

COTTON PRODUCTION TECHNOLOGIES

Desi Cotton Varieties (<i>G.arboreum.L</i>)	: Aravinda, Srinandi (NDLA-2463), Yaganti (NDLA-2933) and Veena (MDL-1875)
Americian Cotton Varieties (<i>G. hirsutum L.</i>)	: Kanchana (LPS 141), LK-861, L-389, L- 603, L-604, Narasimha (NA-1325), Sivanandi (NDLH-1755), MCU5 VT, LRA-5166 and LRK-516.
Intra-specific Cotton Varieties / Hybrids	: LAHH-1, LAHH-4, LAHH-5, Lam Cotton Hybrid-7, NDLHH-390, NDLHH-240 and Orugallu Krishna (WGHH-2), NHH-44, JKHy 1, Savitha, H-6, H-8 and H-10.
Egyption Cotton Varieties / Inter-specific Cotton Hybrids	: Suvin & Jayalakshmi (DCH-32)
Bt. Cotton Hybrids	: Officially identified private Bt cotton hybrids being cultivated and found suitable for the last 3-4 years.
Soils	: Deep black Cotton and Red fertile soils with irrigated or assured rainfall conditions.

Land Preparation

For rainfed cotton, deep ploughing once in 3 years with mould board plough or disc harrow facilitates deep infiltration of water and charging of soil profile with large quantities of water. The land has to be ploughed 2 to 3 times and work with harrow to bring the soil to good tilth. Seeds can be dibbled by maintaining spacing in between plants after running a marker in one or two direction(s). For irrigated crop, ridges and furrows are to be formed at recommended spacings after deep ploughing.

Seed Rate

Americian Cotton Varieties (<i>G.hirsutum.L</i>)	:	2 kg / acre
Desi Cotton Varieties (<i>G.arboreum.L</i> and <i>G.herbaceum.L</i>)	:	4-5 kg / acre
Intra-/Inter-specific Cotton Hybrids	:	0.75-1 kg / acre

Seed Treatment :

For acid delinting, seed should be treated with 80-100 ml H₂ SO₄ per kg of seed for 2-3 minutes followed by lime solution and thorough washing with water 2-3 times to make the seed acid free. Seed treatment with appropriate insecticide(s); imidacloprid 70 WS @ 5 g / kg or thiomethoxam 70 WS @ 4 g / kg or imidacloprid 48 FS @ 9ml/kg or carbosulfan 25 DS @ 40 g/kg of seed. followed by, treatment with *Pseudomonas fluorescens* @ 10 g / kg or *Trichoderma viride* or *T. harzianum* @ 10 g / kg or carbendazim 50 WP @ 2 g / kg or mancozeb 75 WP @ 3 g / kg or captan 50 WP 3 g / kg or thiram 75 WP @ 3 g / kg.

Spacing

Desi Cotton Varieties (cm)	:	60 x 30
American Cotton Varieties (cm)	:	90 x 60 or 105 x 60
Conventional Hybrids (cm)	:	90 x 60 or 120 x 60
Bt. Cotton Hybrids (cm)	:	90 x 45 or 90 x 60 or 120 x 45 or 120 x 60

Sowing with Cut-off dates :

Red soils	:	June – July
Black soils	:	July – 1 st Fortnight of August

Inter Cropping:

Inter cropping with mungbean / urdbean / soybean / cluster bean in 1:2 or 1:3 ratio, and pigeonpea 4:1 or 6:1 or 8:1 ratio.

Gap filling and Thinning:

Gap filling should be done preferably within 10 DAS. Thinning should be done within three weeks after sowing retaining two plants per hill in case of varieties, one plant per hill in case of hybrids.

Manures and Fertilizers:

Apply FYM @ 4 t / acre (10 cart loads) besides the recommended fertilizers.

For Desi Cotton Varieties:

8 N + 8 P₂O₅ kg/acre. Entire P as basal. N is in two splits at 30 DAS and 60 DAS by pocketing method.

For American Cotton Varieties:

36 N + 18 P₂O₅ + 18 K₂O kg/acre. Entire P as basal, N and K in three splits 30, 60 and 90 DAS by pocketing method.

For Conventinol Cotton Hybrids:

48 N + 24 P₂O₅, 24 K₂O kg/acre. Entire P as basal, N and K in three splits 30, 60, 90 DAS by pocketing method.

For *Bt* Cotton Hybrids:

25% excess N over recommended N should be applied. The recommended N and K should be given in 3-4 splits at 20 days interval starting from 20 DAS. Foliar application of 2% urea/ 2% DAP/ 2% KNO₃ at flowering and boll development stages.

