brown in colour with dark markings, larvae are gregarious in the early stages. Pupation occurs in soil. Adults: moth with wavy white markings on a brown forewing. Hind



wings grayish white with a brown patch along the margin. Males have a blue gray band on the inner margin of each forewing.

### **Boll worms**

**American bollworm:** *Helicoverpa armigera* Hubner. (Noctuidae: Lepidoptera)

**Nature of damage:** Newly hatched larvae may often wander for some distance, with occasional surface feeding before settling down at a preferred site, usually on a flower bud or flower, which is eventually hollowed out if it does not first abscise. Older larvae prefer buds and younger boll. However, most buds and bolls which have been attacked show accumulation of faeces between the surface and enclosing bracts.

### **Symptoms of damage**

Larvae damage tender squares and cause shedding. Shed squares with marks of insects or insect damage are seen at the base of plant. Damaged squares retained on the plant flare up. Larvae feed on reproductive parts of flowers. Rarely feed on leaves. Each larvae can feed on 8-10 squares and 2-3 bolls.

**Description:** Egg is sub spherical with a flattened base apical area surrounding the micropyle smooth, the rest of the surface sculptured with approximately 24 longitudinal ribs. Whitish or cream colour after laying and develops reddish brown band as the embryo develops. Newly hatched larvae are translucent yellowish white, with faint darker longitudinal lines and brown to black headcapsules. The fully grown larvae is about 35 to 42 mm long. The integument having a characteristic granular appearance, with a set of minute tubercles. The adults are stout bodied moths with wing span of 35-40mm body length of 18 -19 mm. females are darker than males.

Females are on an average heavier than males. Pupae are formed at a depth of 2.5 - 12.5 cm in the soil. Pupal period ranges from 6 days at 35 °C to over 30 days at 15°C, lasting for about 10-14 days under field conditions in central India.

**Spotted bollworms:** *Earias insulana* Boisd., *Earias. Vittella* Fabricius (Noctuidae: Lepidoptera)



**Distribution:** Widely distributed in India, Myanmar. It is also found to attack Bhindi.

**Nature of damage:** The initial infestation takes place on 6 week old crop in which the larva causes detopping (drooping and drying of the shoot) due to its feeding by boring into it. In the later stages of the crop, the buds, flowers and bolls are damaged and a larva may migrate and attack fresh parts. Heavy shedding of early formed flower buds due to the pest is a common feature in cotton fields. The lint from attacked bolls will not be clean.

**Life history:** The moth of *E. vittella* has green fore wings with a white streak on each of them whereas that of *E. insulana* is completely green. The female moth deposits 2 or 3 eggs on bracts, leaf axils and veins on the under surface of leaf. The egg is crown-shaped, sculptured and deep sky blue in colour. A female may lay about 385 eggs and the incubation period is about 3 days. The larva becomes full grown in 10 – 12 days. The larva of *E. vittella* is brownish with a longitudinal white stripe on the dorsal side and without finger-shaped processes on its cream coloured body and orange dots on prothorax. The boat shaped tough silken cocoon is dirty white brownish and may be found on plants or on fallen buds and bolls. The pupal period is 7 – 10 days. The total life cycle ranges from 20 to 22 days.

**Pink bollworm:** *Pectinophora gossypiella* Saund. (Gelechiidae: Lepidoptera)

**Distribution:** This is a well known pest of cotton found distributed all over the world. Alternate host plants of this pest are Lady's finger, hollyhock and *Thespesia populnea*, etc.

**Nature of damage:** The larva enters the developing boll through the tip portion and the entrance hole gets closed up as the boll matures. It feeds on the seeds and moves to adjacent locule by making a hole through the septum. The infested flower buds shed prematurely. A typical rosette-shaped bloom when examined will contain the larva. The infestation results in the seeds being destroyed in addition to retardation of lint development and weakened lint and staining of the lint both inside the boll and in the gin. Further, infested bolls open prematurely and expose it to



invasion by saprophytic fungi. The seeds from damaged bolls show lower germination.

