

Plant-Protection Measures for Cotton Crop

1. Insect Pests Management (Bt cotton) Bt cotton does not provide effective control of sucking pests and tobacco caterpillar.

Sucking Insect Pests : Among sucking pests, jassid, aphid, whitefly and mealy bug are most serious on Bt cotton and they cause maximum damage during July-September. Nymphs and adults of jassid suck sap from leaves and cause shedding in case of severe infestation. Whitefly adults and nymphs suck sap from leaves and excrete honey dew on leaves which become sticky. Affected leaves and seed cotton turn black due to development of sooty mould. Aphids appear sporadically. The nymphs and adults of aphid suck sap and excrete honey dew on leaves on which black fungus develops. Petioles, internodes, flowers, buds, mature bolls and even leaves fall down and growth of the plant is retarded.

Tobacco caterpillar : It is a polyphagous pest. The larvae cause serious damage to crop from August to October. The small larvae are black whereas grown up larvae are dark green with black triangular spots on body. Its moths lay eggs in masses covered with brown hairs on the lower side of mature leaves. After hatching, first and second instar larvae feed gregariously and skeletonize the foliage. Later on grown up larvae disperse and feed singly. Besides leaves, they also damage the buds, flowers and green bolls. Spotted, pink and American bollworms may also attack Bt cotton late in the season. Due to attack of these bollworms shedding of flowers and bolls may occur.

For effective protection of Bt cotton, it is necessary to adopt the following Integrated Pest Management strategies.

A. Cultural and Mechanical Control

- * Grow only recommended Bt cotton hybrids.
- * Avoid growing castor, *moong*, *dhaincha* and *bhindi* in and around the Bt cotton. These are the most preferred hosts of tobacco caterpillar, helping the pest to multiply and shift to cotton.
- * Keep the fields free from the weed, *itsit* as it acts as an alternate host of tobacco caterpillar.
- * Egg masses and young larvae of tobacco caterpillar feeding gregariously should be collected along with leaves and destroyed.

Management strategy for Mealy bug

I. During off-season

i. Prevention of carryover of pest

- Spray of infested plants/rows of cotton after last picking is useful.
- Dislodge the mealy bugs by shredding the infested sticks against ground and destroy them by burying deep in to the soil.
- Stack the cotton sticks from infested rows separately and use these sticks on priority as fuel, by end of February.
- Remove the stacks of cotton stick from the fields or houses before end February and destroy the mealy bugs by burying them in the soil.
- Do not allow the grazing of sheep and goats and other farm animals in mealy bug infested fields, although sheeps and goats feed on left over bolls to control pink bollworm.
- Prevent the movement of sticks from the infested areas to the new areas.
- Do not stack the cotton sticks in the field.

ii. On alternate hosts

- Eradicate the weeds like *kanghi buti* and *peeli buti*, congress grass, *puthkanda*, *gutputna*, *bhakhra*, *itsit* and *tandla* growing on field bunds, wastelands, roadsides and irrigation channels/canals. Repeat these operations at monthly interval upto the end of April.
- Do not throw the uprooted infested plants in cotton fields/water channels to check further spread.

- The trees/fruit plants near cotton fields harboring mealy bug population should be sprayed with recommended insecticides.

II. During crop season

- Sow only recommended hybrids/varieties of Bt cotton, because undiscrpt hybrids/varieties of Bt cotton help in faster multiplication of mealy bug.

- Grow bajra, maize and jawar as barrier crops, being least preferred hosts

- Do not grow guara, okra in or around the cotton crop as these are most suitable hosts for the multiplication of mealy bug.

- The pest is initially restricted to a few plants in a row, thus spot treatment of pest with recommended insecticides on cotton crop is advocated.

- Thorough coverage of plant with insecticides is essential to check the multiplication of mealy bug.

- Restrict the movement of workers in the infested fields to prevent further spread of pest.

- Control the mealy bug by spraying any of the insecticides given in table 1.

B. Monitoring of bollworms and tobacco caterpillar with sex pheromones

The monitoring of bollworms and tobacco caterpillar should be done with the initiation of flowering stage of crop. Observations on moth catch should be recorded on every alternate day. This monitoring strategy will help in making decision for effective management of bollworms and tobacco caterpillar.