For correcting magnesium, boron and zinc deficiencies, foliar application of MgSO₄ @ 1% twice at 45 and 75 DAS; Boron @ 0.15% twice at 60 and 90 DAS; and ZnSO₄ @ 0.2% twice at 4-5 days interval at 45 DAS is recommended. For correcting iron deficiency due to heavy moisture stress in early crop growth stage, foliar application of 0.5% FeSO₄ along with citric acid should be done twice at weekly interval.

Weed Management:

Spray pendimethalin @ 1.5 to 2.0 l/acre immediately or within 48 hours of sowing. Inter cultivation with tyned harrow and blade harrow 2-3 times upto 90 DAS. For control of grasses and broad leaved weeds post emergence spray of quizalofopethyl @ 400 ml/acre and pyriithiobac sodium @ 250 ml / acre is recommended at 25-30 DAS. Post emergence directed spray of parquat @ 5.0 ml/l of water or glyphosate 10.0 ml + 10.0 g of urea or ammonium sulphate/l of water is recommended for control of the weeds in the cotton crop, where inter-cultivation or manual weeding is not possible due to unfavourable weather conditions.

Irrigation: Generally cotton crop requires 2-4 irrigations depending upon the soil type.

Pest Management in Cotton

Management of Sucking Pests in cotton:

1. Grow sucking pest tolerant / resistant varieties / hybrids.
2. Seed treatment with imidacloprid 70 WS 5.0 g /kg or thiamethoxam 70 WS 4.0 g / kg or imidacloprid 48 FS @ 9.0 ml/kg or carbosulfan 25 DS @ 40.0 g/kg of seed, gives early protection against sucking pests.
3. Growing of intercrops like mungbean or urdbean or soybean or cluster bean in 1:2 or 1:3 ratio will facilitate the buildup of native natural enemy populations that in turn keep sucking pests under check
4. Growing of cowpea as bund crop is advantageous to encourage predacious insects like coccinellids, syrphids and chrysopids
5. Maize or sorghum or pearl millet grown as barrier crops in the border prevents spread from neighbouring fields.
6. Stem application at 30 & 45 DAS with monocrotophos (1:4) and at 60 DAS with imidacloprid (1:20) for protecting the crop from early season sucking pests is highly effective.
7. Setting up of yellow sticky traps @ 10 per acre for monitoring whitefly incidence.
8. Economic Threshold Level (ETL) for sucking pests on cotton is presented hereunder :

Name of the Pest	ETL
Jassids	Two adults or nymphs per leaf or appearance of second grade injury (yellowing in the margins of the leaves)
Thrips	10 adults per leaf
Aphids	15% affected plants
Whiteflies	6-8 adults per leaf
Mealy bugs	5% affected plants
Mites	10 per cm ⁻¹

9. ETL based application of insecticides

Leafhoppers / aphids / thrips	- Monocrotophos 36 SL @ 1.6 ml/l or Acephate 75 SP @ 1.5g/l or Imidacloprid 17.8 SL @ 0.4 ml/l or Acetamiprid 20 SP @ 0.2 g/l or Thiamethoxam 25 WG @ 0.2 g/l or Fipronil 5 SC @ 2.0 ml/l
Whitefly	- Triazophos 40 EC @ 2.0 ml/l or Profenophos 50 EC @ 2.0 ml/l or Diafenthiuron 50% WP @ 1.25 g/l or NSKE @ 5% (extract from 10.0 kg of Neem Powder/acre)
Red mite	- Wettable sulphur 80 WP @ 3.0 g/l or Dicofol 18.5 SC @ 5.0 ml/l

Insecticide Resistance Management Strategies to manage cotton pests in Bt-cotton

Early Sucking Pest Window 1: 0-60 DAS: No foliar spray upto 60 DAS.

- Cultivation of sucking pest tolerant varieties / hybrids
- Use dual gene, such as Bollgard II resistant (Cry I Ac + Cry 2 Ab)
- Raising densely planted border rows of maize / sorghum / pearl millet / pigeonpea
- Mechanical control of *Parthenium* and *Abutilon* weeds to avoid build up of initial mealy bug inoculum.
- Stem application of monocrotophos at 30 and 45, and imidachloprid at 60 DAS.
- Neem oil sprays @ 1.0 l/acre + detergent powder @ 1.0 g or sandovit @ 0.5 ml or Teepol 0.5 ml/l. for the control of whitefly.