**Life history:** The adult is a small dark brown moth and a female lays flattened and striated eggs on the bolls or in between bracts or on buds and flowers, the average being 125 eggs. The egg period varies from 4 - 25 days. The 15 mm long pinkish larva with dark brown head and prothoracic shield becomes full grown in 25 - 35 days and pupates in a thin silken cocoon among the lint, inside a seed or in double seeds, in between bracts or in cracks in the soil. The pupal period is about 6 - 20 days. Both short - cycle larvae and long-cycle larvae occur in Northern India and hibernation during winter takes place in the larval stage. In South India the insect is not known to hibernate in any stage of its development.

#### **Economic Threshold Levels (ETLs) of Major Pests of Cotton**

<b>Insect Pest</b>	<b>Economic Threshold Level</b>
American boll worm	One egg or one larva /plant
Spotted boll worm	10% infested shoots / squares / bolls
Spiny boll worm	10% infested shoots / squares / bolls
Pink boll worm	10% infested fruiting parts
Tobacco cut worm	8 egg masses/100 m row
Leafhopper	50 nymphs or adults/50 leaves
Whitefly	5-10 nymphs and adults / leaf
Aphid	15% of infested plant
Thrips	50 nymphs or adults/50 leaves
Stem weevil	10% infestation
Mite	10 mites/cm <sup>2</sup> leaf area

### **INTEGRATED PEST MANAGEMENT PACKAGE FOR COTTON ECOSYSTEM**

#### **Mechanical control methods**

- Removal and destruction of crop residues after harvest to avoid the carry over population of American boll worm to next season.



- Removal of terminals of cotton crop (topping) at 80-90 days of growth to reduce *Helicoverpa* oviposition and also to encourage sympodial branching which bears more fruiting bodies.
- Removal and destruction of alternate weed hosts of white fly like *Abutilon indicum*, *Chrozophora rottlari*, *Solanum nigrum* and *Hibiscus ficulens* from the fields and neighbouring areas and maintaining field sanitation.
- Collection and destruction of leaves infested with white fly and shed due to the attack of the pest.
- Hand picking and burning of the pink boll worm affected and dropped squares, flowers and fruits and squash the pink boll worms in the rosettes.
- Removal and destruction of egg masses, early stage larvae found in clusters and hand picking and destruction of grown up caterpillars to minimize heavy build up of future population of tobacco cut worm.
- Uproot and destroy the weeds like *Sida* sp., *Abutilon indicum* and *Xanthium* sp. before sowing of cotton crop to reduce the initial build up of boll worm and whitefly.

#### **Cultural control methods**

- Grow one variety throughout the area as far as possible.
- Deep summer ploughing on bright sunny days during the months of May or June should be done to expose soil inhabiting or resting stages of insects, pathogens and nematode population. The field should be kept exposed to sunlight for at least 2-3 weeks.
- Growing of less preferred crops like green gram, black gram, soybean, castor, sorghum etc., along with the cotton as intercrop or border crop or alternate crop to reduce the pest infestation.
- Grow two rows of maize or sorghum or cowpea along the border to sustain and enhance the build up of natural enemies such as lady bird beetles, staphylinids,



*Chrysoperla carnea*, Anthocorids, Reduviids etc. Pollen of maize helps in retaining *Chrysoperla* in main cotton field.

- Plant trap crops like marigold or okra or pigeon pea along the border and irrigation bunds to divert American boll worm oviposition from main cotton crop.
- Growing castor along the border and irrigation bunds as trap crop for tobacco cut worm, okra for spotted boll worm and aphid.
- Use neem cake @ 1 t / ha under assured moisture conditions in nematode infested fields.
- Earthing up on 45th day (stem weevil).
- Basal application of FYM 25 t/ha and 250 kg/ha of neem cake (stem weevil).
- Install 15-20 bird perches per acre for the benefit of predatory birds like black drongo, king crow, orange myna etc. after 90 days of crop growth. Provide drinking pots with water to them by placing them around the perches.