Pink bollworm: Use Sticka/Delta traps with at least 10 micro litre of gossyplure and place it at 15 cm above crop canopy. Replace the lure after 15 days and use 1 trap/ha.

Spotted/Spiny bollworms: Use Sleeve/Moth catch traps for spotted bollworms and replace the lure at 15 days interval. Place the trap at 15 cm above the crop canopy and use 2 traps/ha.

American bollworm: Use Sleeve/Moth catch traps with at least 2 mg of pheromone and place it at 15 cm above crop canopy. Replace the lure after 15 days and use 2 traps/ha.

Tobacco Caterpillar: Use Sleeve/Moth catch trap for tobacco caterpillar. Replace the lure after every 15 days. Place the trap 15cm above crop canopy and use 2 traps/ha.

C. Chemical Control

Sucking insect pests : The decision regarding spray of insecticides should be taken based on economic threshold (ETH). Initiate spray against jassid whenever some of the fully formed leaves in the upper canopy show curling and yellowing at the margins on 50 per cent of the plants. Sprays against whitefly should be done when population reaches six adults per leaf in the upper canopy of plants before 10 AM or when honey dew appears on 50% of the plants. Spray against aphid should also be done on the appearance of honey dew on 50% plants.

Spray the crop as soon as the crawlers/adults of mealy bug appear on the cotton plant. Spray against aphid should also be done on the appearance of honey dew on 50% plants. (Table 1).

Tobacco Caterpillar : Bt cotton does not provide protection against tobacco caterpillar.

Tobacco caterpillar can cause severe damage to the Bt crop if not controlled in time. For effective control of this pest, insecticides mentioned in table 2 should be sprayed when the need arises.

Bollworms : Bt cotton provides effective protection against all cotton bollworms. However, regular monitoring should be done at weekly interval during reproductive phase. Farmers should examine their fields twice a week in order to ensure that bollworms damage does not exceed 5 per cent in shed flowers and bolls. For this purpose divide the field into four quarters and collect 25 freshly shed flowers and bolls at random in each quarter. The bolls damaged by bollworms will have feeding holes or their larvae. In case the damage exceeds 5 per cent, the crop should be sprayed immediately and thereafter spray as when need arises. If at all American bollworms cross ETH level during late crop season, use insecticides as mentioned in table 2. Prefer spinosad and indoxacarb for the control of American bollworm during September.

Resistance Management : To avoid the development of resistance in bollworms to Bt

cotton, 20 per cent area should be sown under non-Bt cotton hybrids around Bt cotton. The refuge should be non-Bt version of the same hybrid. But if it is not possible, the farmers can use non Bt varieties/ hybrids like LH-1556, F-1861, LH-2076, LHH-144 recommended by PAU as refuge. The non-Bt hybrids should be protected against damage by insect pests as mentioned in case of non-Bt cotton hybrids. Alternatively 5 per cent area of non-Bt hybrids can be sown around Bt cotton and this should be kept unsprayed.

2. Insect Pests Management (Non-Bt cotton)

Sucking Insect Pests : (See under Bt-cotton)

Bollworms : Bollworms are the most harmful insects which attack cotton in the Punjab. Spotted bollworms damage growing points during May-June and cause heavy shedding of squares, buds, flowers and bolls during July to October. The American bollworm causes severe shedding of fruiting bodies during September-October especially on American cotton. The colour of its larvae greatly varies. They have one line on upper side and two wavy lines on lateral side of body. Their body also has sparse hairs. Pink bollworm does maximum damage from mid-July to mid-October. Due to severe attack of bollworms, the plants continue to grow without having adequate number of bolls.

Tobacco caterpillar : (See under Bt-cotton).

The larvae of leaf-roller, semi-loopers, hairy-caterpillars and bud moth may also appear sporadically and damage the crop during July-October.

For effective protection of cotton, it is necessary to adopt the following **Integrated Pest Management approach** based on cultural, mechanical and chemical control measures :

(A) Cultural and Mechanical Control

* Burn all trash collected during the ginning process. Remove all seed from the ginneries by the end of April. Fumigate the seed left uncrushed in the mills before end of May with Celphos/ Phostoxin/Delicia @ one 3-g tablet per cubic metre space, giving an exposure of 48 hours or use two tablets with an exposure of 24 hours. No un-fumigated seed should be retained or sold by the ginneries. Only cotton-seed cake (*khal*), should be fed to the cattle and no seed should be kept for this purpose.