Window 2: 60-90 DAS : Initial boll worm infestation. Mostly eggs and young larvae: Biological and bio-pesticide window.

- Hand picking of *Helicoverpa* and *Spodoptera* larvae, and egg masses of *Spodoptera*.
- One spray of novaluron @ 1.0 ml/l or lufenuron @ 1.25ml/l for the control of *Spodoptera* on need basis only.
- Installation of yellow sticky traps @ 10.0 / acre for monitoring of the whitefly.
- Application of 5% NSKE for bollworm and whitefly infestation.
- No spray against minor lepidopteran pests.
- Follow Integrated Nutrient Management practices including foliar spray of nutrients to reduce leaf reddening.

- Neonicotinoids like imidacloprid or acetamiprid or thiomethaxam for the control of sucking pests.
- Spinosad or emamectin benzoate only on non-Bt cotton.

Window 3: 90-120 DAS: Peak Boll worm infestation.

- One application of chlorpyrifos or quinalphos or thiodicarb or spinosad on conventional or Bt-cotton plants showing flared up squares.
- Poison bait (10 kg rice bran +2.0 kg jaggery + chlorpyrifos 500-700 ml or thiodicarb 250-300 g) for the control of grown up larvae of *spodoptera*.

Window 4: >120 DAS : Boll worms & Mealy bugs.

- In case of minimum infestation of mealy bug, uprooting and destroying of infested plants.
- Surrounding weeds especially, *Parthenium* are sprayed with chlorpyrifos and destroyed subsequently.
- In severe mealy bug infestation drenching the affected stems with malathion @ 2.0 ml/l or buprofezin @ 2.0 ml/l or acephate @ 2.0 g/l along with sticky agents.
- Insecticides like chlorpyrifos, quinalphos, profenophos, carbaryl are used in case of severe economic damage due to mealy bug.
- Need based use of insecticides: Spraying of persistent insecticides like thiodicarb 75 WP @ 1.5 g/l or quinalphos 25 EC @ 2.5 ml/l or chlorpyrifos 20 EC @ 2.5 ml/l at 15 days interval.
- Hand picking of surviving bollworm larvae from Bt-cotton fields and destruction of residual pupae by deep ploughing immediately after harvest.

Integrated Pest Management in Cotton:

1. Avoid monocropping of cotton.
2. Application of chemical fertilizer as supplement to organic or biological fertilizers as per the recommended doses.
3. Growing intercrops/strip crops/barrier crops with greengram, blackgram, soybean cowpea, clusterbean, groundnut, foxtail millet and coriander were found better intercrops in increasing the effectiveness of natural enemies like coccinellids, syrphids, chrysopids, spiders, *Trichogrammids*, *Apanteles* etc. Growing fodder sorghum or maize as barrier crops and castor as ovipositional trap crop with in the cotton was also found to be more advantageous to manage the pests of cotton.
4. Seed treatment with recommended insecticides and fungicides.
5. Stem application of Monocrotophos at 30 and 45, and imidacloprid at 60 DAS.
6. Monitoring pests by using light, sticky and pheromone traps. The adults monitoring should be supported by egg and larval monitoring following sequential sampling technique at frequent intervals in case of boll worms.

7. Bird perches should be arranged @ 10 per acre for encouraging bird predation on bollworm larvae.
8. The buildup of broad spectrum predators viz., spiders, coccinellids and chrysopids should be synchronised in other cultural operations. Release of *Trichogramma* egg parasite @ 50,000/ha and *Chrysopa* egg larval predator @ 10000/ha, should be done as soon as the first brood of bollworms are noticed.
9. Topping of cotton plants when maximum egg laying of *Helicoverpa armigera* is noticed (October-November months).
10. Application of HNPV @ 500 LE/ha or neem seed kernel extract (5%) in synchrony with early larvae of *Helicoverpa*. Neem oil formulation to manage initial whitefly.
11. ETLs for Bollworms

Name of the Pest	ETL
American bollworm (<i>H. armigera</i>) and Spotted Boll worm (<i>E. vitella</i>)	Five per cent damaged fruiting bodies or one larva per plant or total three damaged square per plant taken from 20 plants selected at random for counting.
Pink bollworm (<i>P. gossypiella</i>)	Eight moths per trap per day for three consecutive days or 10 % infested flowers or bolls with live larvae.
Tobacco caterpillar (<i>S. litura</i>)	One egg mass or skeletized leaf ten plants

