



Field Guide to
**Non-chemical
Pest Management**



**in Cotton
Production**



Pesticide Action Network (PAN) Germany



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Non-chemical Pest Management in Cotton Production

Pesticide Action Network (PAN)

Founded in 1982, the Pesticide Action Network is an international coalition of over 600 citizens groups in more than 60 countries, working to oppose the misuse of pesticides and to promote sustainable agriculture and ecologically sound pest management.

PAN Germany was established in 1984 as part of this global network and has continually been involved in initiatives to reduce the use of hazardous pesticides and to promote sustainable pest management systems on national, European and global levels.

Acknowledgements

First, we want to express our gratitude to the universities and organisations that have given the permission to use their photos in this field guide. (For more details see p. 27.)

We also wish to thank all the individuals, groups and organizations that have prepared the bases for the most control measures presented in this field guide, may it have been by preserving traditional experience, on field trials, on field research or in the lab.

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Hamburg, August 2005

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Prologue

Pesticides worth more than 30 billion US dollar are intentionally released into the global environment every year. A high proportion of these is highly toxic and has immediate adverse effects on human health, wildlife, local food sources such as cattle or fish, beneficial insects and biodiversity. Some of them have chronic effects including cancers, reproductive problems, birth defects, hormonal disruption and damage to the immune system. Impacts come from direct exposure in use, spray drift, washing work clothes used while spraying, home pesticide storage, pesticide dumps, and persistence in the environment.

Overall aim of the international *Pesticide Action Network (PAN)* is to eliminate the use of hazardous pesticides, reduce overall use, risk and dependence on pesticides, and increase support for community-based control over a sustainably produced food supply. PAN is committed, in its projects, strategies and campaigns to place pesticide concerns in the broad political and economic context in ways that will advance the fight against rural poverty and enhance pro-poor development and ethical trade. PAN aims to help local communities use the initiatives to benefit their day-to-day lives.

PAN Germany is part of the international Pesticide Action Network. Among others by two related projects PAN Germany is supporting non-chemical pest management specifically in cotton production: The Online Information Service for Non-chemical Pest Management in the Tropics, OISAT (www.oisat.org) and PAN Germany Cotton Connection (<http://cotton-connection.pan-germany.org>).

OISAT is web-based system to distribute information on non-chemical pest management that is easy to read and easy to understand. Information provided via www.oisat.org is relevant to small-scale farmers who intend to produce crops using safer and more affordable non-chemical pest management practices. It provides varied information about how to lower cost of production based on the recommended insect/mites pests and disease control methods.

The PAN Germany Cotton Connection on the other hand, informs about the problems in conventional cotton production with the focus on the economic, health, and environmental conditions of cotton producing small-scale farmers in developing countries. It highlights the advantages of organic cotton production, the opportunities to exert influence and it stimulates dialogues among the various stakeholders in the (organic) cotton textile chain.

This 'Field Guide to Non-chemical Pest Management in Cotton Production' is an excerpt taken from the website www.oisat.org. It enables to provide farmers with practical guides and alternatives to eliminate the use and their dependence on synthetic pesticides for the management of cotton pests. The recommended practices are safer, more affordable, and easy to follow. Most of the farm practices, the farmers can do by themselves and the materials that are needed are found in their backyards or in their kitchens or can be purchased in the local agricultural suppliers.

Carina Weber
(Executive Director PAN Germany)

How to use this field guide

This field guide is designed to make the control of cotton pests as easy as possible. Each pest included has a brief description of its lifecycle, damage it causes, and the control measures. It is very important to know how the insect/mite pest develops because the adult does not always cause the damage and sometimes it is not even found where the damage occurred. Also, as not to confuse you with the beneficial ones, a separate description of the natural enemies and their conservation and management are discussed at the last part. Included in the control measures are cultural practices, physical control, plant extracts, other homemade solutions, and other practical methods.

For example, you notice that the cotton leaves are having yellow spots when you're out in the field. What would you do? First, have a closer and careful examination of your plant. If you find the pest and can't identify it, turn the following pages and look at the illustration of an insect and/or the damage or symptom in each pest entry. Once you have identified the pest, look into the corresponding control measures on how to eliminate and/or lessen its population density. You have various options like: cultural practices (e.g. removal of weeds); physical control (e.g. handpicking); plant extract (e.g. neem spray); other homemade solution (e.g. soap spray); other method (use of baits).

However, with every effort made to provide you with complete information on the natural pest control in cotton production, the recommendations may vary from every location. It is highly recommended that you have to try the various control practices in small scale especially for the plant extracts and other homemade solutions, in order to make adjustments that are adaptable to your local farm conditions before going into large scale application. And best of all, always keep farm records to have a list of successes and failures in each time you grow a crop!



