Package of Practices for Cotton Cultivation in Tamil Nadu

Cotton Department, TNAU, Coimbatore, Tamil Nadu

IRRIGATED COTTON

Season and Varieties – Summer and Winter

Season	Duration (Days)	Month of sowing	Districts
Winter Irrigated	150-160	Aug – Sep	Coimbatore, Erode, Tirupur, Namakkal, Salem, Dharmapuri, Krishnagiri, Madurai, Dindigul, Theni, Cuddalore, Villupuram, Trichy, Kallakurichi
Winter Rainfed	140-150	Aug – Sep	Ariyalur, Perambalur, Salem, Namakkal, Kallakurichi
		Sep – Oct	Thoothukudi, Tenkasi, Madurai, Ramanathapuram, Virudhunagar, Sivagangai
Summer – Irrigated	150-160	Feb – Mar	Erode, Ramanathapuram, Sivagangai, Theni, Salem, Thoothukudi, Virudhunagar, Tirunelveli, Tenkasi, Madurai, Dindigul, Thanjavur, Trichy,Tiruvarur
Rice Fallow	125-135	Feb – Mar	Thanjavur,Tiruvarur, Nagapattinam, Parts of Tiruchirappalli, Perambalur, Karur, Cuddalore and Villupuram

Season and Varieties - Summer and Winter

Season & Districts	Month	Varieties
Winter Irrigated Coimbatore, Erode, Tirupur, Namakkal, Salem, Dharmapuri, Krishnagiri, Madurai, Dindigul, Theni, Cuddalore, Villupuram, Trichy, Kallakurichi	Aug – Sep	MCU 5, CO 14, CO 17, Suvin, Suraksha, Suraj
Winter Rainfed Ariyalur, Perambalur, Salem, Namakkal, Kallakurichi	Aug – Sep	KC 3, CO 17
Thoothukudi, Tenkasi, Madurai, Ramanathapuram, Virudhunagar, Sivagangai	Sept -Oct.	KC 3, CO 17 , K 12

Summer – Irrigated Erode, Ramanathapuram, Sivagangai, Theni, Salem, Thoothukudi, Virudhunagar, Tirunelveli, Tenkasi, Madurai, Dindigul, Thanjavur, Trichy,Tiruvarur	Feb – Mar	SVPR 2, SVPR 4, SVPR 6, MCU 5, CO 14, CO 17, Surabhi
Rice Fallow Thanjavur, Tiruvarur, Nagapattinam, Parts of Trichirapalli, Perambalur, Karur, Cuddalore and Villupuram	Feb – Mar	MCU 7, CO 17

Seed treatment

ACID – DELINTING OF COTTON SEEDS

- Use plastic bucket for acid delinting
- Put the required quantity of fuzzy seeds in the bucket
- Add commercial concentrated sulphuric acid @ of 100 ml per kg of fuzzy seed
- Stir vigorously and continuously with a wooden stick for 2 to 3 minutes till the seed coat attains a coffee brown colour
- Wash the treated seeds for 4 or 5 times with water
- Remove the floating, ill-filled and damaged seeds
- Drain the water completely and shade dry the delinted seeds

PRE-SOWING SEED TREATMENT

- Treat the delinted seeds with *Beauveria bassiana* , *Bacillus subtilis* and *Trichoderma asperellum* each @ 10 g/kg of seed on the day before sowing, to protect against sucking pests and soil borne diseases
- Treat the seeds with TNAU *Vidhai Amirtham* @ 11 ml / kg of seeds for enhancing germination and seedling vigour, at the time of sowing

or

- Treat the seeds required for one acre with carrier based biofertilizer formulations *viz.,Azospirillum*, Phosphobacteria (or) Azophos and Silicate solubilizing bacteria (SSB) each @ 400 g or 50 ml of liquid formulation , using rice gruel , 30 minutes before sowing and shade dry

Field Preparation and Sowing

- Plough the field to get fine tilth
- Form ridges and furrows 10 m long with appropriate spacing using ridge plough or bund former

Spacing / Crop geometry

- For pure crop adopt the spacing as follows

Varieties/Hybrids	Row/ Ridge Spacing(cm)	Between plants (cm)
hirsutum varieties	75	30
barbadense varieties	90	45
Hybrid	120	60

- For intercropping situations adopt spacing for cotton as follows

Varieties/Hybrids	Spacing for cotton crop (cm)		
	Within paired row	Between paired rows	Between plants
hirsutum varieties	60	90	30
barbadense varieties	80	100	45
Hybrid	100	140	60

- Adopt the spacing for every two rows of intercrop between each paired row of cotton as follows

Intercrop	Seed rate (kg/ha)	Spacing (cm)	
		Between Rows	Between Plants
Blackgram	5.0	30	10
Greengram	5.0	30	10
Cowpea	3.0	30	20

Seed rate

Adopt the following seed rates for different varieties/hybrids

Varieties / Hybrids	**Quantity (kg per acre)**		
	With fuzz	**Delinted**	**Naked**
hirsutum varieties	6.00	3.0	-
Suvin	-	-	2.40
Hybrids	1.00	0.8	-

Sowing

Dibble the seeds, manually, at a depth of 3-5 cm on the side of the ridge, 2/3 height from the top.

Varieties / Hybrid	No of seeds / hole	
	Fuzzy seeds	Delinted seeds
Varieties	3	2
Hyrbids	2	1

- Gap filling: Take up gap filling on the 10th day after sowing
- Thinning: Thin out the seedlings on the 15th day after sowing. In case of fertile soils, allow only one seedling per hole, where as in poor soil allow two seedlings per hole.

