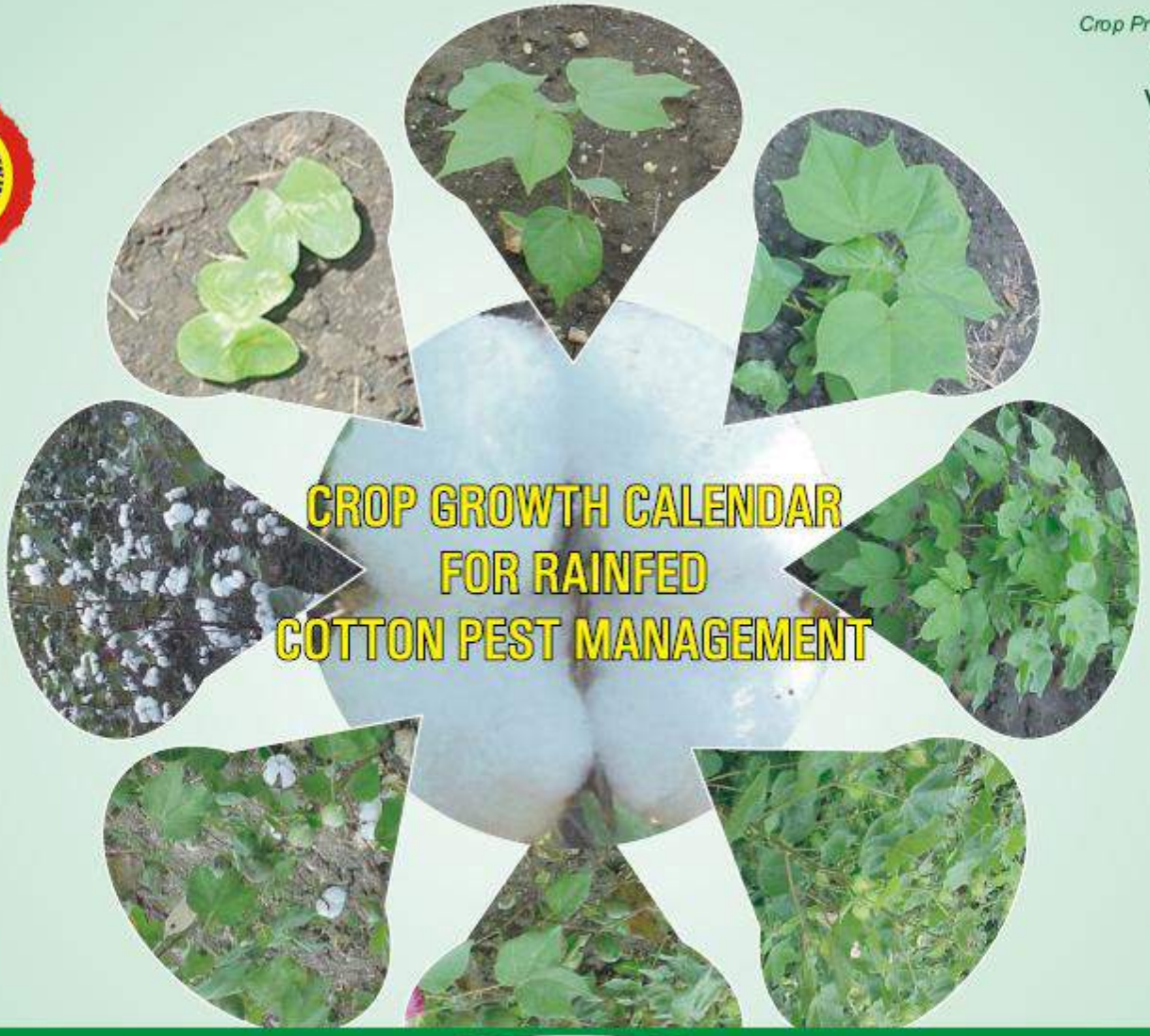
Crop Protection Booklet
English Version



# CROP GROWTH CALENDAR FOR RAINFED COTTON PEST MANAGEMENT

Produced under : Technology Mission on Cotton
Mini Mission I (3.1)

