Package of Practices Organic Cotton

Organic Cotton

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Introduction :

The cotton growing Vidarbha region of Maharashtra falls under the drought-prone, semi-arid region, and has varying soil depths. Cropping pattern in north India's irrigated zone, cotton is grown as a monocrop within a cotton-wheat-sugarcane-cotton rotation, while in the central rain-fed zone, cotton is grown as an intercrop with red gram and sorghum from June to February. The age-old tradition of growing cotton in a cotton-sorghum rotation is no more prevalent. With the recent spurt in the pest menace, more and more farmers are growing cotton with red gram and sorghum as an intercrop. Intercropping of cotton with green gram, black gram, soybean and red gram is also picking up. For maintenance of soil fertility, cotton should be grown in alternate years, in a cotton + legume-sorghum + legume rotation. If this is not possible, then in one year cotton may be grown as the main crop (60%), with red gram, cowpea/soybean and maize/sorghum as the intercrop, while in the second year red gram should be grown as the main crop (35%), and cotton, cowpea/soybean and maize/sorghum as the intercrop.

VARIETIES some of the improved varieties, suitable for organic management in Maharashtra are:

- G. hirsutum type – LRA-5166, LRK-516 (Anjali), Rajat (PKV-84635), PKV-081, DHY-286, Dhaval (JLH-168)
- G. arboreum – AKH-4, AKA-8401, Y-1, PA-183, Namdeo PA- 141, Savita PA-181. PKV Hy2, 3,4

Hybrids developed by Dr. P. D. Krishi Vidyapeeth Akola : H6, 8 and 10, Ankur 651, MECH-1, 4 and NHH-44 have also been found suitable for organic management.

Pre-cultivation practices

1. Deep ploughing once in three years, and two shallow ploughings every year, are essential during the summer.
2. One to two deep ploughings once in three years are necessary to control deep-rooted weeds and to destroy insect pest pupae.
3. Grazing animals in the cotton fields in summer destroy pink bollworm pupae.
4. After one or two showers, the soil should be worked with a harrow 2–3 times before the seeds are sown.
5. Crop residues are one of the major sources of nutrients. The entire crop residue from the previous cotton-legume intercrop should be incorporated into the soil at the time of ploughing. Hard, woody twigs of cotton can be used as fuel or should be recycled after composting.
6. About 20–30 quintals of well-decomposed FYM/compost or 15–20 quintals of on-farm produced vermicompost with 2 kg PSB, 100 kg rock phosphate and 200 kg neem seed manure can provide sufficient nutrition.
7. About 500 kg bone meal can also be used along with the compost to improve the phosphorus content of the soil.
8. Treatment of the crop residue with *Trichoderma viride* hastens in situ decomposition.
9. Legumes need to be intercropped with cotton with a minimum coverage of 30%. Mixing their entire vegetative biomass as mulch maintains high soil fertility.
10. Green manuring is also an important way of maintaining soil fertility, but this can be adopted only under irrigated conditions or under a cotton-legume crop rotation. Trees

of neem, babul,pongamia, sesbania, glyricidia, etc., planted on farm bunds, will produce leaf litter for soil nutrition. Trees also attract birds that control pests.

11. **Seed Treatment** : Treat the seeds with a mixture of beejamrut (200 gm/kg of seed) and ***Trichoderma viride*** (8 gm/kg of seed). Dry the seeds in the shade. After this, again treat the seeds with azotobacter and PSB bio fertilizer (5 gm each per kg of seed) and dry the treated seeds in the shade. The treated seeds should be sown within 6–8 hours of treatment.
12. Cotton is sown using a tractor or bullock-drawn seed drill or by dibbling. Hand dibbling of seeds, at recommended spacing, is commonly practised in rain-fed areas, particularly for hybrid seeds. This system ensures proper plant stand, uniform geometry and utilizes a lesser quantity of seed. Later, the crop is thinned to the recommended population. Recommended seed rate, spacing and required plant population for different varieties in the central cotton zone are as follows:

