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COTTON

INTEGRATED PEST, DISEASE AND NEMATODE MANAGEMENT

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ICAR-CENTRAL INSTITUTE FOR COTTON RESEARCH
Post Bag No. 2, Shankar Nagar P.O., Nagpur - 440010
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CONTENTS

Cotton : Integrated Pest, Disease and Nematode Management

Introduction

Cotton is an important cash crop of global significance and India cultivates the highest acreage in the world. In India, during 2017, cotton was grown on an area of 124.29 lakh ha with expected production of 348.62 lakh bales (1 bale=170kg). Currently, more than 88% of the total area of cotton in India is under Bt cotton Bollgard II (BG II). Wide gap persists in productivities of world and Indian cotton due to several biotic and abiotic stresses that become unmanageable due to lack of timely and proper diagnosis of the problem. In the post-Bt cotton era, as a result of widespread cultivation of Bt hybrids, crop management practices have changed, and become more input-intensive. Also, the uniformity of genotypes across vast areas favor the build-up of epidemics. As a result, growers face several new challenges and many minor insect pests and pathogens have emerged as major problems threatening cotton cultivation.

Infestation of pests start from sowing and last till harvesting and causes economic losses. Sucking pests and bollworms are the major pests of cotton that infest square, flowers, leaves and bolls. In the initial phase of crop growth, sucking pests infest crop while at the time of square, flowers and bolls formation American bollworm, spotted bollworm and pink bollworm (PBW) infest the crop. Currently, Bt cotton protects the crop from American and spotted bollworms but not against PBW.

Pink bollworm has now emerged as a major pest of BG II in parts of central and south India. The pest mainly feed on seeds causing economic loss. Infestation occurs in mid and late stage of the crop, remains undetected due to internal feeding behavior and causes loss of yield and quality. It impacts boll opening, coinciding with the second picking of cotton in most areas. Since the last 3-4 years, PBW is appearing early 45-60 days of crop on BG-II hybrids in central and south India. The infestation varies from place to place ranging from 35-95% in India. During 2017-18, major cotton producing states like Maharashtra, Telangana, Andhra Pradesh and Karnataka were under the grip of PBW damage. Availability of cotton round the year in the field favours the built up of PBW population.

Among diseases, root rot, fusarium wilt, leaf spot, bacterial leaf blight, grey mildew, cotton leaf curl virus and tobacco streak virus are major threats. If timely interventions are not taken to manage these pests and diseases; there is every possibility that more losses would be incurred by the farmers. In this booklet, latest information on pests, diseases and nematodes and their management is given. Hope this booklet will be useful for plant protection specialists, farmers, researchers, planners and students.

Sap sucking insects

Jassid/Leafhopper *Amrasca biguttula biguttula* (Ishida) (Hemiptera : Cicadellidae)

Both nymphs and adults of jassid suck the cell sap from the plant tissue and inject toxin into it resulting in 'hopperburn' symptoms. The affected leaves show crinkling and curling symptoms almost all over the plant. Heavy infestation of jassids result in drying of leaves, reduced photosynthetic activity, that hamperes the productivity of cotton reducing average cotton yield up to 30%. Population of jassid occurs throughout the season but attains pest status during July-August in central India. Hot and humid weather, intermittent rain and low sunlight prevailing for longer period help to build up the population.

Adult Jassid

Symptoms of jassid infestation

Aphid *Aphis gossypii* Glover (Hemiptera: Aphididae)

Aphid causes direct damage by feeding on the phloem sap and indirect damage by excretion

Aphids

Plant infested with aphids

of honeydew which attracts sooty mould fungus resulting in reduced photosynthesis, plant vigor and deterioration in cotton fiber quality due to deposition of honeydew on open bolls. Infested leaves exhibit crumpling and downward curling. Younger plant parts suffer more attack than older one. Aggregating populations are seen at the terminal ends. Largest populations are found on underside of leaves where they are protected from direct sunlight and temperature. Aphid infestation is favored by cloudy weather.

Thrips *Thrips palmi* Karny, *Thrips tabaci* Lind. (Thysanoptera: Thripidae)

Both nymphs and adults lacerate the tissue and de-sap the plants both from the upper and lower surfaces of leaves. While feeding they inject saliva and suck lysed contents of plant cells resulting in silvery or brown necrotic spots. Infested plants demonstrate hampered growth, loss of vigor, leaves become wrinkled and distorted, curl upward with white shiny patches. Rusty appearances in patches develop on underside of leaves. Higher infestation during vegetative stage results in late bud formation. Thrips damage results in premature dropping of squares, delayed crop maturity and reduction in yield. Population peaks can be seen during July-August modulated by rainfall distribution and dry spells with higher temperatures. In north India, during crop season 2017, high infestation of thrips was recorded.

Thrips Adult

Thrips nymph

Whitefly *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae)

Whitefly cause both direct and indirect damage to cotton plant. The direct damage is caused by sucking the sap. Damage from direct feeding reduces the photosynthetic activities of the plant and hence yield get reduced. Indirect damage results from honey dew contamination of lint and associated fungi and through transmission of cotton leaf curl disease (CLCuD). Late season damage severely affects the seed development and the lint quality. Although whitefly occur throughout India, it is the most important sucking pest in North cotton growing states of Punjab, Haryana and Rajasthan by virtue of its capability to transmit CLCuD, especially in *Hirsutum* cotton. Outbreak of whitefly was witnessed during 2015 in North India. Warmer

climate, high RH and scanty rainfall situation aggravate severity of the pest.

Adult Whitefly

Whitefly infested leaf

Mealybugs (Hemiptera: Pseudococcideae)

Both nymphs and adults suck sap from all parts of the plant. Plants infested with mealybugs in the vegetative stage show stem distortion, twisting and bushiness of the affected portion. Sooty mould develops on the honey dew secretions attract ants which act as a carrier of crawlers from one plant to another. Late season infestation cause early senescence as a consequence reduced vigor and significant yield loss.

Cotton mealybug *Phenacoccus solenopsis* Tinsley : Cotton mealybug infestation at most of the places in north and central zones was high during 2007 and 2008 but was reduced to a minor pest from 2009 onwards.

Adult female *P.solenopsis*

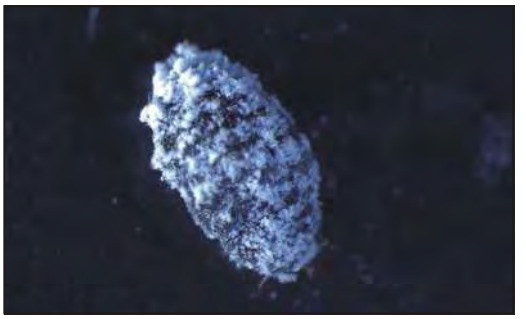
P. solenopsis infested plant

Papaya mealybug *Paracoccus marginatus* Williams and Granara de Willink : Papaya mealybug mainly feed on papaya, however, since the last few years it is infesting cotton crop. Currently, this pest is seen scarcely at few locations of central and south India.