Funded by
Ministry of Agriculture
Government of India

Project on : IPM Implementation at Village Level
for Production of Good Quality Cotton

| DOs | | | | Insect pests suppressed | DON'Ts | |
|---|---|---|---|---|---|---|
| What to do | When to do | Why to do | How to do | | What not to do | Why not to do |
| ***1. Post harvest and pre planting operations*** | | | | | | |
| **1.1. Early crop termination and adherence to closed season** | Immediate to last picking and between two cropping seasons | To prevent the continuous food supply and shelter for multiplication and carry over of insect pests | Removal of the cotton crop immediate to the last picking from the fields and maintenance of host free period | Jassids<br>Aphids<br>Whiteflies<br>Thrips<br>Mirids<br>Stainers and<br>Pink bollworm | Allowing the cotton crop to continue to stand in the field or growing ratoon crop of cotton | Depletes the nutrients of the soil and offer food and shelter for insects to develop continuously in to the next season |
| **1.2. Timely disposal of seed cotton** | Within two months of cotton harvest | To prevent diapausing pink bollworm larvae in double seeds or on lint as sources for carry over into the next season | Disposal of seed cotton in markets at proper time during the procurement season | Pink bollworm | Storing of cotton longer time or for sale during next season | Stored cotton is reservoir for pink bollworm and source of infestation during next season |
| **1.3. Allowing cattle grazing** | Before removal of the standing crop from the field | Standing cotton crop continues to grow with squares, flowers and bolls after final picking, that become source of food and carry over | Allowing animal grazing (cow, buffalo, sheep, goat etc.,) immediate to final picking | Pink bollworm | Allowing the cotton crop to continue to stand in the field | Standing crop serves as habitat for continuos existence of the insects |
| **1.4. Destruction of cotton stalks** | After final picking of cotton is over | Destruction of cotton stalks following harvest reduces the shelter and food supply to pink bollworm and curtails the carry over to next season | The dry cotton stalks should be pulled out of the fields or shredded and incorporated into the fields or burnt off *in situ* before ploughing the field | Pink bollworm | Stacking of cotton stalks in or near to the fields | Diapausing larval population of pink bollworm is harbored and passed on to the next season |

Timely harvest

Removal of crop

Timely disposal

Cattle grazing

Soil health maintenance through organic manuring

Crop rotation with cereals

## 1. Post harvest and pre planting operations

| | | | | | | |
|---|---|---|---|---|---|---|
| **1.5. Destruction of crop residues** | After removal of cotton stalks and before their storage for fuel purpose | To reduce the diapausing larval population in the partial or unopened bolls that serve as starter for the next season infestation | The unpicked, partially opened and unopened bolls should be separated by beating the plants on to the soil surface and then transported to the place of storage for further use as fuel. The heaps of the separated bolls should be burnt off in the field itself | Pink bollworm | Cotton stalks should not be stored near to fields and should not be transported from place to place without removal of unopened dry bolls | Storage of cotton stalks without removal of unpicked bolls not only aid in seasonal carry over but also help in spreading to the areas of less or no pink bollworm |
| **1.6. Summer ploughing** | During off-season in summer | To expose the resting stages of insects esp. bollworms to the heat as well as predatory birds | Deep ploughing once in 2-3 years is recommended to loosen the subsoil.<br>2-3 summer ploughings are a must for removal of weeds as well as for destruction of insect stages | Spotted, American and Pink bollworms | Leaving the lands fallow with weeds | There occurs soil compaction besides the weeds act as intermediary hosts for insect pests |
| **1.7. Field sanitation** | Clean up of field borders/ bunds during off season | Field sanitation is a must as sucking pests of cotton often build up on the flowering plants surrounding cultivable lands | Clean up of the fields free of weeds and alternate host plants including vegetable crops | Pink bollworm and sucking pests such as jassids, mirids and stainers | Allowing weeds and alternate host crops | Weed and alternate hosts surrounding cultivable lands serve as reservoirs for carry over of pests to the next season |
| **1.8. Field selection** | Pre planting period | Compulsory crop diversification in farm holdings with mandatory adoption of crop rotation in cotton based cropping systems | Crop rotation with cereals (sorghum) or pulses (soybean) or green manure crops (sun hemp or daincha) at least once in two to three years | Pink bollworm | Growing cotton year after year | Deteriorates soil health as well as to facilitates the carry over of cotton pest population |

