Package of Practices for Cotton Cultivation in Punjab

CRS, Faridkot and Bhatinda, Punjab

American cotton was grown on 2.49 lakh hectares in Punjab during 2021-22. The total production was 6.39 lakh bales with an average yield of 4.36 quintals lint per hectare (1.76 quintals lint per acre).

Important hints

- Grow only recommended varieties/hybrids of cotton.
- Heavy pre-sowing irrigation is must to obtain good germination and early establishment of plants.
- Complete the sowing by 15 May.
- Grow non-Bt cotton as refuge on the periphery of Bt cotton.
- Give first irrigation 4-6 weeks after sowing depending on soil type. Last irrigation in September is must.
- Avoid growing *bhindi, moong, arhar,* castor and *dhaincha* in and around the cotton fields to avoid simultaneous build up and spread of pests and diseases to cotton.
- Give 4 sprays of 2% potassium nitrate (13:0:45) solution starting at flower initiation at weekly interval.
- The incidence of insect pests increases with excessive use of nitrogenous fertilizers, hence use only recommended dose.
- Regular monitoring is effective strategy for the management of whitefly, pink bollworm and mealybug. Avoid using synthetic pyrethroids before September 15 to minimize resurgence of whitefly. Use recommended insecticides.
- Avoid tank mixing and use of readymade insecticidal mixtures.

Climatic Requirements

A daily minimum temperature of 16ºC is required for germination and 21ºC to 27ºC for proper crop growth. During the fruiting phase, the day temperature ranging from 27ºC to 32ºC and cool nights are needed. The cotton picking period from mid-September to November must have bright sunny days to ensure a good quality of the produce.

Soil Type

Cotton can be successfully grown on all soils, except sandy, saline or waterlogged types. Proper drainage of excess water during rains is essential.

Rotations

Cotton–Wheat/Barley, Cotton–Sunflower, Cotton–*Senji*/*Berseem*/Oats, Cotton-Raya, Cotton–Sunflower-Paddy-Wheat

Improved Varieties

Bt cotton variety

PAU Bt 3 (2022): It is aBt cotton variety with inbuilt resistance against spotted and American bollworms. Its average seed cotton yield is 10.2 quintals per acre. Its average fibre length is 26.2 mm and ginning out turn is 36.5 %. It is tolerant to jassid and cotton leaf curl disease.

PAU Bt 2 (2022): It is a Bt cotton variety with inbuilt resistance against spotted and American bollworms. Its average seed cotton yield is 10.0 quintals per acre. It possesses average fibre length of 27.6 mm and ginning outturn of 34.4 %. It matures in 160-165 days. It is tolerant to jassid and cotton leaf curl disease.

Bt cotton hybrids

List of Bt cotton hybrids recommended for cultivation in Punjab state during Kharif 2023 as evaluated by Interstate Committee of cotton.

S. No.	Hybrid	S. No.	Hybrid	S. No.	Hybrid
1	ACH 133-2 BGII	20	JKCH 0109 BGII	39	SUPER 931 BGII
2	ACH 177-2 BGII	21	JKCH 1947 BGII	40	JKCH 8940 BGII
3	ACH 33-2 BGII	22	KSCH 207 BGII	41	MRC 7041 BGII
4	ANKUR 3244 BGII	23	MRC 7361 BGII	42	VICH 308 BGII
5	KCH 172 BGII	24	MRC 7365 BGII	43	NSPL 252 BGII
6	KCH 999 BGII	25	MRC 7301 BG II	44	NSPL 531 BGII
7	RCH314BGII	26	VICH 310 BGII	45	PCH 877 BGII
8	RCH650BGII	27	NCS 495 BGII	46	RCH 776 BGII
9	RCH 653 BGII	28	NCS 855 BGII	47	SOLAR 75 BGII
10	MH 5302 BGII	29	NCS 9013 BGII	48	SWCH 4704 (SP7172)
11	SUPER 544 BGII	30	NCS 9024 BGII	49	SWCH 4711 BGII
12	SUPER 721 BGII	31	PCH 9611 BGII	50	SWCH 4744 (US 51)
13	ABCH 4899 BGII	32	PRCH 333 BGII	51	SWCH 4755 (US 71)
14	ABCH 243 BGII	33	RCH 773 BGII	52	BIO 846-2 BGII
15	ABCH 252 BGII	34	SHAKTI 9 BGII	53	BIO 311-2 BGII
16	ABCH 254 BGII	35	SOLAR 56 BGII	54	ACH 777-2 BGII
17	ACH 155-2 BGII	36	SOLAR 77 BGII	55	KSCH 213 BGII
18	ANKUR 3224 BGII	37	SUPER 965 BGII	56	PRCH 7799 BGII
19	ANKUR 3228 BGII	38	SUPER 971 BGII		

List of Bt cotton hybrids released & notified by Central Sub-Committee on Crop Standards, Notification & Release of Varieties for Agricultural Crops for North Zone of India on the basis of evaluation under ICAR-AICRP on Cotton

S. No.	Hybrid	S. No.	Hybrid	S. No.	Hybrid
1	Raghuvir	6	RCH 846 BG II	11	C 9313 BG II

2	ACH 945-2 BG II	7	RCH 926 BG II	12	C 352 BG II
3	ACH 955-2 BG II	8	MC 5403 BG II	13	KCH 9323 BG II
4	RCH 938-2 BG II	9	MC 5408 BG II	14	KCH 9333 BG II
5	RCH 951 BG II	10	KCH 307 BG II	15	RCH 960 BG II

Non-Bt cotton

- **F 2228 (2015):** Its' maturity period is 180 days with an average seed cotton yield of 7.4 quintals per acre. It is moderately resistant to jassid and bacterial blight.

