# ECO-FRIENDLY MANAGEMENT OF INSECTS AND DISEASES IN COTTON

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**Cover Page**

Major insect-pests

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## FOREWORD

India is primarily an agrarian country where nearly two-third of its population directly or indirectly depends on agriculture. Agriculture continues to change as per needs of the society, leading to intensification in crop production practices. This intensification coupled with over-use of pesticides eventually encouraged pest incidence and development of resistance. The devastating situation arose particularly in cotton, which has paramount importance in Indian agriculture. Cotton, a commercial crop and backbone of the textile industry, is heaven for insect-pests. Injudicious use of pesticides poses real hazards, resulting in present state of prevailing contamination of air, water, soil and food.

Crop protection practices for management of insect and diseases have come through many phases of changes. More recent being eco-friendly pest management strategies, which are being adopted to minimize long term risk of environmental pollution, human health hazards and agricultural sustainability.

Therefore, it is highly desirable to adopt pest management practices, which include control methods such as resistant varieties, mechanical, cultural and biological control, and need-based insecticides for the sustainability and profitability of the cotton production.

I am delighted to see the endeavour of the author to bring such publication which will serve as a field guide to the users and shall be useful in cotton production practices eventually.

(R. K. Malik)

# INTRODUCTION

Natural fiber is obtained from cotton, jute, sheep and silkworm. More than 90 per cent of the fiber is obtained from cotton crop alone. This crop is the backbone of the textile industry, where 80 per cent of the raw material is obtained from it. The textile industry plays a pivotal role in national economy, which contribute 4 per cent to the GDP, provides employments to (approximately 60 million) people and earns foreign exchange to the tune of 30 per cent. India is a country where all the four cotton species are grown commercially.

Cotton cultivation in India has tremendous scope as its consumption rises by 3 per cent per annum. Although, there is wide gap in its consumption among developing (<5 kg) and developed (15 to 20 kg/annum) countries. Thus, the consumption in India will increase because of increase in population and improvement in economic status of the people.

Cotton is heaven for insect-pests. More than 1326 insect species and a number of diseases have been reported on this crop world over. However, in India about 162 insect species are found damaging the crop out of which about half a dozen are of economic importance. Due to insect and diseases infestation, both quality and the quantity are greatly reduced in various ways *e.g.* premature boll opening results in lint damage and discolouration and immature fiber.

In the urge to harvest maximum yield, conventionally grown cotton crop receives more pesticides than any other single crop. About five per cent area is under cotton crop while more than 50 per cent of the insecticides are used on this crop, which in turn pose a serious threat to the environment, human and animal health. Injudicious use of pesticides has not only eliminated the natural enemies population from the cotton eco-system but also has led to secondary pests becoming primary alongwith and resurgence of insect-pests. Apart from this, insecticides resistance in insects also develops.

Keeping these facts in view, a field guide for the cotton growers and field functionaries has been written so that the insect and diseases in cotton may be identified and properly managed.

# MAJOR INSECT-PESTS AND THEIR MANAGEMENT

## 1. Termites, *Odentotermes obesus, Microtermes obesi*

### Host Range

Polyphagous

### Damaging Stage

Adult (Workers)

### Identification

Workers are small off white in colour

### Seasonal History

Termites remain active throughout the crop season but the maximum damage is done during pre-monsoon (May-June) and post monsoon (September-October) period.

### Nature of Damage

At the seedling stage termites cut the plants from the ground level. The first sign of attack in the young plants is wilting/drying followed by the death of the plant. When the cotton plants are mature, termites construct mud galleries and damage roots and the under ground portion of the stem, the hollowed portion is filled with the mud. Due to such type of damage, the food supply of the plant is blocked which results in death of the plant. The termite-damaged plants can be easily pulled out and usually contain termites on them.

### Economic Threshold

Ten per cent damaged plants.

### Management

- Dig the termatorium and destroy the termite colony.
- Don't use raw farm yard manure as these encourage the termite infestation.
- Remove the stubbles of the previous crop from the field which attract the termites.
- Seed treatment with chlorpyriphos @10 ml chlorpyriphos +10 ml water per kg seed. Dry the treated seed in shade for 30 minutes.
- Use chlorpyriphos @ 2 litre per acre in the standing crop alongwith irrigation.



## 2. Leaf hopper : *Amrasca biguttula biguttula*

### Host Range

It is polyphagous. The important host plants are okra, potato, brinjal, and some wild plants like hollyhock, kangi buti, etc.

### Damaging Stage

Nymphs and Adults

### Identification

Adults are 3 mm long and pale greenish in colour while nymphs are green. Nymphs are found underside of the leaves during daytime. Sideways movement is the peculiar characteristic for the identification of the nymphs. Winged adults fly away at the slightest disturbance.

### Seasonal History

The pest breeds throughout the year on different hosts but maximum activity in cotton takes place during July-August which increases with the intermittent rainfall.

### Nature of Damage

Both nymphs and adults cause damage by sucking the cell sap. The attacked leaves turn pale rusted red. Leaves may turn to cup shape (usually down side) and dry up. In case of severe attack, plant vitality is affected and cotton bolls may also drop off.

### Economic Threshold

Count the leafhopper population on three leaves per plant, one each from top, middle and bottom. Take observation at least from 10 plants from the field. The population is considered to be at economic threshold, if 2 or more than 2 nymphs per leaf are observed or if 20 per cent of the leaves start showing yellowing symptoms from the edge of the leaves.

### Management

Avoid spraying upto 60 days after sowing the cotton crop as normally the pest does not reach to economic threshold. A low level of infestation by leafhoppers helps in the less damage of American bollworm to some extent. Spray the crop with 250-350 ml dimethoate (Rogor) 30 EC or 300-400 ml oxydemeton-methyl (Metasystox) 25 EC or formothion (Anthio) 25 EC or 40 ml imidacloprid (Confidor) 200 SL, 40 g thiomethoxam (Aktara) 25 WG after mixing in 120-150 litre of water.



## 3. Cotton whitefly, *Bemisia tabaci*

### Host Range

Polyphagous insect. Some of the hosts are puthkanda, gutpatni, cabbage, cauliflower, sarson, toria, melon, potato, brinjal and okra.

### Damaging Stage

Nymphs and adults.

### Identification

#### Adults

Adults are 1.0 to 1.5 mm long, yellowish in colour and dusted with white waxy powder. Wings are pure white.

#### Nymphs

Nymphs are yellowish white.

### Seasonal History

The whitefly infestation remains in cotton more or less throughout the cotton season but the maximum damage in cotton is done during August-September. Higher population has been noticed in dry weather conditions which encourage its population build up.

### Economic Threshold

Average six to eight nymphs per leaf. Count the population from three leaves (one each from top, middle and bottom) per plant and take observation at least from 10 plants from the field.

### Nature of Damage

Damage is done by sucking the cell sap from the leaves resulting in loss of vitality of the plant. Normal photosynthesis is affected due to growth of sooty mould on honeydew deposited on upper surface of the leaves, consequently the growth of the plant and yield are affected. Cotton white fly also transmits the cotton leaf curl virus and the veins of diseased leaves get thickened becoming cup shaped (up side).

### Management

Spray the crop with 250-350 ml dimethoate (Rogor) 30 EC or 300-400 ml oxydemeton-methyl (Metasystox) 25 EC or formothion (Anthio) 25 EC or 40 ml imidacloprid (Confidor) 200 SL, 40 g thiomethoxam (Aktara) 25 WG after mixing in 120-150 litre of water.