Crop rotation with pulses

Selection of jassid tolerant cultivar

Optimum time of sowing

Maintenance of plant stand

Intercrop with green gram

.Strip cropping with late variety of red gram

| DOs | | | | Insect pests suppressed | DON'Ts | |
|---|---|---|---|---|---|---|
| What to do | When to do | Why to do | How to do | | What not to do | Why not to do |
| **1. Post harvest and pre planting operations** | | | | | | |
| **1.9. Varietal selection** *1.9.1. Selection of cultivars with tolerance resistance/to jassids and with high yield potential* | Before planting and procurement of seed material | Jassid tolerant cultivars obviate the need to use insecticides early in the season, thus allowing native natural enemies to multiply | Selection of sucking pest tolerant cotton cultivars (even in transgenic hybrids) suited to climate and soil and of rapid fruiting cultivars that make up for damage due to bollworms in conventional cotton | Sucking pests and, Spotted, American and Pink bollworms | Varietal selection with no prior knowledge of their susceptibility to jassids and of their adaptability to the region and the soil | Susceptible cultivars grown lead to reduced plant stand and vigor besides yield reduction even with insecticidal applications |
| *1.9.2. Growing Bt cotton* | | To minimize the yield and quality loss due to bollworms | Growing transgenic Bt hybrids suited to climate and soil in areas of endemic bollworm infestations | Spotted, American and Pink bollworms | Growing Bt cotton in resource poor soils | The economic returns would not justify the investment made on Bt cotton |
| **1.10.Delinting of seeds and treatment of seed stock with any one neonicotinoid group of chemicals** | Prior to sowing/ dibbling in the field | Offers protection against sucking pests including jassids for 45-50 days of crop growth in case of jassid susceptible cultivars | Delinting should be done with commercial sulphuric acid @ 100 ml/kg of seed. Repeated washings with water and neutralization of acid with lime @ 2.0 g/l of water should be done. Mix the Imidacloprid @ 5-7g or Thiamethoxam @ 3 g per Kg of seed and shade dry before sowing. | Pink bollworm and sucking pests | Insecticidal seed treatment to the jassid tolerant cultivars | Unnecessary treatments lead to predisposal of plants for higher bollworm attack |

Marigold as refuge crop

Interculture to maintain field sanitation

Proper dosage of fertilizer use

Knowledge of pests and beneficials

Monitoring bollworms using pheromone traps

Monitoring insect pests, their damage & crop growth

## 2. Planting to first flower

| | | | | | | |
|---|---|---|---|---|---|---|
| **2.1.Optimum sowing dates** | Immediate to receipt of monsoon | Finer adjustments in the dates of sowing just after the receipt of sufficient (2") first rains augment the yield of rainfed cotton by minimizing pest attack | Keeping the fields ready for sowing after the receipt of first rains, and taking up dry sowing | Early sowing provides escape from severity of jassids and the late season pests , such as pink bollworm and stainers through early crop maturity | Delaying the planting beyond the optimal/ normal sowing dates | Late planted crop succumbs to severity of pink bollworm and there is delayed crop maturity, leading to reduced yields and poor fibre quality |
| **2.2. Use of inter/trap/ indicator/ strip crops** *2.2.1. Growing soybean or black gram or cowpea as intercrop* | Along with planting of cotton | Provides risk aversion and compatible with cotton pest management through enhancement of native predators and parasitoids | Adjust the plant spacing between two rows to accommodate one row of pulses | Sucking pests and Spotted bollworm | Monocropping of cotton over large areas of insect pests over time | The narrow genetic diversity leads to outbreaks |
| *2.2.2. Use of late variety red gram as strip or border crop* | | | Growing one or two rows of red gram for every 8 rows of cotton | American bollworm | | |
| *2.2.3. Planting of few castor plants* | | Serves as an indicator cum trap crop | Sowing castor seeds at field borders | Leaf worm | | |
| **2.3. Gap filling of cotton fields with maize or marigold** | After the seedling emergence and within first 20 days of crop age | To serve as source of floral nectar and alternative prey (aphids), shelter, mating and oviposition sites for native predators like coccinellids and chrysopids. Marigold serves as a trap crop for *H. armigera* | While maize seeds can be used for gap filling, seedlings of marigold should be raised in nursery at sowing time of cotton. Seedlings of marigold can also be obtained from the commercial nurseries and used for gap filling | Aphids, jassids, thrips and bollworms esp. *H. armigera* and *E. vittella* | Leaving the gaps without gap filling either with cotton or with other crops | Maintenance of poor plant stand with gaps in the fields lead to reduced yields |