Papaya mealybug

Severely infested leaf

Spherical mealybug *Nipaecoccus viridis* (Newstead): Sperical mealybug is an important pest in central India and attacks wide variety of plants that includes food, forage, ornamentals and fiber crops. It is a minor pest of cotton. Tropical and subtropical climate favous pest build up.



Adult female *N. viridis*

N. viridis infestation

Pink hibiscus mealybug *Maconellicoccus hirsutus* (Green) : Pink hibiscus mealybug is a pest of cultivated and wild plants, trees, and shrubs. It infests crops such as hibiscus, citrus, coffee, guava, mango, soybean, cotton, maize etc. It is sporadic pest of cotton occasionally recorded in central and south India.

Adult female *M. hirsutus*

Infsetaion on branch

Striped mealybug *Ferrisia virgata* (Cockerell) : It is known by several names *viz.* cotton scale, grey mealybug, guava mealybug, spotted mealybug, two tailed coffee mealybug, tailed mealybug; white-tailed mealybug. Now-a-days, the pest is seen in traces.

Adult female *F. virgata*

F. virgata infestation

Mango mealybug *Rastrococcus iceryoides* (Green): It is a minor pest of cotton in central and south India, affecting cotton along with other mealybugs such as *P. solenopsis, P. marginatus* and *N. viridis*. This has been found to damage several hosts like custard apple, mango, guava, citrus, tea, drumstick, hibiscus, etc.

Adult female *R. iceryoides*

Infestation by *R. iceryoides*

Mirid bugs (Hemiptera: Miridae)

Indian cotton mirid bug *Creontiades biseratense* (Distant): Both nymphs and adults damage developing flower buds and tender bolls. One to two days old bolls with intact dried petals provide a good habitat for its feeding and shelter. The characteristic symptoms of

feeding on the flower bud are described as oozing out of yellow fluid from the buds and staining of yellow fluid on the inner surface of the bracts. Heavy shedding of squares and bolls occur which led to significant reduction in seed cotton yield.

Adult *C. biseratense*

Nymph *C.biseratense*

Green mirid *Campylomma livida* Reuter: Nymph and adults feed on the terminal growth, squares, flowers and bolls with their piercing and sucking mouthparts and thus cause excessive shedding of flowers, small squares and immature bolls. Developing bolls usually do not shed, but may have one or more locules damaged and show typical symptoms of 'parrot beak' like structure. Mirids occur throughout the season on cotton with maximum population development between 50 and 100 days of crop age.

Adult *C. livida*

Nymph *C. livida*

Mirid *Hyalopeplus lineifer* Walker: Both nymphs and adults feeds on squares and small developing bolls. They pierce the stylet in plant tissues while feeding. The affected area rapidly turn dull in colour, then blackens and ultimately resulting in death of the cells in the

region. Feeding by these insects results in heavy shedding of medium sized squares and tiny bolls. As the squares and bolls drop off, significant reduction in yield was noticed.

Adult *Hyalopeplus lineifer*

H. lineifer nymph

Bollworms

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

The larvae feed on the tender leaves initially and then bore in squares, buds, bolls and seed with their head thrust into the boll, leaving the rest of the body outside. Excreta surround the entry hole. Damaged squares flare up, have feeding or damaged holes on them and are shed. Clear-cut round feeding holes on squares and bolls with or without larva are seen. Larvae show preference for feeding on squares and flowers when present, however they feed on young bolls too. Damage starts from 60 - 70 days after sowing on squares, flowers and bolls. This pest is currently under control due to wide cultivation of Bt cotton but can be seen on non Bt Cotton.

'Flared up' damaged square

Typical larval feeding habit

Spotted bollworm *Earias vittella* (Fab.), Spiny bollworm *E. insulana* (Boisduvel) (Lepidoptera: Noctuidae)

Earias vittella is confined to south and central India whereas *E. insulana* is prevalent in north India. The incidence commences as early as on three weeks old crop. Terminal shoots dry and withers away when the larvae bore into the pre-squaring plants. The main stem collapses, if the growing point is affected. Feeding holes in squares and on bolls are seen with or without larvae. Flare up of squares and their shedding, premature dropping or opening of attacked bolls are common. Larvae do not confine their feeding to a single boll and hence damage is not proportionate to their numbers. Damaged bolls often succumb to secondary infection by bacterial and fungal pathogens. At present this pest is under control on Bt cotton.

Boll damage

Larva inside Boll

Pink bollworm *Pectinophora gossypiella* (Saunders) (Lepidoptera : Gelechiidae)

Larvae initially feed on the flower buds resulting in failure of opening and shedding. 'Rosetted flower' is the typical symptom of pink bollworm infestation during early reproductive growth phase of cotton. Larva enters into the developing boll through the rind and feed on developing cotton seeds. In younger bolls entire content can be destroyed, in older bolls larva feed on up to 3–4 seeds. Within a boll more than one larva can be seen. Small exit holes are seen on the developing bolls. Quality of lint deteriorates due to the presence of larvae and staining by the pest. Since last 3-4 years, the pest is seen to damage Bt cotton in parts of central and south India. Widespread infestation was observed in Gujarat, Maharashtra, Andhra Pradesh, Telangana, Karnataka and Madhya Pradesh states starting from 2015.

Pink bollworm adaptation to transgenic Bt-cotton expressing Cry1Ac (BG) and Cry1Ac+Cry2Ab (BG-II) was assessed during 2010-2017 in 38 districts of the 10 major cotton-growing states. Field evolved resistance in pink bollworm against BG II has recorded at ICAR-CICR. In central and south India, for Cry 1Ac, the RR increased from a mean of 47.12 (range 18-121) in 2013 to a mean of 1387 (704-2060) in 2017; whereas, for Cry 2Ab, the RR increased from a mean of 5.4 (range 1-31) in 2013 to a mean of 4196 (1306-9366) in 2017. These results indicate imperative need to adopt IRM strategies for pink bollworm management in India.

Larvae feeding inside green boll

Damaged green boll

Other Insects

Tobacco Caterpillar *Spodoptera litura* (Fabricius) (Lepidoptera: Noctuidae)

Larvae attack the crop in large numbers and are damaging and gregarious in nature. The neonate larvae after hatching from egg masses feed gregariously by scraping the leaves leaving behind the veins and veinlets. The grown up larvae feed voraciously and cause heavy defoliation. The larva feeds on a wide range of plants and has been recorded from over 40 mostly dicotyledonous plant families. Since last decade the pest is under control.