## 4. Mealybugs, *Phenacoccus solenopsis* (Homoptera : Pseudococcidae)

### Host Range

Congress grass. Kanghi buti, Okra, tomato, brinja, China rose, ber bushes, ornamental plants.

### Damaging Stage

Nymphs and adults

### Identification

Mealy bugs are creamish to gray in colour, soft-bodied, small, oval and cottony in appearance.

### Seasonal History

The pest is present throughout the year on one or the other hosts plants. However, it is serious in cotton during July onwards till harvest of the cotton crop. During winter it finds shelter under the stacked cottto sticks and some weeds. As soon as it warms up during March- April, it starts breeding on sprouts of cotton stubbles and congress grass and kanghi buti

### Economic Threshold

Sparse population

Management

- All crop residues in previously infested fields should be removed and burnt.
- Field borders should be free from weeds.
- The coccinellid beetles are important predators of mealybug nymphs.
- Spot application of insecticide is advised.
- Spray the cotton crop with the insecticides, thiodicarb @ 1.5 g or profenofos @ 3 ml or quinalphos @ 4ml/liter of water.

### WARNINGS

- Do not move any plant material with suspected meal ybugs. Moving infested plants is the fastest way to spread the pest.
- Do not shake or scatter the infested material.
- Do not spray any chemical insecticide unless mealy bug infestation is confirmed; unnecessary spraying may destroy natural enemies which keep mealybug populations under control.

### Nature of Damage

Mealy bugs damage the cotton crop by sucking large amount of sap from leaves and stems with the help of piercing/sucking mouth parts, depriving plants of essential nutrients. The excess sap is excreted as honeydew which attracts ants and also develops sooty mould inhibiting the plant's ability to make food.




## 5. Spotted bollworm, *Earias insulana* and *Earias vittella*

### Host Range

Cotton, okra, kangibuti, sonchal, hollyhock, gulkhaira and a few other weeds

### Damaging Stage

Larva

### Identification

Full grown larvae, *E. vittella* are stout, spindle shaped and light brown in colour with off white spots on the dorsal surface bearing a number of hairs on the body. The colour of *E. insulana* larvae is generally lighter in comparison to *E. vittella.* Fore wings are green in colour incase of *E. insulana* and off white strip is present in case of *E. vittella.*

### Seasonal History

The pest remains active throughout the year on one or the other host. In cotton, damage is done during August to October.

### Economic Threshold

During vegetative stage larvae of spotted bollworms damage the shoots. For this, observe at least 30 plants from one-acre field. If one per cent shoots are found affected, the pest has reached the economic threshold. During reproductive stage if 5 per cent fruiting bodies are damaged, the pest has reached to economic threshold.

### Nature of Damage

In the vegetative stage larvae bore into the growing shoots and the affected shoots droop down. Later on, during the reproductive stage, larvae bore into the flower buds, flowers and green bolls consequently shedding of the fruiting bodies takes place. The attacked bolls are tunneled and blocked with excreta. The infested bolls open prematurely and the lint is spoiled resulting in lower market value.



## Management

The pest can be controlled by adopting the following practices :

- Destroy the alternative host plants mentioned under host range as these serve as food source. Pest completes its life cycle on these plants and reinfest the cotton in the ensuing crop season.
- If there is infestation of spotted bollworm at vegetative stage, detopping of the infested vegetative shoots may be done to manage the build up of the pest population.
- Spray 1.0 litre neem (Achook/Nimbecidin) or 600 ml endosulphan (Endocel/Thiodan/Hildan/ Thiotox) 35 EC or carbaryl (Sevin/Carbavin/Hexavin) 50 WP or fenitrothion (Folithion/ Sumithion/Ekathion) 50 EC or quinalphos (Ekalux) 25 EC or lindane (Kanodane) 20 EC or profenophos (Curacron) 50 EC in150-175 litre of water.



## 6. Pink bollworm, *Pectinophora gossypiella*

### Damaging Stage

Larva

### Identification

Initial instars are white bearing pinkish ting, which subsequently change to pink colour. Larvae are found inside flower buds and the bolls of cotton.

### Seasonal History

The pest remains active during July to October-November and passes the winter season hibernating in the cotton seeds.

### Economic Threshold

Five per cent damaged fruiting bodies. Observe all the fruiting bodies (fallen or on plants) from 20 plants. For bolls, cut open 100-150 bolls and calculate per cent infestation. Observe the moth population in pheromone traps. Economic threshold for trap is five moths/trap/night during June to mid August and eight moths per trap/night during mid August to October. Use at least two traps per acre. For calculating average, consider the population of three nights.

### Nature of Damage

Larval stage damages the floral buds, flowers and bolls. Rosetted flowers are formed upon the damage done by pest. Entry hole is closed and larva continues feeding inside the bolls. The attacked bolls fall off prematurely and the others, which remain on plant, don't produce good quality lint. Double seeds are formed due to its damage.

### Management

- Remove previous year's refuge of cotton crop, which serves as source of pink bollworm infestation.
- Destroy off-season cotton sprouts, alternate host plants and burn the plant debris from cotton fields to minimize incidence.
- Deep ploughing in the end of February is also helpful in reducing the carry over of the pest.
- Spray the crop with insecticides suggested for the control of spotted bollworms if the damage exceeds 5 per cent.



## 7. American bollworm, *Helicoverpa armigera*

### Host Range

Highly polyphagous

### Damaging Stage

Larva

### Identification

Newly hatched larvae are translucent yellowish white with faint darker longitudinal lines. Full fed larvae are greenish in colour with dark gray broken lines present on the dorsal and lateral sides. Colour variation ranging from blue green to yellow, pink and reddish brown is observed.

### Seasonal History

The pest remains active during September-October.

### Economic Threshold

Five per cent damaged fruiting bodies or 1 larva in two plants.

### Nature of Damage

The newly hatched larva initiates feeding on buds, squares, flowers and bolls of the cotton crop. The larva makes a circular hole on the fruiting bodies. As it growsup, half of the larval body remains outside and releases the fecal material outside. Damaged fruiting body drops down. During early season, the larvae may also be noticed feeding on the succulent leaves.

### Management

- Destroy the weeds, which serve as the alternative host for the cotton bollworm.
- Encourage intercropping of cotton with bajra/til so that natural enemies of American bollworm may build up on intercrop which finally may manage the pest.
- Deep summer ploughing to expose pupae to sunlight so that these may be killed due to desiccation and bird picking.
- Use recommended dose of fertilizers since excessive use of nitrogenous fertilizer encourage pest infestation.
- Spray 1-1.2 litre chlorpyriphos 20 EC or quinalphos 25 EC or carbaryl 50 WP or 600 -750 ml triazophos in 200-250 litre of water.



## 8. Tobacco caterpillar, *Spodoptera litura*

### Host Range

This is polyphagous. Main host plants are castor, groundnut, tomato, sunflower, cabbage and other cruciferous crops.

### Damaging Stage

Larva.

### Identification

Larvae are black with yellowish green alongwith stripes dorsally with white bands laterally.

### Seasonal History

In cotton eco-system, it is present during August to October in the cotton season.