Nutrient Management

Organic manures and biofertilizers

- Spread FYM / compost (5t/ac) or vermicompost 1.0 t/ac on the unploughed soil
- Apply biofertilizers *viz.,Azospirillum*, Phosphobacteria (or) Azophos each @ 1 kg/ac (or) 200 ml / ac along with 1 kg of Silicate Solubilizing Bacteria (SSB) mixed with 10 kg of FYM and 10 kg of sand, before forming ridges and furrows

Inorganic fertilizers

- Apply N: P_2O_5: K_2O fertilizers as per soil test recommendation
- If soil test recommendations are not available, follow blanket recommendation as below

For varieties: 32: 16 : 16 kg N: P_2O_5: K_2O /ac
For hybrids: 48: 24 : 24 kg N: P_2O_5: K_2O /ac

Time of application	Varieties	Hybrids
Basal (If basal application could not be done, apply on the 25th day after sowing)	50 % of N & K_2O, full dose of P_2O_5	1/3rd N & K_2O, full dose of P_2O_5
Top dressing	50 % of N & K_2O at 40 to 45 days after sowing (DAS)	1/3rd N & K_2O – 40 to 45 DAS 1/3rd N & K_2O – 60 to 65 DAS

Soil application of micronutrients

- Apply 5 kg of micronutrient mixture formulated by the Department of Agriculture, Tamil Nadu mixed with enough sand to make a total quantity of 20 kg for one acre

or

- Apply TNAU micronutrient mixture - 5 kg/ac for varieties and 6 kg/ac for hybrids as enriched FYM (Enriched FYM is prepared by mixing MN mixture and FYM in the ratio of 1:10 , at friable moisture and incubated in gunny bag for one month in shade)
- In zinc deficient soils, apply $ZnSO_4$ @ 20 kg/ac as basal

Note:

1. Recommended bio fertilizers, basal dose inorganic fertilizers and micro nutrients should be applied at the last ploughing before formation of ridges
2. To control soil borne pathogens apply *Bacillus subtilis* and *Trichoderma asperellum* each @ 1 kg/ac mixed with 100 kg FYM at the last plough before formation of ridges

Weed Management and Inter Cultivation

- Spray Pendimethalin (38.7% CS) @ 260 ml/ac or Pendimethalin (30%EC) @ 400 ml/ac within three days of sowing followed by one hand / weeding with power weeder on 45th day after sowing .
- If post emergence application of herbicide is warranted, spray pyrithiobac sodium @ 25g /ac + quizalofop ethyl @ 20 g /ac, at 2 to 4 leaf stage of the weeds.
- Sufficient moisture should be present in the soil at the time of herbicide application.
- If herbicides are not applied, perform manual weeding at 20th and 45th days after sowing.
- Reform the ridges and furrows in such a way that the plants are on the top of the ridges and well supported by soil (earthing up)

Irrigation Management

- Irrigate immediately after sowing followed by life irrigation on 5thday after sowing.
- Irrigate twice during vegetative phase (16-44 days), five times during flowering phase (45-100 days for hybrids and 87 days for varieties) and five times during maturity phase (beyond 100 days for hybrids and 88 days for varieties).
- Regulate irrigation according to the soil type, prevailing weather conditions and receipt of rains.
- Ensure irrigation at critical crop growth stages, namely, Square formation and boll maturity stage.

Physiological Interventions

- Spray PPFM (Pink Pigmented Facultative Methylotroph) @ 200 ml/ac mixed in 200 litres of water on 30, 45, 60, and 90 days after sowing.
- Spray cotton plus @ 2.5 kg /ac mixed in 200 litres of water twice during flowering and boll formation stage

Nutritional Deficiency

Nutrient	Deficiency Symptoms	Correction Measure
Nitrogen	• Yellowing of older leaves with reduction in leaf area • Stunted plant growth with few fruiting branches	• Spray 1% Urea (10 g/ lit)
Phosphorus	• Older leaves turn into dark green • Delay in blooming, fruiting and boll maturity	• Spray 2% DAP (2g /lit)
Potassium	• Older leaves become chlorotic and droopy (marginal scorching of leaves) • Bolls remains small and immature • Bolls fails to open	• Spray 1 % KCl (10 g/ lit) at weekly interval till the symptom disappears
Calcium	• Crinkled/distorted leaf • Leaf petioles start bending and collapse	• Spray calcium nitrate @ 1 % (10 g/ lit)
Magnesium	• Reddening symptom appears on older leaves (Reddening in cotton) • Leaf cupping and interveinal chlorosis	• Spray $MgSO_4$ @ 1 % (10 g/ lit)
Iron	• Interveinal chlorosis in younger leaves	• Spray 0.5% $FeSO_4$ (5 g/lit)
Zinc	• Pronounced interveinal chlorosis and bronzing • Malformed leaves and elongation of leaf tips • Shedding of squares and flowers	• Spray $ZnSO_4$ @ 0.5 % (5 g/lit) •
Boron	• Leaf crinkling and dying of terminal buds • Excessive shedding of buds and young bolls • Black discoloration at the base of bolls	• Spray boric acid @ 0.3 % (3 g/lit) at weekly interval till the symptom disappears •

Pest management in cotton

Leafhopper: *Amrasca devastans* (Cicadellidae: Hemiptera)

Symptoms of Damage

- Downward curling and reddening of leaves**.**
- Under severe infestation turn brick red colour.
- Growth retardation and death of plants.

Identification characters and biology

- **Destructive Stage:** Nymphs and adults.
- **Eggs:** Small, delicate and translucent. Egg period: 5 to 15 days
- **Nymphs:** Transparent, yellowish or greenish yellow in colour with reddish brown eyes. Nymphal period: 10-11 days.
- **Adults:** Green in colour. Forewings and vertex have black spots. Adult longevity: 20-23 days.

Economic threshold level: 50 nymphs or adults / 50 leaves.

Integrated management

- Cultivate of hairy (hirsute) varieties of cotton
- Adopt synchronised sowing.
- Treat seeds with *Beauveria bassiana* @ 10 g/kg.
- Apply nitrogenous fertilizers judiciously.
- Maintain weed free condition in field
- Spray any one of the following insecticides when pest population reaches ETL:

Imidacloprid 17.8% SL 40 – 50 ml/acre or Azadirachtin 0.03%WSP or Buprofezin 25%SC 400 ml/acre or Diafenthiuron 50%WP 240 g/acre or Thiacloprid 21.7%SC 40-50 ml/acre or Flonicamid 50% WG 60 g/acre or Thiamethoxam 25% WG 40 g/acre.

Cotton aphid: *Aphis gossypii* (Aphididae: Hemiptera)

Symptoms of Damage

- Leaves are shiny with honeydew or darkened by sooty mould growing on the honeydew.
- Crumpling and downward curling observed under severe attack.
- Activity of ants on the aphid-infested plants is common.
- Contamination of lint with honeydew and associated fungi leads to poor quality cotton.