Gregarious feeding habit of *S. litura*

Solitary larva of *S. litura*

Flower chafer beetle *Oxycetonia versicolor* (Fabricius) (Coleoptera: Scarabaeidae)

The flower chafer beetle is a minor pest of cotton. Since the last three years, it has been seen feeding on cotton flowers in Gujarat and Maharashtra States in sporadic manner. It is migrating between crops. The adult beetles feed on the cotton flowers with peak population occurring during August and September, coinciding with the peak flowering and boll

formation period of the crop. The beetles are basically pollen eaters. Adult beetles feed singly or in a group of 2-3 and devour the flowers and sometimes developing green bolls.

Chafer beetle

Chafer beetle feeding on cotton flower

Cotton leaf folder *Sylepta derogata* (Fabricius) (Lepidoptera: Crambidae)

The cotton leaf folder is a minor pest of cotton as it occurs in October- November coinciding with the reproductive stage of cotton crop and does not appear consistently year after year. The leaf folder and semilooper do not survive on Bt cotton as they are very sensitive to *cry1Ac* toxin. Hence it is common to see leaf folder symptoms in the non Bt cotton if sown as refuge around Bt cotton. Leaf folder population serves as repository for natural enemies in the field. Leaf folder damage appears in the form of leaves turning into funnel shaped structures and each funnel harbors one to few larvae, feeding within, scraping on the leaf lamina.

Larva and fecal pellets in a leaf roll

Typical leaf roller symptom

Cotton semilooper *Anomis flava* (Fabricius) (Lepidoptera: Noctuidae)

Cotton semilooper occurs during peak vegetative stage of the crop. It is common in central India often found feeding on the leaf lamina causing holes in fully expanded tender leaves

during peak vegetative phase. Semilooper infested plants look unhealthy and stressed especially under bright sunlight and high temperature during the day. These caterpillars do not contribute to significant economic loss. Instead they serve as natural biofactories in the field allowing the multiplication of parasitoids.

Semilooper larvae

Semilooper larvae feeding on leaf

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

Both adults and nymphs suck the sap from, green bolls and seeds of partially opened bolls. Affected bolls open abnormally and their lint is stained with the excreta or body juices of the pest. Quality of the lint is affected and the attacked seeds become unfit for sowing or oil extraction. Secondary infection due to bacteria results in rotting of the entire content followed by discolouration of the lint to yellow or brown.

Adult *D. cingulatus*

Boll infested by nymph

Dusky cotton bug *Oxycarenus hyalinipennis* (Costa) (Hemiptera: Oxycarenidae)

Dusky cotton bug suck the sap gregariously from immature seeds thereby affecting their development and maturity, remain light weight, discoloured with severe shrinking and seed

germination is severely affected. Adults found in lint get crushed during ginning, emitting bad odor and stain the lint. They cause irritation to workers during cotton picking. Discolouration of lint by large number of nymphs and adults of brown to black colour are common.

Adult *O. hyalinipennis*

O. hyalinipennis infestation

Cotton grey weevil, *Myllocerus maculosus* (Desb.) (Coleoptera: Curculionidae)

Cotton grey weevil is a minor pest of cotton, adults are grey in colour while grubs are white and legless. The pest remains active in cotton from April to October. Adults feed on leaves, buds and flowers while grubs feed on the roots.

Adult *M. maculosus*

Damage by *M. maculosus*

Natural enemies of pests

Predators

Six spotted lady bird beetle *Cheilomenes sexmaculata* (Fabricius) (Coleoptera: Coccinellidae)

Six spotted lady bird beetle is a general predator of cotton whitefly, mealybugs, jassid, mites,

and early instar lepidopteran larvae. The predator helps to reduce pest's number naturally.

Adult *C. sexmaculata*

Grub *C. sexmaculata*

Mealybug destroyer *Cryptolaemus montrouzieri* (Mulsant) (Coleoptera: Coccinelidae)

The mealybug destroyer's larvae and adult feed on aphids, mealybugs, scales, mites and other soft bodied insects infesting many horticultural and plantation crops such as citrus, coffee, ornamental plants, mulberry, egg plant, guava, mango, grapevine, sapota, etc.

C. montrouzieri adult

C. montrouzieri grub

Green lace wings *Chrysoperla zastrowi silemii* (Esben-Petersen) (Neuroptera: Chrysopidae)

Larvae are active predators and feed on several species of small bodied insects especially aphids, mites, thrips, whitefly, eggs of jassids, etc while adults feed on nectar, pollen and aphid honeydew. The predator has been found to be effective at controlling whitefly and aphid in cotton crop.

Adult *C. carnea*

Grub feeding on mealybugs

Hover fly *Eupeodes confrater* (Wiedemann) (Diptera: Syrphidae)

Maggot of hover fly, feed on aphid while adults are known as pollinators. Aphids on cotton, wheat, mustard, cabbage, pomegranate and chrysanthemum are the preferred host of *E. confrater*. The adult female locates the aphid colonies and lays eggs ensuring hatched larvae get sufficient feed. The adults remain active round the year and the larvae grow up eating only aphids.

Maggot feeding on aphid

Adult *E. confrater*

Predatory stink bug *Eocanthocona furcellata* (Wolff) (Hemiptera: Pentatomidae)

Predatory stink bug is a generalist predator. Nymphs and adults feeds on larvae of lepidoptera, coleoptera and hemiptera. A female adult can consume about 4-5 caterpillars per day.

Dipteran fly *Cacoxenus perspicax* (Knab) (Diptera: Drosophilidae)

Dipteran fly predates on several mealybugs like *Maconellicoccus hirsutus* (Green), *Planococcus lilacinus* (Risso), *Nipaecoccus viridis* (Newstead), *Rastrococcus iceryoides*

(Green), *Saccharicoccus sacchari* (Cockerell), etc. infesting cotton, sugarcane, pomegranate, citrus, guava, mango, etc.

Adult *E. furcellata*

Dipteran fly *C. perspicax*

Predatory spiders

Spiders are the generalist predators, can kill a large number of insects per unit time and hence are of great importance in reducing and even in preventing outbreaks of insect pests in agriculture. Both nymphs and adults are predatory on host insects like jassid, aphids, mirids, whitefly and all lepidopteran larvae feeding on cotton leaves, bolls and squares. In cotton agro-ecosystem wide range of spiders are found which act as efficient biological control agents of cotton insect pests.

Spider *Neoscona theisi* (Walckenaer)

Spider *Thomisus* sp.