### Nature of Damage

The young larvae feed on chlorophyll portion of leaves while the grown-up larva damaged the leaf lamina. If the population is high these may also feed on flowers, buds and bolls.

### Management

- Spray the crop with insecticides suggested for the control of bollworms.



# MINOR INSECT-PESTS OF COTTON

## 1. Surface grasshopper

**Host Range**

Polyphagous.

**Damaging Stage**

Nymphs and adults.

**Identification**

The adults are brownish in appearance with two longitudinal rows of black dots on the underside of the white body. The nymphs are similar in body form but are smaller having wing pads instead of wings.

**Seasonal History**

The pest remains more active in cotton crop during April-May. However the population of grasshoppers may be available round the year.

**Economic Threshold**

No economic threshold has been worked out.

**Nature of Damage**

Both nymphs and adults feed on the cotton leaves where damage can be recognized by presence of feeding holes on the leaves.

**Management**

- Practically there is no need of applying pesticides for the control of this insect-pests. In a serious situation the pest may be controlled by the insecticides recommended for bollworms.

## 2. Cotton semi-looper, *Anomis flava*

### Host Range

Polyphagous.

### Damaging Stage

Larva.

### Identification

The full-grown larvae are pale green with five white longitudinal lines on the dorsal surface. Some times farmers confuse it with cotton bollworms. The difference between the two is quite conspicuous. Semi-looper forms loop while walking on leaves while American bollworm does not.

### Seasonal History

The pest remain active in cotton eco-system during August to October.

### Economic Threshold

No economic threshold has been worked out.

### Nature of Damage

Young larvae feeds on leaves making small holes while grown up larvae feed on leaf lamina.

### Management

- Insecticides meant for bollworm will also control the semi-looprers.
- Practically there is no need of applying pesticides for the control of cotton semi looper.

## 3. Thrips, *Thrips tabaci*

### Host Range

This is Polyphagous.

### Damaging Stage

Nymphs and adults.

### Identification

Adults are 1 mm in length, slender, yellowish brown visible with naked eye. Wings of the female are heavily fringed while males are wingless. Nymphs resemble with adults but are wingless and small.

### Seasonal History

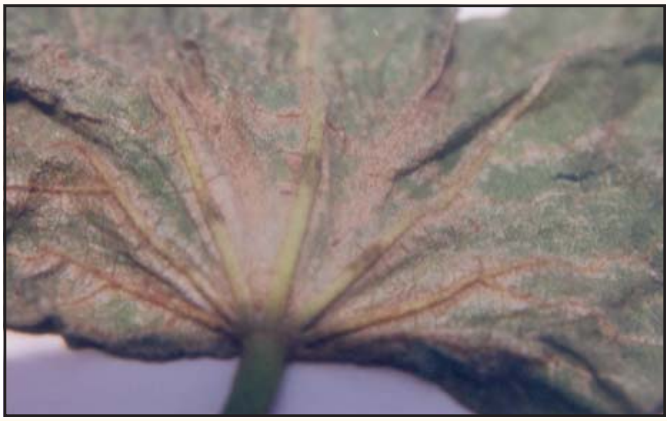
Thrips damage the cotton crop during May-June.

### Nature of Damage

Nymphs do maximum damage by rasping and sucking the sap from the veins of the leaves which ultimatly dry up. Dry weather favours the multiplication of thrips.

### Management

- Not a serious pest thus no need of applying pesticides. In case of severe infestation, use insecticides suggested for sucking insect-pests.



## 4. Dusky cotton bug

### Host Range

Okra , hollyhock and some weeds.

### Damaging Stage

Adults and nymphs.

### Identification

Adults are 4.0 to 5.0 mm long, dark brown and have dusky white. Nymphs are dark brown.

### Seasonal History

The insect is active through out the cotton season. During winter adults are found in unginned cotton and other alternate hosts.

### Nature of Damage

Damage is done by sucking the cell sap from immature seeds thus the seeds may not ripe, loose colour and remain light in weight. Adults get crushed at the time of ginning in cotton thus stain the lint and lower its market value.

### Management

- Not a serious pest, thus this pest can be managed by management practices used for bollworms.

## 5. Red cotton bug

### Host Range

Okra, maize, pearl millet.

### Damaging Stage

Nymphs and adults.

### Identification

Adults are slender crimson red with white bands across the abdomen. Membranous part of the fore wings, antennae, and scutellum is black. Nymphs are crimson red without wings.

### Seasonal History

The insect is active during reproductive phase of crop.

### Nature of Damage

Damage by the pest is done by sucking the cell sap from leaves and green bolls of cotton. The lint from the affected bolls is of poor quality. Seeds produced from the affected bolls may have poor germination and less oil. Bugs stain the lint with excreta or body fluid as they are crushed in the ginning factories. Bacterial growth also spread on lint due to the attack of the pest.

### Management

- No need to adopt separate management practices. Pesticides applied for bollworms will also control this pest.



## 6. Aphid, *Aphis gossypii*

**Host Range**

Polyphagous.

**Damaging Stage**

Nymphs and adult.

**Identification**

Adults are pale green while nymphs are of green color.

**Seasonal History**

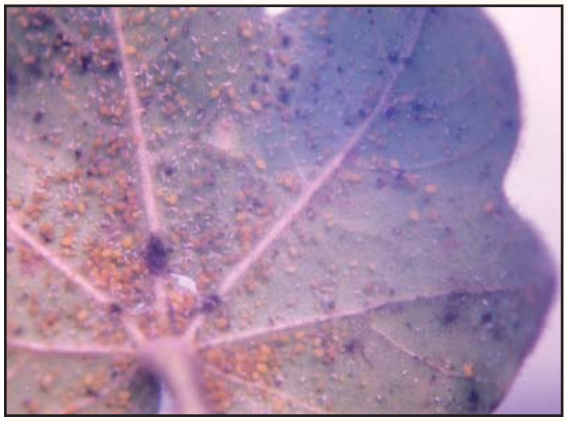
The pests remain active in cotton eco-system during the month of October and remain active till maturity of the crop.

**Nature of Damage**

Nymphs and adults of this pest cause damage by sucking the cell sap from twigs and leaves. Aphids also secrete the honeydew, which covers the upper surface of the leaves. Due to which development of sooty mould takes place ultimately hampering the photosynthetic activity. Lint quality is also affected due to development of sooty mould on open bolls.

**Management**

- Management practices followed for sap-sucking pests would manage this pest also.



## 7. Cotton grey weevil

### Host Range

It is polyphagous and some of the host plants are bajra, maize, sorghum, guava, arhar and groundnut.

### Damaging Stage

Grubs as well as adult (weevil).

### Identification

Weevils are of grey colour, while grubs are white and legless.

### Seasonal History

The pest remains active in cotton from April to October-November. Weevil passes the winter in the adult stage hidden in debris.

### Economic Threshold

No economic threshold has been worked out.

### Nature of Damage

The grubs feed on the roots, while the adults feed on leaves, buds and flowers. Nibbling of the leaves starts from the margins. Nibbling on flowers and buds also takes place.

### Management

- Management practices applied for other cotton pests will also take care of this pest.

# MANAGEMENT PRACTICES OF INSECT-PESTS OTHER THAN INSECTICIDES

## Cultural Practices for the Management of Insect-pests of Cotton

### (i) Phytosanitation

Phytosanitary measures like removal, crops residue, alternative hosts and removal of weeds are helpful to grow pest free crop.