Identification characters and biology

- Destructive stage: Nymphs and adults.
- Reproduction by parthenogenesis and viviparity.
- **Nymphs:** Small, yellowish or brownish in colour and mostly wingless. Nymphal period: 7-9 days

- **Adults:** Yellowish brown to black with black cornicles and yellowish green abdominal tip. Adult longevity: 12-20 days

Economic threshold level (ETL): 15% of infested plant

Integrated management

- Avoid late sowing.
- Treat seeds with *Beauveria bassiana* @ 10 g/kg.
- Apply nitrogenous fertilizers judiciously.
- Grow cowpea as intercrop or on the bunds to increase the natural enemy build up.
- Spray any one of the following insecticides when pest population reaches ETL:

  Imidacloprid 17.8% SL 40 – 50 ml/acre or Azadirachtin 0.03% EC 1000 ml/acre or Buprofezin 25%SC 400 ml/acre or Diafenthiuron 50%WP 240 g/acre or Thiacloprid 21.7%SC 40-50 ml/acre or Flonicamid 50% WG 60 g/acre or Thiamethoxam 25% WG 40 g/acre

Thrips: *Thrips tabaci* (Thripidae:Thysanoptera)

Symptoms of Damage

- Leaf laceration under the under surface of leaves.
- Silvery or brown necrotic spots of 3-5 mm.
- Leaf wrinkling and upward curling.
- Distorted leaves with white shiny patches.

Identification characters and biology

- **Destructive stage:** Nymphs and adults.
- **Eggs:** Minute, kidney shaped laid in slits in leaf tissues. Egg period: 5 days.
- **Nymphs**: Creamy to pale yellow in colour, resemble adults but wingless. Nymphal period: 4-6 days.
- **Adults:** Straw coloured, yellowish brown, and lice-like. Adult longevity: 2-4 weeks.

Economic threshold level: 50 nymphs or adults / 50 leaves

Integrated management

- Avoid planting of cotton near onion fields to prevent the migration of thrips.
- Avoid late sowing.
- Treat seeds with *Beauveria bassiana* @ 10 g/kg.
- Apply nitrogenous fertilizers judiciously
- Spray any one of the following insecticides when pest population reaches ETL:

  Imidacloprid 17.8% SL 40 – 50 ml/acre or Buprofezin 25%SC 400 ml/acre or Diafenthiuron 50%WP 240 g/acre or Thiacloprid 21.7%SC 40-50 ml/acre or Flonicamid 50% WG 60 g/acre or Thiamethoxam 25% WG 40 g/acre or Fipronil5% SC 600-800 ml/acre.

Whitefly: *Bemisia tabaci* (Aleyrodidae: Hemiptera)

Symptoms of Damage

- Appearance of chlorotic spots on the leaves and upward curling of leaves.
- Leaves become reddish, brittle.
- Premature leaf dropping, boll bursting and poor quality lint due to honey dew secretion

Identification characters and biology

- **Destructive stage:** Nymphs and adults.
- **Eggs:** Yellowish white laid singly on the under surface of leaves. Egg period: 3-5.
- **Nymphs:** Yellowish and brownish in large numbers on underside of leaves. Nymphal period: 9-14 days.
- **Pupa:** Resemble nymphs in shape and have brownish opercula (lid). Pupal period: 2-8 days.
- **Adults:** Body dusted lightly with a white waxy powder and white wings.

Economic threshold level: 5-10 whiteflies / leaf

Integrated management

- Avoid alternate cultivated host crops of the whitefly like brinjal, bhendi, tomato, tobacco and sunflower in the vicinity of cotton crop.
- Removal and destruction of alternate weed hosts like *Abutilon indicum* and *Solanum nigrum* from the fields and neighbouring areas and maintaining field sanitation.
- Adoption of crop rotation with non-preferred hosts such as sorghum, ragi, maize.
- Timely sowing with recommended spacing, preferably wider spacing and judicious application of recommended dose of fertilizers, particularly nitrogenous and irrigation management is essential to arrest the excessive vegetative growth and pest build up.
- Monitoring the activities of the adult white flies by setting up yellow sticky traps at 1 foot height above the plant canopy.
- Spray any one of the following insecticides when pest population reaches ETL:
  Imidacloprid 17.8% SL 40 – 50 ml/acre or Buprofezin 25%SC 400 ml/acre or Diafenthiuron 50%WP 240 g/acre or Thiacloprid 21.7%SC 200- 240ml/acre or Flonicamid 50% WG 60 g/acre or Thiamethoxam 25% WG 80 g/acre or Fipronil5% SC 600-800 ml/acre.

Tobacco caterpillar: *Spodoptera litura* (Lepidoptera: Noctuidae)

Symptoms of Damage:

- Leaf skeletonisation by early instar larvae.
- Complete defoliation by older larvae.

Identification characters and biology

Destructive stage: Larva

- **Egg:** Laid in masses and covered with the brown scales of the adult moths. Egg period 2–3 days.

- **Larva:** Pale greenish with dark markings. Gregarious in the early stages. Larval period: 13 to 30 days
- **Pupa:** Brown. Pupation in soil.
- **Adult:** Forewings brown colour with wavy white marking. Hindwings white colour with a brown patch along the margin. Adult longevity: 7-10 days.

Economic threshold level: 8 egg masses/100 m row

Integrated management and application technologies

- Place light trap to monitor and kill the attracted adult moths.
- Install sex pheromone trap at 5/acre to monitor the activity of the pest.
- Grow castor along border and irrigation bunds.
- Remove and destroy the egg masses in castor and cotton crops.
- Remove and destroy the early stage larvae.
- Hand pick and destroy the gown up caterpillars.
- Spray any one of the following insecticides when pest population reaches ETL
  Diflubenzuron 25%WP 120-140g/acre or Chlorantraniliprole 18.5% SC @60 ml/acre or Spinetoram 11.7 % SC 168-188 ml/acre or Nuclear polyhedrosis virus at 6 x 10^{11} POB/ acre.

Leaf roller: *Sylepta 10erogate* (Crambidae: Lepidoptera)

Symptoms of Damage:

- Leaves rolled in the form of trumpets fastened by silken threads.
- Marginal portion of leaves eaten away.

Identification characters and biology

- **Destructive stage:** Larva
- **Eggs:** White and laid on leaves. Egg period: 4-6 days.
- **Larva:** Semi-translucent caterpillars. Bright green (glistening) with dark head.
- **Adult:** Moth with yellow wings having brown wavy markings. Head and thorax have black dots; the abdomen has brown rings.

Integrated management

- Collection and destruction of dried plant parts.
- Hand picking and destruction of grown up caterpillars.