Table: Seed rate and spacing in cotton

S.No	Species	Seed rate (kg/Ac)	Spacing	Population (No/Ac)
1	*G. hirsutum*	7-8	60 x 30	22,240
2	*G.arboretum*	4-5	60 x 30	22,240
3	*G.herbaceum*	4-5	45x30	29,600
4	*Hybrids*	0.8	120x60	05,555
6	*Hybrids-high density Planting*	0.8	60 x 30	22,240

CULTIVATION As per the biodynamic calendar, sowing should be done around full moon days. Seeds are sown in a north-south direction. A north south orientation ensures better sun harvesting and prevents loss of carbon dioxide (CO2) that is emitted by the crop during the night. The crop can re-absorb it during the day, resulting in better growth. For better sun-harvesting, some organic farmers in Maharashtra sow only 2–3 kg seed/Ac with a spacing of 1 x 1 m or 1 x 0.5 m.

Intercropping of cotton with red gram is a common practice in the central cotton zone. Besides red gram, intercropping with green gram, black gram and soybean has also been found to be highly effective and beneficial. Planting of a few rows of sorghum or maize helps in the reduction of the insect-pest problem.

Intercropping is extremely beneficial to keep insect-pest problems below the economic tolerance level or ETL. Any of the following combinations can be used for optimum output, insurance against crop failure, reduced or no pest problem and maintenance of soil fertility:

- One row of maize/sorghum, 2 rows of red gram, 4 rows of cotton (1:2:4)
- 2 rows of cowpea/soybean, 4 rows of cotton, (1:4)
- 2 rows of redgram and one row of maize/sorghum. Four rows of cotton,
- 2 rows of cowpea/soybean, 4 rows of cotton and one row of mixed plants of red gram, maize
- One row of marigold/ambari (Hibiscus) should also be planted every 15–20 rows. Alternatively, 100 marigold/ambari plants may be planted at randomly.

- **Cultural operations** Pruning of main and secondary shoot tips encourages growth of branches, resulting in development of many tertiary branches with more flowers and bolls. Proper pruning can increase productivity by 25–30%.

- **Weeds**:The first 60 days are very important for crop growth. Weeds compete with the crop for nutrients, resulting in poor crop yields if they are not removed in time. In cotton-red gram fields, use of the bullock drawn hoe is commonly used for weeding. The first weeding is done 20–25 days after sowing and the second, 55–60 days after sowing.
- Mulching of the field with a thick layer of crop residue immediately after sowing reduces weed growth.
- In multiple cropping systems, weeding is manually done. Weed biomass should not be thrown away or burned. It should be used in the same field as mulch or should be recycled after composting.

SOIL FERTILITY MANAGEMENT:

Tank Silt Application: Tanks are the naturally formed depressions (small lakes) with a strengthened bund. Tanks are the unique irrigation structures in the Warangal district of Andhra Pradesh. They normally have catchments that are rich in nutrients. Soil loss in the catchments along with run off results in sedimentation of fertile top soil in the tank bed. The silt, which is finer fraction of the soil deposited in the tanks, is excavated and applied as an external amendment in cotton fields to improve water retention capacity and fertility. Basal application of FYM or Tank silt 8 tons/Ac of in summer is necessary.

Vermicompost: Non-burrowing earthworms can convert organic crop and animal residues into compost which is rich in both major and minor nutrients and other plant growth promoting substances. Farmers are encouraged to use 2-3 quintals of vermicompost per acre, as per the availability

Sheep penning, cattle penning and poultry manure: Farmers are encouraged to use sheep penning and poultry manure. Sheep penning and poultry manure are used in the cotton fields, where tank silt cannot be applied. This is suggested to reduce the cost of cultivation and to use resources efficiently.