Due to the lack of knowledge, farmers grow susceptible crops like ladies finger (bhindi) for vegetable purposes in the fields of cotton. But ladies finger harbours the insect pests of cotton crops, and serves as source of infestation.

Crop residues serve as a source of infestation for those insect-pests, which spend the dormant period in crop residues. Cotton sticks left in the field harbours the pink bollworm larvae and serve as source of infestation for the next year crop.

Sometimes farmers don't uproot the cotton ratoons, which encourage the colonization of sucking as well as bollworms of cotton ultimately serving as the source of pest infestation. It is, thus, important that these should be disposed off timely.

Alternative host plants like kangi buti too support the survival of insect-pests of cotton particularly spotted bollworms dusky cotton bug, during off-season, which later on migrate to main crop.


Unattended fields are heavily infested with weeds like bathu/khar bathu, santhi, bhakhri, bharunt, ulta kanta, etc. which not only compete for nutrients with cotton crop but also harbour insect-pests like American bollworm, tobacco caterpillar, white flies, etc.These later on migrate to the cotton crop causing damage.




### (ii) Intercropping

Due to injudicious and irrational use of insecticides, natural enemies population in cotton ecosystem dwindles. So as an integral part of integrated pest management, intercropping of cotton with bajra, cowpea, til, etc. is advised so that natural enemies population may build up on these intercrops and then manage the insect-pests infesting the cotton crop. Due to adoption of this practice, spraying of insecticides may be delayed or total

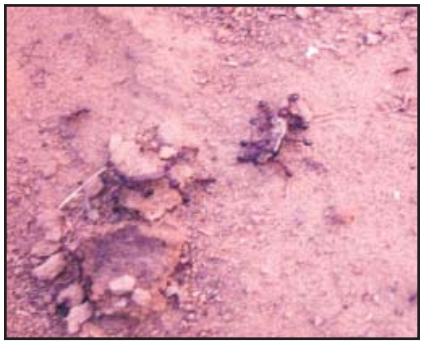

number of insecticides application may be reduced.

Likewise cowpea sowing in cotton is also helpful in encouraging the population of spider and coccinelids in cotton, which contribute to manage the soft-bodied insects like gray weevils, pupae of other pests. Sowing of bajra as intercrop helps in attracting the birds, which ultimately predate upon cotton bollworms.

### Conservation of Natural Enemies

Due to overuse of chemical insecticides in cotton, the most sufferer have been natural enemies. A handful of them like spiders, coccinellids, chrysoperlla, etc. are observed in cotton fields where judicious and rational applying of insecticides has been adopted. Their population can be further encouraged by adopting target specific insecticides instead of broad-spectrum.






## Judicious Use of Insecticides

Following points are important :

- Before taking decision on application of insecticides, ensure scouting of cotton crop for insect-pest to know economic threshold.
- Grow resistant cotton varieties/hybrids suggested by the university scientists.
- No need of application of insecticides till 60 days of sowing as during this period no serious pest infestation takes place. If pest infestation crosses the economic threshold, endosulfan application is suggested as this insecticide is relatively safe for natural enemies.
- Upto 90 days of crop age, use endosulfan or neem-based insecticides, as these insecticides are safer to natural enemies. During this period avoid use of organophosphate/carbamate insecticides. Because broad-spectrum insecticides are harmful for natural enemies.
- From 90 to 120 days of sowing, organophosphate/carbamate/synthetic pyrethroids insecticides can be used, as natural enemies population during this period declines and resistance in insect to these insecticides is also low.
- Application of synthetic pyrethriods for the control of cotton bollworms should be discouraged, since cotton bollworms are relatively resistant to these insecticides.

## Pesticides Application and Handling

- The pesticide must be used before expiry date.

- Apply pesticides at the most vulnerable stage of the pest.
- Proper dosage should be applied evenly.
- Ensure that the insecticides should reach the target.
- Proper droplet size should be maintained.
- Proper density of droplets on the target should be maintained.
- Choose right pesticide to control the pest e.g. systemic insecticide for sucking pests, contact insecticide for caterpillars.
- Do not use spray cocktails because in this process, each pesticide is used at a lower dose than recommended, which results in developing resistance.
- Use the right spray equipments e.g. for field crops use knapsack sprayer.
- Use the right nozzle e.g. for cotton, hollow cone nozzle.
- Medium size droplets are ideal i.e. 100-300 microns, to avoid the chances of the spray drift or drying before reaching the target. If the droplets are too coarse, they may damage crop and result in poor distribution resulting in poor pest management.
- Spray along the wind direction.
- Spray when the wind velocity is less than 5 kilometer/hour.
- Spray during cooler hours of the day i.e. morning or late afternoon.
- Always maintain a slight over lapping of the crop area during spraying.
- Use correct spray volume to ensure proper and uniform coverage.
- Calibrate water quantity before actual spray.
- Use proper pesticide formulation according to the availability of spraying equipment.
- Use proper and well maintained spraying equipments. Because poor maintenance leads to poor application and poor control. It also endangers the health of an operator.
- Direct the nozzles of the spraying equipment to the target for uniform and effective coverage of spray material.
- Spillage of spray material during spraying should be avoided as it leads to pesticide poisoning to the worker and phytotoxicity.
- Always calibrate equipment properly before spraying. Because correctly calibrated equipment reduces the chance of under or over dose.
- Avoid pesticide applications when there is forecast for heavy rain.
- Follow instructions from the label of the pesticide container.

### Formulation

- Spray solution of wettable powders (WPs) should look whitish.
- Granules and dusts should appear dry and not form clumps.
- Emulsifiable concentrate (ECs) normally should look milky.

### Precautions

#### Safe Handling of Pesticides

Danger of exposure to insecticides during handling always exists. The greatest risk to the applicator is in handling and applying highly toxic materials and in mixing and loading pesticide concentration. Before pesticide-handling activities, make sure that we are prepared to deal with emergencies such as spills, injuries and poisoning. Emergency supplies should include at least :

- Clean water, detergent and paper towels in a protected container.
- First aid equipments.
- Spill cleanup equipments.

Always remember that pesticides are poisonous and they are to be handled with care. Keep the following things in mind while dealing with pesticides :

### Purchase

- Buy the genuine products.
- Buy only recommended products in standard pack for use. Carefully check the brand as well as chemical names.
- Do not buy damaged packets.
- Check seals carefully for signs of tampering. Refuse to take any pack that is damaged, leaking or whose seals are tampered or which do not possess original labels.
- Purchase the pesticides from authorized dealer or distributor to get a genuine product.
- Check the date of manufacturing and expiry on the pesticide pack. Do not purchase date-expired stock.
- Insist for a genuine bill.

### Transport

- Obey laws and regulations regarding transportation of pesticides.
- Keep pesticides away from passengers, livestock and foodstuffs.
- Load and unload carefully.

### Storage

- Do not store pesticides alongwith food or animal feed.
- Keep pesticides under lock and key away from children and animals.
- Keep in cool dry place. Read label for advice on storage. Keep away from fires and direct sunlight.
- Never store pesticides in living rooms.
- Inspect packages regularly for leaks and signs of damage.
- Do not store pesticides in a damp room.
- Do not store pesticides on the floor. Store them in/on a rack.
- Do not store pesticides in refilled packs. Store in original packs.
- Do not keep empty containers in house but destroy them.
- Do not store pesticides along with seeds.
- Do not eat, drink, smoke or chew tobacco in the pesticide store.