Cotton Mealybug: *Phenacoccus solenopsisi* and Papaya mealybug *Paracoccus marginatus* (Pseudococcidae: Hemiptera)

Symptoms of Damage:

- Vegetative phase exhibit symptoms of distorted, bushy shoots, crinkled and/or twisted bunchy leaves and stunted plants that dry completely in severe cases.
- Late season infestations during reproductive crop stage result in reduced plant vigour and early crop senescence.

- Honeydew secreted by the mealybug encourages development of black sooty mould which adversely affects photosynthetic activity.

Identification characters and biology

Destructive stage: Nymphs and adults.

- *Phenacoccus solenopsis* is yellowish green in colour with short to medium sized waxy filaments with two short anal filaments and two dark strips on either side of the middle ridge of the body.
- *Paracoccus marginatus* is yellowish and distinctly segmented. Flattened oval body long covered with mealy wax.

Integrated management

- Remove and destroy the infested plant parts.
- Remove the alternate weeds hosts.
- Release encyrtid parasitoids, *Acerophagus papayae* @ 100 per village against *Paracoccus marginatus* and *Aenasiusbam bawaeli* against *Phenococcus solenopsis*.
- Use botanical insecticides like neem derivatives such as neem oil 2%, NSKE 5% and Fish oil rosin soap 25 g/lit. of water.
- Spray any one of the insecticides: Flonicamid 50% WG 60 g/acre or Thiamethoxam 25% WG 80 g/acre.

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

Symptoms of Damage

- Regular circular boreholes on bolls.
- Presence of granular faecal pellets outside bore hole.
- Larva seen hanging in bore hole with head and part of abdomen thrust inside

Identification and biology

Destructive stage: Larva

- **Eggs:** Sub-globular, yellowish white in colour. Laid singly on shoots, buds, bracts tender bolls. Egg period: 4-7 days.
- **Larva:** Greenish brown with brownish grey lines and dark grey yellow stripes on lateral sides. Larval period: 5-18 days.
- **Pupa:** Brown coloured. Pupation in soil. Pupal period: 10-14 days.
- **Adults:** Stout- yellowish brown with 'V' shaped speck, greyish wavy lines and black mark on forewings Hind wings whitish with brown or black border along outer margin, Adult longevity: 10-12 days

Economic threshold level: ETL: 10% infested fruiting parts or one egg or one larva/plant.

Integrated management

- Pest monitoring through light traps 1 /acre, pheromone traps 5 /acre and *in situ* assessments by roving and fixed plot surveys has to be intensified at farm, village, block, regional and State level.
- Synchronized sowing of cotton preferably with short duration varieties.
- Avoid continuous cropping of cotton both during winter and summer seasons in the same area as well as ratooning.
- Avoid monocropping.
- Growing of less preferred crops like greengram, blackgram, soyabean, castor, sorghum *etc.*, along with the cotton as intercrop or border crop or alternate crop.
- Removal and destruction of crop residues to avoid carryover of the pest to the next season.
- Avoid extended period of crop growth by continuous irrigation.
- Judicious use of nitrogenous fertilizers.
- Judicious water management for the crop.
- Application of Nuclear Polyhedrosis Virus (NPV) at 1.2 x 10^{12} POB / acre in evening hours at 7^{th} and 12^{th} week after sowing.
- Application of *Bacillus thuringiensis* var. *kurstaki* 5%WP 300-400g/acre or *Beauveria bassiana* 1.15%WP 160g/acre.
- Inundative release of egg parasitoid, *Trichogramma chilonis* at 2.5 cc / acre at 15 days interval 3 times from 45 days after sowing.
- Release of predator *Chrysopa zastrowi sillemi* at 40000 / acre at 6^{th}, 13^{th} and 14^{th} week after sowing.
- ULV spray of NPV at 1.2 x 10^{12} POB / acre with 10% cotton seed kernel extract, 10% crude sugar, 0.1% each of Tinopal and Teepol.
- Avoid indiscriminate use of insecticides, particularly synthetic pyrethroids.
- Avoid combination of insecticides as tank mix.
- Adopt proper delivery system using spraying equipments like hand compression sprayer, knapsack sprayer and mist blower to ensure proper coverage with required quantity of spray fluid and avoid ULV applications or Akela spray applications.
- Proper mixing and preparation of spray fluid for each filling of spray fluid tank
- At early stages of square formation apply one of the following insecticides *viz.*,
    - Azadirachtin 0.03% EC 1000ml/acre or Diflubenzuron 25% WP 120-140g/acre or Emamectin benzoate 5% SG 76-88g/acre or Fipronil 5% SC 800ml/acre or Flubendiamide 20% WG 100g/acre or Flubendiamide 39.35% SC 40-50 ml/acre or Indoxacarb 14.5% SC 200ml/acre or Novaluron 10%EC 400ml/acre or Pyridalyl 10% EC 300-400ml/acre or Chlorantraniliprole 18.5% SC 60ml/acre or Lufenuron 5.4% EC 240ml/acre or Spinosad 45.0% SC 66-88ml/acre.
- During boll formation and maturation stage, apply any one of the following insecticides *viz.*,Chlorantraniliprole 18.5% SC 60 ml/acre or Lufenuron 5.4% EC 240 ml/acre or Spinosad 45.0% SC 66-88ml/acre.

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

Symptoms of Damage

- Rosetted flowers.
- Excreta observed at the point of bore holes by larval feeding.
- Interlocular boring and formation of double seeds.
- The attacked buds and immature bolls drop off. Discoloured lint and burrowed seeds.

Identification characters and biology

Destructive stage: Larva

- **Egg:** Flat, laid singly on leaves, flowers, bolls. Egg period 4-20 days.
- **Larva**: Young larva are white and late instar becomes almost black, brown or green to pale or pink. Larval period: 25-35 days.
- **Pupa:** Pupation in soil and debris. Pupal period: 8-12 days.
- **Adult**: Small moth. Forewings are brown or dull yellow olive grey with dark spots. Hind wings margins are deeply fringed. Adult longevity: 7-10 days.

Economic threshold: ETL: 10% infested fruiting parts or 8 moths/trap

Integrated management

- Use pheromone traps to monitor the adult moth activity @ 5 / acre.
- Spraying any one of the insecticides *viz.,* Emamectin benzoate 5% SG 76 – 88 g/acre or Diflubenzuron 25%WP 120-140 g/acre or Chlorantraniliprole18.5% SC 60 ml /acre.