- **LH 2108 (2013):** It matures in 165-170 days with an average seed cotton yield of 8.4 quintals per acre.

Agronomic Practices

Sub Soiling: Cross sub soiling at 1.0 m spacing should be done before preparing the field. This is done by tractor drawn sub-soiler (chiseler) to the depth of 45-50 cm. Give planking to break the clods and then prepare fine seed bed. This will help in breaking the hard pan, increasing water infiltration rate and better root development of cotton plants.

Land Preparation: A fine seed-bed is essential for securing a good plant stand.

Time of Sowing: Sow the crop during 1 April to 15 May. Sowing during this period ensures better yield and escapes the attack of insect pests and diseases. Sowing should be done in morning and evening hours.

Seed Rate: Use following quantity of seed:

	Cultivars	**Seed rate (kg per acre)**
Bt varieties	PAU Bt 2 and PAU Bt 3	4.0 + 1.0 (refuge)*
Bt hybrids	Recommended hybrids	0.900+0.240 (refuge)* or two pouches of 475 gram each**
Non-Bt varieties	F 2228 and LH 2108	3.5

* Grow non-Bt cotton as a refuge around Bt cotton variety/hybrids to avoid evolution of resistance in bollworm to Bt toxin.

** Already mixed refuge in seed

Acid Delinting of Seed: Mix 100 g commercial grade concentrated sulphuric acid with 1 kg cotton seed in earthen/ plastic container by stirring it vigorously for two to three minutes with a thick wooden stick. As soon as the fuzz gets dissolved, add 10 litres of water, stir well and drain out water through the perforated plastic basket. Repeat these washings three times to make the seed free from sulphuric acid residue. Dip the washed seed for about one minute in sodium bicarbonate solution (12.5 g sodium bicarbonate in 2.5 litres of water) to neutralize the acid residue on the cotton seed. Give one more washing with water and remove light, damaged and rotten inviable seeds floating on the surface. Dry the healthy fuzz-free seed in the shade by spreading in a thin layer. Adopt

following precautions:

- Metal or wood container should not be used.
- The operator should wear the plastic gloves.
- The water containing acid and alkali residue should be properly disposed off in the waste land.
- Inadequate washing and delayed washing of the seed after acid treatment and residual acid on the seed if not neutralized may impair the germination of seed.

Or rub the non-delinted seed with fine earth, cow-dung or ash to remove its fuzz andensure uniform sowing.

Seed Priming: Soak the seed in a solution of 0.5 g succinic acid and 5 litres of water for 2-4 hours in case of acid delinted seed or 6-8 hours in case of non-delinted seed to promote good establishment of plant stand, better early growth and more yield.

In soils irrigated with sodic water (RSC> 2.5 meq per L), treat the seed with the liquid bioformulations (Halo-Azo+PSB+ZnSB)* along with gypsum (25% of GypsumRequirement) application. This will reduce the adverse effects of sodic water irrigation while sustaining soil health and cotton productivity in cotton-wheat system.

Note: The liquid bioformulations are available at ICAR-CSSRI, Regional Research Station, Lucknow at a nominal price.

Seed should be smeared with 5 g Gaucho 70 WS (imidacloprid) or 7 g Cruiser 30FS(thiomethoxam) per kg seed for preventing damage by cotton jassid.

Sowing and Spacing: Sow in lines 67.5 cm apart with a cotton sowing drill or cotton planter. The plants of non-Bt varieties within rows be kept 60 cm apart during thinning, whereas for PAU Bt 2 and PAU Bt 3, plant to plant spacing within row be kept 30 cm apart after thinning. However forBt hybrids, plant-to-plant distance should be kept at 75 cm. Thinning may be done after first irrigation or heavy shower.

Sowing of Refugia: To avoid the development of resistance in bollworms to Bt cotton, 20 per cent area should be sown under non-Bt cotton hybrids around Bt cotton. The non-Bt hybrids should be protected against damage by insect pests as mentioned in case of non-Bt cotton hybrids. Alternatively, 5 per cent area of non-Bt hybrids can be sown around Bt cotton and this should be kept unsprayed. The refuge should be non-Bt version of the same variety/hybrid. If it is not possible, the farmers can use non-Bt varieties like F 2228 and LH 2108 as refuge.

Intercropping: Intercrop one row of maize/cowpea for fodder in cotton sown at row to row spacing of 67.5 cm for getting higher income as compared to sole cotton. Apply recommended fertilizers to cotton and intercrops on area basis. Harvest maize/cowpea fodder at 45-55 days after sowing.

Ridge sowing: Sowing of cotton on ridges prepared with cotton planter and irrigating the crop in furrows saves considerable amount of irrigation water without reduction in seed cotton yield.

Transplanting of cotton seedlings: For gap filling 3 week old nursery grown in 4”x6” polythene bags, filled with 1:1 mixture of soil and FYM, can be transplanted.

Weed Control: Hoe the crop two or three times. The first hoeing should be done before first irrigation. Use tractor mounted cultivator/ tractor operated rotary weeder/triphali or wheel hand hoe for weeding. Their use after fruiting should be avoided.