### Measuring and Mixing of Pesticides

- Always adhere to the recommended doses and dilutions.
- Read the label and instructions leaflet carefully to determine the proper dose rate, mixing instructions and equipments to be used.
- Ready for use solid/liquid products such as dusts, granules and ULV sprays can be tipped or scooped from their packs directly into application equipment.
- Wear gloves while handling pesticides.
- Do not overfill sprayer tank, they may spill during use.
- Always prepare a spray quantity sufficient for the day only.
- Wear protective clothing.
- Do not measure or mix pesticides in or near houses or where livestock are kept.
- Take care not to contaminate water supplies meant for animal drinking.
- Use suitable equipments for measuring pesticides.
- Use bucket or open drum and use stick or paddle for mixing.
- Never suck liquid pesticide with mouth, even with a tube.
- Handle dusts and wettable powders carefully to avoid fluffing.
- Wash all equipments after use.
- Mixing vessels and measuring cylinder used for pesticides must not be used for any other purpose.

- Close the packages after use to prevent leaks or contamination and store safely.
- Small quantities of leftover and unwanted concentrates should be tipped into a hole in the ground away from dwellings, wells, waterways and crops.

## Application Equipment

### Use, Maintenance and Repair

- Clean and check equipment at the end of each day's operations. Pay particular attention to thorough cleaning of the equipment especially if not to be used again for some time because residual pesticides may cause corrosion and clogging.
- Take the most needed spare parts and tools into the field, so that running repairs can be carried out on the spot such as washers, nozzles, hose clips, batteries, spark plugs, screw drivers, spanners and pliers.
- Do not use leaking equipment, which may cause skin contamination and will result in poor application and crop damage.
- Do not use poor quality equipment, as it is hazardous. Faulty output and poor spraying or dusting patterns will give poor results and may cause damage to crops.

### Pesticide Use in the Field

- Do not apply pesticides without adequate training.
- Never allow children to apply the pesticides. Keep them out of areas being treated.
- Do not allow other workers in the field when pesticides are being applied.
- Read and follow the label instructions or ask for advice regarding dose, technique, protective clothing, timing, repeat applications and re-entry periods and pre-harvesting intervals.
- Be aware of weather conditions particularly wind, which can cause drift. This may make the pesticide ineffective by blowing it away from the target and it is hazardous if it drifts onto the operator, other crops, water, animals and houses.
- Some pesticides are easily washed off by rain, and need a rain-free period after application.
- Keep animals away from freshly treated crops.

### Safe Application Techniques

- Do not spray during strong winds.
- Spray in such a way so that any wind blows the pesticide away from operators, not on them.
- Do not blow out clogged nozzles with the mouth. Clean them with water or a soft probe such as a grass stem.
- Never leave pesticides and equipment unattended.
- Never leave pesticide containers open. Collect all wastes such as empty packages for safe disposal.
- Wash hands and face before eating, drinking or smoking.
- Do not eat, drink or smoke while spraying.
- Do not touch face or other base skin with soiled gloves or hands.
- Wash gloves before removal.
- Wash clothings and undergarments thoroughly after work.

# INTEGRATED DISEASE MANAGEMENT IN COTTON

Insects can be seen by naked eye, therefore, farmers can take suitable control measures in time but disease causing organism are microscopic and their infestation/infection is seen only when the damage has occurred. Therefore, farmers are bound to take suitable control measures well in advance for keeping the disease complex under control. The cotton disease scenario has changed after introduction of tetraploid cotton and further more with the introduction of Bt cotton. The Bt gene can keep the insect problem and more so only the lepidopterous insects under check but this genetic manipulation cannot keep the disease problem at bay. The proper diagnosis of disease and timely control measures are necessary for reducing economic losses. The integrated management practices of cotton diseases causing economical losses in northern India are:

## SOIL BORNE DISEASES

### (a) Seedling diseases

Seedling diseases are now recognized as a world wide problem and constitute a complex caused by several pathogens. Irregular, water-soaked patches are seen on the cotyledons and first true leaves. The lesions become chlorotic, later on grey in colour and the main veins turn light-brown. Several spots may coalesce and the entire leaf may be affected. Seedlings are affected when they are 2-3 weeks old. Below the soil surface roots are damaged several centimeters. Wet weather helps in disease spread.

### (b) Root rot

The disease is caused by *Rhizoctonia solani* and *R. bataticola.* It has been reported from all the cotton growing areas but is a serious problem in Punjab, Haryana, Rajasthan and Gujarat. The most important symptom is the sudden and complete wilting of the plant. All the leaves of the affected plant droop down and the plant is killed within a day. The affected plants can be easily uprooted as most of the secondary roots are decayed and detached. The disease starts much earlier but wilting takes place quite late. The tips of the roots of freshly affected plants are moist, sticky and leave yellowish exudates. The barks of the roots are broken into shreds. The hyphae and sclerotia of the fungus can be seen in rotten cortical tissues of the roots and in the shredded bark.

### (c) Fusarium wilt

The disease is caused by *Fusarium oxysporum* f. sp. *vasinfectum.* The disease can appear at any stage of the plant development. At seedling stage cotyledons and leaves wilt and turn yellow and brown. The base of the petiole shows central ring followed by death and falling off of the seedling. In adult plants, the symptoms appear first on the lower leaves. The leaves lose turgidity, turn yellow, then brown, start wilting and ultimately falloff. Subsequently the symptoms appear on the upper leaves. The wilting may be complete or partial. The vascular system of infected plant is discolored dark brown to black. The cross section of the stem shows dark ring below the bark. In severe cases the browning extends up to the top of the stem, leaves and even the bolls. The disease occurs in scattered plants or a small patch in the beginning but as the inoculum increases, the patches also increase in size.

## FOLIAR DISEASES

### (a) Bacterial blight

This is one of the most serious diseases of cotton in India. The bacterium, *Xanthomonas axonopodis* pv. *malvacearum* is known to affect all above ground parts of cotton plant throughout the growing season. Thus, this disease has acquired different names according to organ or stage it affects, *i.e.* seedling blight, angular leaf spot, leaf vein blight, black arm and bacterial boll rot.

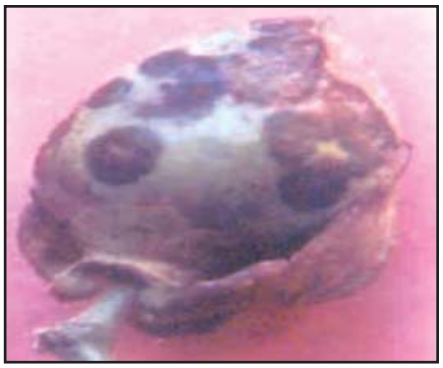
**Seedling blight :** The bacterial blight of cotton can be detected soon after the emergence of seedlings as minute dull green spots on the under surface of the cotyledons. Initially, these spots are circular, oily, water soaked and situated most frequently at the edges of the cotyledons. Later on, the spots increase in size, turn brown to black, form irregular patches and cause the cotyledons to dry and wither. The disease spreads to new leaves and finally the seedlings may collapse and die.