Erecting bird perch


Damage of leaf minor


Colonies of aphids


Aphid infested plant


Jassid adult


Symptoms of jassid injury


Thrips

| DOs | | | | Insect pests suppressed | DON'Ts | |
|---|---|---|---|---|---|---|
| What to do | When to do | Why to do | How to do | | What not to do | Why not to do |
| **2. Planting to first flower** | | | | | | |
| **2.4. Site and field specific management of cotton crop, alternate and weed hosts** | During the vegetative phase of the crop growth | To minimize insect pest population and their carry over | Depending upon the field location, nutrient status the cultural operations such as interculture and fertilizer application should be taken up. Field sanitation by removal of weed hosts of insect pests should form a part of crop management | All insect pests | Excess nitrogenous fertilizer at time of grand growth period should be avoided | Excess nitrogen leads to high vegative growth of the crop and offers attractiveness to many insects and their faster multiplication and hence higher damage |
| **2.5. Monitoring of sucking pests and natural enemies** | Weekly prior to the square stage (5 to 6 true leaves) | To know the type and status of insect pests and their injury besides for the occurrence of natural enemies | Random sampling of 20 plants per acre with observations on the symptoms of damage due to various sucking pests and for presence of natural enemies | Sucking pests | Ignoring to keep a regular watch on crop growth and development of insect population besides their natural enemies | Failure of regular watch on the crop leads to the loss of crop stand and unnecessary applications of insecticides |
| **2.6. Accounting native natural enemies** | When native predators occur along with the occurrence of jassids, aphids and thrips | Natural enemies such as aphidophagous coccinellids and syrphids, besides generalist chrysopids offer significant control of early season sucking pests | At a predator (coccinellids & chrysopids) to prey (aphids and jassid nymphs) ratio greater than 0.5, there occurs substantial natural control and decide not to spray | Jassids Aphids Thrips and Whiteflies | Use of insecticides at times of abundance of natural enemies | Leads to depletion of beneficials of the ecosystem and pest management becomes an "insecticide treadmill" |

Symptoms of thrips injury

Whiteflies

Sooty mould on leaf due to honey dew deposition

Mirid bug

Mirid bug damaged boll

Mealy bug

## 2. Planting to first flower

| | | | | | | |
|---|---|---|---|---|---|---|
| 2.7. Determine action thresholds for chemical insecticide application against management of sucking pests.<br>Spray any one insecticide listed below<br>**Neonicotiniods**<br>Imidacloprid 200 SL @ 100 ml/ha or Thiamethoxam 25 WG @ 100 g/ha or Acetamiprid 20 SP @ 200 ml/ha<br>**Organophosphorus compounds**<br>Methyl demeton 25 EC @1200 ml /ha, Dimethoate 30EC @ 500 ml/ha. | Yellowing and curling along the leaf margins occur due to jassids seen in 25% of plants. | To reduce the yield loss caused due to the jassids | Amount of spray fluid and type of the sprayer used should be depending upon the crop growth. Given as separate table in the Annexure. II. If more than one insecticidal application is warranted the chemicals should be alternated with different groups | Jassids | Spraying of insecticides when not necessary, spraying based on insect counts and spraying of the same chemical repeatedly or using improper dosage and spray volume. | Unnecessary insecticidal sprays lead to loss of friendly entomofauna that regulate the insect pest population. Improper sprays lead to sub lethal dosages and provide selection pressure for development of resistance by the pests for those chemicals |
| | When cupping of leaves on the top one third portion of the plant and aphids all over the plant are seen in 25% of plants. | To reduce the yield loss caused due to aphids | | Aphids | | |
| | Shiny oily patches on the under surface of leaves above mid canopy and the activity of thrips on the terminal leaves of 25% plants | To reduce the yield loss caused due to the thrips | Care should be taken to provide good coverage of the crop canopy including the underside of leaves | Thrips | | |
| Spray any one insecticide listed below<br>**Neonicotiniods**<br>Imidacloprid 200 SL @ 100 ml/ha or Thiamethoxam 25 WG @ 100g/ha or Acetamiprid 20 SP @ 200 ml/ha | More than 25% of leaf coverge by whitefly pupae on the underside of leaves of middle plant canopy and flight of whitish adults visible with a single stroke of plant terminals | To reduce the yield loss caused due to the whiteflies | Care should be taken to provide good coverage of the crop canopy including the underside of leaves | Whiteflies | Spraying during periods of rainfall | |