### Biological control methods

- Application of *Helicoverpa armigera* or *Spodoptera litura* nuclear polyhedrosis virus (NPV) @ 250-500 LE / ha (1 LE =  $6 \times 10^9$  POBs) (1 LE / litre of water) depending upon the crop growth with jaggery and teepol in evening hours at 7th and 12th week after sowing.
- ULV spray of NPV at  $3 \times 10^{12}$  POB /ha with 10% cotton seed kernel extract, 10% crude sugar, 0.1% each of Tinopal and Teepol for effective control of *H.armigera*.
- Inundative release of egg parasitoid, *Trichogramma* spp., at 6.25 cc/ha at 15 days interval 3 times from 45 DAS (American boll worm)
- Inundative release of egg-larval parasitoid, *Chelonus blackburnii* and predator, *Chrysoperla carnea* at 100000 / ha at 6<sup>th</sup>, 13<sup>th</sup> and 14<sup>th</sup> weeks after sowing (American boll worm)



### Botanical control methods

- Spray NSKE 5% or neem oil (5 ml/l) or fish oil resin soap 25 kg / ha @ 1 kg in 40 lit of water or 5 % notchi leaf extract or 5% *Catharanthus rosea* extract (whitefly)
- Spray NSKE 5% or neem oil formulation 0.5% or neem oil 3% thrice at fortnightly intervals (sucking pests)
- Spray NSKE 5% as a strong oviposition deterrent (American boll worm)
- Spray fish oil resin soap 25 kg / ha @1 kg in 40 lit of water (mealy bug)

### Behavioural control methods

- Use pheromone traps for monitoring American boll worm, pink boll worm, spotted boll worms and tobacco cut worm. Install pheromone traps at a distance of 50 m @ 5 traps per acre for each insect pest. Use specific lures for each insect species and change it after every 15-20 days. Trapped moths should be removed daily. If the number of trapped adult moths is 10 (American boll worm), 20 (tobacco cut worm), 15 (spotted boll worm) and 8 (pink boll worm) necessary action should be taken.
- Installing light traps with incandescent lamp (1-2 / acre) for monitoring of insect activity (American boll worm and tobacco cut worm). The crop around the light trap may be sprayed with neem oil.
- Monitoring the activities of the adult white flies by setting up yellow pan traps and sticky traps at 1 foot height above the plant canopy. Locally available empty yellow palmoline tins coated with grease / Vaseline / castor oil on outer surface may also be used.
- Paint yellow colour on plastic drinking water pot, apply castor oil on it and move it on both sides with hand by walking in the field to attract and trap whiteflies.

**Note:** 1. Use only incandescent light in light traps as mercury lamp attracts natural enemies in large numbers.  
2. The light trap should be lighted between 8 – 10 pm.



## **INTEGRATED PEST MANAGEMENT WITH SPECIAL REFERENCE TO BT COTTON**

As Bt cotton has been growing at a rapid pace in India since its introduction in 2002, pest management strategies in cotton need to include Bt cotton as a major component in IPM.

### **Strategy 1: "Refugia"**

- Refuge is one of the most favoured resistance management options that have been preferred all over the world.
- Instead of Non Bt as refugia early duration pigeon pea can be used as border rows by farmers.
- Bhendi crop may also be used as a trap crop for Spotted, American and Pink bollworm.

### **Strategy 2: Need for insecticidal spray in Bt cotton**

- Decline in toxicity of Cry proteins against bollworms especially pink bollworm as crop matures (100 DAS) is of serious concern particularly in Tamil Nadu, where pink bollworm is very common during later phase of cotton crop.
- Hence there is a need for one insecticidal spray (Thiodicarb / Profenophos / Quinalphos) to be used at 100 – 120 DAS.
- Recent outbreak of mealybug, mirid bugs, thrips and aphids are mainly due to the absence of control measures for bollworm.
- Hence, spray at 100 – 120 DAS will take care of the sucking pests especially during later phase of crop, as their damage may result in loss in quality of the lint.

**NOTE: If Mirid bug found to be a serious menace, use Confidor 200SL (100-125 ml) or Actara 25 WG (100-125 gm) or Pride 20 SP (100g) per hectare.**



### **Strategy 3: Promotion of sucking pest resistant / tolerant Bt cotton**

- Bt cotton offers protection only against certain lepidopteran larvae. Other pests like jassids, thrips, aphids, whiteflies, mealybugs and other caterpillars are not affected by Bt cotton.
- Bt hybrids with resistance to jassids (hairyness) should be promoted to withstand sucking insects.
- Monitoring and using insecticide spray for effective management.
- Since seed treatment may not be sufficient to control all the sucking pests, systemic insecticide sprays can be given based on need.