**Angular leaf spot :** The term angular leaf spot has been used to describe the water soaked lesions on cotton leaves. The bacterium, *Xanthomonas axonopodis* pv. *malvacearum* enters the cotton leaves through the stomata and the disease manifests itself as water soaked pin head spots first on the under surface and then on the upper surface. These spots increase in size in susceptible cv. up to 6-8 mm in diameter. They are often delimited by veins and veinlets, thus give an angular outline and turn brown to black. Sometimes, large areas are formed due to coalescence of a number of small spots leading to death and premature shedding of the leaves.

**Leaf vein blight :** In severe cases, the water soaked lesions may follow the principal veins of the leaf blade forming a zigzag line, hence called vein blight or black vein. Sometimes, this vein infection extends to the petiole and appears as brown, black with water soaked area. This is one of the important symptoms of cotton blight for its proper diagnosis.

Angular leaf spot

Leaf vein blight



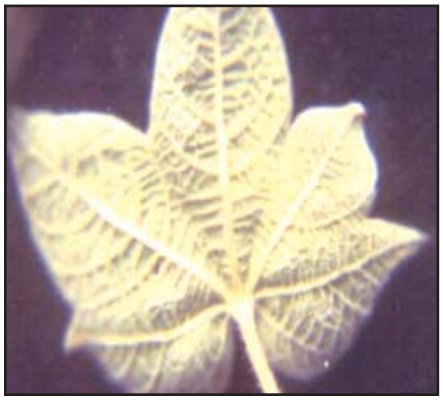
Boll rot

**Black-arm :** In general, the name black arm by which the disease was originally known refers to infection of stems and monopodial or sympodial branches is the most severe manifestation of bacterial blight. Infection may spread from cotyledons and leaves down to parenchymatous tissues of the petiole into the cortex of the stem or may make on entry through wounded tissues. The brown black lesions on stem, petiole and branches appear elongated and sunken. The affected stems exhibit cracks and gummosis and are easily broken by strong surface winds. It girdles the stem and branches causing it to break under the weight of developing bolls leading to heavy losses.

**Boll rot :** Bacterial boll rot occurs directly by extension of infection of the leaves, calyx, bracts, and receptacle or through the vascular system from the infection on a fruiting branch. Lesions on the bolls may appear water soaked at first on the surface. Later on, they turn dark brown and finally become black and sunken. The young and infected bolls fall down prematurely, even if they mature, lint is of not much commercial value

### (b) Cotton Leaf Curl Virus Disease (CLCuVD)

This disease is more prevalent in northern India. Three types of symptoms have been recognized. The main symptoms are mosaic, thickening of small veins and development of **enation** (small, leaf like or boat shaped, green outgrowths arising from the veins on the lower side of the leaf) and upward curling of the leaves. There is reduction in the number of bolls. Main vein thickening which is less common is characterized by severe curling and blistering of the leaves with thickening of the main vein and mosaic of the leaves. Stunting of the plant is visible accompanying reduction in internodal length. Flowering ceases with poor bearing. The disease is caused by **'Gemini Virus'** which is transmitted by **whitefly**. Prolonged rainy days



Cotton curl leaf virus disease

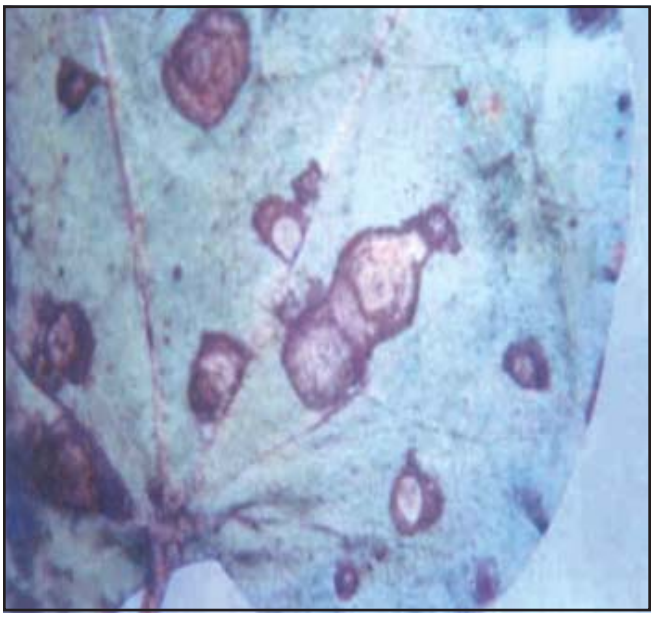
help in secondary spread of the disease because of increased vector population and excessive vegetative crop growth.

### (c) Myrothecium leaf spot

This disease is more prevalent in northern part of India while it is less frequent in southern part. The disease is caused by *Myrothecium roridum.* The characteristic symptoms are appearance of circular or oval light brown to tan coloured spots with violet to reddish brown margin. The lesions may coalesce. The centre becomes dry and drops off causing big **shot holes** in leaves. The lesions are formed on bracts and bolls also.

### d) Anthracnose

This disease is caused by *Colletotrichum capsici*. The disease affects seedling, bracts and bolls. Lesions appear on cotyledons, primary leaves and seedling stem. Small spots with irregular margins appear on cotyledons. The most destructive phase occurs on seedling stage resulting in poor plant population. The bolls are attacked at any stage of their growth which produce small water soaked, circular, slightly depressed reddish brown spots. The fungus after getting entry into the bolls spreads fast through lint and seed. The interior is usually discolored.



The mycelium of the fungus survives in the seed. The spores remain on the seed surface. It preperpetuates on the old rotten bolls and other plant parts in the field. The disease is favored much by high humidity. Rains after seedling emergence causes severe seedling blight. Boll rot also increases if it rains at the time of boll development.

### (e) Alternaria leaf spot

Four species of *Alternaria* have been reported to cause this disease. The primary symptoms on leaves are small, pale to brown, round or circular spots with cracked centre. The spots coalesce to form larger lesions . Mature lesions are dry, dead and fallout causing severe defoliation. Stem cankers are also formed in severe incidence. Boll and seed infection has been reported in desi cotton.

### (f) Helminthosporium leaf spot

The disease is caused by *Helminthosporium spiciferum.* This disease was originally noticed at Hisar on LL 54 and the incidence varied from 5-10 per cent. The disease is characterized by extensive rotting of seed, preemeragnce damping off and defoliation of adult plants. With

such symptoms the disease ought to be called blight. Rotting of seed and seedling blight are the most destructive part of the syndrom.