FYM Application: Farm Yard Manure (FYM) is generally applied in cotton fields. Farmers understand the importance of FYM application and feel the need for it; therefore additional efforts are not required to motivate them. However, there is a greater need to motivate the farmers to change the technique of FYM preparation, as the process is prone to nutrient loss in conventional methods. FYM should not be opened to the sun and should be protected from rain, if possible. Occasional stirring or agitation can provide good aeration during decomposition

Sanjeevak or jeevamrut – fermented liquid manures prepared from cattle dung and cow urine are key on-farm inputs in the management of soil fertility on organic farms. *Amrut pani* , a soil tonic, can also be used in place of ***jeevamrut*** . Around 200 litres of jeevamrut or amrut pani are applied to the soil per acre, either along with the irrigation water or sprinkled over the soil surface during or after mild rains. A minimum of three applications are necessary.

The first after sowing; the second, 25–30 days after sowing (after the first weeding); and the third, 50–60 days after sowing (after the second weeding).For better crop growth, diluted jeevamrut (life tonic) is used as a foliar spray on at least three occasions, with intervals of 20 days in between. The first application is 20 days after sowing. In the south Indian states, farmers use panchagavya in place of jeevamrut as foliar spray (Vijayalakshmi et al , 2005). Use of diluted gomutra or vermiwash (one litre in 15 litres of water) or a mixture of gomutra + vermiwash (1:1) is also very popular among farmers in
Maharashtra.

IRRIGATION WATER MANAGEMENT

Depending upon the climate and variety, cotton needs between 700–1200 mm water during its entire growth period. Water requirements are low during the first 60–70 days and highest during flowering and boll formation stage. In the sandy loam soils (of north India), the crop is irrigated 3–5 times. In red sandy loam soils, with low water retention capacity, 4–10 light irrigations may be needed. In black cotton soils 'protective irrigation' is provided every 20 days, if rains fail, especially during the boll development stage.

Although cotton is commonly flood-irrigated, irrigation by furrow or by alternate furrow method is more effective and conserves water. In sloping areas, channels running parallel to the contour lines, across the slope, prevent erosion. The alternate rows are watered to reduce weeds and root rot disease. Drip irrigation is also very effective. For ratoon crop, Sprinkler irrigation after final picking would be recommended.

Mulching of the soil surface with intercrop (live mulch) or by using crop residues or biomass 60 days after sowing reduces irrigation requirements by 40–60% and weed infestation. Mulching is very effective under purely rain-fed conditions.

In semi-arid tropics, moisture stress during boll development stage is highly detrimental to the yield. In-situ rainwater conservation is the key to success. Cotton cultivation on ridges across the slope conserves more water, reduces soil erosion and improves yield. Ridge sowing on 0.4% slope and fusion of ridges at 6 m intervals just before the normal withdrawal of monsoon is a recommended practice. The excess water can be collected in farm ponds and recycled at the critical boll development stage in order to improve rain-fed cotton yields significantly.

Critical stages of moisture requirement for cotton crop

There are many stages during crop cultivation, when moisture is important for growth. If the plant undergoes water stress during these stages, yields are significantly reduced. Followings are some points that the extension workers should keep in mind with respect to irrigation.

- If water is available for one irrigation, it should be provided at the flowering stage
- If water is available for two irrigations, it should be provided at the flowering and boll formation stage
- If water is available for three irrigations, it should be provided at the seedling, flowering and boll formation stages
- If water is not limited, irrigation should be provided every 15 days and water stagnation should be avoided.

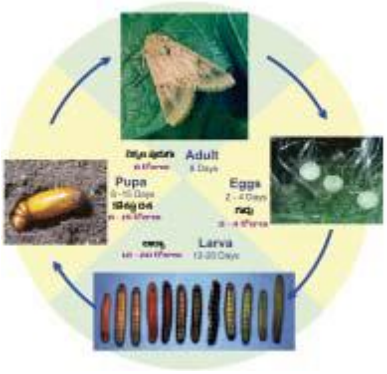
COTTON INSECT PESTS

Broadly cotton insect pests are classified into two groups viz., ...
Important insect-pests of cotton include the American bollworm, the pink bollworm, the spotted bollworm and aphids (*Aphis gossypii*), white flies, red cotton bugs, spider mites, cotton jassids and thrips.

Reasons for more pest attacks in cotton

- Use of monocropping without in field diversity
- Higher dosages and imbalanced fertilizers application
- Indiscriminate use of spray of chemical insecticides and upset the ecological balance.Also lead to insects resistant development.