### **Strategy 4: Encourage Integrated Pest Management (IPM) practices**

In the present cotton scenario in India, Bt cotton has become a major component of Integrated Pest Management (IPM). A special emphasis has to be given to educate farmers and all extension functionaries to understand and implement IPM practices through "Village Concept".

#### **Specific IPM strategies to be advocated**

1. Rotation insecticidal groups can be adopted for bollworm control on Bt cotton.
2. Ensure quality seed
3. Among the Bt hybrids, choose those Bt hybrids with resistance characters (such as hairyness etc) to sucking insects besides its location specificity.
4. Cultural practices like erecting bird perches and topping are considered most important from the point of surviving larvae in Bt cotton in later phase of crop.
5. In cotton stem weevil endemic areas, seed treatment with chlorpyrifos at 10 ml/kg + drenching collar region with chlorpyrifos at 2.5 ml/ lit. at 15 and 30 DAS + earthing up is recommended.



6. Trap crop concept with crops like bhendi, castor etc is very important
7. Pheromone trap monitoring is an important component especially for pink bollworm where emergence of broods can easily be observed by mass collection of adults in traps.
8. "Monitoring for any outbreak of diseases in cotton needs to strengthen. As the diseases of cotton can well be managed with the available chemicals, "Monitoring" assumes importance for timely management. Whenever Fusarium wilt is noticed 0.1 percent carbendazim may be recommended for management.
9. Biological control methods : A) Bt cotton will also help in preserving the populations of predaceous and parasitic insects due to reduced application of broad spectrum chemical insecticide against bollworms. Spraying of HaNPV before attempting insecticide spray especially after 100 DAS, will be ideal. Similarly SLNPV may be used for *Spodoptera litura*. Similarly release of *Trichogrammatoida bactrae* @ 1.5 lakh / ha / week for 3 to 4 times on spotting of brood emerge (through pheromone trap) of pink bollworm (or) preferably from 100 DAS.  
 B) Use of Encyrtid parasitoid, *Aceropphagus papayae* @ 100 per village against *Paracoccus marginatus* and *Aenasius bambewalli* against *Phenacoccus solenopsis*.
10. Hand picking of surviving larvae from Bt cotton fields.
11. Destroy residual pupae by deep ploughing in Bt cotton fields "immediately after final harvest"
12. Timely crop termination and destroy stalk
13. Besides the above, all recommended local specific IPM practices can be followed depending on need.
14. Finally, to make the farmers and field functionaries understand the value of implementing the above practices, especially proper scouting technique and ETL – based



spraying decisions, educational and training programmes need to be arranged periodically.

### **Cotton Mealy bug – Recent Threat to cotton cultivation**

#### **Management**

- Remove alternate host plants like Parthenium and other weed hosts in and around fields before planting.
- Destroy ant colonies during land preparation.
- Do not throw uprooted weeds in water channel since mealy bug spread through irrigation water.
- Raise cowpea, maize, pigeon pea or bajra as a bund/border crop as these crops offer least support for the growth and multiplication of mealy bugs and to encourage the activities of Natural enemies.
- Avoid growing malvaceous and solanaceous crops near the cotton fields. Malvaceous and solanaceous crops are good hosts for mealybugs. They serve as shelter and spread mealybug infestation.
- Monitor the crop regularly at least once in a week after sowing.
- Look for the ant activity / shiny leaves / yellowing , presence of sooty mould (advanced stages)
- Look for the predatory coccinellids, *Chrysoperla* and encourage their activities and avoid using synthetic insecticides when the natural enemy activities are more.
- Microbial Bioagents like *Beauveria* and *Verticillium* are found to be effective. Spray biopesticides viz., *Verticillium lecanii* (Potency 2 X 10<sup>8</sup> C.F.U /gm) 10gm/l and *Beauveria bassiana* (Potency 10<sup>8</sup> spores/ml) 10ml/litre
- Crawlers (Early stage mealybug nymphs) can be controlled by spraying neem oil 2% or fish oil rosin soap 25g/l of water (to get effective control, thorough coverage is essential).
- In case of severe infestation, spray recommended insecticides such as carbamate (carbaryl 50 WP @ 2500 g/ha or thiodicarb 75WP @ 625 gm/ha) or organophosphates (profenofos 50EC @ 1250 ml/ha,



quinalphos 25 EC @ 2000 ml/ha, acephate 75 SP @ 2000 gm/ha or chlorpyrifos 25 EC @ 5000 ml/ha) 1-3 times as per need, in rotation.

