Field Guide to Non-chemical Pest Management in Corn Production

Pesticide Action Network (PAN) Germany
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

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We also wish to thank all the individuals, groups and organizations that have prepared the bases for the most control measures presented in this fieldguide, may it have been by preserving traditional experience, on field trials, on field research or in the lab.
Field Guide to
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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. It is supporting non-chemical pest management on tropical crops that are commonly grown by small landholder farmers through the project: Online Information Service for Non-chemical Pest Management in the Tropics, OISAT (www.oisat.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 on how to lower the cost of production based on recommended insect/mites pests, disease, and weeds control methods.

The ‘Field Guide to Non-chemical Pest Management in Corn 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 corn 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 corn 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 methods, plant extracts, other homemade solutions, and other practical methods.

For example, you notice that the corn stems have holes 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 methods (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 corn 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 corn field. To make a plan for you to grow a healthy crop, the following tips are the steps you ought to take:

1. Learn to identify the pests and other causal agents and the natural enemies
2. Select the proper corn variety that is well adapted to your local conditions
3. Always select good and diseased-free seeds. If possible, treat seeds to kill seed borne pathogens and insect pests
4. Have a healthy soil, but always keep in mind that over-fertilizing isn’t necessarily better
5. Practice crop rotation by planting on the next cropping season- crops of different family group
6. If possible practice intercropping to improve the field’s diversity and to encourage natural enemies
7. Follow the recommended planting distances
8. Prepare the soil thoroughly by appropriate tillage
9. Always practice proper field sanitation by removing and pruning infested plant parts, keeping the area free of weeds and other plant residues, and cleaning regularly all farm tools and implements
10. Monitor your plants regularly
11. When in doubt, always 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 plants/plant parts that are pests-free.
2. When storing the plants/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. Always test the plant extract formulation on a few infested plants first before going into large scale spraying.
7. Wear protective clothing while applying the extract.
8. Wash your hands after handling the plant extract.
Corn production

Climatic and soil requirement

Temperature: 21-30°C is the required daily temperature for adequate growth and development. Corn requires at least 8 hours of direct sunlight daily in order to grow its best.

Rainfall: 600-900 mm of rain is the average water requirement for the entire growing season. Best yield is usually 1,200-1,500 mm average (irrigated farms). Adequate rainfall after five weeks’ growth is found to improve the yield.

Soil pH: 5.5 - 7.0 is the average soil pH requirement but 5.8 is ideal

Soil type: Well-drained, well-aerated, deep soils containing adequate organic matter and well supplied with available nutrients.

Selection of planting materials

Corn is propagated by seeds.

When using corn seeds from your previous harvest as planting materials, do proper seed selection to ensure that the seeds are disease and insect-free.

Ask for assistance from your local agriculturist for the locally available varieties that are resistant to insect/mite pests and diseases and appropriate for the climatic conditions in your area.

Planting materials requirement

10-30 kg/ha with plant density that ranges from 20,000-80,000 plants/ha. The recommended planting rates and the crop density vary depending on the cultivars, planting distance, soil fertility, and climatic condition.

Land preparation

During the land preparation, choose the tillage practices that will ensure to keep the soil in its best physical condition for a favorable crop’s growth and development. To do this, till the soil to a depth which will physically support the plant and allow the use of sufficient moisture and nutrients; sufficient enough to control weeds; and must leave the soil surface level. A level field improves water use efficiency, helps control in crop weeds and allows the rapid removal of excess water.

Conservation and conventional tillage are both appropriate land preparation methods.

Conservation tillage is the planting or sowing in the previous crop’s residues that are purposely left on the soil surface while conventional tillage is the cultivation of the soil using plow, harrow and other farm tools or mechanical implements to prepare the field.

In conventional tillage, plowing and harrowing are practiced. Make the furrows during the last plowing and immediately do the planting to allow corn to germinate before the weeds and to conserve the soil moisture.

Method of planting

Surface or flat-bed planting. The seeds are drilled or hill-planted at a desired depth and row spacing. It is suited for areas with abundant water and heavy soil types.

Listed planting. The seeds are placed at the bottom on the V-shaped furrow. A lister which is double mold board blade is used for opening furrow. It is suited for areas where rainfall is a limiting factor and soil is friable.

Rridged planting. A specific form of no-till wherein seeds are planted on pre-formed ridges or hills or bunds from those of the previous crop. Sticks or other farm tools are used to make the openings for seeds.

The recommended planting distance (in between hills and in between rows) is 0.6-1m x 0.6-1m at 2-3 seeds per hill.

Sow the seeds 2-5 cm deep if the soil contains considerable moisture and 5-8 cm deep during dry weather condition.
Plant establishment

Corn grows well in monoculture as well as in intercropping. Corn monocropping is designed to maximize yield and to make use of the modern machinery. In large scale corn growing, modern machines are used to mechanically plant, control weeds, and harvest the crop in large volumes with maximum time efficiency. Intercropping is the cultivation of corn together with two or more crops simultaneously on the same field to effectively utilize the field, control pests, conserve and improve soil productivity, and improve farm biodiversity.

Intercropping corn with beans and other legumes regulates pests (leafhopper, leaf beetles, stalk borer, and fall armyworm). Intercropping corn with beans and squash enhances caterpillars' parasitism. This practice increases the abundance of natural enemies where food sources for beneficial insects are made available (Altiere; Nicholls, 2000). The intercropping system of corn-beans-squash is a low input and high yield strategy. Corn yield is increased by as much as 50% over monoculture yield. Although the yields for beans and squash are reduced, the overall yield for the three combined crops is greater than when grown separately in monocultures (Agroecology Research Group, 1996).

Intercropping Canavalia (Canavalia spp.) with corn improves soil productivity. Sow Canavalia seeds 4 weeks after sowing corn. Place 1 seed/hole in a row between corn rows with 50 cm between holes. Allow Canavalia to grow after harvesting corn until it is time to plant the next crop. Then plow under the plant materials into the soil (CIAT, 2000).

Desmodium (Desmodium uncinatum) and Melinis grass (Melinis minutifolia) when planted in between corn rows keep the stem borer moths away. These plants produce chemicals that repel stem borer moths. Intercropping corn with silver leaf desmodium and/or green leaf desmodium (D. intortum) controls striga. Desmodium emits chemical into the soil that is unfavorable for striga's growth. 2.5 kg of Desmodium seeds are needed for 1 ha (Herren; Pickett, 2000). Desmodium is a leguminous plant that is a good source of fodder for the farm animals. When planted as an intercrop, it covers the surface in between the rows of corn.

Napier grass (Pennisetum purpureum) and Sudan grass (Sorghum vulgare sudanese) are good trap crops for corn from stem borer attack. Napier grass has its own defense mechanism against crop borers by producing a gum-like substance inside its stem, this prevents larva from feeding and causing damage to the plant. Also, Sudan grass increases the efficiency of natural enemies when planted as border crops (Herren; Pickett, 2000).