Apefly *Spalgis epius* (Westwood) (Lepidoptera: Lycaenidae)

Apefly is a well known butterfly, whose larvae are feeding on various species of pseudococcidae found in India such as *Coccidohystrix insolita* (Green), *Rastrococcus*

iceryoides (Green), *Planococcus lilacinus* (Cockerell), *Planococcus citri* (Risso) and also aphids. *S. epius* was also found to feed efficiently on the ovisacs, nymphs and adult of papaya mealybug infesting cotton and other hosts. Pupation takes place in the mealybug colony and the pupa has a rather characteristic monkey-like or phantom-like appearance, and is known as the monkey-face pupa.

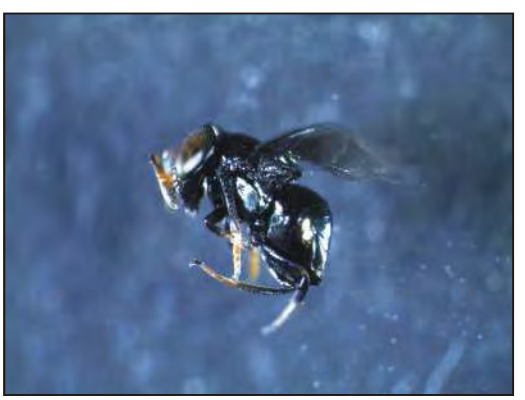
*Larv*ae feeding on *P.marginatus*

S.epius butterfly

Parasitoids

***Aenasius arizonensis* (Girault) (Hymenoptera: Encyrtidae)**

The parasitoid was seen with widespread occurrence of mealybug *P. solenopsis* on cotton and diverse host plants, across three cotton agro ecosystems of India since 2008. This species played a very significant role in keeping *P. solenopsis* population under control. Average 30% parasitism reported in the country. Although it attacks all the stages of mealybug, however, third instar mealybugs are preferred for parasitism over rest of the stages owing to its suitability for survival, reproduction and progeny fitness of the parasitoid offsprings.



A. arizonensis

Parasitized *P. solenopsis* by *A. arizonensis*

***Acerophagus papayae* Noyes & Schauff (Hymenoptera: Encyrtidae)**

A solitary endoparasitoid *Acerophagus papayae* Noyes & Schauff is a biological control

agent of papaya mealybug *P. marginatus*. It parasitizes the early stage (II instar) nymphs of the mealybug. A recent finding supported that *A. papayae* had a higher percentage of parasitism up to 31% and was more efficient in controlling *P. marginatus*.

Aprostocetus sp. (Hymenoptera: Eulophidae)

Aprostocetus sp. (Hymenoptera: Eulophidae) was found to parasitize *P.solenopsis* about 8.5 and 60% at Akola and Jalna respectively, during 2012.

Acerophagus papayae

Aprostocetus sp.

Bracon lefroyi (Dudgeon & Gough) (Hymenoptera: Braconidae)

This parasitoid effectively checks the field population of pink bollworm (*Pectinophora gossypiella* Saundars) with parasitism ranging from 25-81%. Early season pink bollworm populations suffered more larval mortality as compared to later season pink bollworm populations.

Trichogramma bactrae Nagaraja (Hymenoptera: Trichogrammatidae)

Parasitoid *Trichogramma bactrae* is an egg parasitoid of pink bollworm. Trials conducted by

Adult *B. lefroyi*

Trichogramma bactrae

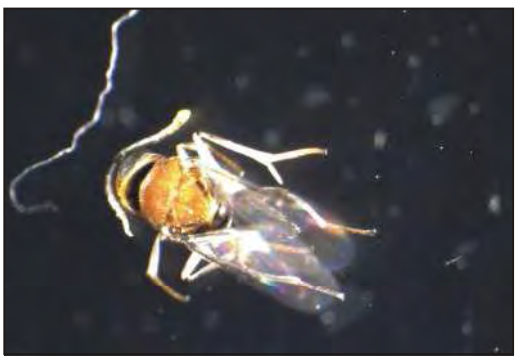
ICAR-CICR on augmentative release of this parasitoid revealed that control of pink bollworm was at par with the insecticides. Release of parasitoid as biological control agent is advocated @ 60,000/ac thrice at weekly interval.

Metaphycus sp. (Hymenoptera: Encyrtidae)

Metaphycus sp. is small primary parasitoid of scale insects belonging to families Coccidae, Eriococcidae and Asterolecaniidae. This parasitoid was recorded parasitizing *P. solenopsis* infesting cotton and other hosts in the range 7-10% in central India.

Anagyrus kamali Moursi (Hymenoptera: Encyrtidae)

Parasitoid *Anagyrus kamali* is a good candidate for classical biological control of pink hibiscus mealybug. The female wasp punctures a live mealybug body and extracts fluid from the wound. The female wasp feeds on the fluid of the dying mealybug, which provides nutrients to wasp's eggs for development.



Metaphycus sp.

Anagyrus kamali

Palexorista laxa Curran (Diptera: Tachinidae)

Tachinid is an endo-larval parasitoid of Lepidopteran insects such as semilooper and *H. armigera*. They occur during month of August to October. A high host mortality (48-100%)

Adult *Palexorista laxa*

Semilooper larvae affected with Tachinid

due to parasitoid attack occurred when small larvae (2nd & 3rd instars) were parasitized.

***Rogas aligarhensis* Quadri** (Hymenoptera: Braconidae)

Rogas parasitoid, is a larval parasitoid of the cotton spotted bollworm, *Earias vittella* (Fabricius). Parasitism rates of greater than 25% in eggs and 37% in pupae have been reported.

***Campoletis chlorideae* Uchida** (Hymenoptera: Braconidae)

Campoletis chlorideae is a larval parasitoid of *Helicoverpa armigera* and *S. litura*. It is a key parasitoid of the early instar larvae of *H. armigera* throughout India. The parasitization rate ranged from 25.1 to 63.1%.

Rhogas

Campoletis chloridae

***Apanteles angaleti* Muesebeck (Hymenoptera: Braconidae)**

Apanteles angaleti is a solitary endoparasitoid of *P. gossypiella* in India and Pakistan. The females prefer 4 to 8 days old larvae for oviposition and the maximum eggs are deposited in 6 days old larvae.