Spotted / Spiny bollworms, *Earias vitella, E. insulana* (Noctuidae: Lepidoptera)

Symptoms of Damage

- Drying and drooping of terminal shoots during pre-flowering stage.
- Shedding of squares and young bolls.
- Flaring up of bracts during square and young boll formation stag[e.
- Holes on bolls and rotting of bolls.

Identification characters and biology

Destructive stage: Larva

E. vitella: Larva: Brownish with white streaks dorsally and pale yellow ventrally, without finger shaped processes. Adult: Small buff coloured and forewings are pea green with a wedge shaped white band running from base to out margin.

E. insulana: Larva: Brown with dorsum showing a white median longitudinal streak. The last two thoracic segments and all the abdominal segments have two pairs of fleshy tubercles (finger shaped processes) one dorsal and the other lateral. Pupa: brown and boat shaped. Adults: Small buff coloured. Forewings are uniformly silvery green.

Eggs are laid singly on young shoots and further on peduncles and bracteoles or squares (flower buds) and young bolls as they are formed. Egg period: 2-3 days, larval period: 10-12 days; Pupal period: 7-10 days and adult longevity: 7-10 days.

Economic threshold level: ETL: 10% infested shoots / squares / bolls.

Integrated management

- Collection and removal infested squares and flowers.
- Alternate crops should be removed.
- Application of *Bacillus thuringiensis* var. *kurstaki* 5% WP300-400g / acre or
- Spray any one of the following insecticides *viz.*,

  Flubendiamide 39.35%SC40-50 ml/acre or Chlorantraniliprole 18.5% SC 60 ml/acre or Indoxacarb 14.5%SC 200ml/acre or Diflubenzuron 25%WP 120-140g/acre or Fipronil 5% SC 800ml/acre or Spinetoram 11.7 % SC @ 168-188 ml/acre.

Cotton stem weevil *Pempherulus affinis*

Symptoms of Damage

- Swellings on the stem just above the ground level
- Young plants are invariably killed
- Older plants that survive lack vigour and strength, breaks at the nodes due to strong wind.

Identification characters and biology

Destructive stage: Larva

- **Egg**: Elongate and white laid beneath the bark . Egg period: 7-10 days.
- **Larva:** Grub, white in colour without legs. Larva feed within the stem and swelling occurs consequently. Larval period: 22-30 days.
- **Pupa:** Exarate, white and pupation within the stem. Pupal period : 10-15 days.
- **Adult:** Small brown coloured weevils with irregular white lines on the dorsum. Adult longevity: 10-15 days.
- **Economic threshold level:** 10 % infestation.

Integrated management

- Basal application of FYM 100 t/acre and 100 kg/acre of neem cake.

DISEASE MANAGEMENT

1. *Fusarium* Wilt: *Fusarium oxysporum* f.sp.*vasinfectum*

Symptoms	• Yellowing and browning of cotyledons followed by browning on the petiole • Loss of turgidity, yellowing, drooping and wilting of leaves • Browning or blackening of vascular tissues. • Infected plants appear stunted with fewer bolls.
Survival and Mode of Spread	• Survive in soil as saprophyte for many years and chlamydospores act as resting spores. • Primary spread is through seed, dormant hyphae and chlamydospores. • The pathogen is externally and internally seed-borne. • Secondary spread by wind and irrigation water.
Favourable Conditions	• Soil temperature of 20-30 ^{0}C • Hot and dry periods followed by rains • Heavy black soils with an alkaline reaction • Increased dose of nitrogen and phosphatic fertilizers • Wounds caused by nematode (*Meloidogyne incognita*) and grubs of Ash weevil (*Myllocerus pustulatus*)
Management	• Remove and burn the infected plant debris in the soil after deep summer ploughing. • Apply farm yard manure or other organic manures @ 4 t/ac. • Follow mixed cropping with non-host plants to reduce the soil temperature below 20^{0}C by providing shade. • Treat the acid-delinted seeds with Chlorothalonil at 4 g/kg of seed • Seed treatment with *Bacillus subtilis* (10g/kg) or *Trichoderma asperellum* @ 4 g/kg. • Apply *Trichoderma asperellum* @ 1 kg/ acre, twice in the soil during sowing and 90 DAS . Multiply 1 kg of *T. asperellum* in 100 kg of Farm yard manure for 15 days before application. • Spot drenching with Carbendazim 50%WP @1g/ lit of water

2. *Verticillium* Wilt: *Verticillium dahliae*

Symptoms	• Affects the crop in square and boll formation stages • Bronzing of veins followed by interveinal chlorosis, yellowing and scorching of leaves • Leaves exhibit drying of leaf margins and areas between veins shows "Tiger stripe symptom" • Affected plants remain barren showing pinkish discoloration in stem and wood.

Survival and Mode of Spread	• Survive in the infected plant debris and in soils as microsclerotia up to 14 years. Seeds also carry microsclerotia and conidia in the fuzz. • Primary spread through soil. • Secondary spread through the contact of diseased roots to healthy ones and through dissemination of infected plant parts through irrigation water and other implements.
Favourable Conditions	• Low temperature of 15-20^{0}C, low lying and ill-drained soils. • Heavy soils with alkaline condition • Heavy doses of nitrogenous fertilizers
Management	• Remove and burn the infected plant debris in the soil after deep summer ploughing. • Apply farm yard manure or other organic manures @4 t/ac. • Follow mixed cropping with non-host plants to lower the soil temperature below 20^{0}C by providing shade. • Follow crop rotation by growing paddy or lucerne or chrysanthemum for 2-3 years. • Treat the acid-delinted seeds with Chlorothalonil at 4 g/kg of seed • Treat seeds with *Bacillus subtilis* (10g/kg) or *Trichoderma asperellum* @ 4 g/kg. • Apply *Trichoderma asperellum* @ 1 kg/ acre, twice in the soil during sowing and 90 DAS . Multiply 1 kg of *T. asperellum* in 100 kg of Farm yard manure for 15 days before application

3. Root rot: *Rhizoctonia solani* (Pycnidial stage: *Macrophomina phaseolina)*

Symptoms	• Germinating seedling shows black lesions on hypocotyls, girdling of stem and death of seedlings. • Affected basal stem becomes dark with bark shredding and sclerotial bodies present in the shredded bark. • The entire root system gets rotted, plants dried and the affected plants can be easily pulled out.
Survival and mode of spread	• The disease is soil-borne and the pathogen can survive in the soil as sclerotia for several years. • Primary spread is through soil borne sclerotia • Secondary spread through sclerotia disseminated by irrigation water, implements, heavy winds and other cultural operations.
Favourable conditions	• Dry weather following heavy rains • High soil temperature (35-39^{0}C), low soil moisture (15-20 per cent) • Cultivation of favourable hosts like vegetables, oil seeds and legumes preceding cotton and wounds caused by ash-weevil grubs and nematodes.
Management	• Remove and burn the infected plant debris in the soil after deep summer ploughing.