12. Poison bait (10.0 kg of rice bran + 2.0 kg jaggery + 500-750 ml of chlorpyrifos or 250-300 g of thiodicarb) for the control of grownup larvae of *Spodoptera*.
13. Resorting to chemical insecticides for the control of leafhoppers spray monocrotophos 36 SL @ 1.6 ml/l or acephate 75 SP @ 1.5 g/l or fipronil 5% SC @ 2.0 ml/l or imidacloprid 17.8 SL @ 0.4 ml/l or acetamiprid 20 SP @ 0.2 g/l or thiamethoxam 25 WG @ 0.2 g/l or flonicamid 50 WG @ 0.3 g/l. For the management of whitefly spray triazophos 40 EC @ 2.0 ml/l or profenophos 50 EC @ 2.0 ml/l or diafenthiuron 50 WP @ 1.25 g/l or neem seed kernel extract @ 5% or neem oil @ 5.0 ml/l; for the control of *Helicoverpa armigera* spray quinalphos 25 EC @ 2.5 ml/l or chlorpyrifos 20 EC @ 3.0 ml/l or acephate 75 SP @ 1.5 g/l or indoxacarb 14.5 SC @ 1.0 ml/l or thiodicarb 75 WP @ 1.5 g/l or spinosad 45 SC @ 0.3 ml/l or flubendiamide 48 SC @ 0.3 ml/l or chlorantraniliprole 18.5 SC @ 0.3 ml/l. For managing red spider mites, application of wettable sulphur 80 WP @ 3.0 g/l or dicofol 18.5 SC @ 5.0 ml/l. Similarly if mealy bugs spread in patches to alarming level spray acephate 75 SP @ 2.0 g/l or profenophos 50 EC @ 3.0 ml/l mixing with sandovit or teepol.
14. Removal of cotton stubbles after last picking without opting for ratoon crop or prolonging the crop growth with irrigations and fertilizer applications. This is essential to break the cycles of problem pests in the system as a whole

Mealy bug management in Cotton

- Adopt crop rotation
- Removal and burning of alternate weed hosts like *Parthenium*, *Abutilon* etc. in the vicinity of cotton crop
- Control mealy bug population on the alternate crop hosts during on and off season
- Stem application of monocrotophos diluted with water in 1:4 ratio during vegetative and early reproductive stage of the cotton crop at 30, 45 and 60 DAS as a prophylactic measure.
- Monitoring the initial infestation of mealy bug, particularly on border plants and shaded areas for timing of control measures.
- Need based spraying of insecticides, triazophos 40 EC @ 3.0 ml/l or prophenophos 50 EC @ 3.0 ml/l or acephate 75 WP 2.0 g/l mixed with stickers like triton or sandovit or teapot etc @ 1ml/l of spray fluid
- Spot application of insecticides is desirable when the infestation is confined to isolated pockets in the field.
- Removal and destruction by burning of heavily infested dried / dead cotton plants may be taken up to arrest further spread of the pest incidence.
- Removal and burning of left over cotton stubbles after harvesting.

Management strategies for pink bollworm:

1. Grow early maturing varieties so that the cotton bolls mature before the heavy population of pink bollworm builds up.
2. Avoid staggered sowing in an area and take up timely sowings.
3. Use of acid delinted seed.
4. Adopting efficient and timely agronomic practices such as use of organic manures and recommended doses of 'N' fertilizers only.
5. Keep the crop free from weeds.
6. Regular monitoring for pest build up with field scouting and pheromone traps.
7. Destroy pink bollworm larvae in rosette flowers and also through periodical removal of dropped squares, dried flowers and pre-matured bolls, to suppress pest population in the initial stage.
8. Avoid ratooning and summer cotton.
9. Allow cattle, sheep and goats to graze upon immature green bolls and attacked bolls after final picking to prevent carry-over of the pest to the next season.
10. Prompt removal and destruction of cotton stubbles to prevent carryover of pest to next season.
11. Restrict the movement of cotton seed from other areas/states
12. Need based use of insecticides: Spraying of persistent insecticides like thiodicarb 75 WP @ 1.5 g/l or quinalphos 25 EC @ 2.5 ml/l or chlorpyrifos 20 EC @ 2.5 ml/l at 15 days interval.

Management of Cotton Diseases:

Bacterial blight: Angular leaf spots develop and spread through veins causing vein blight. Under severe conditions disease spreads to branches causing black arm. Dark green spots develop on bolls which turn black and bolls rot.