American bollworm (*Heliothis armigera*)



The young larvae vary in colour from bright green, pink and brown to black, with a lighter underside. Alternating light and dark bands run lengthwise. The head is yellow and the legs are almost black. The larvae feed on tender leaves, buds and flowers and later bore into the bolls. They deposit faeces at the base of the entrance hole. The eggs are pinhead size, yellowish in colour and found singly laid,
on the leaf surface and squares. Mature larvae drop to the ground and pupate in the soil. Adult moths are grey to brown in colour and have dark spots on the front wings.

Management practices

- 2-3 rows of trap cropping with marigold around the cotton
- Intercrop with groundnut/cowpea/green gram/soybean is helps in the growth beneficial of beneficial insects like chrysopa, siriphid fly etc., for biological pest control.
- Monitor the pest by installing pheromone traps @ 4/acre.
- Nipping the tender shoots at 45 days age will destroy eggs.
- Spray NSKE 5% during early infestation to avoid egg laying
- Release *Trichogramma* @ 40000/acre 3-4 times during the egg stage (about 45 days after sowing)
- Spray chilli garlic mixture during heavy infestation.
- Random planting of Marigold, Bhendi as trap crops-collect and destroy larvae and eggs
- Jowar/maize as border crop-obstructs entry of pests and increases natural enemies.
- Arrange 10 bird perches/acre-birds land and feed on pests.

Tobacco Caterpillar *(Spodoptera litura)*

The moths lays eggs on the underside of the leaves in mass (100-300) and are covered with buff coloured scales and hairs. Each female lays 1000-2000 eggs in life cycle. The eggs hatch in 3-4 days.The larval stage is completed in about 28 days. Pupation take place in the soil and pupal period lasts for about 9 days. The longevity of adult is 9-10 days. It has 6-8 generation in a year.

The early instar larvae feed gregariously on the under surface of the leaf leading to skeletonisation of the leaves. Later they disperse, become solitary and nocturnal. They also feed on the flower buds, flowers, calyx, squares and bolls. The pest is polyphagous in nature.

Management practices

- Collection and destruction of egg masses and skeletonised leaves with first stage larvae.
- Grow castor as trap crop-collect and destroy larvae and eggs
- Monitoring the pest with pheromone traps @ 4-5/acre.
- Foliar spray of 5% NSKE (neem seed kernel extract) is quite effective at early larval stage.
- Erecting bird perches @ 10/Acre.

Pink bollworm (*Pectiniphora gossypiella*) the young larvae are tiny white caterpillars with dark brown heads. When fully grown, they are to 12 mm long with wide, transverse, pink bands on the back. The eggs are small, elongated and laid at the bottom of the green bolls. The larvae burrow into the bolls through the lint and feed on the seed. They do not deposit faeces at the base of the entrance hole. Adults are small, greyish brown moths.

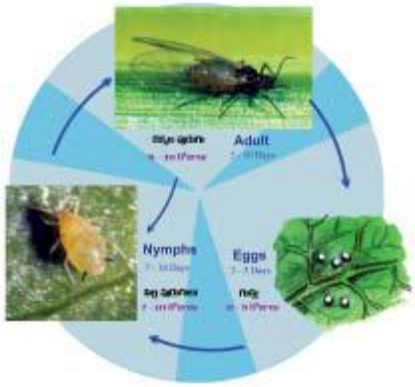
- Deep summer ploughing exposes and kills the inactive stages of pests.
- Aborted flowers, bolls and leaf litter at the base of the plant should be collected and
- destroyed. Stubbles should be burnt after harvesting the crop. This helps in destroying
- the hibernating larvae and pupae.
  Seed treatment with sulphuric acid@ 100 ml per kg seed for 3-5 mts afterwards rinse
- the seed with water. This helps in killing the insects hiding in seeds and pupal stages.
  Intercropping cotton with cowpea, groundnut, greengram or soya helps in the growth
- of beneficial insects like chrysopa, siriphid fly etc., for biological pest control.
- Natural enemies increase when pesticide spraying is stopped. Based on pest intensity
- release trichogramma 60,000/acre (3 cards)
- Monitor the pest by installing 4 pheromone traps/acre
- To avoid egg laying spray 5 % NSKE
- Grow bhendi as trap crop - collect and destroy larvae and eggs
- Avoiding the use of chemical sprays will encourage natural enemies like chrysopa,
- siriphid and helps in biological control