	• Apply farm yard manure @4 t/ac or neem cake @ 60 kg/ac. • Take up sowing in the first week of April or last week of June. • Adopt intercropping with sorghum or moth bean (*Phaseolus aconitifolius*) to lower the soil temperature. • Treat the acid-delinted seeds with Chlorothalonil at 4 g/kg of seed • Treat seeds with *Bacillus subtilis* (10g/kg) or *Trichoderma asperellum* @ 4 g/kg. • Treat seeds with Tetraconazole 11.6% w/w (12.5% w/v) SL @2 g /kg of seed Carboxin 37.5% + Thiram 37.5% WS @2.5g/ kg of seed • Apply *Trichoderma asperellum* @ 1 kg/ acre, twice in the soil during sowing and 90 DAS . Multiply 1 kg of *T. asperellum* in 100 kg of Farm yard manure for 15 days before application • Spot drench with Carbendazim @ 1 g/l or Trifloxystrobin + Tebuconazole @ 0.75g/l at the base of affected plants and surrounding healthy plants

4. Anthracnose: *Colletotrichum gossypii*

Symptoms	• The fungus infects the seedlings and produces small reddish circular spots on the cotyledons and primary leaves. • The lesions develop on the collar region, stem may be girdled, causing seedling to wilt and die. • In mature plants, the fungus attacks the stem, leading to stem splitting and shredding of bark. • The most common symptom is boll spotting with small water soaked, circular, reddish brown depressed spots on the bolls. • The lint is stained to yellow or brown, becomes a solid brittle mass of fibre.
Survival and Mode of Spread	• The pathogen survives as dormant mycelium in the seed or as conidia on the surface of seed . • It also perpetuates on the rotten bolls and other plant debris in the soil. • Primary spread is through infested seed and soil. • Secondary spread is through air-borne conidia.
Favourable Conditions	• Prolonged rainfall at the time of boll formation and close planting.
Management	• Remove and burn the infected plant debris and bolls in the soil. • Rogue out the reservoir weed hosts. • Treat the acid-delinted seeds with Chlorothalonil at 4 g/kg of seed • Spray Copper oxychloride @ 500 g / acre, at boll formation stage

5. Grey or Areolate Mildew : *Ramularia areola*

Symptoms	• Irregular to angular pale translucent lesions bound by veinlets and grey powdery growth appear on lower surface of leaf

	• Correspondingly light green specks appear on the upper surface of leaves. • In severe cases whitish grey powdery growth appear on upper surface. The affected leaves dry up inward, turn yellow and fall prematurely.
Survival and Mode of Spread	• The pathogen survives during summer in the infected crop residues. The perennial cotton plants and self-sown cotton plants also harbour the pathogen. • Primary spread is through conidia from infected plant debris • Secondary spread is through wind, rain splash, irrigation water and implements.
Favourable Conditions	• Wet humid conditions during winter cotton season • Intermittent rains during North-East monsoon season • Low temperature (20-30 ^{0}C) during October-January • Close planting • Excessive application of nitrogenous fertilizers • Very early sowing or very late sowing of cotton
Management	• Remove and burn the infected crop residues. • Remove the self-sown cotton plants during summer months. • Avoid excessive application of nitrogenous fertilizers/manures. • Adopt correct spacing based on soil conditions and varieties. • Spray Wettable sulphur @ 400 g /acre or Chlorothalonil@ 200 g / acre or Difenaconazole @ 100 ml or Kresoxim Methyl @ 200 ml/ acre or Tebuconazole @ 200 ml/ acre or Propiconazole @ 200 ml/acre or Metiram 55% + Pyraclostrobin 5% WG @ 200g/ acre or Azoxystrobin 18.2% + Difenoconazole 11.4% w/w SC 200ml/ acre at 60, 90 and 120 days after sowing.

6. Boll Rot: Fungal complex

Fungal pathogens involved in boll rot are *Fusarium moniliforme, Colletotrichum capsici, Aspergillus flavus, Aspergillus niger, Rhizopus nigricans, Nematosporanagpuri*and *Botryodiplodia sp.*

Symptoms	• Disease appears as small brown or black dots which later enlarge to cover the entire bolls. • Infection spreads to inner tissues and rotting of seeds and lint occur. • The bolls never burst open and fall off prematurely. • Fruiting bodies of fungi are observed on the bolls
Survival and Mode of Spread	• The fungi survive on the infected bolls in the soil. • Primary spread is through infected bolls • Secondary spread is through air-borne conidia.

Favourable Conditions	• Heavy rainfall during the square and boll formation stage • Punctures caused by the insects • Closer spacing • Excessive nitrogen application.
Management	• Adopt optimum spacing. • Apply the recommended doses of fertilizers. • Spray Copper oxy chloride @1000 g/acre or Carbendazim @ 200 g /acre or Mancozeb @ 800 g / acre

7. *Alternaria* Leaf Spot: *Alternaria macrospora*

Symptoms	• Small, pale to brown, irregular or round spots, appear on the leaves. • Each spot has a central lesion surrounded by concentric rings. • Several spots coalesce together to form blighted areas. • The affected leaves become brittle and fall off. • The spots also appear on bracts and bolls.
Survival and Mode of Spread	• The pathogen survives in the infected crop debris as dormant mycelium. • Primary spread is through infected crop debris • Secondary spread is through air-borne conidia.
Favourable Conditions	• High humidity, intermittent rains and moderate temperature of 25-28^{0}C.
Management	• Remove and destroy the infected plant residues. • Perform deep ploughing during summer • Avoid seeds from infected crop • Spray Copper oxychloride @ 500 g or Chlorothalonil @ 200 g or Difenaconazole @ 100 ml or Kresoxim methyl @ 200 ml or Tebuconazole @ 200 ml or Trifloxystrobin + Tebuconazole @ 120g or Propiconazole @ 100 ml or Metiram 55% + Pyraclostrobin 5% WG @ 100 g or Fluxapyroxad 167 g/l + Pyraclostrobin 333 g/l SC @ 150 g or Pyraclostrobin 20% WG @ 100g or Propineb 70% WP @ 500g per acre at 60, 90 and 120 days after sowing. • Apply *Bacillus subtilis* (BSC5) @ 400 g/ac on 60, 90 and 120 days after sowing.