- Do not allow the cattle to graze in infested fields after harvest.
- Remove all crop residues in previously infested fields, bury them and spray with any one of the recommended insecticide or bio-pesticide such as *V. lecanii*.
- Store cotton stalks away from the fields and if possible a barrier of insecticide (e.g. malathion dusting) should be made around the stacks.
- Avoid ratoon cropping or allowing the cotton crop to continue to stand in the field after the final harvest, since ratoon crop offer food and shelter for mealybugs and provides inoculum for next season.

### **Technologies developed through TMC MMII 3.2 Development and Validation of IPM/ IRM strategies in conventional and Bt Cotton under different ecosystems**

#### **1. Detection of right time of infestation by stem weevil *Pempherulus affinis* to facilitate timely application of insecticide**

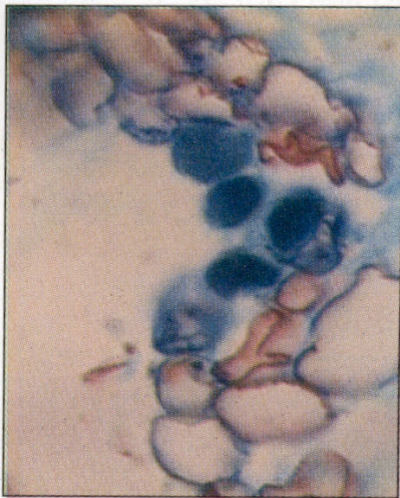
##### **Description of the technology:**

##### **a. Current status of the existing technology:**

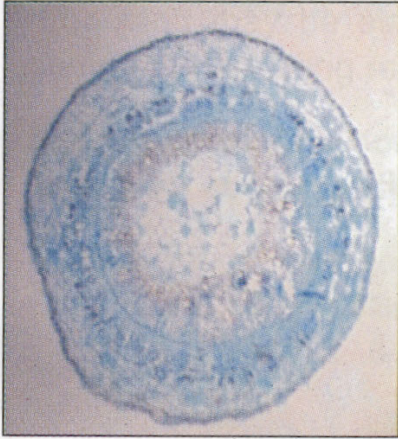
Stem weevil incidence normally prevail up to 40 days old crop and can cause 95-100 per cent mortality. Current pest management recommendation involves drenching the collar region of young stem with Chlorpyrifos 20 EC @ 2.5 ml/lit on 20 days after sowing (DAS) and 40 DAS followed by earthing up, as the weevil deposits the eggs in the region of nodes which are tender, soft and succulent. But, the recommendation did not yield fruitful results in controlling stem weevil infestation. Hence, histopathological studies were undertaken with the stem tissue samples taken from 10 DAS onwards to get a clear picture about the timing of egg laying by the stem weevil in cotton crop.



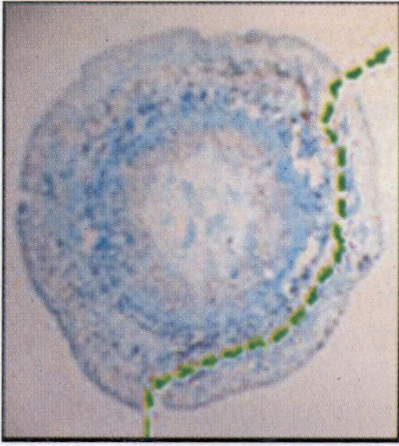
## Histopathological Studies - Stem weevil



Eggs laid by stem weevil in groups on the epidermis (10 DAS)



Uninfested stem



Infested stem (18 DAS)



Bore hole by maggot (19 DAS)



Thickening of Pericycle and endodermal layer (19 DAS)



### **b. Description of the developed technology:**

Histopathological studies carried out with the stem tissues of cotton plants of different age helped to trace the path of stem weevil (*Pempherulus affinis* Faust.) infestation in cotton. Presence of eggs in 10 DAS sample clearly reveal that egg laying by the adults have taken place in the very early stage, i.e. around 7-8 DAS contrary to the current theory of 20 DAS.