Apanteles angaleti

Parasitized larvae of semilooper

Pest management strategies

Pre-season and in-season cultural, mechanical and physical methods for minimizing pest populations

S. No.	Physical/ cultural/ mechanical practices	Target pest(s)	Impact
1	Timely termination of crop	ABW, SBW, PBW	Reduces carry over by breaking cycle of pest
2	Avoid ratoon crop. Allow grazing of cattle, sheep, goat after last picking	MB, PBW	
3	Collection and destruction of bad opened bolls. Destruction of previous season cotton stalk. Do not stack cotton stalks on the field bunds	PBW	
4	Install pheromone traps in market yard and ginning mills	PBW	
5	Avoid pre monsoon sowing	PBW	Adults that emerge from pupae will die for the want of suitable host stage to oviposit and thus it will help reducing population built up for subsequent generations
6	Growing of non Bt (20% refuge) around Bt-cotton field or Built-in-refuge (5-10% not Bt seeds)	ABW, SBW, PBW	Delay of resistance to Bt
7	Destruction of cotton stalk and weeds during off-season and in-season	MB, WF	Reduces carry over pest infestation
8	Growing strips of pigeon pea/ bajra/ sorghum/ maize crop between cotton rows	MB	Act as a physical barrier and check spread
		ABW	Delay in resistance development in ABW. Additionally help to increase natural enemies colonization
9	Destruction of infested plants and weeds	MB	Reduce spread of pest
10	Pre season deep ploughing	ABW, PBW, TC	Pupal mortality through bird feeding and high temperature
11	Removal of infested terminal shoots	SBW, ABW	Reduces infestation
12	Use of sucking pest tolerant genotypes tested and recommended for the agro ecological zone	PBW	To escape from pink bollworm by avoiding unnecessary spayas for the the control of sucking pests.
13	Installation of yellow sticky trap	WF	Monitoring and managing whitefly population

ABW- American bollworm, PBW-Pink bollworm, SBW–Spotted bollworm, TC- Tobacco caterpillar, MB - Mealybug, WF-Whitefly

Economic Threshold Levels (ETLs)

Based upon the result of survey/field scouting etc for different pests, farmers are adviced to initiate pest management practices accordingly as soon as the pest crosses ETL. The ETLs for major pests are as under.

Insect pest	ETL : Pest count in a sample of 20 plants per acre
Jassid	≥5 plants showing (25% plants infested) damage grade II/ III/ IV
Thrips	≥5 plants showing silvery patches on underside of leaves above mid canopy (25% plants infested)
Whitefly	6 Whitefly/leaf
Aphids	≥2 affected plants counted randomly showing symptoms cupping / crumpling of few leaves on the upper portion of plant (10% plants infested)
Mealybugs	≥20 plants/acre showing damage grade II/ III/ IV
Mirid bugs	≥5 mirid nymphs or adults per plant (from top canopy squares) (25% plants infested)
Spodoptera	≥2 Egg mass / cluster of gregarious larvae or ≥10 infested plants (50%) having ≥5 solitary full grown larvae/plant
	Bollworms
American & Spotted bollworms	20% plants having one or more 'flared up' square.
Pink bollworm	More than 8 moths / trap per night for 3 consecutive nights or more than 10 % infested flowers or bolls with live larvae.

Pheromone trap

Sticky trap

Pictorial representative of sucking pest grades

JASSID

Grade I : Entire foliage free from crinkling or curling with no yellowing.

Grade II : Crinkling and curling of few leaves in the lower portion of plant + marginal yellowing of leaves.

Grade III : Crinkling and curling of leaves almost all over the plant. Plant growth hampered.

Grade IV : Extreme curling, crinkling, yellowing, bronzing and drying of leaves.

Grade I

Grade II

Grade III

Grade IV

APHID

Grade I : Entire plant free from cupping/ crumpling.

Grade II : Cupping / crumpling of few leaves on the upper portion of plant.

Grade III : Cupping of leaves upper leaves and aphid all over the plant.

Grade IV : Extreme cupping, sickness/ sooty mould.

Grade I

Grade II

Grade III

Grade IV

THRIPS

Grade I : No visible symptoms.

Grade II : Silvery patches on underside leaves above mid canopy.

Grade III : Light brown patches visible alongside of veins.

Grade IV : Stiffness of leaves to severe rusty appearance of the crop.

Grade I

Grade II

Grade III

Grade IV

MEALYBUG

Grade I : About 1-10 mealybugs scattered over the plant.

Grade II : One branch infested heavily with mealybugs.

Grade III : Two or more branches infested heavily with mealybugs, up to 50% plant affected.

Grade IV : Complete plant affected.

Grade I

Grade II

Grade III

Grade IV

Advisory for probable situations of insect pest infestation

Pests	Pests management advisory
Crop growth stage : 0-60 Days After Sowing (DAS)	
Tobacco caterpillar	• Collect and destroy egg masses/ gregarious larvae/ solitary larvae by hand picking • Spray crop with Neem oil 5ml + NSE 50ml + 1gm detergent powder per litre of water to kill residual larvae
Tobacco caterpillar, American and spotted bollworm	• For the control of early season Tobacco caterpillar, American & Spotted bollworm under emergency situation spray Clorantraniliprole 18.5 SC 3ml/10 liter water
Mealybugs	• Destroy congress grass and other weeds from field and field boundaries prior to the onset of season • Do not disturb young cotton plants that have slight infestation of the mealybugs in early stages of the crop because mealybug crawlers spread through human interventions
Other sucking pests	• Avoid spraying of any chemical insecticides during initial crop growth stage if seeds treated with insecticide used for sowing which gives protection upto initial 30-45 DAS. • During the initial phase of crop growth, natural enemies are abundant and keep the pest population under check • Sprays of harmful chemicals destroy the natural enemies. • Avoid repeated sprays of neonicotinic group of insecticides against sucking pests • If 25% plants are infested by sucking pest, spray Flonicamid 50 WG 4 g/ 10 liter water
Pink bollworm	• Install pheromone traps @5/ha at 45 days after sowing for monitoring of pink bollworm • If moth catches crosses ETL, install pheromone trap @ 20/ha for mass trapping • Spray crop with Neem oil 5ml + NSE 50ml + 1gm detergent powder per litre of water at 50-60 DAS, mandatorily
Crop growth stage: 60-90 DAS	
American and Spotted bollworms	• If 20% plants having one or more 'flared up' squares by bollworm infestation, spray Clorantraniliprole 18.5 SC @ 3ml/10 liter water
Pink bollworm	• Initiate pink bollworm monitoring starting from flowering stage, observe for rosette flowers, remove from plant and destroy them • Assess ETL by plucking 20 green bolls from randomly selected plants across one acre • ETL of pink bollworm -10% infested flowers or 10% infested