* The seed meant for sowing should be acid-delinted in the ginneries before it is sold. The acid treatment kills the larvae of the pink bollworm and the bacterial pathogen of bacterial blight. It also removes fuzz and thereby facilitates mechanical sowing.

* Even the apparently healthy seed-cotton (*kapas*) may be harbouring larvae of pink bollworm. Hence, *kapas* retained by the farmers should be ginned by the end of March and seed fed to cattle. If this seed is to be retained for sowing, it should be acid-delinted/fumigated or thoroughly dried in the sun in a thin layer for 3-4 consecutive days in April.

* Sow only recommended varieties/hybrids because they are moderately resistant to jassid and due to their early maturity they also escape the late-season attack of bollworms.

* Terminate the crop as early as economically feasible. For this purpose give last irrigation by end of September. It would reduce bollworms damage and their carryover.

* After the last picking, allow sheep, goats and other farm animals into cotton fields to feed on plant debris and un-opened bolls.

* Stacking of cotton sticks in a shaded place and in horizontal position favours the survival of the overwintering larvae of pink bollworm. Stacking in the field helps in easier spread of the first brood. Therefore, bundles of sticks should be stacked vertically in the open within the village premises. Before stacking the sticks, dislodge the burs and unopened bolls by beating them against the ground or just pluck them. The burs and bolls so collected should be burnt immediately.

* Uproot and destroy the alternate host plants of spotted bollworms/*kanghi buti* and *peeli buti*, growing on field bunds, water channels and waste land in the area during the off-season of cotton.

* Avoid growing *bhindi*, *moong* and *arhar* in the cotton crop and as border rows in order to reduce the incidence of *Helicoverpa*, spotted bollworms, jassid and whitefly. *Bhindi*, *moong*, *dhaincha* and castor are also the most preferred hosts of tobacco caterpillar, helping the pest to multiply and shift to cotton. The above pests on these crops grown in the vicinity of cotton fields, should be properly controlled in order to check their migration to the cotton crop.

* Egg masses and young larvae of tobacco caterpillar feeding gregariously should be collected along with leaves and destroyed.

(B) Monitoring of bollworms with sex pheromones : (See under Bt-cotton).

(C) Chemical Control

Sucking pests : (See under Bt-cotton).

Table 1. Insecticides for the control of sucking insect pests

<i>Insecticides</i>	<i>Dose</i>	<i>Brand (s)</i>
Jassid		
Neonicotinoids		
(a) Seed treatment: At the time of sowing smear the seed with any of the following insecticides.		
i) Imidacloprid 70 WS	5 g/kg seed	Gaucho
ii) Thiomethoxam 70WS	3 g/kg seed	Cruiser
(b) Spray : Spray any of the following insecticides, if incidence is noticed in standing crop.		
i) (a) Imidacloprid 200 SL	40 ml/acre	Confidor
(b) Imidacloprid 555 40 ml/acre Confidence		
(c) Imidacloprid 17.8 SL	40 ml/acre	Imidacel/Markdor
ii) Thiomethoxam 25 WG	40 g/acre	Actara/Extra super
Pyridine Carboxamid		
iii) Flonicamid 50 WG	80g/acre	Ulala
Whitefly		
Organophosphates		
i) Triazophos 40 EC	600 ml/acre	Hostathion
ii) Ethion 50 EC	800 ml/acre	Fosmite/E-mite/Volthion
Mealy Bug		
(a) Carbamate Group		
Thiodicarb 75 WP	250 g/acre	Larvin
Carbaryl 50 WP	1 kg/acre	Sevin/Hexavin
(b) Organophosphates		
Profenophos 50 EC	500ml/acre	Curacron/
Carina/Profex/ Celcron		
Quinalphos 25 EC	800ml/acre	Ekalux/
Quinalphos/ Quingaurd		
Acephate 75SP	800g/acre	Orthene/Asataf/Starthene/Markphate
Chlorpyriphos 20 EC	2000ml/acre	Coroban/Dursban/Durmet Chloruard/Radar/Lethal Force/Markpyriphos

(c) Insect growth regulator

Buprofezin 25 EC* 500 ml/acre Applaud/Tribune

* Use this pesticide as first spray for the control of mealy bug as this pesticide is safe for natural enemies.