For control of weeds particularly*itsit*, *madhana/makra*, apply 1.0 litre per acre Stomp30 EC (pendimethalin) as pre-emergence within 24 hours of sowing. In situations whereweeds emerge after first irrigation or with the rain shower, Stomp 30 EC can also be applied as post-emergence after first irrigation in 200 litre of water. If some weeds emerge before the application of the herbicide, a light hoeing/interculture may be done. The herbicide can also be sprayed with tractor mounted sprayer fitted with flat fan nozzle either in morning or evening hours. Ensure a fine seed bed free from plant residues and clods, adequate moisture in the field at the time of spray of herbicides.

Alternatively, spray 500 ml per acre Hitweed Maxx 10 MEC (pyrithiobac sodium6%+quizalofop ethyl 4%) by dissolving in 150 litres of water after first irrigation, in moistsoil, to control annual grass and broadleaf weeds. This herbicide also provides effective control of*lapeta* (*guara*) *vel* (*Ipomoea* sp.) when weed plants are at 2 to 5 leaf stage.

Alternatively, at 6-8 weeks after sowing when the crop is about 40-45 cm in height, spray 500 ml per acre Gramoxone 24 SL (paraquat) or 900 ml per acre Sweep Power13.5 SL (glufosinate ammonium) in 100 litres of water as a directed spray to control weedsin between the crop rows. The directed spray can be done by using a protective hood. Paraquat and glufosinate are non-selective herbicides and can cause injury to the crop ifthese fall on the crop leaves.

Fertilizer Application: Apply fertilizer on soil test basis.
The fertilizer recommendations for medium fertility soils are as under:

	***Nutrients (kg per acre)**		**Fertilizers (kg per acre)**		
	N	P_2O_5	Urea	DAP	or Single Superphosphate
Non-Bt varieties	30	12	65	27	75
Bt varieties	37	12	80	27	75
Bt hybrids	42	12	90	27	75

* These nutrients can also be supplied from other fertilizers available in the market (Appendix IV).

Note:

- Omit application of phosphorus to cotton when it follows wheat which had received recommended dose of phosphorus. Where 27 kg DAP is used, reduce the urea dose by 10 kg.
- Apply 20 kg muriate of potash and 10 kg zinc sulphate heptahydrate (21%) or 6.5 kg zinc sulphate monohydrate (33%) per acre to cotton in light soils.

Drill all phosphorus at sowing. Apply 25 kg magnesium sulphate as basal dose at the time of sowing. Apply half nitrogen at thinning and remaining half at the appearance of

flowers. If the soil is low in fertility, the first half dose of nitrogen may be applied at sowing instead of at thinning.

Apply 400 g boron (4 kg borax) per acre at sowing to boron deficient (<0.5 kg available boron per acre) calcareous soils having 2% or more calcium carbonate. However, boron should not be applied indiscriminately, as excessive boron application may cause toxicity.

PAU-Leaf Colour Chart (PAU-LCC) for need based Urea application

- Match leaf colour greenness of the topmost fully developed intact leaf from the randomly selected ten cotton plants with PAU-LCC under shade of your body at thinning and initiation of flowering.
- Apply urea based on leaf greenness of six or more leaves out of ten leaves as per following table:

Leaf Colour as per PAU LCC	More than LCC shade 4.5	LCC shade 4.5	LCC shade 4.0	LCC shade 3.5 or below
Urea dose (Kg per acre)	0	20	35	50

Note: The leaves selected for measuring leaf greenness should be free from insect/disease incidence. There should not be water stress/logging and nutrients other than nitrogen should be supplied as per recommendations. The PAU-LCC can be purchased from PAU Seed Shop at Gate No. 1, *KrishiVigyanKendras* and Farm Advisory Service Centres in different districts.

To get higher yields, give 4 sprays of 2% potassium nitrate (13:0:45) at weekly interval starting at flower initiation. For high yield and management of leaf reddening in Bt cotton, give 2 sprays of 1% magnesium sulphate (1 kg magnesium sulphate in 100 litres of water per acre) at 15 days interval during full bloom and boll development stages.

Use of growth retardant

In heavy soils, cotton attains excessive vegetative growth during rainy season. Thick crop canopy prevents the penetration of sunlight which results in shedding of flower buds, flowers or bolls and ultimately causes yield reduction. To check excessive vegetative growth in heavy soils, give 2 sprays of 300 ml per acre Chamatkar (mepiquat chloride 5%w/w) at 60 and 75 days after sowing using 80-100 litres of water.

Irrigation and Drainage

Cotton requires 4-6 irrigations depending upon the seasonal rainfall. The first irrigation should be given 4 to 6 weeks after sowing and the subsequent ones at interval of two or three weeks. However on light soils or in crop sown on ridges, the first irrigation may be advanced, if necessary. Sowing cotton on ridges and irrigation in furrows save considerable amount of water. Under poor quality irrigation water conditions, give pre-sowing irrigation with canal water and subsequent irrigations can be applied with poor quality tube well water in alternate furrows. In soils irrigated with saline water (EC upto 10 dS/m), application of 16 quintal per acre of rice-residue biochar reduces adverse affect ofsalinity and increases seed cotton yield.

The crop must not be allowed to suffer from water stress during the flowering and fruiting stages, otherwise a lot of shedding of flowers and bolls will take place resulting inlow yield. Cotton during its early growth is very sensitive to water stagnation. Therefore, drain out the stagnant water if such a situation arises. To hasten boll opening, give the last irrigation by the end of September.