Spotted bollworm (*Earias vittella*) and spiny bollworm, (*E.insulana*) The young larvae are spindle shaped, greyish brown or greenish in colour. The eggs are small, round and light blue-green in colour.
The pupae are enclosed in cocoons shaped like inverted boats. The wings of the adult moths are silvery green to yellow with three transverse lines of a darker shade. The larvae bore into the shoot and bolls of the cotton plant. Infested bolls have small holes with excreta inside.

- Deep summer ploughing exposes and kills the inactive stages of pests.
- Intercropping cotton with cowpea, groundnut, greengram or soya helps in the growth of beneficial insects like chrysopa, siriphid fly etc., for biological pest control.
- Nipping the tender shoots at 45 days age will destroy eggs.
- Drooping heads, damaged branches bolls to be collected and destroyed.
- To avoid egg laying spray 5 % NSKE
- Bhendi as trap crop-collect and destroy larvae and eggs
- Jowar/maize as border crop-obstructs entry of pests and increases natural enemies.
- 10 bird perches/acre-birds land and feed on pests.

Insect Pests	Recommended trap crop (100 plants/ acre	Type of observation and action required
Helicoverpa	Marigold and sunflower	Pluck the marigold flowers and market
Spodoptera	Castor	Collect and destroy egg masses and skeletonised leaves.
Spoted bollworm	Okra	Infested bhindi should be harvested and destroyed.

Aphids (Aphis sp.) Aphids are plant-sucking pests. Their mouth parts are like tiny straws, with which they pierce the plant tissue and suck the sap. They produce a large amount of sugary liquid waste called honeydew. Moulds grow on this honeydew, turning the leaves and branches black. The eggs are very tiny, shiny, black and found in the crevices of the buds, stem and bark of the plant. Winged adults are produced only when they need to migrate.

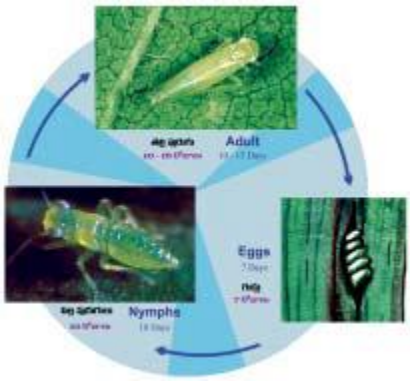


- Avoiding the use of chemical sprays will encourage natural enemies like chrysopa, siriphid and helps in biological control.
- Rain water or water sprays will wash out the pest.
- Sowing of varieties that are tolerant to aphids.
- Spray tobacco decoction (only once)
- Spray 5 % vitex decoction

Whitefly *(Bemisia sp.*) White fly adults are about 1 mm long with two pairs of white wings and light yellow bodies. They pierce the leaf tissue and suck the sap, causing the leaves to weaken and wilt. Their severe infestation also causes yellowing, drying and premature dropping of leaves, resulting
in the death of the plant. The white fly also produces honeydew and moulds. White flies are the potential carriers of viruses that cause diseases. Tiny white or brownish eggs are laid below the leaves.

Jassids (*Amrasca devastans, A. biguttula)*

Adult are green colour insect measuring about 3-4 mm having black spots on forewings. Nymphs are green in colour without wings. Female lays yellowish eggs in the leaf veins on the underside. The eggs hatch in 6-10 days and nymphal period is about 7-9 days. Both nymphs and adults suck sap from the leaf tissue and meanwhile inject a toxin into the plant tissue, resulting in hopper burn. The insect feeds on the under surface of leaves causing curling of leaf edges and leaves turn red or brown. Jassids typically damage the lower leaves first and progressively move to the upper leaves. The leaves dry up and shed.