## EMERGING PROBLEMS

### (a) New wilt/sudden wilt/Drying off of plants

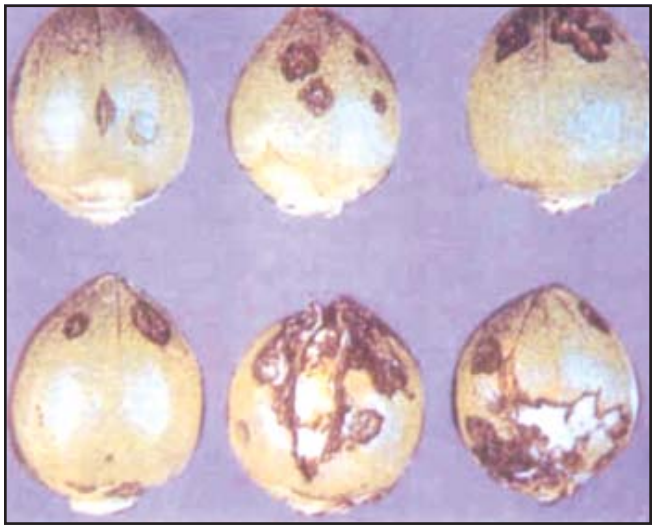
This problem is increasing day by day and in the coming years can be a potential threat to cotton cultivation. The disease generally appears at flowering and boll development phase/stage. Wilted plant show dropping of leaves starting from the crown downwards. On the basis of symptom logy and behavior, the wilt could be categorized into slow and quick types. In slow type, the malady can be recognized before wilting takes place by the stunted and dull green appearance which turn to yellow and gradually to red. Petiole and stems also get pigmented. **Epinasty** of petiole is quite common. Leaves fall off later, denuding the whole plant. It take 10-15 days to complete the process. Since slow wilted plants normally remain alive throughout the growing period but are unproductive. Quick wilt is characterized by sudden dropping of the leaves and tender shoots. It generally manifests after 45 days of crop growth and often vigorously growing plants with flowers and bolls and found wilted within a day or two of its initiation. Pigmentation of the foliage, petiole and stem generally does not take place in quick wilt. The leaves dry suddenly and the dried leaves and bolls remain attached with the plants. The progress of wilting is completed in 7-10 days. Root do not show any vascular discoloration or disintegration.

Direct and indirect evidences suggest that the disease is not caused by any fungus, bacterium, virus or mycoplasma. It is neither transmitted through grafting nor affected plant debris or soil. Soil factors such as pH, nutrition did not appear to play any role in causation of wilt; however, wilt incidence was more in sandy loam soil as compared to heavy soils. It has been observed that excess production of ethylene may be responsible for this wilting. Studies have revealed that soil drenching with 0.5 per cent nitrogen + 0.5 per cent phosphorus within 12 hr of initiation of wilt resulted in quick recovery of the plant.

### (b) Boll Rot

Boll rot is an important problem in cotton cultivation in humid regions. Severity of the disease depends upon the atmospheric humidity, plant density and crop canopy, and the losses also very accordingly. In India the losses have been reported from 10-30 per cent. Several fungi associated with boll rot and also established the primary and secondary pathogens. The primary pathogens invade mainly through the basal portion of the bolls and then the secondary pathogens grow and aggravate the disease Thus it becomes a complex problem. Besides *Xanthomonas,* several fungi have been found to be associated with the disease. Changes in microclimate within the canopy indicated that reduced light intensity and longer period of 95 percent or more R.H and free moisture favored boll rot development. Fungus colonization of

cotton bolls took place between 1st and 2nd week after flower opening and the contaminants isolated during 7th week were 'species of *Aspergillus, Curularia, Helminthosporium, Rhizopus stolonifer* etc" Since there are several micro-organisms involved in the boll rot complex, its control through any single method is very difficult. Therefore, boll rots can be managed by integrating the use of a mixture of compatible chemicals and cultural practices.



Delinting of seeds from boll rot affected bolls with sulphuric acid was recommended quite early. As insects plays role in predisposing the bolls for invasion by the fungi and bacteria, insect control reduces the boll rot to a great extent" Good control of boll rots by applying. insecticides (conventional/synthetic pyrethroids) together with fungicides and antibiotics. Use of disease free seed specially from anthraconse and bacterial blight infection is very important. Avoiding dense canopy to provide sunlight and good aeration is very essential to reduce boll rot, more particularly in the lower portion of the plant.

### (c) Stenosis or Smalling of leaves

Stenosis is also called "smalling" or "small" leaf. Symptoms appear when plants are two-three months of age. It is marked by malformation of the entire plant or only of some of the clusters of numerous, small leaves are produced. This disease appears to be caused by a mycoplasma like organisms (MLO). The disease is graft-transmissible, nor by soil or seed borne. No insect vector has been identified. Stenosis occurs only in the dry, hot regions. It affected only the *Gossypium arboreum* cotton and not the *G. hirsutum* cotton.

## INTEGRATED DISEASE MANAGEMENT

The objective of disease management is to prevent, the devastation caused by a disease. This can be accomplished best through integration of various approaches. These involve the choice of suitable variety, the crop rotation to be followed, cultural practices, proper nutrient and water management. Procurement of seed from reliable source, delinting and recommended seed treatment to be followed, the spacing to be adopted, the best time to sow taking into consideration the duration of the crop, the climate, availability of water, the quality of seed and its treatment.

### 1. Chemical control

**Acid delinting :** 1/10 quantity of acid is required for the total quantity of seed. After delinting the seed should be dried in shade. The following are the advantages of acid delinting.

a) Immature, light and diseased seeds can easily be separated.

b) By removing the fuzz, the seed can easily be sown by drill.

**Seed treatment :** In general, seed treatment is comparatively easy, cheap, safe and sure method of plant protection. Seed treatment with a fungicidal solution of streptomycin sulphate (1 g) plus Emisan (5 g) in ten litres of water for a period of 1-2 h (delinted seeds); 6-8 h (undelinted or *fuzzy* seeds) and 3-4 h (saw ginned seed) should be strictly followed to have healthy crop. This treatment will ward off both

seed and soil borne infections. For root rot *(Rhizocronia* spp.) seed treatment with carbendazim (2 g/kg seed) after the shade dry of the general treated seeds.

**Soil drench :** For the control of root rot in the standing crop, drench the affected area (healthy plants in the radius of one meter of the affected plant) with a solution of carbendazim (2 g/l). Fully saturate the healthy plants with this solution to get better control.

**Foliar sprays :** Foliar sprays with a mixture of streptomycin sulphate (6-8 g) plus copper oxychloride (600-800 g) per acre in 200-250 litres of water twice or thrice at 15-20 days interval, starting from the initial appearance of the symptoms, will check the spread and growth of fungal foliar diseases as well as bacterial blight. The first spray should be given 6-8 weeks after sowing or last week of June or before the onset of monsoon.

These chemicals are also compatible with the recommended insecticides for the bollworm control. Streptomycin sulphate/copper oxychloride/carbendazim may be added in the insecticidal sprays for the bollworm control to check the boll rot complex due to micro-organisms.

### 2. Cultural methods

Some of the procedures that can be modified to control diseases include selection of field or crop history, seed quality, deep ploughing, burning of disease debris, seed rate and sowing methods, varying the dates of sowing, crop rotation, field sanitation, spacing, fertilizers application, soil amendments, inter-cropping, clean cultivation, cultural operations, irrigations, picking and storing practices, soil sterilization, removal of stalks at the end of season, tillage, selection of resistant cultivars, avoidance of susceptible American cultivars, sowing of susceptible cultivars in and around citrus orchards, rouging of CLCuVD affected plants up to vegetative phase, avoidance of okra cultivation in autumn season in hot spot areas of CLCuVD, mixed cropping, avoidance of cultivation of susceptible American cotton varieties in hot spots of CLCuVD, use of higher seed rate, creation of buffer zones.

### 3. Biological control

Seed coating with *Trichoderma* spp. reduced root rot incidence due to *Rhizocronia* spp. Different bioagents namely *Pseudomonas fluorescens* (4 isolates), *Bacillus subtilis, Aremonas* sp. were compared with the recommended practices to control bacterial blight.