Water stress management through Salicylic acid: To minimize loss of cotton yield owing to water stress (due to no rainfall or sudden canal closures), dissolve 12.5 g Salicylic acid in 375 ml of Ethyl alcohol and then add it to 125 litres of water for spraying crop per acre on stress appearance.
Caution: Application under well watered conditions may not increase yield.

Drip irrigation and Fertigation

American Bt cotton hybrids should be drip irrigated at 7 days interval with a lateral pipe laid at 67.5 cm apart and dripper placed at 75 cm apart having dripper discharge of 2.2 litre per hour as per the following schedule. Start fertigation of 100 kg urea (45 kg N) /acre at 35 days after sowing and complete in 110-120 days in 10 equal splits at 7 days interval.

Month	Time of irrigation (min)*
May/June	50
July	45
August	40
September	35

If discharge rate is different, then time of irrigation may be adjusted proportionally by the formula:-

Adjusted time (min) = (2.2 × Time of irrigation (min)*) ÷ Discharge of dripper (litre/hour)

Under scarcity of good quality irrigation water, alternate use of good quality canal waterand saline tubewell water through surface drip irrigation is recommended in light-textured soil for obtaining sustainable seed cotton yield with a minimal adverse effect on soil quality.

For sub-surface drip irrigation and fertigation, see chapter on ‘Multiple Cropping’ under cotton-wheat cropping system.

Plant-Protection

A. Insect-Pests

i. Cultural and Mechanical Management

- Grow only recommended Bt cotton cultivars.
- Prefer to grow *desi* cotton in area of high infestation of whitefly and leaf curl.
- Even the apparently healthy seed-cotton (*kapas*) may be harbouring larvae of pink bollworm. It should be acid delinted or thoroughly dried in the sun in a thin layer for 3-4 consecutive days in April.
- Complete the sowing up to 15th May.
- Avoid excessive use of nitrogenous fertilizer.
- Eradicate weeds like *kanghibuti, peelibuti, puthkanda*, congress grass, *itsit* growing on field bunds, waste lands, road side and irrigation channels/canals to avoid further spread of whitefly, mealybug, tobacco caterpillar and spotted bollworm to cotton fields
- Regular surveillance on alternate host crops like brinjal, cucurbits (cucumber, long melon, *chappankadu*), tomato, chilli, okra from February onwards and on cotton, moong from April onwards should be carried out for timely management of whitefly on these crops.
- Use low cost yellow sticky traps @ 40 per acre during initial phase of cotton crop to check early infestation of whitefly.
- Grow bajra, maize and *jawar* as barrier crops, being least preferred hosts for the mealybug.
- Do not grow *bhindi*, moong and *arhar* in the cotton crop and as border rows in order to reduce the incidence of American bollworm, spotted bollworms, jassid and whitefly. Bhindi, moong, dhaincha and castor are also the most preferred hosts of tobacco caterpillar, helping the pest to multiply and shift to cotton. The above pests on these crops grown in the vicinity of cotton fields, should be properly controlled in order to check their migration to the cotton crop.
- Do not throw the uprooted infested plants in cotton fields/water channels to check further spread of mealybug.
- Prevent movement of sticks from infested areas to new areas to avoid spread of mealybug.
- The trees/fruit plants near cotton fields harboringmealybug population should be sprayed with recommended insecticides.
- Egg masses and young larvae of tobacco caterpillar feeding gregariously should be collected along with leaves and destroyed.
- Terminate the crop as early as economically feasible. For this purpose give last irrigation by end of September. It would reduce bollworms damage and their carryover.
- After the final picking, PBW infested cotton field should be shredded with the help of shredder to kill the larvae.
- Destroy all trash collected during the ginning process. Remove all seed from the ginneries by the end of March. Fumigate the seed left uncrushed in the mills before end of April with Celphos/Phostoxin/Delicia @ one 3-g tablet per cubic metre space, giving an exposure of 48 hours or use two tablets with an exposure of 24 hours. No un-fumigated seed should be retained or sold by the ginneries. Only cotton-seed cake (khal) should be fed to the cattle and no seed should be kept for this purpose.
- The seed meant for sowing must be acid-delinted in the ginneries before it is sold. The acid treatment kills the larvae of the pink bollworm. It also removes fuzz and thereby facilitates mechanical sowing.

- Even the apparently healthy seed-cotton (kapas) may be harbouring larvae of pinkbollworm. Hence, kapas retained by the farmers should be ginned by the end of Marchand seed fed to cattle. If this seed is to be retained for sowing, it should be acid-delinted/fumigated or thoroughly dried the sun in a thin layer for 3-4 consecutive days in April.
- After the last picking, allow sheep, goats and other farm animals into cotton fields to feed on plant debris and un-opened bolls.
- Do not stalk the cotton sticks under shade or in the field. Beat the sticks on ground to dislodge the pink bollworm larvae surviving in the unopened bolls. Stalk the cotton sticks vertically.
- Prevent the movement of the cotton stalk from the infested areas to the new areas.
- Mating disruption based management of pink bollworm: Apply 125 g per applicationper acre of gossyplure 4% (7,11 Hexadecadienyl acetate) paste based formulation, CREMIT-PBW/NATMATE-PBW in the form of dollops (peanut size) starting from theappearance of squares (45-55 days after sowing) at 400 uniformly distributed spots, followed by next two applications at 30 days intervals. The paste should be applied at the nodal junction of the 5th or 6th main stem leaf from the top (Plate No. 1, page 183). To realize the optimum efficacy, timely and area-wide application is indispensable. If it rains within 4-5 hours, the application has to be repeated.

ii. Chemical Control

a. Insect Pests (Bt cotton)

Bt cotton provides effective protection against all cotton bollworms except pink bollworm. Regular monitoring should be done at weekly interval during reproductive phase. If at all American bollworms cross ETL level during late crop season, use insecticides as mentioned in Table 2.Bt cotton does not provide control of sucking pests.