The winged adults are wedge shaped with two black spots on vertex and black spots on each forewing. Adult live for 2-3 weeks. It completes 7-8 generations in a year.

- Adopt adequate spacing in black cotton soils to avoid compact growth
- Growing resistant varieties such as L 604, Savitha, Narasimha (LHH-390), LRA-5166, NHH 44.
- Crude neem oil spray @ 3 lts in 100 lts of water.
- Light traps
- Spraying NSKE 3% spray.
- Spraying vitex leaf spray 5 %.

S.No	Name of the recipe	Insect pests to be Managed
1	Neemasthram	Sucking insects and Small caterpillars
1	Agniasthram	All borers (hidden larvae and other insects
2	Brhamasthram	Large scale catarpillars

Biodiversity is the key to keeping pest populations below the ETL. Intercropping of cotton with red gram, cowpea, soybean, moong, sorghum/maize and random planting of marigold and *Hibiscus subdariffa* (***lalambari***) helps in keeping the pest population under the ETL. Sunflower is also an important trap crop for the control of insect pests in cotton. Assassin bugs, predatory beetles, ants, lacewing larvae, parasitic wasps (Trichogramma), etc., are some of the important natural enemies of these pests. Cotton-sorghum, cotton-sunflower and cotton-red gram rotations have also been found to be effective in keeping pests below the ETL. Hand picking of infested buds and bolls and removal of cotton stocks help in control of bollworms. Jaggery powder (10 kg/ha) sprayed on the soil surface will attract ants that feed on the larvae. About 10–12 bird perches installed in one hectare attract birds that also consume cotton pests. Yellow rice (one kilo rice cooked with turmeric powder) kept on or near perches attracts predatory birds. Yellow coloured sticky plates (up to 10/ha) and pheromone
traps or light traps (10–12/ha) can also be used for the control of insect pests.

Inundated release of 5000 Chrysoperla eggs after 15 days of sowing and 50,000 *Trichogramma* sp. eggs (2–3 cards), 15,000 to 20,000 Trich*ogramma chilonis* per ha and 15,000 to 20,000 Apanteles sp. per ha after 30 days of sowing can keep the problem of pests below the ETL.

Economical threshold limits

- American and spotted bollworm: one larva/5 plants or 5–10% damage to bolls
- Pink bollworm: 5% rosette flowers
- Aphids: 20% infested plants
- Jassids: 5–10 insects per plant

General control measures

Spotted bollworms (brown) damage the shoots. The American bollworm (green) or the pink bollworm damage flowers and fruits when the crop is about 40–45 days old.To control these insects, the following measures are recommended:

- Use of dashaparni and gomutra (2.5 litres ***dashaparni*** extract and 2.5 litres cow urine in 200 litres water) can also effectively control these bollworms.

- Garlic-chili-ginger extract has been found effective and is used by a large number of farmers in Maharashtra. To make this extract, crush 1 kg green chili in 3 litres of water, crush 1 kg garlic in 3 litres of water and crush 0.5 kg ginger in 2 litres of water, all separately. Boil each solution individually, till each is reduced to half. Filter and collect extracts. Mix the three extracts at the time of use. About 50 to 70 ml of this solution is mixed with an equal quantity of cow urine, diluted in 15 litres of water and used as a foliar spray.

- In case of a severe attack of bollworm, use alternate sprays of dashaparni and garlic-chili-ginger extract. 5–10 % spray of HNPV can also control attacks of bollworms.

f) Some other control measures adopted by farmers in Maharashtra include the following:

- Onion (20–25 kg) is crushed and applied as soil treatment through irrigation to control soil-borne pests and diseases.
- The hairy/woolly caterpillar is controlled by spraying one litre aloevera juice mixed in 80 litres of water per ac.
- In the fourth month, two litres of lemon juice and 200 litres of water are sprayed over 1 ha to reduced bollworm incidence.
- Crush tamarind and mahua tree bark, 10 kg each, in 5 litres of water. The filtered and diluted extracts can be sprayed over one hectare area control the worms.
- Flour spray (2 cups of fine white flour and half a cup of soap in water) and soft soap spray (15 gm soft soap powder in 15 litres of water) have been found to be effective in control of aphids, jassids, spider mites, thrips and whitefly.
- Crush 5 kg lantana leaves in 5 litres of water and 10 litres of cow urine and ferment for 4 days. Dilute thereafter with 60 litres of water and spray on 1 ha to control fungal and viral diseases. The solution also repels white flies.