Control: Seed treatment with *Pseudomonas fluorescens* @ 10.0g/kg seed; spraying copper oxy chloride 3.0 g/l + streptomycin 100 mg/l starting from 50 days after sowing, 2-3 times, at fortnightly intervals.

Alternaria leaf spot: Brown spots with concentric rings develop on leaves, join together and dry; defoliation occurs. Lesions on stem extend and break.

Helminthosporium leaf spot: Light brown spots with ashy centres and red margins

Cercospora leaf spot: Dark brown circular spots with white centres and purple margins develop on leaves.

Control: For the control of leaf spots seed treatment with *P. fluorescens* @ 10.0 g or carbendazim 2.0g or thiram 3.0g or vitavax 2.0 g/kg of seed; spraying copper oxy chloride 3.0 g/l or mancozeb 3.0 g/l or propiconazole 1.0 ml/l or captan + hexaconazole 1.0 g/l starting from 50 DAS, 2-3 times, at fortnightly intervals.

Grey mildew: Angular, white, powdery spots develop on leaves, spread and defoliation occurs. Control: Spraying water soluble sulphur 3.0 g/l or carbendazim 1.0 g/l, 2-3 times, at 10-15 days interval.

Rust: Yellowish brown to reddish brown pustules develop on both sides of the leaves.

Control: Spraying water soluble sulphur 3.0 g/l or tridemorph 1.0 ml/l or propiconazole 1.0 ml/l, starting from 75 DAS, 2-3 times, at fortnightly intervals.

Boll Rots: Dark spots or lesions develop on bolls.

Control: Spray copper oxy chloride 3.0 g/l + streptomycin 100 mg/l or carbendazim 1.0 g/l or dithane M-45 2.5 g/l.

Root rot: Sudden death of young plants in patches, roots become sticky and bark shreds in grown up plants.

Fusarium wilt: Damping off symptoms at seedling stage, lower leaves wilt early and drop. Brown streaks are visible in split open branches or stems, sometimes with black spores.

Verticillium wilt: Interveinal chlorosis and dark lesions develop on leaves with appearance of tiger stripes, brown discoloration is visible in split open stems, branches and also inside the bark, plants die in the centre of infected patch.

Control: Seed treatment with *Trichoderma viride* @ 10.0 g or *P. fluorescens* @ 10.0 g or carbendazim 2.0 g or thiram 3.0 g or vitavax 2.0 g/kg of seed; soil application of *T. viride* or *P. fluorescens* @ 1.0 kg/acre developed in 100.0 kg FYM or vermicompost along with 20.0 kg of neem cake. Balanced Nitrogen application and correcting micronutrient deficiencies. Soil drenching at the base of infected plants with copper oxy chloride 3.0 g/l or carbendazim 1.0 g/l or benomyl 1.0 g/l.

Harvesting :

1. Kapas from fully opened bolls should be collected during cooler times of the day.
2. Kapas picked should be free from debris like dried leaves, dried bracts etc.
3. Kapas from the first and last pickings should not be mixed with middle pickings, which are of better quality.
4. Kapas damaged by bollworms should be picked separately.
5. The cleaned kapas is to be graded and stored in heaps or in gunny boras in dry and well ventilated godowns.

Post-harvest Technology:

1. It is essential that proper care is taken at various stages of handling and processing to ensure that the inherent quality of cotton is not adversely affected so as to realize maximum price.
2. Watering the kapas before weighing should be avoided.
3. Admixtures of different varieties should be avoided. The admixture of the inferior type lowers the quality of the superior type, due to differences in the fiber quality traits.
4. Only one variety of cotton should be heaped and packed to maintain the purity and quality of the cotton.
5. For supply of high quality of cotton, proper packing should be done to protect from contamination and dampness.
6. Improper drying due to lack of proper yard at village will generally result in to the discoloration of the fibres.
7. Even at the market level, the conventional packing of kapas in bales gives rise to problems such as requirement of large space and possible fire hazards. Storing in open yards at the market should be avoided.
8. The seeds from insect attacked and immature bolls being more fragile get crushed during ginning resulting in staining of lint by the oil oozing out of the cut-seeds. This oil acts as a medium for growth of the micro-organisms which will destroy the lint. So, the insect infested kapas should be separated.
9. Difficulties in handling of kapas due to its bulky nature – adequate storage space is to be provided both at the farmer's level as well as at the market.