General recommendations

Throughout this field guide you will find suggestions for stopping or lessening the pests' population before they have control over your cotton field. To make a plan for you to grow a healthy crop, the following tips are the steps you ought to take:

1. Select the proper cotton variety that is well adapted to your local conditions
2. Always select good and diseased-free seeds
3. Have a healthy soil, but always keep in mind that over-fertilizing isn't necessarily better
4. Practice crop rotation by planting on the next cropping season- crops of different family group
5. If possible practice intercropping to improve the field's diversity and to encourage natural enemies
6. Timed your planting
7. Prepare the soil thoroughly by proper tillage
8. Always practice proper field sanitation
9. Monitor your plants regularly
10. Ask for assistance from your local agriculturists

When controlling pests using the plant extracts and other homemade solutions, the following are the standard procedures for their preparation and application;

1. Select plant parts that are free from diseases.
2. When storing the plant parts for future usage, make sure that they are properly dried and are stored in an airy container (never use plastic container), away from direct sunlight and moisture. Make sure that they are free from molds before using them.
3. Use utensils for the extract preparation that are not used for your food preparation and for drinking and cooking water containers. Clean properly all the utensils every time after using them.
4. Do not have a direct contact with the crude extract while in the process of the preparation and during the application.
5. Make sure that you place the plant extract out of reach of children and house pets while leaving it overnight.
6. Harvest all the mature and ripe fruits before plant extract application.
7. Always test the plant extract formulation on a few infested plants first before going into large scale spraying. When adding soap as an emulsifier, use a potash-based one.
8. Wear protective clothing while applying the extract.
9. Wash your hands after handling the plant extract.

Armyworm

Damage

The larvae can eat the entire leaves of field crops and grasses. When feeding, they chew from the leaf edges until only the midrib is left. They feed on various crops and grasses during their migration, and often

bare crops of tender leaves after passing through. They travel from field to field in great numbers, hence the name "armyworm".

Description

The eggs of armyworms are white and are found in clusters. One egg mass contains 200-300 eggs. These turn yellowish when mature. Hatching occurs in about 2-5 days.



The larva varies its colors according to the species. Sizes vary from 2-4.5 cm long. The larva has 6 small legs just behind the head and 10 fleshy legs at the rear. The larva eats voraciously as it grows. It digs 3-6 cm below the soil surface to pupate.

The pupa is brownish red in color and about 2-3 cm long. Pupation takes about 7-16 days depending on the climatic conditions.

The moth has 3-4 cm wingspan and 1.5 cm long. Colors vary from light green, light pink, tan, to dark brown in color. The tiny white dot in the center of each forewing is an important feature to identify the armyworm moth. The moth is seldom seen because it is active only at night time, either mating or searching for suitable egg-laying sites. The female moths lay eggs on the lower leaves of growing grasses or small grains.

Control measures

Cultural control

1. Practice proper field sanitation. Cut weeds from bordering fields. Remove weeds regularly to reduce breeding sites and shelter for armyworm.
2. Remove all plant debris after harvesting.
3. Employ proper seed selection when seeds for sowing are taken from the previous harvest. Adults might have laid eggs on the seeds during armyworm infestation.
4. Plow and harrow the field thoroughly. Sometimes, the small grains or grasses are plowed-under after the eggs are laid on them. As the field is planted and the plants begin to grow, the larvae will continue to develop and will start attacking the plants.

Physical control

Deep ditch

Plow a deep ditch. Keep it filled with water. This method is helpful, when larvae are found to be moving towards your field from the adjacent fields. Another method is to dig a deep ditch with vertical sides to trap

the larvae and prevent them from crawling out. Dig a hole, a diameter of a fence post, in every 10 meters within the ditch. Larvae are lured to congregate in the holes. Collect and properly dispose the trapped larvae.

Plant extracts

Chili and neem leaves extract

Pound 10-20 pieces of hot pepper and 2-2.5 kg fresh neem leaves. Add 1 liter of water. Let it stand overnight. Strain. Dilute the filtrate with 20 liters of water. Add 2 tbsp of powdered soap. Stir well.

Garlic bulb extract

Chop 85 grams of garlic. Soak in 50 ml of mineral oil (cooking oil) for 1 day. Add water to the filtrate to make a 1-liter extract. Add 10 ml of soap.

Lansones seed extract

Pound finely 500 grams of seeds. Add 20 liters of water. Soak in water for 1 day. Strain.

Cotton boll weevil

Damage

1. Feeding punctures on squares and bolls as results of adult's feeding damage. The boll weevil uses its small mandibles (located at the end of their snouts) to chew and feed into the inner portion of the boll.
2. A raised, pimple-like scar is found on the square or on the boll as a result of female depositing its egg on the feeding puncture and sealing it with a glue-like substance.
3. 'Flared square' is wherein bracts spread away from the floral bud, as a result of larval feeding.

Description

The eggs are small and ovate-shaped. These are deposited inside a square or boll. One square is one egg laying site, where the female lays only one egg. More eggs are found in 1 boll. Egg period is 3-5 days.

The larva is white C-shaped grub, legless, long, and wrinkled with light brown head and mouthparts. It is about 13 mm long.

The pupa is found inside the same square or boll where it develops. Pupa looks very similar to the adult but with soft skin. It pupates within the square that falls into the ground.