Fertilizer requirements

Corn harvested at 2 t/ha grain and 5 t/ha stover utilized about 60 kg N; 10 kg P; and 70 kg K from the soil (CABI, 2005).

Corn is a heavy user of Nitrogen (N). While some nitrogen is supplied with manure, salt damage may occur if all the nitrogen comes from manure. Nitrogen requirement of corn is 220 kg/ha for maximum yields. Any decrease in the rate of N fertilizer applied will reduce yields. This suggests that the usual N fertilizer recommendation is much below the optimum level. N should be applied as split applications, ¼ - ½ either before or at planting. Depending upon the N leaching and the crop appearance, the remainder can be applied in one or two applications at about 40 days after germination (IFA, 2003). N deficiency results in a loosely filled cob, however, overuse of N should be avoided.

Many soils provide substantial amounts of the phosphorus (P) and potassium (K) but this is not adequate enough, especially at the seedling stage. Apply P near the seed for early seedling vigor. K is taken up in large quantities but plants' requirement can usually be estimated by soil analysis. K deficiency results in empty cob ends, while P deficiency results in hollow grains.

Sowing the seeds during the first rain allows the roots to absorb the natural nitrates formed by the bacterial action in the soil.

Soil analysis provides the very best chance of getting the right amount of fertilizer without over or under fertilizing. Ask for assistance from your local agriculturist office for soil sampling and soil analysis procedures.

Pest management

Refer to p.p. 13
Weed management

Weeds are reduced when the field is thoroughly plowed and harrowed twice during the land preparation.

When the plants reach a height of about 1 meter, do inter-row cultivation to control the weeds. Removal of weeds is done by hand weeding, shallow cultivation, or by harrowing.

Corn is very sensitive to weed competition during the first 4-6 weeks after emergence. Off-barring and hilling-up are cultivation practices that control weeds.

Harvesting

60-70 days for the very early maturing varieties and up to 200 days for very late maturing ones.

Sweet corn is harvested 60 days after sowing.

Yield

60-70 days for the very early maturing varieties and up to 200 days for very late maturing ones.

Handling and storage

Corn for storage must have a moisture content of 12-14%.

Store the sun-dried kernel or cobs on a well-ventilated area.
Insects/Mites

Ants

Damage

Ants take the sown seeds back to their colony, feed on germinating seeds and on young seedlings. They tend insect pests like aphids, scales, whiteflies, mealybugs, and other honeydew producing insects. These actions result in missing hills, thus loss of plant stand, uneven growth distribution in the field, and an increased incidence of diseases caused by the abovementioned insects.

Description

Eggs are delicate, soft, white, and are laid in clusters of 75-125 eggs.

The larva is grub-like, legless, very soft, and whitish in color. It inflicts no damage as it depends on the worker ant (older sibling) for care and food. The pupa is whitish and develops inside the ant’s nest. It has visible legs and in some cases, wings. The pupal stage is the transitional stage between the larva and the adult which emerges during the final molt.

An adult ant varies in color, from blackish to reddish-brown depending on its species. It has robust mandibles with strong teeth that could inflict painful bites. It has elbowed- antennae, a thin waist, and if it is winged, the hind wings are smaller than the front wings and have few veins.

Ants are also beneficial insects because they prey on termites, eggs, pupa, and caterpillars of other insect pests. Nevertheless, ants should not be introduced into corn fields for insect pest control.

Control measures

Cultural practices

1. Increase the seeding/seedling rate. This practice turns out cheaper than with the use of insecticide.
2. Control mealybug, aphid, whitefly, and other insects that excrete honeydew. The ants are likely to be found in plants infested by these insects because they protect them for their food.

Other solutions

Ant oil spray
Mix 2 tbsp dish washing soap, 2 tsp vegetable oil, 2 tbsp salt, and few drops of vinegar into 4 liters of water

Soap spray

Method of preparation
Mix 2½ tbsp of liquid soap to a gallon of water.
Stir well.

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

Pests controlled
Ants
Leafhoppers
Mealybugs
Psyllids
Scales
Spider mites
Thrips
Whitetlies and
Plant diseases
Aphids

**Damage**

The leaves wilt, curl, and have yellow patches. The tassels and silks are covered with honeydew. Damage during the late-whorl and pollination stages causes shortening of the inter-nodes, shriveled and shrunk ears, and empty cobs.

Aphids produce large amounts of a sugary liquid waste called honeydew. A fungus, called sooty mold, grows on honeydew deposits that accumulate on leaves and branches, turning leaves and branches black. The appearance of a sooty mold on plants is an indication of an aphid infestation.

**Description**

The eggs are very tiny, shiny black, and are found in the crevices of bud, stems, and barks of the plant.

The nymphs look like the young adults, mature within 7-10 days, and are then ready to reproduce.

The adults are small, 3-4 mm long, soft-bodied insects with two projections on the rear end and two long antennae. Their body color varies from yellow, green, brown, to purple. Females can give birth to live nymphs as well as can lay eggs. However, the primary means of reproduction for most aphid species is asexual, with eggs hatching inside their bodies, and then giving birth to living young. Winged adults, black in color, are produced only when it is necessary for the colony to migrate, or there is either overcrowding in colonies, or unfavorable climatic conditions.

**Control measures**

**Cultural practices**

1. Control and kill ants. Cultivate and flood the field. This will destroy ant colonies and expose eggs and larvae to predators and sunlight. Ants use the aphids to gain access to nutrients from the plants.

**Physical methods**

- **Yellow basin trap**
  Half-fill yellow pan or basin with soapy water. Place the pan close to the plant but exposed enough so that aphids will see it.
  
- **Yellow sticky board traps** (refer to p. 18)

**Plant extracts**

- **Ginger rhizome extract**
  Grind 50 g of ginger and make into paste. Mix with 3 liters of water. Strain. Add 12 ml of soap. Mix well. Ten (10) kg of ginger in needed for 1 ha.

**Other solutions**

- **Ammonia spray**
  Mix 1 part ammonia with 7 parts water. This spray also controls flea beetles, scales, thrips, and whiteflies.

- **Neem leaf extract** (refer to p. 16)

- **Neem powdered seed extract** (refer to p. 16)

- **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. This spray also controls other caterpillars.

- **Flour spray**
  Method of preparation
  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.

- **Flour spray (refer to p. 13)**

- **Soap spray**
  (refer to p. 13)

- **Pesticide Action Network (PAN) Germany**

- **Pests controlled**
  Aphids
  Spider mites
  Thrips
  Whiteflies
Army worm

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

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 when 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.