The infestation of stem weevil starts around 10 DAS. The current recommendation is drenching the collar region with insecticide on 20 and 40 DAS followed by earthing up. The present study indicates that egg laying by adult weevil in the collar region starts around 10 DAS. So the control strategy needs a change i.e. drenching may be started around 10DAS. Based on the above finding the following recommendation was evolved found effect.

### **Recommendation concluded through control experiments based on above findings:**

- Seed treatment with Chlorpyrifos (10 ml / kg) + drenching collar region with Chlorpyrifos @2.5 ml/l at 15 & 30 DAS & earthing up will effectively control stem weevil.

### **2. Development of economic threshold levels for *Helicoverpa armigera* on Bt cotton**

ETL for *Helicoverpa armigera* was worked out in Bt Bunny for three years 2007-08, 2008-09 and 2009-10.

<b>Year</b>	<b>ETL (larvae / plant )</b>
2007-08	0.70
2008-09	0.72
2009-10	0.62
<b>Mean</b>	<b>0.68</b>



Infestation under caged condition revealed that in Bt Bunny *Helicoverpa* damage was noticed significantly only on 100 DAS indicating the need for insecticidal spray around 100 DAS through careful monitoring.

### 3. Integration of all eco-friendly strategies and validation of IPM packages

Field of farmer, namely, Mr. S. Dhandapani of Sendhampalayam village, Ponnegoundanpudur, Coimbatore district of Tamil Nadu was identified to take up sowing of Bt Bunny.

S. No.	Particulars	Strategy	Area cultivated	Date of sowing
1.	Bt Bunny	IPM	1 acre	16/08/2010
2.	Bt Bunny	without IPM	1 acre	16/08/2010

Sowing of Bt Bunny was done on 16-08-2010 in an area of 1 acre in the field Mr. S. Dhandapani wherein IPM strategy was be implemented. Five rows of non Bt cotton were sown all along the periphery which would act as a refugia crop. In the field wherein IPM strategy was evaluated, one row of pigeonpea [Co(Rg) 7] was shown on all borders of the trial field as it attracts *Helicoverpa armigera*. Castor (TMVCH 1) seeds were also sown in the borders as it would act as a trap crop for controlling *Spodoptera litura*. Cowpea [Co(Cp) 7] was raised as an intercrop in cotton to facilitate the augmentation of coccinellid predators which would in turn control sucking insect pests of cotton. It would also act as an excellent trap crop for aphids. Simultaneously, Bt Bunny seeds were sown in an area of 1 acre with five rows of non Bt cotton in the periphery and no IPM strategy was be followed in this trial field. Observations were recorded on the incidence and population of key insect pests of cotton at fortnightly intervals.

Observations were recorded on the incidence and population of key insect pests of cotton for the entire crop period. Observations on the population of sucking pests and natural enemies were recorded in 25 randomly selected plants in Bt



Bunny trial fields involving IPM and Non IPM. Population of sucking pests, namely, aphids, leaf hoppers, thrips, whiteflies, were observed in three leaves per plant. Natural enemies, namely, coccinellids, spiders and syrphids present per plant were recorded. Presence of mirid bugs in the squares of plants were also assessed. Larval stages of *Earias* sp, *Spodoptera litura*, *Helicoverpa armigera* were also observed, if any, in the plants.

## Findings

### A) Insect occurrence

- Population of sucking pests, namely, Leaf hopper, crossed ETL only once (93 DAS) jassids / 3 leaves in IPM and Non IPM, respectively).
- Stray incidence of mealybugs infestation were noticed around 107 DAS in both IPM and Non IPM trial fields and the infestation was found to be less than 1 % and grading was 1 (scattered appearance of mealybug).
- No eggs of *Helicoverpa armigera* or egg mass of *Spodoptera litura* were found in the top growing shoot of the plants observed. No larval stage of *Helicoverpa armigera* or *Spodoptera litura* or *Earias* sp. were observed in the plants.
- No rosette flowers were observed in the plants which is the typical damage symptom of pink bollworm.
- An average of 46 and 42 bolls were present per plant involving IPM and Non IPM, respectively.
- Boll damage was found to be very low (less than 0.5 %) in both Bt Bunny trial fields involving IPM and Non IPM.
- In addition to coccinellid beetles, Chrysoperla and syrphids were also found in IPM practice.
- One spray was given to control sucking pests in both fields involving IPM and Non IPM. on 100<sup>th</sup> DAS (Sucking pests: Imidacloprid 200 SL @ 100 ml / ha).
- No pink bollworm larvae were observed inside the bolls in both the IPM and Non IPM trials.