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Tobacco Caterpillar : (See under Bt Cotton).

Bollworms : In order to control bollworms, conduct sprays on different varieties during their

effective boll formation period based on economic threshold (ETH). Farmers should examine their fields twice a week in order to ensure that bollworms damage does not exceed 5 per cent among the freshly shed fruiting bodies (squares, buds and young bolls). For this purpose divide the field into four quarters and collect 25 freshly shed fruiting bodies at random in each quarter. The fruiting bodies damaged by bollworms will have feeding holes or their larvae. In case the damage exceeds 5 per cent, the crop should be sprayed immediately and thereafter spray as when need arises. The effective boll formation period of different varieties/hybrids of American cotton during which spray of insecticides should be done is as follow :

Effective boll formation period in different varieties/hybrids of American Cotton

<i>Variety/hybrid</i>	<i>Effective boll formation period</i>
LH 1556	4 th week of July to mid September
LH 2076, F 1861 and LHH 144	2 nd week of August to 1 st week of October
Long duration undescrpt varieties	3 rd week of August to end October

3. Insect Pests Management (*Desi Cotton*) :

In case of *desi* cotton, the first spray against bollworms should be done when 25 per cent plants start producing squares. Subsequent spray should be need based.

Detopping : *Desi* cotton grown on medium to high fertility soils generally attain unmanageable height for effective spraying against bollworms. The top portion of plants with excessive height usually remain unsprayed. Fruiting bodies of these uncovered plant portions contribute very little towards yield but greatly help in bollworms build up. Plants attaining height more than 1.5m should be detopped as and when required by using pruning scateur/sickle/green mulberry stick.

Insecticide Resistance Management (IRM) Strategy: IRM is component of Integrated Pest Management (IPM) programme. The adoption of this strategy helps in reducing/delaying the insecticide resistance to insects. It also increases functional life of the insecticides.

1. Sucking pests management (Sowing – first week of July)

- i) Sow recommended varieties which are resistant to sucking pests and cotton leaf curl virus to avoid early sprays.
- ii) Destroy alternate hosts of cotton leaf curl virus and whitefly.
- iii) Timely sowing, judicious use of fertilizers, irrigation, proper spacing and clean cultivation will prevent the early build up of pests and help conserve natural enemies.
- iv) Treat seed with Gaucho/Cruiser to control the cotton jassid in susceptible cultivars.
- v) Do not use any insecticide during this period to conserve natural enemies.
- vi) Do not spray against thrips and black semilooper, as they do not cause any economic damage to the crop.

2. Sucking pests and bollworms management (second week of July–first week of August)

- vii) Use endosulfan for bollworms infestation as it is less toxic to natural enemies. It gives moderate control of cotton jassid also.
- viii) Avoid the use of synthetic pyrethroids for the control of spotted bollworms (SBW). Use them only if endosulfan fails to give satisfactory control.
- ix) Avoid the use of chloronicotinoid compounds against jassid as these are toxic to natural enemies.
- x) Do not use organophosphates/carbamates against bollworms.

3. Bollworms and tobacco caterpillar management (Mid to end August)

- xi) Use profenophos/quinalphos/carbaryl flubendiamide in alternation with synthetic pyrethroids for the control of bollworms.
- xii) Prefer the use of acephate for the control of grown up larvae of American bollworm. It will also provide effective control of tobacco caterpillar.
- xiii) Use spinosad only in case of severe infestation of American bollworm.

4. Bollworms and tobacco caterpillar management (September-October)

xiv) Use profenophos/triazophos/quinalphos/thiodicarb/flubendiamide for younger larvae of American bollworm. Prefer chlorpyrifos for grown up larvae. Chlorpyrifos, thiodicarb and quinalphos will also provide effective control of tobacco caterpillar.

xv) Use indoxacarb/spinosad in case the American bollworm is serious.

xvi) Use triazophos/ethion for the management of whitefly. It will also provide effective control of pink bollworm and spotted bollworms.