Pests	Pests management advisory
	bolls or 8 male moths catches/trap/night for 3 consecutive nights • If ETL crossed, spray Thiodicarb 75 WP 20g or Quinalphos 20AF 20ml per 10 liters of water • Collect and destroy fallen squares, flowers and bolls.
Mealybug	• Destroy congress grass. Remove infested plants in plastic bag and destroy. Conserve parasitoid, *Aenasius arizonensis* and *Acerophagus papaya* by avoiding harmful chemicals
Jassid	• If 25% plants show Grade II/III/IV by jassid, spray Flonicamid 50 WG @ 4g or Dinotefuran 20SG @3g. /10 liter water
Whitefly	• Install yellow sticky traps for monitoring and management of whitefly as well as Jassid • If whitefly crosses ETL, spray Buprofezin 25 % SC 10ml Or Diafenthiuron 50 % WP 12g Or Spiromesifen 22.9% EC 12ml Or Pyroproxifen 10%EC 20 ml per 10 litres of water
Leaf reddening	• Apply spray of $MgSO_4$ 1 %, Urea 2%, followed by DAP 2%
Crop growth stage : 90-120 DAS	
American and spotted bollworms	• If 20% plants having one or more 'flared up' square by bollworms, spray Flubendiamide 39.35% SC 3ml Or Indoxacarb 14.5 SC 5ml Or Spinosad 45% SC 2.5ml per 10 liter of water
Jassid, thrips	• If 25% plants show Grade II/III/IV symptoms by jassid or 50% plants showing silvery patches on underside of leaves by Thrips, spray Thiomethoxam 25%WG 2g per 10 liter of water
Whitefly	• If whitfly population crosses ETL (6 whitefly/leaf), spray Diafenthiuron 50%SC 12g per 10 liter of water
Pink bollworm	• Release parasitoid *Trichogramma bactrae* @60000/acre if available • Spray Chlorpyrifos 20%EC 25ml Or Thiodicarb 75 WP 20g per 10 litres of water after 10 days of parasitoid release. • Picking of clean and infested cotton may be carried out separately. Clean cotton may be stored or marketed. Infested cotton should be destroyed
Pink bollworm & Mealybug	• If 20 plants / acre having infestation Grade II/III/IV of Mealybugs and or pink bollworm infestation observed, spray Thiodicarb 75 WP 20g Or Quinalphos 20AF 25ml Or Chlorpyrifos 20 % EC 25ml per 10 liter of water
Crop Growth Stage: >120 DAS	
Pink bollworm	• On 10% infested bolls with live larvae of Pink bollworm spray Fenvalerate 20% EC 10 ml Or Cypermethrin 10% EC 10 ml or lamda cyhalothrin 5% EC 10 ml per 10 liter of water

Note: Use triple dose for power spray

Packages of practices for pink bollworm management

- Crop rotation to be followed to break the life cycle of pink bollworm.
- Procure seeds of authentic Bt-cotton hybrids or variety.
- Timely sowing of short duration Bt-cotton hybrids/ varieties recommended for the region.
- Inspect the crop at squaring and flowering stage for presence of pink bollworm larvae within flowers. Remove rosette flowers whenever seen and destroy them.
- Do not extend cotton crop beyond January in central India.
- Clean up fields of residual stalks and partially opened bolls. Do not stack stalks on bunds.
- Do not store infested or stained cotton in godowns.
- Install pheromone traps in the fields during the season and also near go-downs, ginning mills, market yards, storage rooms etc. to trap moths
- Do not sow cotton crop in the month of April as it would be susceptible to PBW.
- Fields that have suffered heavy damage due to PBW last year may be closely monitored during the current season.
- Monitoring of pink bollworm using pheromone traps may be initiated 45 days after sowing. Install pheromone traps @ 5/ha for monitoring moth activity of PBW.
- Use lures of authentic quality and change them at recommended intervals. Beware of spurious lures.
- Inspect the crop at squaring and flowering stage for presence of PBW larvae within flowers. ETL at this stage is 10% damaged flowers (Rosette flowers). If necessary spraying of recommended insecticide may be advocated.
- At boll formation stage, farmers are advised to inspect cotton crop for presence and damage of PBW by plucking 20 green bolls from different plants randomly. ETL at this stage is 10% damaged green bolls (at least two bolls having white or pink larvae/ exit holes).
- Strictly avoid spraying pyrethroids before November or any insecticide mixtures at any time to prevent whitefly and aphid outbreaks.
- Spray NSE 50 ml + Neem oil 5 ml/ + detergent powder/ soap 1g in 1 litre of water at 50-60 DAS
- Release of *Trichogramma bactrae* @ 60000/acre thrice at weekly intervals between 90-120 DAS

- Picking of clean and infested cotton may be carried out separately. Clean cotton may be stored or marketed. Infested cotton should be destroyed.
- Do not use insecticides belonging to class 1a and 1b (WHO classification) as these insecticides are not only ecologically hazardous, but are also detrimental to several important predatory insects such as the coccinellid beetles and several parasitoid wasps that control mealybugs and other insect pests.
- Advised use only label claim insecticides for pest control.
- Never use tank mixtures of any agrochemicals alongwith insecticides.
- Use protective aids while handling chemical pesticides.

Packages of practices for whitefly managment

- Mass campaign among farmers.
- Monitoring of whitefly should be done on alternate hosts such as vegetables, ornamentals, weeds and plantation crops starting from pre-sowing.
- Avoid excessive urea application during early vegetative phase of the crop.
- Maintain field sanitation by keeping fields, bunds and the vicinity free of weeds before and after sowing of cotton.
- Destroy volunteer / ratoon cotton plants as well as weed hosts growing near the irrigation channel/ canal and fallow lands.
- Install yellow sticky traps 20/ha during July to August.
- Vacuum suction pumps can be used during August coinciding with high whitefly population.
- Apply two sprays of neem oil at initial stage of crop.
- Avoid using synthetic pyrethroids or organophoshate or any insecticide mixtures. These insecticides are known to cause and aggravate resurgence of whitefly when used indiscriminately.
- Chemical insecticide spray suggested - Diafenthiuron 50%WP, Buprofezin 25%SC, Spiromesifen 22.9%SC, Pyriproxyfen 10%EC, Flonicamid 50%WG, Clothianidin 50% WDG after mid August. These insecticides are effective on whitefly and are relatively safer to its natural enemies.

Root rot *Rhizoctonia solani, R. bataticola, Sclerotium rolfsii*

Root rot is caused by fungus *Rhizoctonia solani, R. bataticola* or *Sclerotium rolfsii*. Symptoms include drooping of leaves and wilting. The infected plants can be easily uprooted, lack secondary roots and discoloration of roots is seen. *R. solani* and *R. bataticola* infection can be differentiated based on the discoloration and wetness of the infected roots, brown and wet in case of *R. solani* while black and dry in case of *R. bataticola*. Shredding of bark is another characteristic symptom. Root rot caused by *Sclerotium rolfsii*, a fungus characterized by the production of spherical sclerotial bodies in culture as well as on infected plants. High soil moisture coupled with high temperature favors the infection.

Infected cotton root

Root rot infected field

Fusarium wilt *Fusarium oxysporum* f. sp. *vasinfectum*

Fusarium wilt in cotton is caused by a fungus *Fusarium oxysporum* f. sp. *vasinfectum* that can infect the crop. Wilt disease can appear at any stage of plant development. Dry soil

Plant infected with Fusarium wilt

Fusarium wilt affected field

conditions normally favor infection and often this is associated with nematode infestation, the later facilitating entry of the wilt pathogen. Typical symptoms include loss of turgidity, yellowing and browning of the foliage followed by death of plants. In many cases one branch or a part of the plant exhibits the symptoms due to blocking of xylem vessels in that particular region.