The emerging adult chews the square for its exit. The newly emerged adult is reddish or pinkish, with not



fully hardened skin. It becomes grayish or brown and becoming nearly black with age. Its body is hard-shelled and is sparsely covered with small light-colored hairs, which are dense near the center of the thorax, creating an indistinct light-colored stripe (on the center of the thorax). It has an elongated snout (beak), which is true to all weevils but its most distinguishing feature is the 2-branched veins near the end of the front thigh, the inner one being much longer than the other. Boll weevil varies considerably in size, ranging in length from 3-8 mm. It has a great ability to travel from one field to another.

Control measures

Cultural practices

1. Select cotton cultivars that are resistant to boll weevil. Ask for assistance from local agriculturist office for the availability in your area.
2. Destroy plants immediately after harvest to eliminate possible feeding and reproductive sites of boll weevils.

Physical control

Pheromone trap

How to make a pheromone trap?

1. Make 10 to 12 holes into an old 1 liter plastic bottle or 3 holes on each side of 1-liter ice cream container, big enough to allow the boll weevil to enter.
2. Heat a small piece of metal to make the holes easily.
3. Put a wire from the bottle cap to suspend the bait.
4. Secure the pheromone dispenser - align with the entrance holes inside the bottle trap.
5. Make a rectangular opening into the lower part of the bottle for removing the moths caught.

How to use?

1. Half-fill the bottle with soapy water
2. Put bait in the pheromone dispenser or suspend the pheromone capsule from the lid using string or wire.
3. Close the bottle cap or lid.
4. Attach the trap to a bamboo or wooden stake or hang on branch of a tree.
5. Place traps for different pests at least 3 meters apart. If traps are used for monitoring the pests, 2-3 traps are enough for 1 ha field.

'Grandlure' bait stick is the commercial version of pheromone produced by male boll weevils. The pheromone traps when baited with 'Grandlure' are extremely attractive to any boll weevil.

The male boll weevil produces a pheromone in his frass (waste matter) that is attractive to both sexes. This pheromone helps both locate one another for mating and attracts other weevils to the food source as far as 500 feet.

Ask for assistance from your local agriculturist office on where to purchase the bait.

Cotton bollworm

Damage

Cotton bollworm bore holes on the flowers and pods causing these to defoliate. The young larva feeds on tender leaves, buds, flowers, and later bore into the bolls. While feeding, its head and part of the body is

inside while the other half is found outside the boll. This feeding habit distinguishes *Heliothis* from other bollworm species.

Description

The eggs are pinhead-size and yellowish-green in color. They are found singly laid on the surface of the leaves. Hatching occurs within about 2-5 days.

The larvae vary in color from bright green, pink, brown, to black, with lighter undersides. Alternating light and dark bands run lengthwise along their bodies, the heads are yellow and the legs are almost black. Mature larvae vary in length from 3-5cm. They drop to the ground to burrow into the soil to pupate. The larval stage lasts from 12-24 days.



The pupae are yellowish-green and turn brown as they mature. Pupation takes place under the soil. Pupal period is 12-24 days.

The adult moths are gray to brown in color and have dark spots on the front wings. Each has a wing-spread size of about 3.8 cm. A female may deposit 200-2,000 eggs in her entire lifetime. The total development period from egg to adult is 34-45 days.

Control measures

Cultural practices

1. Practice crop rotation. Avoid planting crops successively that are susceptible to bollworm like cotton, corn, sorghum, tobacco, soybean, and tomato.
2. Grow a row of castor as border crop. Castor plants attract caterpillars that feed on cotton. Sow seeds of sunflower, black gram, and/or cowpea as trap crops in every 5 rows of cotton. These plants attract bollworm as well as provide habitat for natural enemies, which feed on bollworms.
3. Burn cotton branches and debris heavily infested by bollworm.
4. After harvest, plow-in plant residues immediately by incorporating these into the soil. Remove weeds surrounding your fields when your area is not planted with crops since these are the good laying sites for adults.
5. Clear areas of weeds 2 weeks before planting. Removal of weeds kills the pests harboring in them.

Physical control

Light trap

1. How to install and make use of a light trap?
2. Install the light trap near or within the field where you want to trap the flying insects.
3. Secure the poles firmly on the ground.
4. Mount the lamp or the bulb on the frame, 5 meters from the ground. When using electric bulb, make sure that the bulb and wiring are not in contact with water to avoid electrocution. Place the shallow basin with soapy water or the jute sack underneath the light.

5. Put the light trap from early evening until early morning.
6. Collect the trapped insects daily and dispose them properly.

Bird perches

Bird perches are resting places for predatory birds to rest and to look for preys. Predatory birds prefer to look for prey in field crops where they have places to rest.

To make bird perches, use bamboo or wooden poles or tree branches. Erect either of these at regular intervals in the field. To have live bird perches within the field, plant *Setaria* species (foxtail cultivars). These plants are found to be attractive to predatory birds. The birds feed on their seeds. In cotton field, plant *Setaria* in every 9th or 10th row of cotton. Once the birds are on the field, they prey on cotton bollworms and other insects.

Plant extracts

Madre de cacao (Gliricidia sepium) leaf extract
Pound or grind ½ kg of leaves. Soak overnight in 1 liter of water. Strain. Add water to have 20 liters of extract.