## **B) Economic Returns**

- **Yield** was found to be 30 Q/ha and 29 Q/ha in IPM and Non IPM practices, respectively.
- **An additional income** of Rs 2500 obtained due to cowpea (inter crop) and castor (border crop) in the IPM practice.

**C:B ratio** was found to 1:12.2 and 1:11.6 in case of IPM and Non IPM practices, respectively.

## **C) Sucking pests scenario in cotton**

- Significant finding from IPM trials conducted since last four years revealed that the sucking pests like aphids, Leaf hopper and mealybugs were found throughout the crop period.
- In the IPM plots timely control of sucking pests through insecticidal sprays, and intercrop with cowpea for augmenting the natural predators resulted in good returns compare to Non-IPM (CB Ratio in IPM: 1:6.6 : Non-IPM: 1:5.3).
- Damage by bollworms were insignificant in all the four years.

## **4. Survival of Pink bollworm on Bt cotton**

Experiment was carried out in the field located at Dept. of Cotton, Tamil Nadu Agricultural University, Coimbatore-3. Sowing of Non Bt cotton i.e. MCU 5 on one acre and sowing of Bt Bunny (Bollgard) in another one acre was done on 13-08-2010.

### **Observation recorded**

Observation were made on the pink bollworm incidence in flowers and green bolls in both Bt cotton and Non Bt cotton.

### **Inference**

#### **Rosette Flower**

- Observations were recorded on the rosette flower damage from 90 DAS.



- The first incidence of rosette flowers was observed when the crop was 100 days old in MCU 5.
- The rosette flower observed in MCU 5 is ranged from 1 - 3 in numbers/100 flowers.
- 1 – 3 rd instar larvae were found in the rosette flowers.
- No rosette flower was observed in Bt Bunny.

#### **Green boll damage**

- Twenty five green bolls observed for pink bollworm damage and the damaged percent in MCU 5 ranged from 4-12%.
- The first incidence of pink bollworm in MCU 5 at 125 DAS. The stage of the larvae observed was 2 to 4<sup>th</sup> instar in MCU 5.
- No bolls were infested by PBW larvae in Bt Bunny.

#### **Locule damage**

- The open boll (at harvest) was observed for pink bollworm damage (135 DAS).
- The open damage ranged from 8-20% and locules damaged ranged from 1-3%.
- The larva stage observed was 3 and 4<sup>th</sup> instar.
- No pink bollworm damage was observed in Bt Bunny.



## RECOMMENDED PESTICIDES IN COTTON PEST MANAGEMENT

	Dosage (g.a.i./ha)	Stage of Crop
<b>Leaf hopper / Aphids / Thrips</b>		
Neem products (1500 ppm)	2.5 lit/ha	Early phase of crop growth
Oxydemeton methyl 25 EC	300	Early phase of crop growth
Phoshamidon methyl 85 WSC	200	Early phase of crop growth
Acephate 75 SP	290	Above 90 days
Monocrotophos 36 SL	350 - 600	Above 90 days
Acetamiprid	15	
Imidacloprid	25	
Thiamethoxam	25	
<b>Whitefly</b>		
Neem products (1500 ppm)	2.5 lit	
Triazophos 40 EC	600 - 800	
Acetamiprid	30 - 40	
Imidacloprid	25	
Thiamethoxam	25	
<b>Bollworms</b>		
Neem products (1500 ppm)	2.5 lit	40 - 60 day
Phoshalone 65 EC 35 EC	700 - 900	40 - 60 day
Quinalphos 20 AF	500 - 700	During fruiting stages
Chlorpyrifos 20 EC	500 - 700	During fruiting stages
Profenofos 50 EC	1000 -1250	During fruiting stages
Thiodicarb 75 SP	500	During fruiting stages
<b>Pyrethroids</b>		
Deltamethrin 2.8 EC	10 - 12.5	
Alphamethrin 10 EC	15 - 25	Above 75 days only
Cypermethrin 10 EC	40 - 60	once or twice in the cropping period
Indoxcarb	75	
Deltamethrin tablet 0.5	25 tablet/ha (12.5 g.a.i./ha)	
Lambdacyhalothrin 5 EC	15 g.a.i./ha	
Spinosad 48 SC	50 - 75	
Novaluron	609 g/ha	
<b>Note</b> : Repeated application may lead to resurgence of sucking pests		
<b>Spodoptera &amp; Others</b>		
Chlorpyrifos 20 EC	500	
Quinalphos 20 AF	500	
Diflubenzuron 50 WP	75	For early instars only
Poison bait using Monocrotophos 36 SL	250 - 500	Early & grown up larvae
<b>Seed Dresser</b>		
Imidacloprid 70 WS	5 - 10 g/kg of seed	Early sucking pests
Carbosulfan 20 SP	20 gm/kg of seed	Early sucking pests
Thiomethoxam 70 WS	5 g/kg	
Acetamiprid 20 SP	20 g/kg	
<b>Soil Insecticides</b>		
Carbofuron 3 G	750	Early sucking pests
Phorate 10 G	1000	Early sucking pests