Sucking Insect Pests: Among sucking pests, whitefly, jassid, mealybug, thrips and aphid are most serious on Bt cotton and they cause maximum damage during July-September.

Whitefly adults and nymphs suck sap from leaves and excrete honey dew on leaves which become sticky ((Plate No. 2, page 182)). Affected leaves and seed cotton turn black due to development of sooty mould.

Nymphs and adults of jassid suck sap from leaves and cause shedding in case of severe infestation (Plate No. 3, page 183).

Aphids appear sporadically. The **nymphs and adults of aphid** suck sap and excrete honey dew on leaves on which black fungus develops. Petioles, internodes, flowers, buds, mature bolls and even leaves fall down and growth of the plant is retarded.

Both **nymph and adults of thrips** first lacerate the leaf tissue and later feed on the

- **Spray against whitefly should be done when population reaches 6 adults per leaf in the upper canopy of plants before 10 AM**
- **Initiate spray against jassid whenever some of the fully formed leaves in the upper canopy show curling and yellowing at the margins on 50 per cent of the plants**
- **Spray against thrips should**

oozing cell sap. Initially silver streaks appeared especially around the midrib and veins of the leaves. Later silvering got more severe and slight cupping of the leaves. Under severe infestation, leaves gave blasted appearance and extreme level of cupping observed. The decision regarding spray of insecticide should be taken based on Economic Threshold Level (ETL).

Spray against whitefly should be done when population reaches six adults per leaf in the upper canopy of plants before 10 AM or when honey dew appears on 50 per cent of the plants. Initiate spray againstjassid whenever some of the fully formed leaves in the upper canopy show curling and yellowing at the margins on 50 per cent of the plants. Spray againstthrips should bedone when population of nymphs and adults reaches twelve per leaf in the upper canopy of plants. Spray against aphid should also be done on the appearance of honey dew on50 per cent plants. Spray the crop as soon as the crawlers/adults of mealybug appear on the cotton plant.Use following insecticides (Table 1) for control of sucking insect pestsgiven below.

be done when population of nymphs and adults reaches twelve per leaf in the upper canopy of plants.

- **Spray against aphid should also be done on the appearance of honey dew on 50 per cent plants.**
- **Avoid using synthetic pyrethroids (cypermethrin, fenvalerate, deltamethrin), acephate and acetamiprid to minimize resurgence of whitefly**

Table 1. Insecticides for the management of sucking insect pests

Brand (Insecticides)	Dose/acre
Whitefly	
Sefina 50 DC (afidopyropen)	400 ml
Osheen 20 SG (dinotefuran)	60 g
Polo/Craze/ Ruby/ Ludo/Shoku 50 WP (diafenthiuron)	200 g
# Lano/Daita10 EC (pyriproxyfen)	500 ml
# Oberon/ Voltage 22.9 SC (spiromesifen)	200 ml
Ulala 50 WG (flonicamid)	80 g
Dantotsu 50 WG (clothianidin) Fosmite/E-	20 g
mite/Volthion/ Gold Mit 50 EC (ethion)	800 ml
Nimbecidine or Achook (Neem based	1.0 litre
biopesticide) *PAU Homemade neem extract	1200 ml
Jassid	
(a) Seed treatment: At the time of sowing, smear the seed with any of the following insecticides.	
Gaucho 70 WS (imidacloprid)	5 g/kg seed
Cruiser 30 FS (thiamethoxam)	7 g/kg seed
(b) Spray: Spray any of the following insecticides, if incidence is noticed in standing crop.	
Keefun 15 EC (tolfenpyrad)	300 ml
Osheen 20 SG (dinotefuran)	60 g
Neon 5 EC (fenpyroximate)	300 ml
Ulala 50 WG (flonicamid)	80 g
Actara/Extra super/Dotara/Thomson 25 WG (thiamethoxam)	40 g
Thrips	
Delegate 11.7 SC (spinetoram)	170 ml
Curacron/ Celcron 50 EC (profenophos)	500 ml
Polo 50 WP (diafenthiuron)	200 g
Mealybug	
Transform 21.8 SC (sulfoxaflor)	150 ml

These insecticides are more effective against nymphs of whitefly. Wait for 5-7 days to see the effective results.

Method of preparation: Boil 4.0 kg terminal parts of the shoots of neem trees including leaves, green branches and fruits in 10 liters of water for 30 minutes. Then filter this material through muslin cloth and use the filterate for spraying at the recommended dose.