Control measures

Cultural methods

1. Practice proper field sanitation. Cut weeds from bordering fields. Remove weeds regularly to reduce breeding sites and shelter for armyworm. Remove all plant debris after harvesting.
2. 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.
3. Plow and harrow field thoroughly. Sometimes small grains or grasses are plowed-under after the eggs are laid on them and then the field is planted to new crops. As the plants begin to grow, the larvae develop and work-up through the soil and attack the plants.

Physical methods

1. Deep ditch. Plow a deep ditch and keep it filled with water, if larvae are found to be moving towards your field crops from adjacent fields. This will prevent larvae from transferring. They will drown if they try. Another method is to dig a deep ditch with vertical sides to trap larvae and prevent them from crawling out. Holes with a diameter of a fence post should be dug every 10 meters apart in the ditch. Larvae will congregate in the deeper holes where they maybe crushed.
2. Pitfall traps. Make pitfall traps. Pitfalls are the best means of collecting crawling insects.
3. Bring herds of cattle, sheep, or goats back and forth across affected areas to step on the worms.
4. Beat worms with sticks and twigs.
5. Hand pick the larvae or let chickens feed on larvae.
6. Listen to radio announcements for armyworm outbreaks.
Corn borer

Damage

Corn borer larvae begin feeding on leaf surface or in the whorl. There are pinholes on leaves at the whorl stage. As the plant grows, they bore holes into leaf midribs down into the stalks. Excreta or frass are found near entrance holes. Tassels are clumped where they later feed. Stalks and tassels are broken. They feed last on corn cob and cause ear to drop, in severe cases.

Description

The egg is white and laid in masses like fish scales. An egg mass has 5-50 eggs. The egg mass or 2-3 more can be found on the plant leaf. Eggs become cream-colored and dull as they mature. Before hatching, the black heads of the larvae can be seen through the transparent egg membrane. Eggs hatch 4-9 days later.

The larva is flesh colored, ranging from light gray to light pink with small round dark brown spots on each segment. The larva has a brown head and indistinct reddish stripes running the length of its body. A mature larva is about 2-3 cm in size. The reddish brown pupa is found inside the larval home (inside the stems or ear where it has been feeding).

The pupa is reddish-brown and approximately 2-2.5 cm long with segments evident on half of the body. The pupal stage lasts about 2 weeks.

The adult female is a creamy, brownish yellow moth, and about 3 cm long. The forewings of the female are usually lighter in color than that of the male. The hind wings of both males and females have light markings. The reddish-brown male has a long slender body and is smaller than the female.

Control measures

Plant extracts

Pongam seed extract (Pongamia pinnata, P. glabra)

Add 50 grams of pongam seed powder into 1 liter of water. Strain. Add a few drops of soap. Stir.

Physical methods

Detasseling

Remove 75% of the tassels of the total plant population before the pollen shed. Follow a 1 tasseled and 3 detasseled ratio. The first row should always be with tassels. Detasseling is the removal of corn tassels. It helps minimize corn borer infestation since the larva wants to stay first in the tassels before going into the ear. Get the assistance from a local agriculturist when doing this for the first time.

Neem powdered seed extract

Method of preparation

Add 50 grams of powdered kernel in 1 liter of water. Let it stand for 6 hours but not more than 16 hours. Add soap and stir. Constantly shake the container or stir the extract while on the process of application.

Pests controlled

Aphids
American bollworms
Cotton leaf rollers
Diamondback moths
Grasshoppers
Leafhoppers
Leafminers
Mexican bean beetles
Whiteworms

Neem leaf extract

Method of preparation

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.

Pests controlled

Aphids
Colorado potato beetles
Grasshoppers
Grubs
Japanese beetles
Leaffoppers
Locusts
Plant hoppers
Scales
Snails
Thrips
Weevils
Whiteworms
Corn earworm

**Damage**

Larvae feed on leaves, tassels, whorls, silks, and within ears. When larvae feed on corn silks, they clipped these off prior to feeding on the corn ears. The ears are the preferred sites for corn earworm attack. Ear damage is characterized by extensive excrement at the ear tip. They remain feeding in the tip areas until they leave to pupate in the soil.

**Description**

The eggs are pinhead-size and yellow-green in color. These are found singly laid near the midrib usually underneath the leaf. 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 about 3-5 cm. They drop to the ground to burrow into the soil to pupate. The larval stage lasts from 12-24 days.

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

An adult male is yellow-brown while a female is orange-brown in color. It has a wingspread size of about 3.8cm. Each female may deposit 200-2,000 eggs in her entire lifetime. Total development period from egg to adult is 34-45 days.

**Control measures**

**Cultural practices**

1. Do not plant other solanaceous crops after harvesting corn. Never use corn as rotation crop for sorghum, cotton, and other solanaceous crops and vice versa.
2. Avoid planting tomato near corn or cotton or other solanaceous crops to prevent heavy pest infestations.

**Plant extracts**

*Ginger, garlic, and chilli extract*

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

Add 3 liters of water.

**Physical methods**

*Pheromone traps*

Place pheromone traps at a distance of 3 meters. If use to monitor the pest, place 2-3 traps in a hectare field area. Buy the pheromone that attracts the pests you want to control. Read the label and follow the instructions properly.

To make your own traps, make 10-12 holes into an old plastic bottle or 3 holes on each side of a used 1 liter ice cream container to allow moths to enter. Place a wire to suspend the bait. Half-fill the container with soapy water. Hang the pheromone capsule using a string or wire. Attach the trap to a stake or hang it on branch of a tree.
Corn seedling maggot

Damage

Larval feeding causes deadhearts, wherein the central tiller of the seedling is dry. It causes the plant to die causing missing hills in the field. Unlike the damage caused by stem borers, the dried tiller is rotten at the base when pulled. The infested leaves are ragged in appearance, discolored with transparent patches of damaged leaf tissue along the margins. Larval feeding damages rice seedlings less than one month old and damages corn seedlings after emergence.

Description

Eggs are white, elongated, and 1.5 mm long. They are laid singly or in mass on the leaf blades of the rice/corn seedlings that are glued to the leaf blades by a sticky substance secreted by the female. Egg incubation is 3 days and hatching occurs in the morning.

The larva is very shiny yellow and is maggot-like. The morning dew allows the maggot to move up and down the leaf blade to feed on the internal tissue of the plant. After passing through three larval instars in 6 to 10 days, the maggot pupates in the soil or within the base of the tillers or stem.

The pupa is small and brown in color. Pupation lasts about 8 days.

The adult fly is yellowish gray and about 3 to 3.5 mm long. It has an angular head with deep-set antennae and two to three pairs of dorsal black spots located on the lower half of the yellow abdomen. The female flies are attracted to plants less than a month old, where they lay their eggs. They can lay as many as 100 individual eggs in her life span of 3 to 7 days. The adult can live for 10 to 12 days.