Ginger, garlic, and chili extract

Soak 50 g of peeled garlic overnight in 10 ml kerosene. Combine garlic, 25 g of green chilies, and 25 g of ginger. Add 50 ml of water to the mixture. Grind them. Add 3 liters of water.

Cotton stainer

Damage

Cotton stainers feed both on immature and mature seeds. Their penetrations into the developing cotton bolls transmit fungi on the immature lint and seed, which latter on stain the lint with typical yellow color,

hence the name 'cotton stainers'. Heavy infestations on the seeds affect the crop mass, oil content, and the marketability of the crop.

Description

The eggs are pale, small, and are laid in the soil, or under soil and plant debris, or in the cotton plant in batches of about 7-100 eggs. Incubation period is about 4-13 days depending upon the temperature and the species.

The nymphs are found together in the area where the eggs had been laid and later disperse to look for food. Then they tend to meet again while feeding on seeds and while resting. They look similar to their adult counterparts but without wings. Nymphs molt five times and their development stages depend upon the temperature and their nutrition.

The adult cotton stainers are true bugs with piercing and sucking mouthparts. Their colors vary from bright red, yellow, and orange depending on the species. They are about 1-1.5 cm long. Adults can



tolerate a wide range of climatic conditions and can disperse and fly up to 15 km.

Control measures

Cultural practices

1. Remove cotton plants and all its debris as soon as the cotton has been picked and once harvesting is over. Proper crop destruction of host plants is necessary because the cotton stainers' population depends only on few host plants.
2. Clean storage area free of cotton seeds, where cotton stainers can live upon.

drown them. Though this practice will not remove all the bugs, but it will reduce their population density.

Plant extracts

Custard apple leaf extract

Boil 500 g of leaves in 2 liters of water until the remaining liquid is about ½ liter. Strain. Dilute filtrate with 10-15 liters of water.

Physical control

Handpick the cotton stainers as they usually congregate in groups. Bring a pail of soapy water to

Cutworm

Damage

Seedlings are often cut off at ground level. Cutworm larvae can be found in the soil (up to a depth of about 5 cm) near the cotton plant. They always curl-up when disturbed. Cutworms feed only at night. Generally, they are not found on plants or on the soil surface during the day. The newly hatched larvae feed

from the base towards the tip of the leaf. At this stage, they first feed on the epidermis and may discolor the entire leaf surface. Young caterpillars eat the soft leaves of the plant. The fully-grown caterpillars are capable of eating the entire plant.

Description

The eggs are tiny pearl white, round, and have a ridged surface.

The newly hatched Spodoptera larvae are greenish and about 1 mm long.

The full-grown larva has a cylindrical body, brown or brownish-black with a tinge of orange. The thoracic segments have one to two dark spots near the base of the legs. The abdominal segments generally have two light brownish lateral lines on each side, one above and one below the



spiracles. Above the top lines are broken lines composed of velvet semi-crescent patches that vary in color among cutworms. The pupa is black or brown in color and measures about 22.5 mm long and 9.2 mm wide. The adult has dark brown forewings with distinctive black spots and white and yellow wavy stripes. The hind wings

are whitish with grayish margins. The total developmental period from egg to adult is about 35-40 days.

Control measures

Cultural practices

Removal of weeds in and around fields will reduce egg-laying sites and will help in the prevention of cutworm infestation. Do this at least 2-3 weeks before planting to reduce the incidence of cutworm larvae transferring to newly planted crops.

Plow and harrow fields properly before planting. This will destroy eggs and expose larvae to chicken, ants, birds, and other predators.

Interplant main crops with onion, garlic, peppermint, coriander, or garlic every 10-20 rows to repel cutworms. Sunflowers and cosmos can also be planted as a trap crop in or around fields.

Plant extracts

Finger euphorbia plant extract

Cut a branch and collect the oozing sap. Add 1 liter of water to every 10 drops of the sap.

Another method is to cut a mature branch and pound it finely to make it into a paste. Add this to 10 liters of water. Leave it for sometime then strain.

Basil plant extract

Pound or grind of 50 g of basil leaves. Soak it overnight in 2-3 liters of water. Add 8-12 ml of soap. Stir well.

Other method

Bacillus thuringiensis (BT)/bran bait

Moisten bran with a diluted solution of BT. Sprinkle the moist bran on the planting plots' surfaces 2 weeks before planting. Buy BT at your local agricultural suppliers.

Stinkbug

Damage

Adults and nymphs suck plant sap from leaves, flowers, bolls, and the seeds. Feeding on bolls prevents bolls to open or causes bolls to drop, and stains the lint.

Description

The eggs are yellow and barrel-shaped. These are laid on the lower surface of the leaves in clusters of 20-130 in 5-8 parallel rows.

The nymph has varied colors (green, tan, brown or gray). It is oval-shaped, wingless but looks similar to an adult counterpart. The first nymphal instars do not feed. The nymphs form clusters at the natal site. The second and third instars are also found in clusters but they disperse when disturbed. The fifth nymphal instars are sensitive to day length, which also



causes the adults to begin diapauses. The nymphal development lasts for about 8 weeks.