Terminal bunching due to mealy bug feeding

Square feeding by *Earias*

Flower feeding by *Earias*

Green boll feeding by *Earias*

Square damage by *H. armigera*

Flower damage by *H. armigera*

| DOs | | | | Insect pests suppressed | DON'Ts | |
|---|---|---|---|---|---|---|
| What to do | When to do | Why to do | How to do | | What not to do | Why not to do |
| **3. First flower to first open boll** | | | | | | |
| **3.1. Monitoring of bollworms**<br>***3.1.1. Monitoring the activity of adults of bollworms*** | Twice weekly at intervals of 3 to 4 days from square initiation to first flower | To know the initiation and degree of population development in the fields of cotton | Pheromones in traps are used for monitoring adults of bollworms *viz.*, *Helicoverpa*, *Earias* and *Pectinophora*. Trap height for pink and spotted bollworms should be 60 cm above ground level in the early season and 15 cm above crop canopy in the late season. For *Helicoverpa* the trap height should be one metre above ground level in early season and one metre above crop canopy during late season | Spotted, *viz.*, American and Pink bollworms | Deciding to spray insecticides without monitoring the type of pests and their level of infestation | Leads to indiscriminate use of insecticides, high plant protection cost, resistance development in insect pests, destruction of natural enemies and environmental pollution |
| ***3.1.2. Monitoring the activity of damage due to bollworms*** | When the damage to the developing fruiting structures occur | To assess the damage levels and to take action to reduce their population | Bollworm damage is assessed through visual observations of the damaged out of the total fruiting structures (squares, flowers and bolls) from among the 20 randomly selected plants per acre | All the bollworms | Non assessment of damage caused by bollworms | Leads to loss in yields |
| **3.2. Selection of non insecticidal bollworm management strategies** | With the visible symptoms of collapse of terminal shoots of growing plants | Reduces damage due to Spotted bollworm | Removal of wilting shoots and destruction of tip boring larvae | Spotted bollworm | Spray of insecticides | Insecticidal sprays are ineffective on larvae inside tuunels of the stems |

Green boll damage by *H. armigera*

Flared up squares due to bollworms

Flower damage by *P. gossypiella*

Green boll damage by *P. gossypiella*

Damage in open boll by *P. gossypiella*

## 3. First flower to first open boll

| | | | | | | |
|---|---|---|---|---|---|---|
| *3.2.1. Mechanical collection* | During epidemics of *H. armigera* | Control failures occur during outbreak years and insecticides are ineffective | Hand picking of visible larvae and their destruction or their utilisation for NPV production | American bollworm | Repeated sprays of insecticides | Insecticidal sprays are ineffective and the damage to fruiting structures occur before the suppre-ssion of larvae |
| *3.2.2. Augmentative biological control* | When there is heavy egg laying by *H. armigera* | Curtails the larval development and hence larval damage to squares | Application of trichocards @ 5/ha (one lakh parasitoids/ha) to | All bollworms | Not to release in the absence of egg load on the | As they are stage specific improper time of applica- |
| ***3.2.2.1.Use of egg parasitoid Trichogramma chilonis*** | (more than two per plant) | and bolls | coincide with peak oviposition periods | | crop and not within a week of insecticidal spray if done. Not to be used on Bt cotton | tion become cost ineffective. Persistence of insecticides cause mortality of parasitoids. incompatible with mode of action of Bt cotton |
| ***3.2.2.2. Use of nuclear polyhedrosis virus*** | When the initial population of *H. armigera* is moderate and further build up is anticipated or predicted with rainy periods ahead | Negates the use of insecticides. Conserves the native parasitoids and predators. Virus perpetuates in the system through rain splashes to inflict infection to the next generation | Ha NPV spray @ 250 larval equivalents (LE) (1LE = 2 x $10^9$ polyhedral inclusion bodies) coinciding with early instars of American bollworm larvae | American bollworm | Late instar larvae should not be the targets. Should not be mixed with extract (NSKE). Not to be used on Bt cotton. | Late larval instars are immune to virus. Deterrent action of neem seed kernal NSKE reduces the intake of virus by larvae. Does not fit into incompatible with Bt cotton |