Note:

- In the beginning of crop season on appearance of whitefly, first spray of Nimbecidine or Achook @ 1.0 lire per acre should be given.
- Do not spray any insecticide for the management of thrips on cotton up to 30 day old crop. In case thrips attack observed, irrigate the field immediately.
- In case of attack of aphid use the same insecticides as recommended for jassid.
- Use fix type solid cone nozzle. Thorough coverage of plants with insecticides is essential to check the multiplication of whitefly and mealybug.
- Spray insecticides before 12 PM or in the evening. Community approach should be adopted at village level for the application of insecticides
- Use only recommended insecticides with recommended dose and time. Avoid tank mixing and use of readymade insecticidal mixtures
- Mealybug is initially restricted to a few plants in a row, thus spot treatment with recommended insecticides is advocated. Spray of mealybug infested plants/rows of cotton after last picking

b. Insect Pests (Non-Bt cotton)

Sucking Insect Pests: See under Bt-cotton

Bollworms: Bollworms are the most harmful insects which attack cotton in the Punjab state. Spotted bollworms damage growing points during May-June and cause heavy shedding of squares, buds, flowers and bolls during July to October. The American bollworm causes severe shedding of fruiting bodies during September-October especially on American cotton. The colour of its larvae greatly varies. They have one line on upper side and two wavy lines on lateral side of body. Their body also has sparse hairs. Pink bollworm does maximum damage from mid-July to mid-October (Plate No. 4, page 183). Due to severe attack of bollworms, the plants continue to grow without having adequate number of bolls.

Tobacco caterpillar: It is a polyphagous pest. The larvae cause serious damage to crop from August to October. The small larvae are black whereas grown up larvae are dark green with black triangular spots on body. Its' moths lay eggs in masses covered with brown hairs on the lower side of mature leaves. After hatching, first and second instar larvae feed gregariously and skeletonize the foliage. Later on grown up larvae disperse and feed singly. Besides leaves, they also damage the buds, flowers and green bolls. Control the tobacco caterpillar by spraying any of the insecticides given in Table 2.

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

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

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

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

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

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

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

Table 2. Insecticides for the control of bollworms in cotton

Brands (Insecticides)	Dose/acre
Pink and spotted bollworms	
A. Synthetic Pyrethroids	
Danitol/Meothrin 10 EC (fenpropathrin)	300 ml
Fastac/Alphagaurd/Merit Alpha 10 EC (alphamethrin)	100 ml
Bulldock 0.25 SC (β-cyfluthrin)	300 ml
Ripcord/Bilcyp/Bullet/Ustad/Cypergaurd 10 EC (cypermethrin)	200 ml
Cymbush/Cyperkill/Hillcyper/Colt/Basathrin/Agrocyper/Cypergaurd 25 EC (cypermethrin)	80 ml
Decis/Rukrain/Decicare 2.8 EC (deltamethrin)	160 ml
Sumicidin/Fenval/Agrofen/Fenlik/Triumph card/SB Fenvalerate/Milfen/ Markfenval 20 EC (fenvalerate)	100 ml
Pink, spotted and younger larvae of American bollworm	
A. Macrocyclic lactones or evermectins	
Proclaim 5 SG (emamectin benzoate)	100 g
B. Carbamates	
Larvin 75 WP (thiodicarb)	250 g
C. Organophosphatic	
Curacron/Carina/Profex/Celcron 50 EC (profenophos)	500 ml
Fosmite/E-mite/Volthion 50 EC (ethion)	800 ml
D. Miscellaneous group	
Fame 480 SC (flubendiamide*)	40 ml
Grown up larvae of American bollworm	
A. Naturalyte	
Tracer 48 SC (spinosad)	60 ml

B. Oxadiazine	
Avaunt 15 SC/ Avaunt 15 EC (indoxacarb)	200 ml
C. Miscellaneous group	
Sumipleo 10 EC (pyridalyl)	300 ml
Coragen 18.5 SC* (chlorantraniliprole)	60 ml
D. Organophosphates	
Coroban/Dursban/Durmet/Chlorgaurd/Radar/Lethal/Force/Markpyriphos 20 EC (chlorpyriphos)	2 litres
Orthene/Asataf/Starthene/Markphate 75 SP (acephate)	800 g
Tobacco caterpillar	
A. Insect Growth Regulator	
Rimon 10 EC* (novaluron)	150 ml
B. Miscellaneous group	
Coragen 18.5 SC* (chlorantraniliprole)	60 ml

Note:

- Do not repeat the insecticide of same group in subsequent sprays.
- Do not use synthetic pyrethroids on cotton for the control of bollworm complex before September.
- Repeat the spray immediately if it rains with in 24 hours after spray.
- If hairy caterpillars damage cotton crop during June-July use 500 ml quinalphos 25 EC in 100 litres of water per acre.
- **PRECAUTIONS: Cotton is highly sensitive to the 2, 4-D herbicide.** Some farmers spray the ester form of 2, 4-D for controlling weeds in maize grown near the cotton fields. Owing to the volatile nature of 2, 4-D ester, its vapours cause serious injury to the cotton crop. Hence avoid the application of this herbicide in maize, if cotton is grown in the adjoining fields.
  - After using 2, 4-D on any crop, fill all spraying equipment as well as tubs, buckets, etc. with 0.5 per cent washing soda solution (500 g of washing soda in 100 litres of water) in the evening. Next morning, flush all equipments thoroughly with fresh water.
  - To avoid the use of contaminated insecticides on cotton. It is advisable to test insecticide at least two weeks in advance on a few plants. If the insecticide is contaminated with 2, 4-D the tender leaves and shoots could become distorted and lanceolated within 10 days. Reject such an insecticide.

Spray Technology

The insecticides recommended for control of sucking pests, bollworms and tobacco caterpillar should be sprayed using 125-150 litres spray material per acre with the manually operated knapsack sprayer or 75 litres with the shoulder-mounted power sprayer and tractor mounted sprayer or 12-15 liters spray material per acre by using backpack type air-assisted electrostatic sprayer or 300-400 litres spray material per acre by using Auto rotate gun type sprayer or 250-400 litres spray material per acre by using PAU multipurpose high clearance sprayer. Quantity of spray material may vary with different types of sprayers and nozzles. However, actual amount of insecticide recommended should not be reduced. Making pathways by pressing the branches on both sides helps in efficient spraying. Make

such pathways at 2 meters distance for the manually operated knapsack sprayer and at 4 meters for the shoulder-mounted power sprayer.