The adult is shield-shaped and green, tan, brown or gray in color. Most of the adults are shiny, but other species are spiny and rough-textured. The female starts mating one week after emergence and lives for about 30 days.

Stinkbug emits a foul odor when disturbed, hence the name.

Stinkbug emits a foul odor when disturbed, hence the name.

Control measures

Cultural practices

1. Remove and control weeds from fields and also in the adjacent fields. Weeds serve as the pests' alternate hosts.
2. Plant small flowering plants to attract native parasitic wasps and flies.
3. Plow-under all plant debris after the harvest to destroy all possible breeding sites.

Plant extracts

Yam bean seed extract

Grind ½ kg of yam seeds. Soak in 20 liters of water for 1-2 days. Strain.

Thrips

Damage

Thrips have rasping-sucking mouthparts and feed by rasping the surface of the rapidly growing tissues of the leaves and sucking up the released plant fluid. Thrips cause tiny scars on leaves and fruit, called

stippling, which can cause stunted growth. Damaged leaves may become papery and distorted. Infested terminals lose their color, rolled, and drop leaves prematurely.

Description

The egg is very tiny and is impossible to see. A single egg is 0.25 mm long and 0.1 mm wide. It is white when freshly laid and turns pale yellow toward maturation.

The nymph is elongated, elliptical, slender, and is pale yellow in color. It is very small from 0.5-1.2 mm in size. Its eyes have darker coloration and are easy to see. Immature thrips do not have wings. The pupa appears as an intermediate form between the nymph and the adult. It has short wing buds that are not functional. At this stage, they do not do any damage to the plant.



The adult has a slender small body, yellowish to dark brown in color, and is cigar-shaped. It is 1-2 mm long with a well-pronounced 5-8 segmented antennae. It can exist in two forms, winged or wingless. The winged form has two pairs of elongated narrow wings which are fringed with long hairs.

Female thrips can reproduce both sexually and asexually.

Control measures

Cultural practices

1. Cotton should not be planted following onions. Volunteer onion plants should be removed.
2. Keep plants well irrigated. Lack of water increases the susceptibility of plants to thrips damage.
3. Prune off and remove heavily infested plant parts.
4. Remove weeds as the thrips population builds-up on them.

Physical control

1. Collect thrips by gently shaking leaves and flowers onto a white sheet of paper or into a shallow carton box. This will not remove all the thrips but lowers its population density.
2. Bright blue or royal blue sticky traps

To make your own sticky trap, spread petroleum jelly or used motor oil on a blue shade painted plywood, 6 cm x 15 cm or up in size. Place traps near the plants with enough distance that the leaves from sticking to the board. The traps when hung should be positioned at a 61 cm zone above the plants.

Thrips are attracted to blue colors.

Plant extracts

Neem leaf extract

Pound gently 1-2 kg of neem leaves. Place in a pot. Add 2-4 liters of water. Cover the mouth of the pot securely with the cloth and leave it as such for 3 days. Strain to get clear extract. Dilute 1 liter of neem leaf extract with 9 liters of water. Add 100 ml of soap. Stir well.

Other substances

Ammonia spray

Mix 1 part ammonia with 7 parts water

Flour spray

Add 2 - 4 tbsp of wheat or potato or any baking flour into 4 cups of warm water.

Add 1 tsp of soap as sticker. Stir the filtrate prior to application.

Soap spray

Mix 2 1/2 tablespoons of liquid soap to a gallon of water. Stir well.

Another method is to mix 1 tablespoon of dishwashing detergent with 1 cup of cooking oil, to make a stock solution. For a gallon of spray, add 5 to 8 tablespoons of stock solution to a gallon of water.

Whitefly

Damage

Whiteflies, both the larvae and adults, pierce and suck the sap of the leaves. This causes the weakening and early wilting of the plant resulting in reduced plant growth. Their feeding may also cause yellowing, drying, premature dropping of leaves that result in plant death.

Whitefly produces honeydews that serve as the substrates for the growth of black sooty molds on

leaves and fruit. The mold reduces photosynthesis causing the poor plant growth of the plant. Whitefly is the most important carrier of plant viruses that causes diseases of fiber crops, vegetables, fruit trees, and ornamentals.

Description

The eggs are tiny, oval-shaped, about 0.25 mm in diameter, and stand vertically on the leaf surface. Newly laid eggs are white then turn brownish. They are deposited on the underside of leaves, sometimes in a circle or oval-shaped patterns.



The larvae are transparent, ovate, and about 0.3 to 0.7 mm in size and they move around on the plants looking for a feeding site upon hatching. The pupae are dirty white and surrounded by wax and

honeydews. During this stage, the red eyes of the emerging adults are visible.

The adults are about 1mm long with two pairs of white wings and light yellow bodies. Their bodies are covered with waxy powdery materials. They are found feeding on top of the plants. A female can produce as many as 200 eggs in her

lifetime and mating is not necessary. It takes about 40 days to develop from egg to adult.