Leaf roller


Semi-looper


Tobacco caterpillar


Hairy caterpillars


Red cotton bugs


Tunneling by stem borer

| DOs | | | | Insect pests suppressed | DON'Ts | |
|---|---|---|---|---|---|---|
| What to do | When to do | Why to do | How to do | | What not to do | Why not to do |
| **3. First flower to first open boll** | | | | | | |
| ***3.2.3.Deploying gossyplure baited traps*** traps for mass ***@ 20 per hectare*** | From the peak<br><br>would be crop harvest | Towards mass trapping of flowering till<br><br>that would disrupt mating and population build up of pink bollworm | Trap height for pink male moths in the fields<br><br>ground level in the early season and 15 cm above crop canopy in the late season. Lures in septa should be changed once in 30-45 days. | Pink bollworm should be 60 cm | Deployment of above<br><br>trapping purpose in only few fields | Mass trapping<br><br>successful only when large areas are covered as the dispersal of males from neighbouring fields would make management option cost ineffective |
| **3.3. Bollworm management using insecticides**<br><br>*3.3.1. The insecticides that are recommended with their dosages for bollworm management are in Annexure II*<br><br>*3.3.2. Selection of chemical groups should be in rotation*<br><br>*3.3.3. Costly chemicals should be chosen only when the control efficacy anticipated in terms of yield saving is more than the cost of the chemical* | In the event of excessive damage by any one or combination of bollworms from the start of first flower on the crop | Results in yield loss | Strategy of crop protection should focus on the developing bolls against *Helicoverpa*, *Earias* as well as from pink bollworms. Damage to bolls in conjunction with the presence of damaging larvae on the crop should be considered for insecticidal spray. Monitor the moth activity of pink bollworm using pheromone traps and take spray decisions when there is catch of eight moths/trap for three consecutive days | Spotted, American and Pink bollworms | Avoidance of insecticidal application against bollworms occurring on first flush when more than 90% of fruiting structures are squares<br><br>Decision to spray based on the advice of pesticide dealers<br><br>Improper attention during the boll maturation phase | Insecticidal sprays do not justify the yield saving<br><br>Advice of dealers is based on the products they handle and profit motivated. Often times result in unnecessary sprays. |

Coccinellid grub

Syrphid maggot

Chrysopid grub

*Zanchius* sp.