Control measures

Physical methods

Fish meal bait

Adult flies are highly attracted to fish meal. Attach an inverted wire mesh cone trap (with the bait) to bamboo or wooden stake measuring 1-2 meters high.

Sticky board trap

To use, place 1-4 sticky cards per 300 sq m field area. Replace traps at least once a week. To make your own sticky trap, spread petroleum jelly or used motor oil on painted plywood of desired color, 6 cm x 15 cm in size or up. Place traps near the plants but far away enough to prevent the leaves from sticking to the board. Traps when hung should be positioned 61 cm zone above the plants.

Pests monitored/controlled

Blue sticky cards
Thrips

White sticky cards
Flea beetles, tarnished plant bugs

Yellow sticky cards
Aphids, cabbage root maggots, carrot rust flies, cabbage white butterflies, gnats, whiteflies
Corn stalk borer

**Damage**

Feeding damages of the larvae are holes in the leaves, holes on stalks, death of the plants’ growing points, and damaged developing cob seeds.

**Description**

The eggs are laid in cluster of 30-50 and are found between the leaf sheath and the stem.

The larva is pale yellow or pink in color with black spots along its body. It grows to about 4 cm long. Before pupation, the larva bores an exit hole to prepare its escape when it becomes an adult. Laval stage lasts for about 35 days or longer, depending upon the climatic condition.

The pupa is found inside the hollowed out stalk. The pupal stage lasts about 2-3 weeks.

The adult moth is brown with a wingspan of 35 mm. It is active during the night.

**Control measures**

**Physical methods**

*Ash-chilli powder*

Place a pinch of chilli powder and ash mixture at the funnel of the plant when pin-sized holes are found. To make your own mixture, sieve ash to remove the big particles and grind finely dried chilli fruits. Mix 2 kg of ash with 50 g of powdered pepper, a mixture which is good enough for a 0.4 ha area.
Cutworm

**Damage**

Cutworms feed on seedlings. The seedlings are often cut off at ground level. The larvae can be found in the soil (up to a depth of about 5 cm) near the 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 full 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 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**

Sunflowers and cosmos 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.
Flea beetles

**Damage**

The beetle is a leaf feeder. It chews long, narrow feeding scars on the primary leaves and first 3 or 4 true leaves. Heavy damage gives plants a grayish-white or silvery appearance. The beetle transmits pathogen that can cause bacterial wilt on corn.

**Description**

The eggs are oval and yellow in color. These are laid singly or in a small group near the base of the corn plant.

The larva is small, white, and not very active. It resembles a small rootworm that feeds on corn roots but causes no significant injury.

The pupa is white, shaped roughly like adult and pupates in the soil. It is found in the soil near the base of the plant on which it has been previously feeding.

The adult is a very small, smooth, shiny, somewhat round, black beetle. The hind legs are distinctly enlarged and thickened. They all jump vigorously like fleas when disturbed, hence the name.

**Control measures**

**Cultural practices**

Try a high seeding rate and thin plants once established.

**Physical methods**

- *White or yellow sticky board traps*

  (refer to p. 18)

- *Mulching*

  Place 2-3 inches of cut grasses or 2-4 inches of bark mulch and wood chips or 3-4 inches of compost as your mulching materials to interfere the larvae’s root feeding activities.

**Plant extracts**

*Neem oil spray*

*Neem kernel extract*

Add 30 grams of powdered kernel in 1 liter of water. Let it stand for 6 hours but not more than 16 hours. Add soap and stir. Constantly shake the container or stir the extract while in the process of application.

**Neem oil spray**

**Method of preparation**

Add 30 ml of neem oil into 1 liter of soapy water. Constantly shake the container or stir the extract while in the process of application to prevent oil from separating.

**Pests controlled**

Flea beetles
Gall midge
Leafhoppers
Japanese Beetles

**Damage**

The beetles’ feeding damage is on the maturing silk that prevents proper pollination. This results to missing seeds in the corn ear.

**Description**

The eggs are white, small (about 1.5 mm), and oblong when newly laid. These are laid in moist soil at a depth of 7.5 cm, either singly or in a batch of 4. The eggs absorb water from the soil, become spherical, and double in size within a week. The developing embryos are visible within the eggs when they are about to hatch. The eggs hatch after 2 weeks.

The larva is called the white grub with a V-shaped series of stiff hairs on the snout. It has yellowish-brown head with strong mandibles. The body has 3 segments, each segment having a pair of jointed legs. It is usually in a C-shaped position when found in the soil. Newly hatched larva is about 1.5 mm long and reaches 3.2 cm long when fully matured. Upon hatching, the larva starts feeding on the fine roots and organic matters in the soil.

The fresh pupa is creamy, turns reddish-brown, and finally becomes metallic-green when it reaches maturity. It looks like the adult but the wings and other appendages are closely folded to the body.

The adult is broadly ovate-shaped with shiny metallic-green color body and dark-copper green legs. The wings’ covers are copper-brown. Its abdomen is colored green with white patches and has a row of five tufts of white hairs on each side. The white patches on the green abdomen distinguish Japanese beetles from all other beetles. The newly emerging adult beetle (from the ground) immediately looks for food. Then it releases an odor as a signal to other emerging adults where it is located. This will result to a group of adults meeting and feeding on a single host plant.

**Control measures**

**Pathogens**

*Bug juice spray*

Pound or grind ½ cup of beetles in 2 cups of water. Strain. Dilute ¼ cup of this concentrate in 1-2 cups of water. The odor of crushed beetles sprayed on the plants repels new beetles of the same species to come and also the odor attracts the natural enemies of the pests. Use the spray to control the same pest species that is in the mixture. Spray the plants thoroughly. You can apply once or twice but bug spray is reported to be effective for as long as 2 months.

Precaution: There has not been much research done on bug juice. Avoid direct contact while preparing juice. Wash materials used thoroughly and wash sprayed produce before using or eating it.

**Physical methods**

1. *Bird perches*
   Build perches made of bamboo/wooden poles and place in strategic locations to attract birds to rest. Cooked rice can be used as an additional bird attractant. Birds are good pests’ predators.

2. Raise chickens in backyards. They are good white grub eaters.

3. Handpick beetles and feed to chickens or place in a pail of soapy water to drown.

4. Collect beetles by shaking the plants to let them fall onto the sheet of old/used papers placed underneath the plants. Put collected beetles into a bucket of soapy water to drown. The soapy water will prevent them from flying away.

5. Make bait traps of mashed fruit, sugar, yeast and water. Place these baits on the perimeter of the field in plastic containers with an entrance hole cut at the top. Beetles love to feed on sweet smelling food. Choose sunny spots and strain the bodies out of traps every day.
Seedcorn maggots

Damage

The maggot burrows into the seeds and the seedlings, proceeds into the lateral roots, then tunnels into the taproot, and sometimes bores into the base of the stem. Damaged plants will wilt, stunt, and/or eventually die. The damaged seedlings do not have primary leaves and/or severely damaged primary leaves.