Control measures

Cultural practices

1. Do not plant cotton near crops that have whitefly infestation. This would lead to early infestation of your crop and could ruin the whole field crop.
2. Even after the crops have been harvested, the whiteflies continue to live on the abandoned crop residues. To stop the lifecycle, plow the field immediately after harvest and incorporate the plant debris into the soil.
3. Remove and destroy any whitefly-infested plants.
4. Whiteflies are attracted to Nicotiana, a flowering tobacco plant variety. Plant Nicotiana as a trap crop.

Physical control

Sticky board traps

Traps give early warning and serve as natural control method.

To use, place 1 to 4 yellow sticky cards per 300 square meter field area. Replace traps at least once a week. It is difficult to determine the population of newly trapped whiteflies on a sticky card to those previously trapped ones.

To make your own sticky trap, spread petroleum jelly or used motor oil on yellow painted plywood, 6 cm x 15 cm in size or above. Place traps near the plants, preferably 25 cm away from the plant to ensure that the

leaves will not stick to the board. Alternatively, the traps can be hung and positioned at 61 cm zone above the plants.

Plant extracts

Madre de cacao & neem

Shred 1 kg of Madre de cacao leaves and 1 kg of neem leaves. Soak leaves in 5 liters of water for 3 days. Strain. Add water to make up 20 liters of filtrate. Spraying interval is 4-5 days.

Other solutions

Ammonia spray

Mix 1 part ammonia with 7 parts water

Flour spray

Add 2 - 4 tbsp of wheat or potato or any baking flour into 4 cups of warm water.

Add 1 tsp of soap as sticker. Stir the filtrate prior to application.

Soap sprays

Mix 2 1/2 tablespoons of liquid soap to a gallon of water. Stir well.

Another method is to mix 1 tablespoon of dishwashing detergent with 1 cup of cooking oil, to make a stock solution. For a gallon of spray, add 5 to 8 tablespoons of stock solution to a gallon of water.

Diseases

Anthracnose

Symptoms

Anthracnose disease attacks all plant parts at any growth stage. The symptoms are most visible on leaves and bolls. At first, anthracnose generally appears on leaves as small and irregular yellow, brown, dark-brown, or black spots. The spots can expand and merge to cover the whole affected area. The color of the infected part darkens as it ages. The disease can also produce cankers on petioles and on stems that causes severe defoliation and rotting of fruits and roots.

An early symptom of infestation is damping-off due to the cotyledon's rotting. Infected leaves have pinkish-

brown spots that appear especially on their under surfaces. Large areas of the tissues around the veins become yellowish to brownish and eventually dry out. The fungus causes pink boll rot. It first appears as small, rapidly expanding, reddish-brown spots on the capsule that blacken as they age. Then the surface of the boll is coated with thick, grayish to pinkish mycelium, which leads to the growth of small black fruiting bodies of the fungus.

Prevention and control

1. Proper seed and planting materials selection. Sow only disease-free seeds
2. Proper field sanitation
3. Remove and destroy infected parts but avoid touching other plant parts, especially when these are wet
4. Plow under all the plant debris after harvest
5. Practice crop rotation. Take notes of plants that are susceptible to anthracnose disease and rotate these with those that are resistant
6. Keep area free of weeds
7. Baking soda spray

Mix 1 tbsp of baking soda and 1 tbsp of dormant oil or vegetable oil. Add 4 liters of water. Stir well. Add ½ tbsp of dish washing liquid soap. Stir it again.

8. Bordeaux mix

To prepare a gallon mixture, mix 3 ½ tbsp of copper sulphate, 10 tbsp of hydrated lime, and 1 gallon of water in a plastic bucket or pail. Stir well using a wooden stick. Spray plants thoroughly preferably early in the morning, in a dry and sunny day. In this way, the plants have the time to dry and the solution can not penetrate into the leaves' tissues. Constantly shake the sprayer while in the process of application to prevent the solution from clogging.

Bacterial leaf blight

Symptoms



Infected leaf has angular, dark-green water soaked spots with red to brown margin that will eventually turn dark-brown or black due to death of the infected tissues. Severe infestation leads to premature falling of leaves (defoliation). As the disease progresses, the leaf petiole and stem may become infected resulting in premature defoliation. An infected stem is girdled with black lesions (black arm syndrome) causing it to die and break. An infected boll has round water soaked spots causing it to rot.



Leaf curl virus

Symptoms

Infected plant has stunted young leaves and shoots. It grows very slowly, becomes bushy, and dwarfed. The leaf margin rolls either inward or upward and is rather stiff with yellowish margin. Its leaves are thicker than normal, with leathery texture. The young leaves have yellowish color, cupped, thick, and rubbery. The flowers fail to open and drop so with the bolls.



Prevention and control

1. Use resistant or tolerant cultivars
2. Protect seedlings from whiteflies
3. Use only good seeds and healthy transplants
4. Control whiteflies
5. Immediately remove infected-looking plants and bury them
6. Control weeds
7. Do not plant cotton near tomato and/or other crops susceptible to whiteflies or vice versa
8. Plow-under all plant debris after harvest or burn them when possible
9. Practice crop rotation by planting crops that are not susceptible to whitefly

Root knot nematode

Symptoms



Infected plants have swollen, impaired roots.