### 4. Disease resistance

One of the major aims of these investigations have been to identify the stable sources of resistance to different diseases under artificial disease stress conditions. The lines thus identified have been used as resistant donors for resistance breeding programme.

## STEPWISE INTEGRATED DISEASE MANAGEMENT PRACTICES

### 1. Pre-sowing

**Soil borne pathogens, root rot, CLCuVD.**

- Deep ploughing to expose the soil borne pathogens
- Removal of alternate hosts of CLCuVD during January-April
- Adopt crop rotation for soil borne diseases
- Avoid mono-cropping
- Avoid cultivation of cotton in severly affected root rot fields
- Add trash or “busha” in root rot affected patches, burn slowly
- Destroy crop residues stubbles and ratoon cotton

- Add FYM, BGS, SD amendments
- Growing of “Bhindi” from February to April should be avoided
- Avoid irrigation from root rot fields to healthy
- Proper level of the field should be maintained
- Gulkhera, China rose and Holyhock should be avoided in CLCuVD hot spots

**2. At sowing**

**Soil borne, seed borne disease, CLCuVD, root rot, Fusarium wilt, bacterial blight**

- Select tolerant/resistant cultivars
- Use certified seed
- Avoid sowing of undescript cultivars
- Sowing dates should be adjusted
- Inter-cropping with “Moth” in root rot fields
- Avoid staggered sowing
- Judicious use of fertilizers and water management
- Synchronized and timely sowing of short duration varieties
- Sow the seed at proper depth and moisture
- Avoid cultivation of American cotton varieties in and around citrus orchards
- Use 10kg/acre seed in hot spot of CLCuVD
- Removal of weeds in and around fields
- Cultivation of American varieties in Fusarium wilt affected areas
- Seed treatment with Streptocycline + Emisan in general
- Dry seed treatment with carbendazim in root rot affected fields
- Soil application of *Trichoderma* spp.in root rot affected patches
- Cultivation of “desi” varieties in hot spots of CLCuVD
- Seed coating with *Trichoderma* spp. To check root rot

**3. Vegetative growth stage**

**Seed, Soil borne diseases, CLCuVD, bacterial blight (20-40DAS)**

- Removal and destruction of diseased plants
- Adopt proper spacing by thinning

- Maintain weed free crop
- Monitor the disease incidence every week
- Making “Bandh” around the infected patches of root rot before rains and irrigation
- Drenching with carbendazim at initial root rot appearance
- Spray systemic insecticides for whitefly control at 4-5 leaf stage
- Spray Streptocycline to check bacterial blight
- Spot application with *Trichoderma* spp. To control root rot

**4. Early fruiting stage**

**Root rot, Fusarium wilt, CLCuVD, foliar disease**

- Removal and destruction of affected plants
- Monitor the disease incidence every week
- Maintain weed free crop
- Avoid excessive use of nitrogenous fertilizers
- Judicious use of irrigation to check root rot spread
- Spot application with carbendazim in root rot patches
- Spray systemic insecticides for CLCuVD vector (whitefly)
- Do not use the same pesticides every time
- Spot application with *Trichoderma* spp. in root rot patches
- Spray Streptocycline and copper oxychloride to check foliar diseases

**5. Peak flowering and fruiting stage**

**Root rot, Fusarium wilt, CLCuVD, foliar diseases, boll rot (60-80DAS).**

- Remove and destroy the diseased plants
- Spot application of carbendazim/bioagents to check root rot
- Maintain weed free crop
- Monitor the crop for diseases every week
- Avoid excessive use of nitrogenous fertilizers
- Foliar application of urea in sandy areas
- Spray Streptocycline plus copper oxychloride to control foliar diseases
- Add Streptocycline/copper oxychloride/carbendazim in recommended insecticides for bollworms to control boll rot complex
- Spray “neem” products to control whitefly, vector of CLCuVD

## 6. Boll development stage

### Foliar diseases, boll rot, CLCuVD (80-100DAS)

- Monitor the crop for diseases every week
- Spray streptocycline plus copper oxychloride to control foliar diseases
- For boll rot complex, add Streptocycline/copper oxychloride/carbendazim in recommended insecticides for follworms
- Spray triazophos/acephate to control whitefly
- Avoid synthetic pyethroids under dry spell conditions

## 7. Boll opening stage

### Foliar diseases, CLCuVD, boll rot (100-150DAS)

- Spray Streptocycline plus copper oxychloride to control foliar diseases
- Monitor the crops at regular interval
- Add Streptocycline/copper oxychloride/carbendazim in recommended insecticides for bollworms to control boll rot complex
- Avoild picking of rotten bolls
- Opened boll picked immediately to avoid seed borne infection

## 8. After last picking

- Dry the lint before storage to avoid micro-organism damage
- Terminate the crop at maturity early to prevent the reinfestation of diseases
- Destroy crop residues
- Trash should be destroyed
- Acid delinting in combination with gravity grading of seeds prior to storage
- Seed should be stored in well aerated dry stores.

## Publications of Directorate of Extension Education, CCSHAU, Hisar

1. Herbicide Resistant *Phalaris minor* in Wheat – A Sustainability Issue
2. Major Weeds of Rice-Wheat Cropping System
3. धान–गेहूँ फसल–चक्र में समन्वित पोषक तत्व प्रबन्धन : वर्मी तकनीक
4. फसलों में खरपतवार नियंत्रण
5. भूँईफोड़/मरगोजा (आरोबेंकी इजिप्टियाका पर्स.) की तिलहनी तोरिया में ग्रस्तता एवं प्रबंध हेतु विकल्प
6. Broomrape (*Orobanche aegyptiaca* Pers.) Infestation in Oilseed Rapes and Management Options
7. Long-term Response of Zero-Tillage – Soil Fungi, Nematodes & Diseases of Rice-Wheat System
8. IPM Issues in Zero-Tillage System in Rice-Wheat Cropping Sequence
9. Zero Tillage – The Voice of Farmers
10. कृषि में विविधीकरण – खुम्बी उत्पादन का सफल प्रयास
11. Animal Production and Health : Frequently Asked Questions
12. Project Workshop Proceedings on Accelerating the Adoption of Resource Conservation Technologies in Rice-Wheat Systems of the Indo-Gangetic Plains, June 1-2, 2005
13. आंवला उत्पादन एवं परिरक्षण
14. Addressing Sustainability Issues of Rice-Wheat Cropping System
15. ग्रामीण उत्थान में डेयरी का महत्त्व
16. ब्रायलर पालन
17. मधुमक्खी पालन – लाभदायक व्यवसाय
18. बेर – उत्पादन व परिरक्षण
19. ग्रामीण जैविक संसाधन – पशुपालन की भूमिका
20. नीबूंवर्गीय फल – उत्पादन एवं परिरक्षण
21. कृषि विविधीकरण में बागवानी
22. गेहूँ–धान फसल चक्र में ग्रीष्मकालीन मूँग
23. खुम्ब–उत्पादन : लाभकारी व्यवसाय
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25. सब्जी उत्पादन : समस्या व समाधान
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27. Direct Marketing
28. जीरो टिलेज : किसानों की आवाज
29. Bed Planting – A Novel Technique to Encourage Multiple Land Use
30. Diversification through Farming System Approach
31. फल, फूल व सब्जियों का नर्सरी प्रबन्धन,
32. Improving the Productivity and Sustainability of Agriculture based Rural Bio-Resources.