Source	Ministry of Agriculture, Department of Agriculture & Cooperation Directorate of Plant Protection, Quarantine & Storage, Government of India, 2003-04.
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*Aphis - Aphis gossypii*



Adult



Crinkling and curling of leafves



Nymphs and adults

**Mealy bugs**





**Thrips – *Thrips tabaci***



Adults



Red eyed nymph



Adults

**White fly – *Bemisia tabaci***

**Stem weevil - *Pempherulus affinis***



Swelling of collar region



Grub



Adult



*Spider mite - Tetranychus urticae*



Damaged leaf



Eggs and nymphs



Adult mites

*Mirid bugs Creontiades biseratense*



Parrot beaking symptom



Adult





**Leaf worm - *Spodoptera litura***



Egg mass



Larva



Damaged leaf



Adult

**Leaf Hopper - *Amrasca biguttula biguttula***



Bronzing of leaf



Damaged shoot



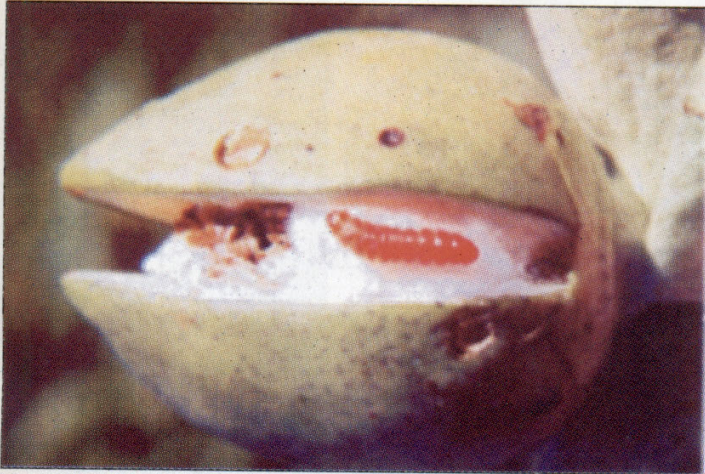
Adult



*Pink boll worm - Pectinophora gossypiella*



Rosette of flowers



Damaged boll with Larvae



Damaged Seeds



Adult



*American bollworm - Helicoverpa armigera*



Egg



Egg



Damaged boll



Larva



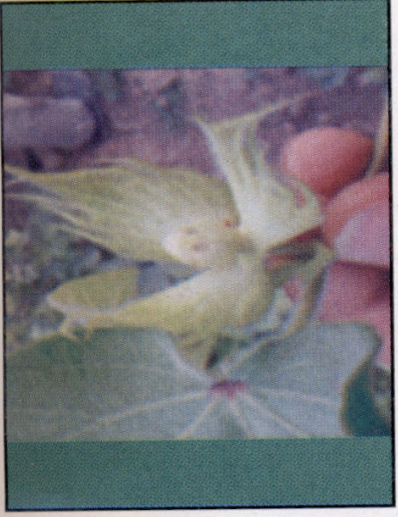
Adult



Spotted boll worm - *Earias insulana* / *E. Vitella*



Damaged square



Flared square



Larva - *E. vitella*



Adult - *E. Vitella*



Larva - *E. insulana*



Adult - *E. insulana*





Printed at TNAU Offset Press, CBE-3