Nematode's feeding stimulates the production

of galls (root knots). Galls are found on the root system both on the primary and secondary roots. Their sizes vary from .02 to 20 cm in diameter.

Severe infestation results in stunted growth, yellowing of leaves, wilting, and poor yield because the galls

disturb the roots ability to absorb water and nutrients. They also serve as openings for pathogens, such as fungi and bacteria, which cause plant diseases.

The gall is characterized by smaller swellings and more uniformly distributed infection on the lateral feeding roots. Inside the gall are shiny white bodies of the female nematodes (about the size of a pinhead). At the root surface, shiny white to yellow egg masses are found. A closer look with a magnifier may show the adults, but mostly they are not seen with the naked eye.

Prevention and control

1. Crop rotation. Broccoli, cauliflower, sorghum, Sudan grass, rape, and mustard seed are resistant to nematodes
2. Fallowing
3. Deep plowing
4. Use of resistant cultivars
5. Grow healthy plants
6. Remove weeds
7. Plant French marigold (*Tagetes patula*). Planting distance is 17.5 x 17.5 cm in between hills and rows. Two months after, plow them under.
8. Garlic oil emulsion. Mix 50 ml of garlic oil and 1 ml of soap. Blend well by stirring thoroughly. Add 950 ml of water. Stir again. To prevent oil from floating, apply extract immediately.
9. Fermented marigold extract
10. Fermented marigold extract
11. Fill-in drum with ½ - ¾ of flowering plants. Leave to stand for 5-10 days. Stir occasionally. Strain. Dilute the filtrate with water at a ratio of 1:2. Add 1 tsp of soap in every liter of extract.

Natural enemies

Damsel bug

Hosts

Aphids, armyworms, asparagus beetle, Colorado potato beetle eggs and nymphs, corn earworm, corn borer, imported cabbageworm, leafhoppers, mites, moth eggs, sawfly larvae, and tarnished plant bug

nymphs. Although they can survive for about two weeks without food, they will eat each other if no other prey is available.

Description

Eggs are deposited in soft plant tissues where they are so difficult to find.

Nymphs resemble adults and develop through 5 nymphal stages in about 50 days.

Adults are tiny, about 2-4 mm long, with slender bodies and are yellowish or gray or reddish-brown in color. They have piercing-sucking mouthparts, a 4-segmented beak, elongated heads, and 4 long segmented antennae. They are fast runners with long slender back legs and enlarged forelegs for grasping prey. They are commonly found in most agricultural crops, especially legumes, throughout the year. Adults begin laying eggs soon after emergence.



Conservation

They prefer to live in soybeans, grassy fields, and alfalfa. You can collect damsel bugs in alfalfa fields and release them around your garden.

Ground beetle

Hosts

Slugs, snails, cutworms, cabbage root maggots, grubs and insect pupae, and small caterpillars.

Description

Eggs are normally laid singly in the soil.

Larva is elongated and tapered toward the end, worm-like in appearance and have a large head directed forward.

Pupa is brownish black, small and found in the soil.

Adult ground beetles or Carabids are about 2-6cm long, dark shiny brown to metallic black, blue, green, purple, or multi-colored. They vary in shapes,- from elongated to heavy-bodied, - tapered head end with threadlike antennae, and have a ringed wing cover. Their heads are usually smaller than their thorax. Both adults and larvae have strong pincher-like mandibles. They have prominent long legs, which make them fast moving insects. Most species are nocturnal and they hide during the day in soil crevices, under rocks and stones, decaying logs, leaf litter, or composting ma-

terials.

When disturbed or when other vertebrates prey upon them, they emit an odor or gas, as a type of

defense mechanism, preventing them from being eaten by other predators. Ground beetles live on or below the ground, hence the name. Development from the egg to the adult stage takes about a year, although adults may live 2 to 3 years or longer.



Conservation

1. Practice mulching in some sections of your field to provide a habitat for the ground beetles.
2. Provide permanent beds and perennial plantings to protect population.
3. Plant white clover and/or amaranth as ground covers.

Hoverfly

Hosts

Aphids, thrips, psyllids, scale insects, small caterpillars, and larvae of Heliothis.

Description

Eggs are tiny, about 1mm in size, ovate-shaped, and glistening white. These are found laid singly and close to the developing aphid colony in the leaves, shoots, or stems of the plants. They hatch within 2-3 days.

The larvae, known as Syrphids, are legless slug like maggots, about 1-13mm in length depending on their larval stages. They usually have a mottled gray, beige, or light green color. They lift their pointed heads to look for preys. Once preys are located, their mouthparts suck out the contents of the preys. Larvae are frequently found feeding on aphids in the sheltered and curled portion of leaves. They blend well with their habitat and therefore they must be looked for closely to locate them.

Pupae are teardrop shaped and are found in the soil surface or in the plant's foliage.

Adult hoverflies are true flies with only two wings instead of four, which most insects have. Adults are large and beautiful insects about 13 mm long. They



have a dark head, a dark thorax, and a banded yellow and black abdomen. They closely resemble bees or wasps rather than flies. Their habit of hovering like humming birds gave them the names hoverflies or flower flies. They feed on pollen, nectar, and honeydew. They are good pollinators.