Description

Eggs are elongate and pearly white with a diagonal pattern. They are deposited near the seeds or seedlings, especially those grown in soil with abundant organic matter.

Larvae are small maggots, yellowish white to dirty yellow, and legless. They undergo three larval stages. Larval development lasts for about 12-16 days.

Pupae are tan to brown in color. They are situated near the host plant. The pupal stage is about 7-20 days.

The adult flies are grayish brown and look like small houseflies. The female adults prefer to lay their eggs in newly harrowed fields. They can lay about 100 eggs over a 3-4 week period. Life span is about 1-2½ months.

Control measures

Cultural practices

1. Sowing shallow in a well prepared soil to ensure quick germination of seeds.
2. Allow plant residues to decompose properly for a moist heavy-textured soil is very attractive to the pests.
Spider mites

Damage

Generally, mites feed on the undersides of leaves. They use their sucking mouthparts to remove plant sap. The upper leaf surface has a speckled or mottled appearance while the underneath appears tan or yellow and has a crusty texture. Infested leaves may turn yellow, dry up, and drop in a few weeks. Mites produce large amount of webbing. Heavy infestation will result in a fine cobwebby appearance on the leaves. Plants die when infestation is severe.

Description

The eggs are tiny, spherical, pale-white, and are laid on the undersides of leaves often under the webbings. Eggs hatch in 4 or 5 days.

Nymph looks similar to the adult but is only the size of an egg. It has only 6 legs. It molts 3 times before becoming an adult.

The adult is also very tiny, maybe yellowish, greenish, pinkish, or reddish depending on the species. It looks like a tiny moving dot. It has an oval body with 8 legs and with 2 red eyespots near the head of the body. The male is smaller than the female with a more pointed abdomen. A female usually has a large, dark blotch on each side with numerous bristles covering her legs and body. Spider mite is not an insect.

Control measures

Cultural practices

1. Provide plants with adequate water. Water-stressed plants are prone to damage by mites.
2. Avoid the use of broad spectrum insecticide for this may cause a mites’ outbreak. This practice kills the natural enemies of mites and stimulates mites’ reproduction.

Physical methods

1. Hosing with a strong jet of water knocks off mites and destroys their webs. Be sure to include the underneath of the leaves.
2. Apply water to pathways and other dusty areas at regular intervals.

Plant extracts

Coriander seed extract

Pound or crush 200 grams of coriander seeds. Boil in 1 liter of water for 10 minutes. Cool and strain. Dilute extract with 2 liters of water. This extract also prevents fungal diseases.

Basil leaf extract (refer to p. 27)

Other solutions

Horticultural oil

Spray 2% solution against mites. To make a 2% solution, pour 1/3 cup oil into a 1 gallon container, and then fill with water to make a 1 gallon solution. For a 3% solution, start with ½ cup of oil. Apply successive sprays at least 6 weeks apart. You can apply 1% oil solution by mixing 2.5 tbsp of oil in 1 gallon of water. Horticultural oil is concentrated and must be mixed with water.

Milk spray

Method of preparation

Mix ½ liter of milk to 4.5 liters of water (Milk and water ratio is 1 part milk to 9 parts water). Spray at weekly interval as a preventive control measure.

Pests controlled

Spider mites
Mildews
Mosaic virus
Leaf blights
Fungal diseases

Other substance

Milk spray
White grubs

**Damage**

White grubs feed on the main roots of the plants. They cut the main stems and roots of plants below the surface of the soil. They tunnel into tubers of root vegetables and root crops. These feeding habits affect the underground portion of the stems and roots causing the plant to wilt and eventually die.

**Description**

The white grubs are the larvae of Japanese and May/June beetles. They are white or yellowish in color, with tan or brown heads, and with 6 spiny legs. They have fleshy, wrinkled C-shaped bodies. Upon hatching they are quite small but can measure up to 2-4 cm when they mature.

**Control measures**

**Cultural practices**

Ensure proper drainage. Grubs love moist soil, especially with decaying organic matter. Female beetles prefer to lay eggs on moist-decaying organic matter.

**Plant extracts**

- **Papaya water extract**
  
  Pound 1 kg of papaya leaves. Add the pounded leaves in 10 liters of water. Leave to stand for 2 days. Strain.

**Pathogens**

- **Bug juice spray**
  
  Pound or grind ½ cup of beetles in 2 cups of water. Strain. Dilute ¼ cup of this concentrate in 1-2 cups of water. The odor of crushed beetles sprayed on the plants repels new beetles of the same species to come and also the odor attracts the natural enemies of the pests. Use the spray to control the same pest species that is in the mixture. Spray the plants thoroughly. You can apply once or twice but bug spray is reported to be effective for as long as 2 months.

  **Precaution:** There has not been much research done on bug juice. Avoid direct contact while preparing juice. Wash materials used thoroughly and wash sprayed produce before using or eating it.

**Physical methods**

1. **Bird perches**
   
   Build perches made of bamboo/wooden poles and place in strategic locations to attract birds to rest. Cooked rice can be used as an additional bird attractant. Birds are good pests' predators.

2. Raise chickens in backyards. They are good white grub eaters.

3. Handpick beetles and feed to chickens or place in a pail of soapy water to drown.

4. Collect beetles by shaking the plants to let them fall onto the sheet of old/used papers placed underneath the plants. Put collected beetles into a bucket of soapy water to drown. The soapy water will prevent them from flying away.

5. Make bait traps of mashed fruit, sugar, yeast and water. Place these baits on the perimeter of the garden in plastic containers with an entrance hole cut at the top. Beetles love to feed on sweet smelling food. Choose sunny spots and strain the bodies out of traps every day.
Wireworm

**Damage**

Wireworms destroy the germinating seeds and tiny seedlings by cutting off underground roots resulting in missing stands. They attack the stems of newly set plant by boring into the stems near the soil surface. Some plants may wilt and die within a few days or may have stunted growth. Often, the wireworm is found near the damaged or missing seed or plant.

**Description**

Wireworms are the larvae of different species of Click beetles. Larvae are slender and hard and feel somewhat like wires. Their bodies are segmented and shiny and are usually cylindrical, but flat on the lower sides. There are three pairs of legs close together near the head and no prolegs. Some of the most common species are white, yellowish-brown to reddish-brown, although other species may vary in color.

**Control measures**

**Cultural practices**

1. Where damage has been severe in the previous cropping seasons, avoid planting or fallow the area. Click beetles, the adult wireworms, return to the same fields to lay eggs.
2. If field is irrigated, flood it for at least a month, during sunny weather, to eliminate wireworms.
3. Grow Flax (*Linum species*) as a cover crop to kill wireworms. It is also good for controlling root knot nematodes. White mustard and Buckwheat plants are also found to reduce the wireworm population.