8.*Cercospora*leaf Spot: *Cercospora gossypina*

Symptoms	• Round or irregular greyish spots appear on leaves • The spots may have dark brown or blackish borders in older leaves
Survival and Mode of Spread	• The pathogen survives in the infected plant debris as conidia • The conidia are disseminated by wind or rain splash.

Favourable Conditions	• Dense planting • Cloudy weather coupled with intermittent rain followed by dry weather • High Relative humidity
Management	• Remove and destroy the infected plant residues. • Spray Mancozeb @ 400g/ acre or Copper oxychloride @ 500 g/ acre or Carbendazim 50% WP @ 200g/acre or Propiconazole @ 200 ml/ acre or Metiram 55% + Pyraclostrobin 5% WG @ 200g/acre or Kresoxim-methyl 44.3% SC @ 200 ml/ acre at the intimation of the disease.

9. Bacterial Blight: *Xanthomonas axonopodispv. malvacearum*

Symptoms	The bacterium attacks all stages from seed to harvest. **Five common phases of symptoms** **1.Seedling blight** • Small, water-soaked, circular or irregular lesions on the cotyledons. • Infection spreads to stem through petiole and cause withering and death of seedlings. **2.Angular Leaf Spot** • Small, dark green, water soaked areas develop on lower surface of leaves • The spots become angular restricted by veins and veinlets and are visible on both the surface of leaves. • Later they turn reddish brown colour and infection spreads to veins and veinlets. **3.Vein necrosis or Vein banding** • Blackening of the veins and veinlets, gives a typical 'blighting' appearance. • On the lower surface of the leaf, bacterial oozes are formed as crusts or scales. • The leaves become crinkled and twisted inward and show withering. • The infection also spreads from veins to petiole and cause blighting leading to defoliation. **4. Blackarm** • On the stem and fruiting branches, dark brown to black lesions are formed. • Girdle the stem and branches to cause premature drooping off of the leaves.

	• Cracking of stem and gummosis, resulting in breaking of the stem and hang typically as dry black twig to give a characteristic "black arm" symptom. **5. Square rot or boll rot** • On the bolls, water soaked lesions appear and turn into dark black and sunken irregular spots. • Infection slowly spreads to entire boll and shedding occurs. • Infection on mature bolls lead to premature bursting. • The bacterium spreads inside the boll and lint gets stained yellow because of bacterial ooze and loses its appearance and market value. • The pathogen also infects the seed and causes reduction in size and viability of the seeds.
Survival and Mode of Spread	• The bacterium survives on infected, dried plant debris in soil for several years. The bacterium is also seed-borne and remains in the form of slimy mass on the fuzz of seed coat. • The primary infection is through seed-borne bacterium. • Secondary spread is through wind, windblown rain splash, irrigation water, insects and other implements.
Favourable Conditions	• Optimum soil temperature of 28˚C, • High atmospheric temperature of 30-40˚C, • Relative humidity of 85 per cent • Poor tillage, late irrigation • Potassium deficiency in soil. • Rain followed by bright sunshine during the months of October and November.
Management	• Delint the cotton seeds with concentrated sulphuric acid at 100ml/kg of seed. • Treat the delinted seeds with Carboxin or Oxycarboxin at 2 g/kg or Carboxin 37.5% + Thiram 37.5% WS @2.5 g/ kg • Remove and destroy the infected plant debris. • Rogue out the volunteer cotton plants and weed hosts. • Follow crop rotation with non-host crops. • Early thinning and early earthing up with potash. • Spray Streptomycin sulphate @ 100g +Copper oxychloride@500 g/acre

10. Cotton Necrosis: Tobacco streak virus

Symptoms	• Initiallychlorotic yellow spot appear on the infected leaves • Later spot turn into distinct necrotic purple spot with yellow halo • Necrotic streaks are produced on the petiole

	• Bud and flower productions are reduced • Severe infection resulted in drying of squares.
Survival and Mode of Spread	• Virus survives in alternate hosts.. • Primary spread is From infected plants • The virus is transmitted by Thrips (*Thrips tabaci*)
Favourable Conditions	• Minimum temperature, High relative humidity with leaf wetness
Management	• Remove infected plants and other host plants • Periodical weeding should be done • Seed treatment with imidacloprid 70WS at 7g / kg • Spray Dinotefuran 20% SG 60 g/acre or Flonicamid 50% WG @ 60 g/acre or Imidacloprid 17.8%SL 40- 50 ml/acre for controlling thrips

11. Cotton Leaf curl: Cotton leaf curl virus

Vector: White fly *(Bemesia tabaci)*

Symptoms	• Downward and upward curling of leaves, thickening of veins and enation on underside of leaves • In severe infection growth retards. • Boll bearing capacity is reduced.
Survival and Mode of Spread	• Alternate hosts and cultivated hosts also serve as virus reservoirs throughout the year • Primary source is the viruliferous whitefly (*Bemisia tabaci)*vector.
Favourable Conditions	High temperature
Management	• Remove the infected plants and bury them • Spray Dinotefuran 20% SG 60 g/acre or Flonicamid 50% WG @ 60 g/acre or Imidacloprid 17.8%SL 40-50 ml/acre for controlling whitefly • Foliar application of neem oil @ 200 ml / acre • Practice crop rotation by planting crops that are not susceptible to whitefly

HARVESTING

- Harvest kapas at an interval of 5-7 days
- Immediately after harvesting, shade dry the kapas to avoid dis-colouration

II.RICE FALLOW COTTON

SOWING

- Dibble 6 kg of fuzzy seeds or 3 kg of de-linted seeds / ac when the field is in waxy condition
- Adopt a spacing of 60cm between rows and 30 cm between plants in a row