Conservation

Hoverflies are attracted to all flowering plants but even more so to small-flowered herbs like wild mustard, coriander, dill, lupines, sunflower, and fennel. It is advisable to have multiple crops as adults basically feed on pollen and nectar and it is advisable to allow

flowering weeds such as wild carrot and yarrow to grow between crop plants. Hoverflies' larvae are most noticeable in the latter half of the growing season when aphids are established.

Ladybird beetles

Hosts

Aphids, mealybugs, scale insects, spider mites, whiteflies.

Description



Eggs are yellow to orange in colour, football-shaped, and are laid in circular clusters of 10 -50 eggs on the underside of leaves or near the aphid colony.

Newly hatched larvae are gray or black and less than 4 mm long. They emerge as dark alligator-like flightless creatures with orange spots. Adult larvae can be gray, black, or blue with bright yellow or orange

markings on the body. The larvae are elongate and slightly oblong in shape. They undergo four instars before pupating.

The pupae are usually brightly patterned and can be found attached to the leaves and stems of plants where larvae have fed and developed.

Adults are oval to hemispherical and strongly convex with short legs and antennae. Most species are brightly colored. Body length ranges from 0.8-16 mm. Their colors tell other predators that they are tasteless and toxic. When disturbed, some of them emit a strong smelling yellow liquid as a protection against other predators. Their colors vary from red, orange, steel blue, yellow-brown, or yellow elytra, frequently spotted or striped with black. They feed on pollen, nectar, water, and honeydew but aphids or other prey are necessary for egg production. They are the best-known predators of aphids and are capable of eating up to 50-60 per day and about 5000 aphids in their lifetime.

Conservation

Lady bird beetles are found in most agricultural and garden habitats. Their presence indicates that natural biological control is occurring. It is important to maintain habitats planted with several flowering crops. These give the ladybird beetles varied food sources. When

food is not available, they tend to eat each other. Their beneficial predatory behavior and activities are continuous when there is no indiscriminate use of synthetic pesticides.

Spider

Hosts

Moths, caterpillars and any other insects they can catch

Description

1. Crab spiders are colorful crab-like spiders generally found on the blossoms of plants. They have the tendency to camouflage in their habitat so as to catch prey, unaware as they pass by. They are called crab spiders because their first four legs are larger than their hind legs and because of their capability to walk forward, backward, or sideways like a crab.
2. Dwarf spiders are very small and are always mistaken for spiderlings (newly hatched spiders) of other spider species. They measure about 1 to 5 mm in length. Adults have three pairs of spots or gray markings on the dorsal part of their spherical abdomen. They are normally found in groups at the base of a plant. They build webs and catch their prey by trapping them in their webs.
3. Grass spiders are moderately sized, brownish-gray weavers of funnel-shaped webs. Their webs are not sticky and can often be found on low-growing shrubs.
4. Jumping spiders are brown jumping spiders with brown hairs covering their body. They have two bulging eyes and these are arranged in three distinct rows. They have broadly or partly ovoid abdomens with light transverse basal bands
5. Long-jawed spiders have long legs and bodies, measuring 6 to 10 mm in length. Their eyes are arranged in two distinct rows. Their abdomens are brownish-yellow, with or without markings and are usually four or more times longer than their width. They prey on moths and flies and can consume 2 to 3 preys a day. Once their preys are caught, these are wrapped with silk in their webs.
6. Orb weavers, Argiope spiders are large yellow-black garden spiders, which produce zigzag stitches in the bottom center of large webs hanging between stems

of plants. They have poor vision and

can locate their preys by the vibrations and tension on their web

7. Wolf spiders have forked or Y-shaped median light bands on their outer coverings. Wolf spiders prey on moths and butterflies. They feed on 5 to 15 preys daily and they eat each other when their population is high.

Some spiders' eggs are laid in a cluster in silken sacs, while some species lay their egg masses covered with silks within folded leaves. Some of these sacs are attached to the mother spiders or mothers stay nearby to guard their egg sacs. Eggs usually hatch into spiderlings within three weeks. The spiderlings may remain attached to the mother for several days on some species, but for some species they are left on their own.

Spiders are not insects. They have 8 legs while insects have 6. They do not have wings whereas insects do. They have two body sections; a united head and thorax and abdomen, while insects have three; head, thorax, and abdomen.

A female can produce 200-400 eggs but only 60-80 spiderlings can hatch from these. Females can survive 2-3 months. In some species, females die after laying eggs.

All spiders are poisonous to insects but only a few species are poisonous to humans, like the Black widow and the Brown recluse.



Conservation and management

Mulching along some sections in dikes of rice paddies, in field corners, or a portion of the fields can increase the number of spiders. They can hide in the layer of mulch that serves as their alternate habitat. They can also prey on other small insects inside the mulch.

Remember, that the more food the spiders can eat, the faster their population build-up will become. Cover

crops are also important to provide over-wintering sites of spiders' sacs. A spider population depends on the availability of food, the habitat, and the environmental conditions. Avoid use of pesticides as much as possible, for broad-spectrum insecticides can easily kill them.

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