Boll rot

Boll rot can be caused by pathogens like *Colletotrichum gossypii*, *Diplodia gossypina, Ascochyta gossypii* and *Fusarium* spp. Visible symptoms like deformity and immature boll opening, drying and visible fungal growth on infected bolls are seen. Boll rots usually first appear as water-soaked spots in case of bacterial infections. In fungal infections, they are generally covered with a fungal growth.

Since last couple of years internal boll rot was observed in some districts of Maharashtra. It was found that boll rot caused due to penetration of infective propagules i.e. saprophytic fungi and bacteria through the holes caused by injury by insect bite, mechanical injury or natural opening on the bolls. In addition, dry petals attached to the upper portion of bolls enhance the infectivity of propagules by retaining the moisture for long time on upper surface of bolls. While dissecting bolls at CICR, bacterial infection inside the boll was observed that restricted to one or two locules.

Fungal mycelia on infected boll

Internal boll rot

Alternaria leaf spot *A. gossypina*, *A. macrospora* and *A. alternata*

Alternaria leaf spot is caused by a fungal genus *Alternaria*. Alternaria pathogen kills the surrounding tissues and produces more spores on the surface of the lesions within a few days. Numerous spores are produced on defoliated leaves on the ground under the crop. Alternaria leaf spots are more severe on lower leaves as compared to upper leaves. When a susceptible crop is exposed to a favorable environment, defoliation occurs rapidly.

A typical lesion of *Alternaria* leaf spot

Alternaria blight affected leaf

Grey Mildew *Ramularia areola*

The disease is characterized by irregular, angular, pale, translucent spots measuring 1-10 mm in size surrounded by veinlets. The disease appears on the older leaves usually when the plants are reaching maturity. In Maharashtra State, the grey mildew is commonly referred to as 'Dahiya' or 'Dahya' disease because of the symptoms resembling sprinkled curd on foliage. A frosty or mildew growth consisting of conidiophores of the fungus appear first on the under surface and subsequently on the upper surface of affected leaves.

Grey mildew on leaf

Severely infected plant in the field

Bacterial leaf blight *Xanthomonas axonopodis* pv. *malvacearum*

Bacterial leaf blight (BLB) also known as angular leaf spot is caused by a bacterium *Xanthomonas axonopodis* pv. *malvacearum*. Four phases of the disease viz., seedling phase, Angular leaf spot and vein blight phase, black arm phase and boll rot phase are recognized. The disease is very severe during high humid conditions. Typical symptoms include seedling blight, blackening of stems, leaf spots and boll rot. Symptoms appear as small, angular water soaked spots on the underside of young leaves. Such spots turn brown to black as infection progresses.

Leaf infected with BLB

BLB infected field

Cotton leaf curl disease

Cotton leaf curl disease (CLCuD) is transmitted by whitefly (*Bemisia tabaci*). It is one of the most serious virus diseases caused by Gemini virus. This disese is prevalent in north Indian cotton growing states viz., Punjab Haryana and Rajasthan. The disease caused massive losses to cotton crop production in India and Pakistan during epidemics. The disease is characterized by small vein thickening symptoms on young upper leaves of plants, upward or downward leaf curling followed by formation of cup shaped leaf laminar outgrowth of veinal tissue on the abaxial side of the leaves. Severely affected plants due to infection at early stage are stunted and such plants often do not bear any fruiting bodies.

CLCuD infected leaf

CLCuD infected field

Tobacco streak virus disease

This disease is prevalent in the Southern part of India but also found in Marathwada and Vidarbha region of Maharashtra. TSV disease is caused by an RNA virus which is transmitted by thrips. Chlorosis of young leaves at the growing tip, discoloration, bronzing,

necrosis, curling and dwarfing of affected leaves are the visible symptoms of this disease. Infection severity is dependent on thrips multiplication on weeds like parthenium and movement on the cotton crop.

TSV infected leaves

TSV infected plant

Disease management strategies

Prevention of disease during pre-sowing and at sowing

- Field should be deeply ploughed and left for solarization to expose the soil borne pathogens
- Fields with long history of Fusarium wilt/root rot should be avoided for growing cotton crop.
- Adopt crop rotation, avoid ratoon crop and destroy crop residues.
- Avoid cultivation of cotton in fields which were affected with root rot in previous years.
- Do not allow irrigation water to flow from root rot affected fields to healthy fields.
- Avoid mono-cropping and cultivation of cucurbitaceous and solanaceous crops in adjoining fields.
- Remove weeds in and around fields.
- Opened boll should be picked immediately to avoid seed borne infection

Chemical and biological control of diseases

Disease	Duration of occurrence	Control measures
Root rot	Seedling to vegetative	Apply ZnSO4@24kg/ha as soil application. Seed treatment with Trichoderma @ 4g/kg seed Or bio-agent *Pseudomonas fluorescens* @ 10g/ kg seed Or Thiram 75% WS 3g/kg seed Or Soil drenching with Trichoderma @ 10kg/ha mixing with 200kg moist FYM. Spot drenching with Carbendazim 50%WP 2g/L water at the base of affected plants as well as surrounding healthy plants.
Fusarium wilt	Any stage of crop growth	Seed treatment with Thiram 75% WS 3g/kg seed Or Spot drenching with Carbendazim 50%WP 2 g/L water
Boll rot	Fruiting stage	Spray Carbendazim 50%WP 2 g/L water. For internal boll rot spray with streptocycline 2.5g + Copper Oxycloride 25g/10L water
Alternaria leaf spot	Vegetative and flowering stage	Spray Pyraclostrobin 20%WG 2g Or Metiram 55%+ Pyraclostrobin 5% WG 20g /10 L water.
Bacterial leaf blight	All stage	Seed treatment with Carboxin 75% WP 1.5 g/kg seed or Carboxin 37.5% + Thiram 37.5%DS 2.5g/kg seed. Foliar spray with streptocycline 1g + copper oxychloride 25g/ 10 L water.
Grey Mildew	Fruiting	Foliar spray of Carbendazim 50 WP 20g Or Pyraclostrobin 20%WG 2g Or Metiram 55% + Pyraclostrobin 5% WG 20g per 10 L water when symptoms seen.

Root knot nematode: *Melidogyne incognita*, Reniform nematode: *Rotylenchulus reniformis*

Plant parasitic nematodes cause losses in cotton crop by feeding on roots and are also involved in disease complexes resulting in yield reduction. About 10% of agricultural production worldwide is lost due to nematode damage. The nematode infection causes stunting, yellowing, chlorosis, mid-day wilting, reduced boll size and reduction in lint percentage. The nematode infected plant roots are shorter with fewer roots and root hairs. Appearance of patches of stunted plants in field is indicative of nematode damage. These patches grow in diameter every year in nematode infected fields.