- **Color traps:** Some sucking insect pests get attracted to specific colours. Colored boards/sheets/round tins should be arranged one foot above the crop by applying castor oil on each surface and tied to a stake. Yellow colour bait trap works for trapping whiteflies while white colour boards works for thrips. The insects attracted to the colour boards get stuck to the sticky traps and can be checked for the

Yellow colour bait trap works for trapping whiteflies- @ 10 /Ac.
White colour boards works for Thrips- @ 10/Ac

Cotton Diseases :

Cotton wilt is a soil born disease caused by the fungus, *Fusarium spp.* The fungus invades cotton plants via the roots, from where it moves up into the woody tissues. The fungus blocks the plant's water conducting tissues and reduces the flow of water, which leads to wilting and eventual death of affected plants. Affected woody tissues are discoloured in various shades of brown. Death of leaf tissue occurs and defoliation develops when symptoms a severe. External plant symptoms include stunted growth and wilted leaves, followed by yellowing or browning and eventual death from the top of the plant.

Symptoms can appear in the crop at any stage, though they are most common in seedlings or after flowering during boll fill. Symptoms also appear in individual plants or small patches in low lying areas or near tail drains.

Disease spores can survive in the soil for at least 10 years, even in the absence of cotton. If continue to grow susceptible varieties in infected fields, the fusarium population will build up to the point where production of cotton will no longer be possible, even with the most tolerant varieties.

Management

- Maintain good farm hygiene.
- Seed treatment with trichderma viridae / mix with FYM and apply.
- Avoid crop stresses.
- Delay sowing until soil temperature is well above 17^{o}C.
- Retain crop residues on surface for as long as possible.
- Control weeds, as many weeds are hosts for fusarium.

Controlling small patches

- If fusarium is detected in small patches, physical control is possible to prevent further spread. Small patches of infected plants can be pulled out and burned on the spot
- Stop irrigating these areas. Collect trash from the infested fields and burn onsite to minimise movement of infested trash to other fields.
- Solarisation is a useful practice where only small patches are found.

Bacterial blight (*Xanthomonas malvacearum*) is favoured by wet windy weather, and injured tissues are very susceptible to infection. Disease symptoms are favoured when temperatures rise above 25^{o}C and relative humidity exceeds 85 per cent. Hail-damaged crops are often severely infected. The use of acid delinted seed will provide good control of seed-borne bacteria. Prompt cultivation of crops after harvest, so residues have ample time to decompose, will also assist in controlling the disease.

Symptoms

- The leaves have small, angular, water-soaked spots 1-5 mm across that become reddish-brown in colour. Large brown areas with greasy margins may also extend along the main veins, causing yellowing and death of large parts of the leaf. Symptoms are more prevalent on lower leaves than upper leaves. Lesions dry and darken with age. Leaves may prematurely shed, resulting in extensive defoliation of the plant.
- The bolls have small, round, water-soaked spots 2-10 mm across that become black and depressed. Affected bolls may be shed or fail to open and have poor-quality lint. Secondary rots may cause extensive breakdown.
- The bracts have brown to black spots.