NUTRIENT MANAGEMENT

- Apply 24:12:12 kg N :P_2O_5:K_2O/ac.
    - For old delta, apply 50% N and K_2O, and 100% P_2O_5 on 35th day and remaining 50% N and K_2O on 55th day after sowing
    - In new delta, apply full P_2O_5 and 1/3 of N and K_2O at 20 day after sowing ; 2/3 N and K_2O at 40 day after sowing

- Apply basally 5 kg/ac micronutrient mixture prepared by Department of Agriculture
- Apply $MgSO_4$@ 8kg/ac to prevent reddening as basal dose

WEED MANAGEMENT AND INTER CULTIVATION

- Apply Pendimethalin (38.7% CS) @ 260 ml/ac or Pendimethalin (30%EC) @ 400 ml/ac within three days of sowing followed by one hand weeding or weeding with power weeder on 45th day after sowing .
- Sufficient moisture should be present in the soil at the time of herbicide application.
- If herbicides are not applied, perform manual weeding on 20th and 45th days after sowing.
- If post emergence application of herbicide is warranted apply pyrithiobac sodium @ 25g /ac + quizalofop ethyl @ 20 g /ac at 2 to 4 leaf stage of the weeds.

IRRIGATION MANAGEMENT

- Form ridges and furrows, on alternate rows of plants, from one end to the other end of the field without forming any separate channels
- Skip furrow method of irrigation to prevent excessive moisture
    - Regulate irrigation according to the soil type, prevailing weather conditions and receipt of rains.
    - Ensure irrigation at critical crop growth stage namely, square formation and boll maturity stage.

Physiological interventions

- Spray PPFM (Pink Pigmented Facultative Methylotroph) @ 200 ml/ac mixed in 200 litres of water on 30, 45, 60, and 90 days after sowing.
- Spray cotton plus @ 2.5 kg /ac mixed in 200 litres of water twice during flowering and boll formation stage
- Nip the terminal portion of the main stem beyond the 15thnode from 75th to 80th days after sowing

Harvesting

- Harvest kapas at an interval of 5-7 days
- Immediately after harvesting, shade dry the kapas to avoid discolouration

III.RAINFED COTTON

Seed treatment

FIELD PREPARATION AND SOWING

- Plough the field to get fine tilth immediately after harvest of the previous crop
- Adopt permanent broad ridges system

NUTRIENT MANAGEMENT

Organic manures and biofertilizers

- Apply 5 t /acre of farm yard manure
- Apply carrier based formulation or liquid formulation of biofertilizer

Carrier Based Formulation of biofertilizers :

- Apply 1 kg each of biofertilizers *viz.,Azospirillum*, Phosphobacteria (or) Azophos, and Silicate solubilizing bacteria (SSB) per acre mixed with 25kg of FYM and 25kg of sand

or

Liquid Formulation of bio fertilizers:

- Apply 200 ml each of biofertilizers *viz., Azospirillum*, Phosphobacteria (or) Azophos, and Silicate solubilizing bacteria (SSB),per acre mixed with 25kg of FYM and 25kg of sand
- Broadcast any one of the above biofertilizer mixture uniformly at the time of last ploughing

APPLICATION OF INORGANIC FERTILIZERS

- Apply NPK fertilizers as per soil test recommendations
- If soil tests are not done, follow the blanket recommendation as follows

Varieties	Nutrient dose (acre)
arboreum / Karunganni cotton	8 : 0 : 0 kg of N: P_2O_5: K_2O
hirsutum / American cotton	16 : 8 : 16 kg of N: P_2O_5: K_2O

- Apply micronutrient mixture formulated by the Department of Agriculture, Tamil Nadu @ 5.0 kg / ac mixed with enough sand to make a total quantity of 20 kg

(or)

- Apply TNAU MN mixture @ 3 kg /ac as Enriched FYM (Prepare enriched FYM at 1:10 ratio of MN mixture & FYM ; mix at friable moisture & incubate in gunny bags for one month in shade)
- Apply the mixture uniformly over the furrows.
- Do not incorporate the mixture in the soil.

Note:

1. Recommended bio fertilizers, basal dose of inorganic fertilizers and micro nutrients should be applied at the last ploughing before formation of ridges
2. To control soil borne pathogens apply *Bacillus subtilis* and *Trichoderma asperellum* each @ 1 kg/ac mixed with 100 kg FYM at the last plough before formation of ridges

SEED RATE

- Adopt the following seed rate

Varieties	Seed rate
arboreum / *Karunganni* cotton	8 kg of fuzzy seeds / acre
hirsutum / American cotton	8 kg of fuzzy or 6 kg of delinted seeds/acre

- Dibble the seeds at a depth of 3-5 cm on the side of the ridge

SPACING

- Adopt a spacing of 45 cm between rows and 15 cm between plants
- For cotton intercropped with pulses, adopt the following spacing

Spacing for cotton crop (cm)		
Within Paired row	Between Paired rows	Between plants
30	60	15

- Sow intercrops in a spacing of 30 x 10 cm in between each paired row of cotton.

WEED MANAGEMENT

In rainfed condition application of herbicide mainly depends on sufficient soil moisture

- Spray Pendimethalin (38.7% CS) @ 260 ml/ac or Pendimethalin (30%EC) @ 400 ml/ac as pre-emergence application, followed by one hand weeding and weeding with power weeder on 45th day after sowing.
- If post emergence application of herbicide is warranted apply pyrithiobac sodium @ 25g /ac + quizalofop ethyl @ 20 g /ac at 2 to 4 leaf stage of the weeds.
- If herbicides are not applied, perform manual weeding at 20th and 45th days after sowing.
- Work *dhanthulu* or blade harrow on the 30th and 45th day of sowing
- Sufficient soil moisture should be present at the time of herbicide application.
- Based on moisture limitations above operations may be altered

Physiological interventions

- Spray 0.5% urea and 1% KCI on the 45th and 65th day of sowing if sufficient moisture is available.
- Spray PPFM (Pink Pigmented Facultative Methylotroph) @ 200 ml/ac mixed in 200 litres of water on 30, 45, 60, and 90 days after sowing.
- Spray cotton plus @ 2.5 kg /ac mixed in 200 litres of water twice during flowering and boll formation stage

Harvesting

- Harvest kapas at an interval of 5-7 days
- Immediately after harvesting, shade dry the kapas to avoid discolouration

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Information provided by: Cotton Department, TNAU, Coimbatore, Tamil Nadu. (2023)

Information collected and uploaded by Dr. M. Sabesh, CICR