Tractor mounted sprayer should have hallow cone nozzles fixed on the boom. Each nozzle should discharge 500-600 ml spray solution per minute. The tractor should be operated at 4.0 and 2.5 km per hour speed for spraying against sucking pests and bollworms, respectively. Use the same tyre tracks and run the tractor in the same direction for all sprays. Keep the spray boom about 50 cm above the crop canopy.

Insecticide Resistance Management (IRM) Strategy

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

i. Sucking pests management (From sowing up to first week of July)

- Sow recommended varieties which are tolerant to sucking pests and cotton leaf curl virus to avoid early sprays
- Destroy alternate hosts of cotton whitefly, leaf curl virus and mealybug
- Timely sowing, judicious use of fertilizers, irrigation, proper spacing and clean cultivation will prevent the early build up of pests and help conserve natural enemies
- Treat seed with Gaucho/Cruiser to control the cotton jassid in susceptible cultivars
- Do not use any insecticide during this period to conserve natural enemies

ii. Sucking pests and bollworms management (From second week of July to first week of August)

- Avoid the use of synthetic pyrethroids for the control of spotted bollworms
- Avoid the use of neonicotinoid compounds against jassid as these are toxic to natural enemies
- Do not use organophosphates/carbamates against bollworms

iii. Bollworms and tobacco caterpillar management (From second week of August to end August)

- Use profenophos/quinalphos/flubendiamide in alternation with synthetic pyrethroids for the control of bollworms
- Use spinosad only in case of severe infestation of American bollworm.

iv. Bollworms and tobacco caterpillar management (September to October)

- Use profenophos/quinalphos/thiodicarb/flubendiamide for younger larvae of American bollworm. Prefer chlorpyriphos for grown up larvae. Chlorpyriphos, thiodicarb and quinalphos will also provide effective control of tobacco caterpillar
- Use of indoxacarb/spinosad in case the American bollworm is serious
- Use ethion for the management of whitefly. It will also provide effective control of pink and spotted bollworms

B. Diseases

Leaf curl: Disease is caused by whitefly transmitted virus. The diseased plants become stunted and have twisted internodes. Leaves remain small, show cupping and curling. Veins on the lower-side of the leaves become thickened with netted appearance. Small leaflets (enations) also develop on the under side of the leaves on the main as well as lateral veins (Plate No. 5, page 183). Number of fruiting bodies are reduced in the diseased plants. The disease can be reduced by adopting the following integrated measures:

- Avoid growing American cotton in and around citrus orchards and adjoining *bhindi* crop.
- Uproot and destroy the diseased plants from time to time.
- Protect the crop against whitefly vector by using recommended insecticides.
- Follow clean cultivation and destroy *Kanghibuti* (*Abutilon* sp.) and *Peelibuti* (*Sida* sp.) which act as collateral hosts.

Parawilt: Parawilt is a physiological disorder and no pathogen is involved. It generally occurs after droughts when the crop is heavily irrigated or there is heavy rain. Plants show sudden drooping of leaves which ultimately get wilted but the root system remains intact (Plate No. 6, page 183). The affected plants can be saved by spraying cobalt chloride @ 10 mg per litre of water (10 ppm) immediately after the appearance of symptoms. There would be no recovery if permanent wilting has already set in.

Root rot: This disease is caused by *Rhizoctoniasolani* and *R. bataticola*. The main symptom are drying and shedding of leaves leading to complete wilting and death of the plant. The disease spreads in field in round patches. The affected plants can be pulled out very easily. The bark of the roots is broken into shreds.

Bacterial blight: It is caused by *Xanthomonasaxonopodis*pv. *malvacearum* which survives in seed and plant debris. Lesions on the leaves appear as minute, water-soaked, angular spots, which subsequently turn brown and then are transformed into black angular dead lesions on both sides of the leaf. The bacterium also infects the young developing bolls and causes small, round, water soaked spots depressed in the centre. Use disease free seed.

Leaf spots: Foliar leaf spots are caused by different fungi. Leaf spots caused by *Myrotheciumroridum* appear on leaves, bracts as well as on bolls. The disease is characterized by circular to semicircular brown coloured spots with broad violet margins. At later stage, shield shaped, small size fruiting bodies appear in the central necrotic portion of the spot. The pathogen is seed borne and also survives on the dead leaves. High humidity and intermittant rains are congenial for the development of the disease.

The fungus *Alternariagossypina* also causes blightening of the leaves. In the early-stages, the spots have a pale green area with irregular margins. As the spots enlarge, irregular concentric zones are formed. Sometimes severe shedding of leaves occur due to this disease. The plants with low vigour because of drought or deficiency of potash favour the development of this disease. The disease perpetuates through diseased debris.

Another type of leaf spots are caused by *Cercospora* sp. which generally appears towards the end of the season. It produces small, circular to irregular spots having whitish centre with dark brown margin. In advance stages, necrotic central portion may fall out

giving shot hole appearance. Low temperature (<25$_{o}$C) and high relative humidity favours development of disease. Diseased debris is the main source of primary inoculum of the disease. Use disease free seed.
To control these fungal leaf spots, spray the crop with 200 ml Amistar Top 325 SC(azoxystrobin + difenconazole) in 200 litre of water per acre immediately on the appearanceof symptoms. If needed, repeat the spray at 15-20 days interval.