Table 2. Insecticides for the control of bollworms in cotton

<i>Insecticides</i>	<i>Dose/acre</i>	<i>Brand (s)</i>
Pink and spotted bollworms		
A. Synthetic Pyrethroids		
i) Alphamethrin 10 EC	100 ml	Fastac/Alphagaurd/Merit Alpha
ii) □-cyfluthrin 0.25 SC	300 ml	Bulldock
iii) (a) Cypermethrin 10 EC	200 ml	Ripcord/Bilcyp/Bullet/Ustad/Cybergaurd
(b) Cypermethrin 25 EC	80 ml	Cymbush/Cyperkill/Hillcyper/Colt/Basathrin/Agrocyper/Cybergaurd
iv) Deltamethrin 2.8 EC	160 ml	Desis/Rukrain/Decicare
v) Fenvalerate 20 EC	100 ml	Sumicidin/Fenval/Agrofen/Fenlik/Triumphcard/SB Fenvalerate/Milfen/Markfenval
vi) Fenpropathrin 10 EC	300 ml	Meothrin
Pink, spotted and younger larvae of American bollworm		
A. Carbamates		
i) Carbaryl 50 WP	1 kg	Sevin/Hexavin
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ii) Thiodicarb 75 WP	250 g	Larvin
B. Organochlorinated		
iii) Endosulfan 35 EC	1 litre	Thiodan/Endocel
C. Organophosphatic		
iv) Profenophos 50 EC	500 ml	Curacron/Carina/Profex/Celcron
v) Monocrotophos 36 SL	500 ml	Phoskill/Monocil/Monolik/Kadett/SB Monocrotophos/Luphos/Azophos/Corophos/Milphos/Markphos
vi) Quinalphos 25 EC	800 ml	Ekalux/GAIC Quinalphos/Quingaurd
vii) Triazophos 40 EC	600 ml	Hostathion
viii) Ethion 50 EC	800 ml	Fosmite/E-mite/Volthion
D. Miscellaneous group		
ix) Flubendiamide 480 SC	40 ml	NNI 0001
<i>Insecticides Dose/acre Brand (s)</i>		
Grown up larvae of American bollworm		
A. Organophosphates		
i) Acephate 75 SP	800 g	Orthene/Asataf/Starthene/Markphate
ii) Chlorpyrifos 20 EC	2 litres	Coroban/Dursban/Durmet/Chlorgaurd/Radar/Lethal/Force/Markpyrifos
B. Naturalyte		
iii) Spinosad 48 SC	60 ml	Tracer
C. Oxadiazine		
iv) (a) Indoxacarb 15 SC	200 ml	Avaunt
(b) Indoxacarb 15 EC	200 ml	Avaunt
D. Miscellaneous group		
v) Pyridalyl 10 EC	300 ml	Sumipleo
vi) Chlorantraniliprole 18.5 SL	60 ml	Coragen
Tobacco caterpillar		
A. Carbamate		
i) Thiodicarb 75 WP	250 g	Larvin

B. Organochlorinate

ii) Endosulfan 35 EC	1 litre	Thiodan/Endocel
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C. Organophosphates

iii) Acephate 75 SP	800 g	Orthene/Asataf/Starthene
iv) Chlorpyrifos 20 EC	2 litres	Coroban/Dursban/Durmet/Chlorgaurd/ Radar/Lethal/Force
v) Quinalphos 25 EC	800 ml	Ekalux/GAIC Quinalphos/ Quingaurd

D. Insect Growth Regulator

vi) Novaluron 10 EC	150 ml	Rimon
E. (vii) Pyridalyl 10 EC	300 ml	Sumipleo
(viii) Chlorantraniliprole 18.5 SL	60 ml	Coragen

Note : a) Regularly monitor the pest population.

b) For effective insecticide resistance management do not repeat the insecticide of same group in subsequent sprays.

c) Do not use mixtures of insecticides as they will result in faster development of resistance and resurgence of pests.

d) Do not use synthetic pyrethroids on cotton for the control of bollworm complex after mid September.