The root knot nematode of cotton is predominant in north India. It has been reported on Bt cotton from almost all the districts of Punjab and Haryana. The root knot nematode produces galls on roots. The intensity of *Fusarium* wilt increases in nematodes infected fields. The reniform nematode (*Rotylenchulus reniformis*) is dominant species causing damage to cotton in central and south India. Pericycle and phloem tissues of cotton roots are damaged by immature female of reniform nematode. The reniform nematode may remain dormant for at least two years in absence of host.

Reniform Nematode infected plant

Root-knot nematode infected root

Integrated nematode management

1. Keep fields free from weeds.
2. Application of well decomposed compost/FYM in the field.
3. Deep ploughing during summer season and/or soil solarisation with polyethylene / polypropylene cover.
4. Adopt crop rotation with non host crop such as sugarcane, maize, mustard, wheat, barley, marigold, zinnia, sorghum, safflower, custard apple etc. with cotton.
5. Use trap crop *Crotolaria spectabilis* for root knot nematode and then plough in plants at 30-45 days after sowing.
6. Seed treatment with biocontrol agent *Gluconacetobacter diazotrophicus* strain 35-

Reniform nematode affected cotton field

47 CCSHAU, Hissar @ 1kg a.i/ha have been found effective against root knot nematode of cotton.

7. Egg parasitic fungi, *Paecilomyces lilacinus* that parasitizes the eggs of nematodes has shown promising results.

8. Soil amendments with non-edible cakes of Neem, Karanj, Mahua etc. have been reported effective against root knot nematodes.

Acknowledgements

Aga T. M., Tambe V. J., Nagrare V. S. and Naikwadi Bhausaheb (2016) Parasitoid, *Aenasius arizonensis* (Girault) (Hymenoptera: Encyrtidae): Its biology, morphometrics, host stage preference and use in biological control. *Journal of Biological Control,* 30(2): 91-98.

Chinna Babu Naik V., Kranthi S., Gharade S., Kumbhare S., Nagrare V.S and Singh L. R. K. 2018. Endoparasitoid: *Bracon Lefroyi* (Dudgeon and Gough) of Pink bollworm *Pectinophora gossypiella* (Saunders) On Cotton. *Indian Journal of Entomology*, 80(2), 361-366 .

Chinna Babu Naik V., Kumbhare S., Kranthi S., Satija U., Kranthi K.R. 2018. Field-evolved resistance of pink bollworm, *Pectinophora gossypiella* (Saunders) (Lepidoptera : Gelechiidae), to transgenic *Bacillus thuringiensis* (Bt) cotton expressing crystal 1Ac (Cry1Ac) and Cry2Ab in India. Pest Manag Sci, 74: 2544–2554

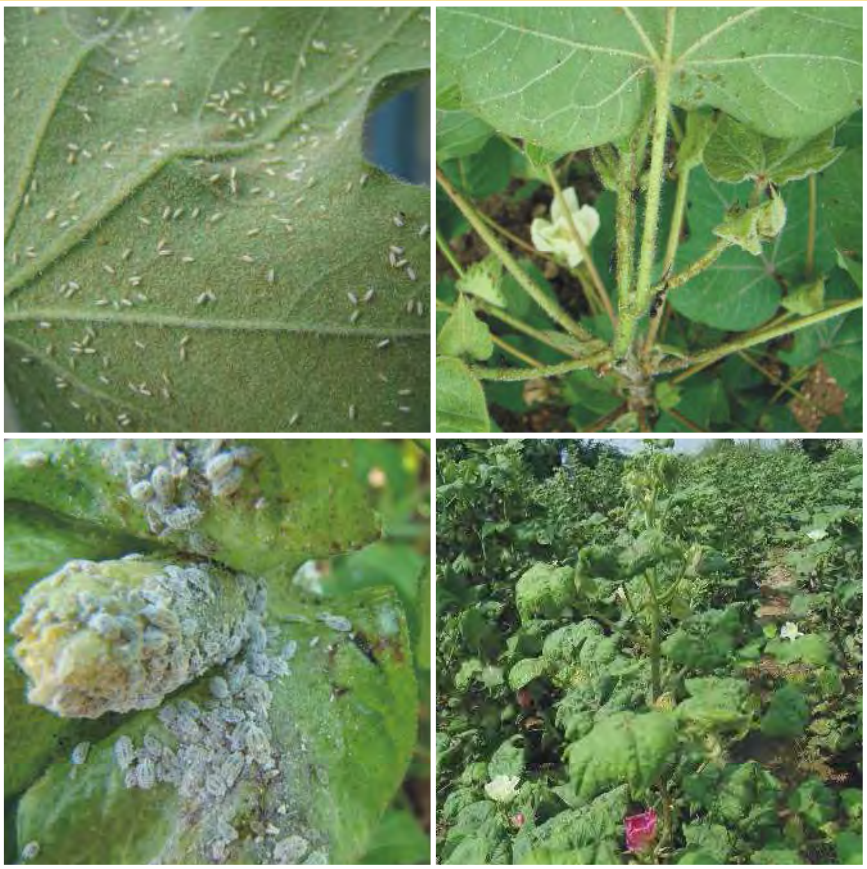
Henneberry T.J. (2007) Integrated Systems for Control of the Pink Bollworm *Pectinophora gossypiella* in Cotton. In: Vreysen M.J.B., Robinson A.S., Hendrichs J. (eds) Area-Wide Control of Insect Pests. Springer, Dordrecht, https://doi.org/10.1007/978-1-4020-6059-5_53.

Kranthi K. R. 2015. Pink Bollworm Strikes Bt-Cotton. *In* Cotton Statistics and News. Cotton Association of India. No. 35 1 December 2015.

Kranthi K. R. 2015. Whitefly –The Black Story. *In* Cotton Statistics and News. Cotton Association of India. No. 23, 8 September 2015.

Nagrare V. S., Kumar Rishi, Dharajothi B. 2014. A record of five mealybug species as minor pests of cotton in India. *Journal of Entomology and Zoology Studies* 2 (4): 110-114.

Nagrare V.S., Kranthi S., Kranthi K. R., Naik V. Chinna Babu, Kumar Rishi, Dharajothi B., Udikeri S.S., Mukherjee A.K., Mukherjee P. K, Monga D., Sampath Kumar A., Narkhedkar N.G., Banu Gulsar, Raju A.R., Tayade A. S., Prakash A.H., Khader S.E.S.A. (2013). Handbook of Cotton Plant Health, Central Institute for Cotton Research, Nagpur pp: 100.



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