**Physical methods**

*Corn/wheat seed mixture bait*

Soak mixture in water for 24 hours to facilitate germination. Place ½ cup (of a 1:1 corn/wheat seed mixture) in a hole that is 12 cm wide and 30 cm deep. Cover with soil. Cover the topsoil with plastic to warm the surface and to speed up germination.

Cover the edges with soil to prevent wind from blowing away the plastic. Remove the plastic, the soil cover, and the bait. Destroy larvae trapped in the baits. This method is also used to monitor white grub population.

*Potato/carrot bait*

Cut potatoes or carrots into chunks. Remove the potato 'eyes' to prevent from further growing. Make the pieces big enough and put in sticks. Bury "staked potatoes/carrots" at a depth of 3-6 cm in the ground. The stick serves as the handle to easily pull the baits out. Bury randomly in the field. Leave baits in the soil for 2-3 days. Wireworm will feed on the baits. Dispose the baits and the wireworm properly.

**Plant extracts**

*Red cedar leaf extract for seed treatment*

Pound 1 kg of red cedar leaves. Soak the pounded leaves in equal amount of water overnight. Strain to get a clear filtrate. Treated seeds should be sown immediately.
Nematodes

Root knot nematodes

**Host**

A wide variety of agricultural crops and weeds.

**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.

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.

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.

**Prevention and control**

1. *Basil leaf extract*
2. *Fermented marigold extract*
3. *Neem seed extract*

   Pound gently 3-5 kg of de-shelled neem seeds. Add 10 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 this extract with 9 liters of water. Add 100 ml of soap. Stir well. This spray material also controls most of the insects/mites pests of tomato.

### Fermented marigold extract

**Method of preparation**

- Fill-in container with ½ - ¾ of flowering plants
- Leave to stand for 5-10 days.
- Stir occasionally
- Strain
- Dilute filtrate with water at a ratio of 1:2

**Diseases controlled**

- Tomato blights
- Rice blast
- Coffee berry disease

### Basil leaf extract

**Method of preparation**

- Grind leaves 50 g of basil leaves
- Soak overnight in 2-3 liters of water
- Strain
- Add 8-12 ml soap
- Stir well

**Pests controlled**

- Caterpillars
- Fruit flies
- Red spider mites
- Red scales
- Spotted leaf beetles
- Fungal diseases
- Nematodes
Diseases

Anthracnose

Symptoms

Small, round to irregular watersoaked spots first appear on the lower leaves. Spots later turn yellow and then brown with reddish-brown borders. Yellow zones often develop around the leaf spots. Numerous spots expand and join all together causing the leaf tips or the entire leaves to turn yellow.

Prevention and control

1. Baking soda
2. Basil leaf extract (refer to p. 27)
3. Compost tea spray
4. Onion bulb extract

Baking soda

Method 1
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

Method 2
Dissolve 1 tbsp of baking soda in 4 cups of warm water
Add 1 tsp of liquid soap
Stir well

Method 3
Mix 1 tbsp of baking soda and 2 ½ tbsp of vegetable oil
Add 4 liters of water
Stir well

Onion bulb extract

Method of preparation
Finely chop 50 g bulb onion.
Add to 1 liter of rain water.
Strain.

Diseases controlled
Alternaria
Anthracnose
Fusarium wilt
Fungal leaf blight

Compost tea spray

Method of preparation
Put a gallon (4 liters) of well-matured compost into a 5 gallon (20 liters) container.
Add water until the container is full.
Stir well.
Place in warm place for 3 days to ferment.
Strain.

Diseases controlled
Fungal diseases

Diseases controlled
Powdery mildew, black spot, and other fungal diseases.
Bacterial soft rot

**Symptoms**

An infected plant has a tan or dark-brown, water-soaked, soft stalk that suddenly collapses and is usually twisted. The initial sign is the premature withering and drying up of the tips of the uppermost leaves, then the lower leaves, soon followed by the appearance of a slimy soft rot at the base of the whorl. The decay spreads rapidly downward until the affected plant collapses. The diseased plant often has a foul odor.

**Prevention and control**

1. Compost tea spray (refer to p. 28)
2. Copper spray / Bordeaux mix
3. Garlic bulb spray
4. Lemongrass extract
5. Mint leaf extract

Corn rust

**Symptoms**

The initial symptoms are yellow spots on leaf surfaces. The spots develop into oval to elongate reddish-brown powdery and elevated lesions that contain a powdery mass of orange to reddish-brown spores (pustules) on the upper and lower leaf surfaces. The pustules are generally small, less than 0.6 cm, and are surrounded by the leaf epidermal layer which appears as a whitish covering. The spores became brownish-black when they mature. Damage is most abundant on the leaves but may appear on any above ground portion of the plant.

**Prevention and control**

1. Papaya leaf extract
   - Soak 50 grams of finely shredded papaya leaves. Stir vigorously. Let it stand overnight. Squeeze the extract using muslin cloth. Dilute the filtrate with 2-3 liters of water.
2. Copper spray / Bordeaux mix

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<td>Grind 250 g of mint leaves Make into a paste Add 2 liters of water Stir well and ready for use or strain it to have a clear extract</td>
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**Copper spray (Bordeaux mix)**

**Method of preparation**
Mix 3 ½ tbsp of copper sulphate, 10 tbsp of hydrated lime and 1 gallon of water (4 liters of water) in a plastic bucket Stir using wooden stick

**Pests controlled**
Flea beetles Anthracnose Bacterial blight Bacterial wilt Black spot Downy mildew Late blight Powdery mildew Rust and many other disease causing pathogens

**Cautions**
Use only plastic or any non-corrosive containers Shake or stir to prevent extract from clogging Spray only on dry and sunny day, preferably early morning.
Corn smut

**Symptoms**

An infected kernel is enclosed with spongy, white-silvery or greenish-white coating and as the disease intensifies, the coat bursts and a brown or black, powdery mass of spores is exposed. The tassel and corn ear infection is the most noticeable but the fungus may infect any aboveground parts at all growth stages. An infected corn ear is enclosed partially or wholly by the smut gall on the outer corn husk.

**Prevention and control**

1. Baking soda (refer to p.28)
2. Copper spray (refer to p. 29)

Gray leaf spot of corn

**Symptoms**

Initial leaf infestation appears as tiny to slightly elongated, roughly parallel-sided spots with yellow margins. The later stage of infestation shows rectangular tan to gray spots that remain evident on completely blighted leaves. The fungal growth on the lesions gave a characteristic grayish cast, hence the name.