e) Repeat the spray immediately if it rains within 24 hours after spray.

f) If hairy caterpillars damage cotton crop during June-July use 500 ml endosulfan 35 EC/quinalphos 25 EC or 200 ml of Nuvan/DDVP 100 in 100 litres of water per acre.

g) Never follow the wrong advice of the pesticide dealers.

h) Cotton is highly sensitive to the 2, 4-D weedicide. Some farmers spray the ester form of 2, 4-D for controlling weeds in maize grown near the cotton fields. Owing to the volatile nature of 2, 4-D ester, its vapours cause serious injury to the cotton crop. Hence avoid the application of this herbicide in maize, if cotton is grown in the adjoining fields. The other precautions are :

(1) After using 2, 4-D on any crop, fill all spraying equipment as well as tubs, buckets, etc. with 0.5 per cent washing soda solution (500 g of washing soda in 100 litres of water) in the evening. Next morning, flush all equipments thoroughly with fresh water.

(2) To avoid the use of contaminated insecticides on cotton. It is advisable to test insecticide at least two weeks in advance on a few plants. If the insecticide is contaminated with 2, 4-D the tender leaves and shoots could become distorted and lancolated within 10 days. Reject such an insecticide.

Spray Technology

The insecticides recommended for control of sucking pests, bollworms and tobacco caterpillar should be sprayed using 125-150 litres spray material per acre with the manually operated knapsack sprayer or 75 litres with the shoulder-mounted power sprayer and tractor mounted sprayer. Quantity of spray material may vary with different types of sprayers and nozzles. However, actual amount of insecticide recommended should not be reduced. Making pathways by pressing the branches on both sides helps in efficient spraying. Make such pathways at 2 meters distance for the manually operated knapsack sprayer and at 4 meters for the shoulder-mounted power sprayer. Tractor mounted sprayer should have 13 triple action nozzles fixed on the boom at 75 cm distance from each other. Each nozzle should discharge 500-600 ml spray material per minute. The tractor should be operated at 4.0 and 2.5 km per hour speed for spraying against sucking pests and bollworms, respectively. Use the same tyre tracks and run the tractor in the same direction for all sprays. Keep the spray boom about 50 cm above the crop canopy. Each run of the tractor should cover about 10 meters width of the crop.

Diseases

Leaf curl : Disease is caused by white fly transmitted virus. The diseased plants become stunted and have twisted internodes. Leaves remain small, show cupping and curling. Veins on the lower-side of the leaves become thickened with netted appearance. Small leaflets (enations) also develop on the under side of the leaves on the main as well as lateral veins. Number of fruiting bodies are reduced in the diseased plants. The disease can be reduced by adopting the following measures:

- (i) LHH 144 and *desi* cotton varieties are resistant to leaf curl virus. LH 1556 and F 1861, LH 2076 are tolerant to this disease.
- (ii) Avoid growing American cotton in and around citrus orchards and adjoining *bhindi* crop.
- (iii) In non Bt cotton use 4 Kg seed per acre and go on uprooting and destroying the infected plants upto initiation of fruiting phase.
- (iv) Protect the crop against whitefly vector at 4-5 leaf stage by using recommended insecticides.
- (v) Follow clean cultivation and destroy *Kanghi buti* (*Sida* sp.) and *Peeli buti* (*Abutilon* sp.) which act as collateral hosts.
- (vi) Destroy volunteer/ratoon cotton plants during the off season.

Root rot : This disease is caused by *Rhizoctonia solani* and *R. bataticola*. The main symptom is sudden and complete wilting of plant. The disease spreads in field in round patches. The affected plants can be pulled out very easily. The disease starts much early but wilting takes place quite late. The bark of the roots is broken into shreds and gives foul smell.

Bacterial blight : It is caused by *Xanthomonas axonopodis* pv. *malvacearum* which survives in seed and plant debris. Lesions on the leaves appear as minute, water-soaked, angular spots, which subsequently turn brown and then are transformed into black angular dead lesions on both sides of the leaf. The bacterium also infects the young developing bolls and causes small, round, water soaked spots depressed in the centre. Spray with Blitox 50 WP (500 g) + Agrimycin (20 g)/Streptocycline 3 g per acre at 15-20 days interval starting just after the first shower of rain. Three sprays will be enough. The quantity of water will depend upon the crop growth and the spray pump to be used.