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

Defoliation in cotton: Chemical defoliation with single spray ofEthrel 39% (Ethephon 39%) @ 5.0 ml/litre of water should be applied in last week of October. It leads to 85-90% defoliation after seven days of spray. Defoliation allows better sunlight penetration thereby resulting in early and uniform boll opening with increased productivity.

Picking: Cotton should be picked clean and dry to get a good price in the market. Picking should be done after every 15-20 days to avoid loss because of the *Kapas* falling to the ground. Do not keep the picked cotton in wet water channels in the field, as this practice impairs the quality of cotton. Store kapas in a dry godown. Keep produce of different varieties separately.

Removal of cotton sticks: Soon after the last picking, remove the cotton sticks alongwith the roots from the field and bury the remaining plant debris with furrow turning plough as sanitary measure against pests and diseases. Use or burn cotton sticks by the end of February at the latest.

Use two-row tractor operated Cotton Stalk Uprooter for uprooting of cotton stalks. The Cotton Stalk Uprooter should be operated at a speed of 7 to 9 km/hr and at a depth of 12 to 15 cm with 45hp tractor for efficient field operation. This equipment will provide 10 to 15% more cotton sticks by weight than conventional manual stalk chopping method with a field capacity of 1.25 to 1.50 acre/hr.

Marketing Hints

- Cotton should be picked dry, free from trash, with no dew on it.
- The first and the last pickings are usually of low quality and should not be mixed with rest of the produce. High-grade kapas mixed with low grade kapas sells at a relatively low price.
- Store cotton in damp proof and rat-free room.
- Store different varieties separately.

DESI COTTON

In Punjab, *desi* cotton was grown on 2.0 thousand hectares during 2021-22. The total production was 7.0 thousand bales with an average lint yield of 5.96 quintals per hectare (2.41 quintal per acre).

Note: Climatic requirements, soil type, rotations, agronomic practices, seed treatment, time of sowing, weed control, fertilizer application, irrigation etc. are same as recommended for American cotton.

Improved Varieties

- **LD 1019 (2018):** This is a shattering tolerant variety requiring 2 or 3 pickings as compared to atleast 5 pickings needed by other *desi* cotton varieties. Average seed cotton yield of LD 1019 is 8.6 quintals per acre. It possesses ginning out-turn of 35.7% and its fibre length is 22.6 mm. It has green, broad leaves and cream flowers. LD 1019 is tolerant to jassid, whitefly, Fusarium wilt and bacterial blight.
- **LD 949 (2016):** Its' plants are reddish-brown with narrow- lobed deep cut leaves and pink flowers. It possesses lint percentage of 40.1. Its' fibres are short, coarse and suitable as absorbent cotton. This variety is moderately resistant to Fusarium wilt and bacterial blight. It is tolerant to whitefly and jassid. Its' average seed cotton yield is 9.9 quintals/acre.
- **FDK 124 (2011):** It has green plant body and narrow lobed leaves. It is synchronous in maturity and takes about 160 days to mature. It is short staple, coarse fibre variety with 2.5% span length of 21.0 mm and ginning outturn of 36.4%. It produces an average seed cotton yield of 9.28 quintals per acre. It is resistant to jassid and whitefly.

Seed Rate: Use 3.0 kg seed per acre.

Acid delinting of seed: As per American cotton.

Sowing and Spacing: Sow in lines 67.5 cm apart with a cotton sowing drill. The plants of *desi* cotton varieties within rows be kept 45 cm apart at thinning.

A. Plant-Protection

Insect Pests

Sucking Insect Pests: See under American Cotton

Bollworm: In case of *desi* cotton, the first spray against bollworms should be done when 25 per cent plants start producing squares. Subsequent spray should be need based. For its effective management use the insecticides given in Table 2 for American cotton.

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

Tobacco caterpillar: See under American Cotton

B. Diseases

Wilt: It is a fungal disease caused by *Fusariumoxysporum*f.sp. *vasinfectum*. The pathogen of disease is both soil and seed-borne. In the diseased seedlings and plants, the leaves loose their turgidity, first turn yellow, then brown, start wilting and finally drop off. Discoloration of the leaves start from the margins and spreads towards the mid-ribs. The older leaves are affected first, followed by the younger ones towards the top. Wilting may be complete or partial. In the later case only one side of the plant is affected while the other remains apparently healthy. In complete wilting, the plant remains stunted, wilt rapidly and dies. The most prominent diagnostic symptom of the disease is browning and blackening of the vascular tissues. Five to six year rotation with non-host crops may help in controlling the disease. In the infested field, sow wilt tolerant *desi* cotton varieties namely LD 1019 and LD 949. In the highly infested fields grow American cotton because it remains free from this disease.

Note: Desi cotton is resistant to cotton leaf curl disease. For the management of other diseases, see under American cotton.

Picking

Cotton should be picked clean and dry to get a good price in the market. *Desi* cotton is ready for picking in the third week of September. Picking should be done after about 15 days to avoid loss because of the Kapas falling to the ground. Do not keep the picked cotton in wet water channels in the field, as this practice impairs the quality of cotton. Store kapas in a dry godown. Keep produce of different varieties separately.

Note: Removal of cotton sticks and marketing hints for *desi* cotton are same as those of American cotton.