**Prevention and control**

1. Aloe and vitex extract
2. Basil leaf extract (refer to p. 27)
3. Compost tea (refer to p. 28)
4. Onion bulb extract (refer to p. 28)

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Aloe and vitex extract

**Method of preparation**

Soak 5 kg of vitex leaves in sufficient amount of water and then bring to boil for 30 minutes

Strain

Add 2 liters of aloe vera juice

Stir in 50 ml of soap

Add 50 liters of water

**Pests controlled**

Bacterial and fungal diseases

Armyworm

Hairy leaf-caterpillar

Rice leaf roller

Rice stem borer

Semi-looper
Natural enemies

Braconids

Hosts

Ants, aphids, armyworms, beetle's larvae, bollworms, cabbageworms, caterpillars, codling moths, corn borers, cutworms, imported tent caterpillars, leafhoppers, leafminers, maggots, midges, plant bugs, scales, tomato hornworms, weevils, and many more.

Description

Eggs and larvae of Bracons are found inside the host's bodies.

The larvae are tiny, cream-colored grubs that feed in or on other insects. Larvae molt five times and undergo 5 instars.

Pupae of some species live and pupate within the host until they mature; others pupate in silken cocoons on the outside of the body of the host, while others spin silken cocoons away from the host.

Adult wasps are tiny, about 2.5 mm in size, slender black or brown with threadlike waists.

Female wasps lay eggs into the eggs of hosts' pests but prefer caterpillars' bodies.

In cases where aphids are the host pests, aphids are not killed instantly. Aphids continue to feed on plants' tissues until the Braconid larvae inside their bodies completely consume them. The fully-grown Braconid larvae cement the dead aphids to the leaf surface making aphids' shells black and mummified. About a week later, the adult Bracon wasps cut round holes in the mummies and emerge. The empty mummies remain on the leaf. The presence of mummies in a colony of aphids is a sign that Bracons are present.

Conservation

Adult Bracons feed on nectar, honeydew, or pollen before laying eggs. Dill, parsley, yarrow, zinnia, clover, alfalfa, parsley, cosmos, sunflower, and marigold are flowering crops that attract the native braconid populations and provide good habitats for them.
Damsel bugs

**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.

Encarsia

**Hosts**

Various whitefly species

**Description**

Eggs are found inside the body of the host larva.

The larvae develop within the whitefly larvae passing through four larval stages. The host pupa turns black when Encarsia pupates inside the whitefly. Adult wasps emerge from the parasitized pupae by chewing a hole in the top of the scale.

Adults are very tiny wasps, about 1 mm in size. These parasitic wasps can look actively and effectively for whiteflies. They can cover distances of 10-30 m looking for hosts. Adult females attack young whitefly larvae by stinging and laying eggs inside them. An adult female wasp can lay 60-100 eggs. The life cycle is completed within 2-4 weeks depending on the climatic conditions. Adults can live for 30 days but are active for about 10 days.

Adult wasps feed on honeydew and the body fluids of whitefly larvae. They also feed directly on the scales. However, honeydew restricts their movements so that it is difficult for them to have a wider feeding coverage. With the exception of the adult, all stages of Encarsia occur inside the whitefly host.
Conservation

Conserving natural enemies is probably the most important practice farmers could do. Practicing multiple cropping (including flowering crops) provides pollen, honeydew, and nectar for adult wasps. The practice can increase the diversity of habitats that provide shelter and other food sources to the natural enemies.

Some Encarsia species are native to crop production environments. When introduced, they have the tendency to adapt to the local environments.

Weekly field monitoring or a visual inspection of plants is important to notice the presence of pests and beneficial insects in order to consider when to make pest management decisions.

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 materials. 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 Heliotes

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 teardrops 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.

Lacewing

Hosts

Aphids, leafminer, mealybugs, thrips, whitefly, armyworms, bollworms, cabbage worm, codling moths, corn borer, cutworm, DBM, fruitworm, leafhopper nymphs and eggs, potato beetle, scale insects, spider mites, and caterpillars of most pest moths. If given the chance, they can also prey on adult pests.

Description

Eggs are found on slender stalks or on the underside of leaves. Each egg is attached to the top of a hair-like filament. Eggs are pale green in color.

Larvae are known as aphid lions. Newly hatched, they are grayish-brown in color. Upon emerging, larvae immediately look for food. They grow to about 1 cm in length. They attack their prey by taking them with their large sucking jaws and injecting paralyzing poison, and then sucking out the body fluids of the pest. A larva can eat 200 or more
pests or pest eggs a week. An older larva can consume 30-50 aphids per day. It can consume more than 400 aphids during its development. The larvae resemble alligators with pincers like jaw. However, they become cannibalistic if no other prey is available. They feed for 3 to 4 weeks and molt three times before pupation. They cover their bodies with prey debris.

Pupae are cocoons with silken threads. These are found in cracks and crevices. The pupal stage lasts for approximately 5 days.

**Conservation**

Flowering plants such as dill, cosmos, sunflower, carrots, and dandelions are good source of pollen and nectar for adults. Provide source of water during dry season.

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### Ladybird beetles

#### Hosts

Aphids, mealybugs, scale insects, spider mites, whiteflies

#### Description

Eggs are yellow to orange in color, 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.

Adulst 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

Ladybird 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.
Rove beetles

Hosts

Both adults and larvae are predators of root maggots' eggs and larvae, mites, worms, nematodes, and other small insects. Adults tend to be cannibalistic, eating their own eggs and attacking other adults when food supply is low.

Description

Eggs are tiny, about 0.5 mm long and 0.4 mm wide, pear-shaped, pale green in color, and are covered with a gelatin-like material. These are laid by female adults in the soil among the roots of the root-maggot infested plants. The eggs hatch 5-10 days later.

The first instar larvae are pale brown, about 1.5 mm long, slender, segmented, and tapered toward the anterior. They have large heads. The parasitic second and third instar larvae are white, have rudimentary legs, and are found within the host puparium. Before pupating, a larva will actively search for a host (pupa of maggot) in the surrounding soil. It will pupate in the pupa of the maggot by entering into its cocoon and feeding its contents, and then pupate itself inside for about 3-4 weeks before emerging as an adult. It is possible that two or more larvae enter into one maggot pupa but only one will survive and mature.

Adult rove beetles are brown, reddish-brown, or black or have gray markings on the wings and abdomen, with slender elongate bodies. Their wing covers are shorter than the abdomen where most part of the abdomen is exposed. Both adults and larvae have well-developed 'jaws' cross in front of the head. They live mostly in decaying organic matter but are also found in moist agricultural soils or in habitats where large numbers of fly larvae live. When disturbed, they run very fast, with their abdomen lifted upward, like that of scorpions. Adults are good fliers as well.