Anthracnose : It is caused by *Glomerella gossypii* which survives on crop debris in the soil. It produces small, round reddish spots on leaves, bracts and bolls. The disease is severe at the seedling stage.

Leaf blight : The disease is caused by *Helminthosporium speciferum*. The fungus generally attacks the seedling causing pre and post emergence deaths. Light brown spots occur on the leaves. During severe infection, there is shedding of leaves, flowers and bolls. The fungus *Alternaria gossypina* also causes blighting of the leaves. In the early-stages, the spots have a pale green area with irregular margins. As the spots enlarge, irregular concentric zones are formed. Sometimes severe shedding of leaves occur due to this disease. The plants with low vigour because of drought or deficiency of potash favour the development of this disease.

Leaf spots : The disease is caused by *Myrothecium roridum* and the symptoms appear on leaves, bracts as well as on bolls. The disease is characterized by circular to semicircular brown coloured spots with broad violet margins. At later stages, shield shaped, small size fruiting bodies appear in the central necrotic portion of the spot. The pathogen is a seed borne and also survives on the dead leaves. High humidity and intermittant rains are congenial for the development of the disease. Another type of leaf spot disease which is caused by *Cercospora* sp. generally appears towards the end of the season. It produces small, circular spot having white centre with purple margin. In advance stages, necrotic central portion may fall out giving shot hole appearance. To control anthracnose, leaf blights and leaf spots, the crop should be sprayed alternately with Blitox 50 WP or Captan 83 (500 g in 200 litres of water) at interval of 15 to 20 days starting just after the first shower of rain. Two to three sprays will be enough.

Wilt : It is a fungal disease caused by *Fusarium oxysporum f.sp. vasinfectum*. The pathogen of disease is both soil and seed-borne. In the diseased seedlings and plants, the leaves lose their turgidity, first turn yellow, then brown, start wilting and finally drop off. Discoloration of the leaves start from the margins and spreads towards the mid-ribs. The older leaves are affected first, followed by the younger ones towards the top. Wilting may be complete or partial. In the later case only one side of the plant is affected while the other remains apparently healthy. In complete wilting, the plant remains stunted, wilt rapidly and dies. The most prominent diagnostic symptom of the disease is browning and blackening of the vascular tissues. Five to six year rotation with non-host crops may help in controlling the disease. In the infested field, sow LD 694 variety of desi cotton since the same is tolerant to wilt. In the highly infested fields grow American cotton because it remains free from this disease. For the chemical control of wilt soak 3 kg seed in 6 litres of water containing 6 g of Bavistin/ Derosal for 6-8 hrs. (non delinted seed) or 2-3 hrs. (acid delinted seed).

Grey mildew : Grey mildew or *dahiya* disease caused by *Ramularia areola* occurs sporadically during humid weather. It appears on leaves as dull white, irregular, translucent spots bordered by veinlets with frosty growth on the lower surface of the leaves. It may cause defoliation and premature boll opening.

Tirak : It is a physiological disorder. It is characterized by the yellowing and reddening of leaves, followed by the bad opening of the bolls. The disease appears now and then. The attack is more pronounced in the dry belt adjoining Rajasthan and Haryana. It is particularly serious in pockets where cotton suffers from persistent drought, inadequate water supply, nutrient deficiency on light sandy soils, too early sowing or lack of plant protection measures. These factors may operate singly or in different combinations. Spells of high temperature prevailing during the flowering and fruiting further aggravate the intensity of this malady. Judicious fertilization and timely watering particularly during flowering and fruiting stages, and the adoption of recommended plant protection schedule help to mitigate the intensity of this disease.

Parawilt : Parawilt is a physiological disorder and no pathogen is involved. It can occur when crop is applied irrigation or after heavy rains occur. Plants show sudden drooping of leaves which ultimately get wilted but the root system remains intact. The affected plants can be saved by spraying cobalt chloride @ 10mg/one litre of water (10 ppm) immediately after the appearance of symptoms. There would be no recovery if permanent wilting has already set in.