Spider

| 3. First flower to first open boll | | | | | | |
|---|---|---|---|---|---|---|
| *3.3.4.Pyrethroids are to be used only during November- December* assessed *months against pink bollworm* | During boll maturation phase | Since the damage by pink bollworm is not visible it is necessary to monitor through pheromone traps | | Pink bollworm | | Pink bollworm larvae and damage cannot be through scouting and damage is obvious only after bolls are open |
| *3.3.5. Spray fluid varies with crop age, size of canopy and type of sprayer* Given as separate table in the Annexure. I | During all the insecticidal applications | Proper selection of insecticide at correct dosage and time with uniform crop coverage results in better control of bollworms | Required dosage of insecticide for area and crop stage should be mixed with water in larger drums and used for filling spray tanks of sprayer | All bollworms | Tank mixing of insecticides should be avoided | Results in inadeq-uate and improper sprays and lead to sub lethal dosages of insecticides and resistance development in target insects |
| **4. Open boll to final harvest** | | | | | | |
| **4.1. Assessment of pink bollworm damage should be based on destructive sampling (boll cracking method) when pheromone traps are not used** | When the bolls outnumber the squares and flowers on the plant or the crop growth has attained >20 nodes | Since no visible damage occurs till the boll opens, pink bollworm infested bolls result in heavy yield losses | Collect twenty randomly the developing bolls of 20-25 days old per acre and examine for pink bollworm infestation | Pink bollworm | To assume that once the green bolls are on the plant they would develop to maturity without damage | Such an assumption lead to yield loss and reduction in fibre quality |
| **4.2. Management of stainers** | When majority of bolls are yet to open | To reduce the population build up of stainers and to harvest good quality cotton | Dislodging the gregarious population of the stainers on the bolls in to a vessel containing water with a thin film of kerosene | Red and dusky cotton bugs | Ignoring their population build up | Pest status of stainers would severely affect the lint quality |
| **4.3. Management of sucking pests esp. resurging aphids and whiteflies** | During outbreak of aphids when more than 50% bolls are yet to open | To prevent lint contamination and harvest quality produce | Use any one organo-phosphorous insecticidal compound (refer Annexure I) | Aphids | To spray just before harvest | To avoid toxic residues of insecticides in the seed cotton and lint. |

***Eocanthecona* bug**

**Ants**

**Wasp**

**Bird**

**Preying mantid**

## Annexure I. Spray volumes for field use at different crop growth stages for insecticidal application

| Stage of the crop growth (Number of nodes above cotyledonary nodes)* | Required volume of spray fluid (l/ha) | Type of sprayer |
|---|---|---|
| < Four nodes | 100-125 | Hand operated knapsack sprayer |
| > four nodes to ≤ eight nodes | 150-200 | Hand operated knapsack sprayer |
| > 8 nodes to ≤ sixteen nodes | 200-250 | Power sprayer |
| > 16 nodes | 250-300 | Power sprayer |

* : Cotyledonary nodes are the first pair of nodes exactly opposite to each other on the main stem


*Campoletis chlorideae*


*Apenteles* adult


*Rogas aligarhensis*


*Palexorista laxa*


*Bracon greenii*


*Aphilinus* sp.

## Annexure II. Insecticides for use against bollworms

| Name of chemical group and insecticide | Formulation | Dosage (g a. i./ha) | Quantity of chemical (ml/ha) |
|---|---|---|---|
| **Cyclodiene** | | | |
| Endosulfan | 35 EC | 875 | 2500 |
| **Carbamates** | | | |
| Carbaryl | 50 WP | 1000 | 2000 |
| Methomyl | 25 EC | 500 | 2000 |
| Thiodicarb | 75 WP | 1500 | 2000 |
| **Organophosphorus compounds** | | | |
| Acephate | 75 WP | 584 | 780 |
| Chlorpyriphos | 20 EC | 250 | 1250 |
| Ethion | 50 EC | 500 | 1000 |
| Profenophos | 50 EC | 750-1000 | 1500-2000 |
| Quinolphos | 25 EC | 500 | 2000 |
| Triazophos | 40 EC | 600-800 | 1500-2000 |
| **Synthetic pyrethroids** | | | |
| Cypermethrin | 10 EC | 50 | 500 |
| Cypermethrin | 25 EC | 50 | 200 |
| Decamethrin | 2.8 EC | 12.5 | 450 |
| Fenvalerate | 20 EC | 100 | 500 |
| Lambda-cyhalothrin | 5 EC | 15 | 300 |
| Bifenthrin | 10 EC | 80 | 800 |
| β Cyfluthrin | 25 EC | 18 | 75 |
| **Insect growth regulators** | | | |
| Novuluron | 10 EC | 100 | 1000 |
| Lufenuron | 5 EC | 60 | 1200 |
| Diafenthiuron | 50 WP | 300 | 600 |
| **Oxidiazine** | | | |
| Indoxacarb | 15 EC | 75 | 500 |
| **Spinosyn** | | | |
| Spinosad | 48 EC | 50-75 | 100-150 |
| **Avermectin** | | | |
| Emamectin benzoate | 5 EC | 10 | 200 |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