Control of diseases Root rot, wilt and browning of leaves are common diseases of cotton. For their control, the following measures are often adopted:

- Deep ploughing during summer prevents the occurrence of soil borne pathogens.
- Use of ***Trichoderma viride*** as seed treatment can effectively control the incidence of root rot and **Fusarium** wilt.
- Use of neem leaf/seed manure (10 q/ha) has also been found to be effective in the control of soil borne pathogens.
- For the control of rust and root rot, fermented (sour) buttermilk (5 litres) in lime water (100 litres) per ha may be sprayed.
- Foliar spray of ***Trichoderma viride*** powder (25 gm), milk (50 ml) and water (10 litres) can reduce the incidence of brown leaf

Disease Management Strategy:

- Conducting your own field disease survey in November and February of each season. Know what diseases are present and where they are present if diseases are increasing, confirm with experts. Train farm staff to recognise cotton plant diseases.
- Practising farm hygiene. This includes encouraging all visitors to 'come clean-go clean' and minimising the risk of moving diseases from one field to another.
- Planting resistant varieties.
- Maintaining good soil nutrition, as a healthy crop is more able to express its natural resistance to disease.
- Managing crop residues to minimise the risk of diseases carrying over to the next crop
- Developing a crop rotation strategy. Repeated cultivation of cotton can contribute to a rapid increase in disease incidence.
- Deep summer ploughing destroy soil borne pathogens.
- Follow clean cultivation and weed management.
- Fermented buttermilk spray: ferment buttermilk in an air tight bottle/can for 3–4 weeks; dissolve 6 litters of butter milk in 100 litters of water and spray on 1 ac. It is effective against leaf spot diseases of cotton

Trichogramma spp.	**Egg parasites of borers and defoliators**
Chelonus, Cotesia,Bracon, Campoletis (Wasps)	Larval parasites
Nuclear polyhedrosis virus	Laval disease
Chrysopa Grub and Adult	Feed on Aphids, Whiteflies, Mealy bugs and Egss & early instar larve of bollworms.

HARVEST AND STORAGE

The time of picking is an important aspect for maintaining seed quality. Picking should only commence when the cotton is fully mature, i.e., when the bolls begin to open. Several pickings may be necessary since bolls ripen every two to three months. Early cotton picking gives slightly better seeds for germination. In addition, the planting seed is best gathered at the peak of the harvest. The cotton picked from late-formed bolls (last pickings) should not be kept for seeds.

Precautions to be taken in picking:

1. Picking should be started when bolls are fully mature.
2. Picking should not be done while the bolls are wet from dew or rain.
3. Bolls spoiled by rains, or damaged by insects, or otherwise damaged, should be picked separately and discarded. Such bolls can be picked 10 to 15 days ahead of the first picking. The damaged bolls should not be picked during normal pickings for seed purposes.
4. Cotton should be clean, with a minimum amount of material such as leaves and plant parts. This reduces the possibility of mechanical damage from excessive machining of the fibre during ginning.
5. Moist cotton should not be picked or stored in any way. At a moisture content of twelve per cent, or more, heating may occur and damage the seed and fibre. Further, damp cotton requires more processing in the gin.
6. The picked cotton, when it is completely dry, should be stored in a dry place and should be covered if not ginned immediately.

CROP RESIDUE MANAGEMENT

Cotton stubbles contain more than 1.11% of Nitrogen, 0.1% of Phosphorous, and 3.98% Potash. *This* means that the grown crop can supplement 1.5 tons of Carbon, 20-25 Kgs of Nitrogen, 72 Kgs of Potash from the cotton stubbles collected from one hectare of cotton cultivated area. The stubbles can be chopped through a chipper to chips or powder. The chips can be used as a feeding material for composting process, or in vermicompost preparation and other compost pits. Commercial microbial cultures can be used on the chips/ powder of stubbles to hasten the decomposition process.

Otherwise, with the help of a rotavator, a tractor driven machine, the stubbles/stalk can be chopped in the field and residues can be incorporated into the soil, as it can till the soil up to 6 inches. This operation should be taken up well before the rainy season so as to permit *faster* decomposition of the chopped stubbles. This operation improves the soil porosity and productivity. It also helps in leveling of the soil, and retains the moisture.

There is another way of utilizing the cotton stubbles by forming briquettes. Cotton stubbles inherently have substantial energy content. The energy content varies from 17 MJ/kg to 18 MJ/kg. The stubbles can be chopped and then processed mechanically in a briquetter to form briquettes. These briquettes can be used as a renewable source of energy in substitution to fossil fuel.