Conservation

Provide ground covers or mulches within and around fields for rove beetles love to stay in moist decaying organic matter; provide hiding sites and alternative habitats and plant flowering borders, hedges, and other perennial habitats as a source of food and shelter; and provide protection by not spraying broad spectrum pesticides.

Spider

Hosts

Moths and caterpillars

Description

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.

Tachinid fly

Hosts

Aphids, armyworm, beetles, bollworm, bugs, cabbage looper, cotton stainer, cutworm, grasshoppers, hornworm, leafhoppers, mole crickets, moths, sawflies, scale insects, stem borers, stick insects.

Description

Eggs are ovate-shaped and white in color. They are found in the skin of the host insect or in leaves near the host and are hatched when the host ingests them.

The larvae or maggots are worm-like and lack appendages like all other fly larvae. They are greenish-white in color. They have three larval instars and then leave the hosts to pupate in the soil. Before pupation, some mature maggots produce hard cocoons. The larval stage takes about 4 days to 2 weeks depending on the climatic conditions. The newly hatched larvae enter into its host and feed on the content before pupating into the soil. Some tachinid species are hosts’ specific, for example for a certain species; it is parasitic only on leaf rolling caterpillars, or only on sugarcane stem borer.

Pupae are oblong, yellowish and turn dark reddish as they mature.

Adults measure between 3 and 10 mm and have very stout bristles at the tips of their abdomens. They look very similar to the common housefly but are larger with stocky and soft bodies. They vary in appearance from gray black to brightly colored, or sometimes looking like bees. Adult Tachinid flies have only 1 pair of wings. They feed on honeydews and flower pollen. Different species have varied modified sucking type mouthparts: the cutting sponging, the piercing-sucking, and lapping-sponging. Adult flies are found in almost all crop habitats, either resting on foliage or feeding on nectars and pollen. Additionally for females, they search for hosts to lay their eggs. The female adult lays her eggs near or into the larvae, or on another insect. She can lay as many as 1000-2000 eggs in her lifetime. Adults can live from 3 days to 2 months depending on the species.

Conservation

Providing sources of food like dills, parsley, clover and other herbs are the most efficient ways to conserve Trachinid flies in the agricultural ecosystems.
Trichogramma

Hosts

Trichogramma species parasitize eggs of over 200 species of moth and caterpillars. Among these are; the rice and corn stem borer, cabbageworm, tomato hornworm, Heliotis and Helicoverpa species, codling moth, cutworm, armyworm, webworm, cabbage looper, fruit worms, and sugarcane borer.

Description

Trichogramma adults are extremely small. The female adult lays her eggs on other moths’ eggs. First, she examines the eggs by antennal drumming, then drills into the eggs with her ovipositor, and lays one or more eggs inside the moth’s eggs. She usually stays on or near the host eggs until all or most of them are parasitized. When the parasitized moth’s eggs turn black, the larvae parasites develop within the host eggs. The larva eats the contents of the moth’s eggs. Adults emerge about 5-10 days later depending on the temperature. Adults can live up to 14 days after emergence. Female adults can lay up to 300 eggs.

Conservation and management

Trichogramma species differ in their searching behavior, host preferences, response to environmental conditions, and suitability in biological control uses. The timing of Trichogramma releases in the field is important. Non-parasitism could be due to the use of less suitable Trichogramma strains to the host pests, environmental conditions, and untimely release of parasitoids. It is best to release parasitoids at the beginning of a pest infestation (when moths are first seen in the field), followed by regular releases until a natural breeding population of Trichogramma is established. An example of this approach is the corn borer control. The first release should be during the first appearance of moths and corn borers’ eggs in the cornfields. Weekly releases thereafter are to ensure the Trichogramma population build-up and parasitism occurrence. The build-up of the parasitoids depends on the presence of the pest or alternative hosts and food for adults. It is important to regular monitor pest population, egg parasitism (parasitized eggs are black in color), and the larval infestation. Trichogramma are released as pupae in parasitized host eggs. The pupae can be pasted on cards or put in various containers. To be successful in the field, food, host eggs and shelter must be available.

Modify cropping practices by practicing crop rotation and by planting cultivars which are favorable to Trichogramma population build-up such as wild carrots, dill, golden rod, leguminous plants, and flowering vegetables. Adults feed only on nectar, pollen, and honeydew. Many of these species are found naturally occurring in agricultural and garden habitats. Many adult parasitoids and predators benefit from sources of nectar and the protection provided by refuges such as hedgerows, cover crops, and weedy borders. Avoid indiscriminate use of hazardous pesticides to ensure their presence in agricultural fields.
Photo credits

01 Corn. qay / pixelquelle.de
13 Ants. Takumasa Kondo
15 Army worm. Courtesy of University of Arkansas
16 Corn borer. Department of entomology, Kansas State University
17 Corn earworm. R. Coutin, OPIE
18 Corn seedling maggot. IRRI & University of Queensland
19 Corn stalk borer. ICIPE.
20 Cutworm. Clemson University.
      http://entweb.clemson.edu/cuentes/eiis/factshot/pages/Cutworm.htm
21 Flea beetles. Texas A&M University
21 Leafhopper. Photo courtesy of Ric Bessin, University of Kentucky
22 Japanese beetle. Photo courtesy of Clemson University - Department of Entomology
23 Seedcorn maggot. R. Coutin, OPIE
25 White grubs. Department of Entomology, Texas A&M University.
26 Wireworm. Texas A&M University.
28 Anthracnose. Ohio State University.
31 Braconid. IRRI & Queensland University. IRRI, Los Banos, Philippines.
32 Encarsia. Mark Hoddle, University of California.
33 Ground beetle. IRRI & Queensland University. IRRI, Los Banos, Philippines.
34 Hoverfly. Canola Council of Canada.
34 Lacewing. Photo courtesy of Clemson University - Department of Entomology
35 Ladybird beetles. Kok, L.; Kok, V.
      http://www.ento.vt.edu/~kok/Biological_Control/Main_body.htm
36 Spider. IRRI & Queensland University. IRRI, Los Banos, Philippines.
37 Tachinid fly. IRRI & Queensland University. IRRI, Los Banos, Philippines.
38 Trichogramma. Cornell University.
      http://www.nysaes.cornell.edu/ent/biocontrol/parasitoids/trichogramma_ostriniae.html
## Alphabetical list of the mentioned control methods

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References

The information and the photos in this fieldguide are taken from the OISAT PAN Germany website www.oisat.org.


IRRI & Queensland University. (2001): Rice IPM. An interactive information and identification system for integrated pest management in rice. University of Queensland and IRRI.


For more information on non-chemical pest management see:

www.oisat.org

Pesticide Action Network (PAN) Germany

Nernstweg 32 • 22765 Hamburg • Germany
Phone: +49 (0)40 - 3991910 - 0 • Email: info@pan-germany.org
Internet: www.pan-germany.org • www.oisat.org