Information of www.infonet-biovision.org

Scab

Scab
Host plants: Avocados Cucumber Potato Pumpkin

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Storage moths and bruchid beetles

Storage moths and bruchid beetles
Host plants: Groundnut Soybean

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Spider mites

Spider mites

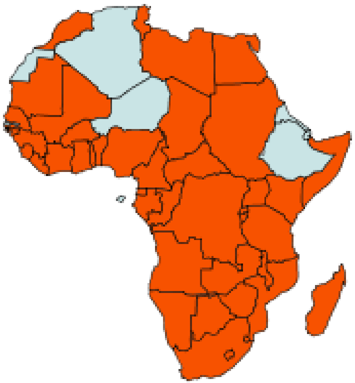
Scientific name: *Tetranychus* spp., *Mononychellus* spp., *Oligonychus* spp.

Type: pest (insect/mite)

Host plants: African Nightshade Amaranth Avocados Beans Cassava Coffee Cotton Cucumber Eggplant Groundnut Maize Mango Okra Papaya Passion fruit Peas Peppers Pigeon pea Sesame Tea Tomato

General Information on Pest and Damage

Geographical distribution



Geographical Distribution of Spider mites in Africa *(red marked)*

Damage

Generally, spider mites prefer the undersides of leaves, but in severe infestation will occur on both leaf surfaces as well as on the stems and fruits. They suck the sap of plant tissues. Infestations are most serious in hot and dry conditions. Because they multiply very fast they are able to destroy plants within a short period of time. Spider mites spin silk threads that anchor them and their

eggs to the plant. The fine web produced by spider mites protects them from some of their enemies and even from pesticide applications.

Fruit damaged by spider mites.

The most destructive spider mite species in East Africa is the tobacco or tomato red spider mite *(Tetranychus evansi)*. This mite is a very serious pest in tomato crops and other members of the Solanaceae family (tomato, potato, eggplant, tobacco and wild plants and weeds like black nightshade, bitter apple and wild gooseberry). This species originates from Brazil, South America and was accidentally introduced into Southern Africa during the 80's.

Since then this spider mite has slowly been moving northwards. Nowadays it is one of the major constraints in tomato production in Kenya, Mozambique, Malawi, Namibia, Zimbabwe and Zambia. When left uncontrolled the farmer can loose his or her production within a week time.

The two spotted spider mite (*Tetranychus urticae*) and the carmine spider mite (*Tetranychus cinnabarinus*) cause yield loss on tomatoes only in exceptional cases such as: very hot and dry conditions, destruction of natural enemies, the presence of other highly infested crops in the near vicinity and insufficient water supply to the crop. For more information on this species refer to datasheet on tomato (click here).

Damage by spider mites on beans is most severe when mite feeding occurs early in the vegetative period. For more information refer to section on spider mites on datasheet of beans (click here).

Another important species is the cassava green mite (*Mononychellus tanajoa*), an important pest of cassava. This mite is green in colour at a young age turning yellowish as adult. It was accidentally introduced from South America and it rapidly spread becoming one of the most important pests of cassava in Africa. For more information refer to datasheet on cassava (click here)

The cotton red mite (*Oligonychus gossypii*) is a widely distributed mite in Africa. It is commonly found on cassava, mainly during mainly during the dry season, but it is much less economically important than the cassava green mite. It also attacks cotton, citrus, peach, papaya, beans, okra, peanut, and ornamentals.

The coffee red mite (*Oligonychus coffeae*) may be a pest of unshaded coffee and tea in localised attacks during the dry season. They attack the upper surface of mature leaves. As a result the upper surface of fully hardened leaves turn a rusty, purple or yellow brown colour. Under drought stress young leaves may also be attacked.

Host range

Spider mites have been recorded from a wide range of wild and cultivated plants, including beans, cassava, cotton, citrus, okra, tomato, papaya, potato, tobacco, strawberry, and various cucurbits and legumes.

Symptoms

First symptoms are usually clusters of yellow spots on the upper surface of leaves, which may also appear chlorotic. This gives the leaf a speckled or mottled appearance. Feeding by spider mites may lead to a change of leaf colour in some plants such as okra, cotton, coffee and tea and some ornamentals. Attacked leaves turn bronze, or a rusty, purple or yellow brown colour. Spider mites and webbing are present on the lower leaf surface, which may appear tan or yellow and have a crusty texture.

Feeding by the cassava green mite leads to stunted and deformed cassava leaves. Severe attacks cause the terminal leaves to die and drop, and the shoot tip looks like a "candle stick".

Initial infestation of spider mites on tomato. Note mites seen as reddish specks on underside of leaflet.

© A. M. Varela, icipe

Under severe infestations leaves redden, whither, and drop. Some spider mites (e.g. *T. evansi*) produce large amount of webbing. Heavy infestation will result in a fine cobwebby appearance on the leaves and the whole plant. Plants die when infestation is severe.

Spider mites on tomato. Note the mites and their webbing visible beetween the leaves.

Affected plant stages

Vegetative growing stage, flowering stage, post-harvest

Affected plant parts

Leaves, inflorescences, fruits.

Symptoms by affected plant part

Leaves: lesions, abnormal colours, abnormal leaf fall, yellowed or dead. Inflorescences: yellow or abnormal colour, abnormal flower fall, premature fall of young fruits.

Biology and Ecology of Spider Mites

Introduction

Mites are not insects; they are related to spiders and ticks, they are very tiny (they rarely exceed a size of 0.5 mm). Spider mites are normally active within a temperature range of 16 to 37°C. They are more numerous in hot, dry weather. They are normally less numerous after rains. Wind plays an

important role in the dispersal of spider mites. The lifecycle of a spider mite may take 10 to 30 days depending on temperature. It includes five stages: egg, larva (first instar) and two nymphal stages and adult. A female may lay over 100 eggs during its lifespan. Spider mites spin silk threads that anchor themselves and their eggs to the plant. This silk protects them from some of their enemies and even from pesticide applications.

Description

Eggs are tiny, spherical, pale-white, and are laid on the undersides of leaves often under the webbings. They can only be seen with a magnifying lens. Eggs hatch in 4 or 5 days.

The larvae are light green or pinkish, slightly larger than the eggs and have six legs.

The nymphs look similar to the adults but are smaller. They are green or red in colour in colour

and have eight legs.

Eggs and larva of the cassava green mite *(Mononychellus tanajoa)*, real size 0.2 mm.

© F. Haas, icipe

The adults are oval and have eight legs; they are very tiny (they rarely exceed a size of 0.5 mm) resembling tiny moving dots to the naked eye. The male is usually smaller than the female and have a more pointed abdomen. Spider mites are variable in colour depending on the species. Many of the species are bright red in colour; and that is reason why spider mites are sometimes referred to as red spider mites. Others are

Female of the cassava green mite *(Mononychellus tanajoa)*, real size 0.8 mm.

© F. Haas, icipe

yellowish, greenish, pinkish, orange or reddish in colour. The two-spotted spider mite has a large dark blotch on each side of the body.

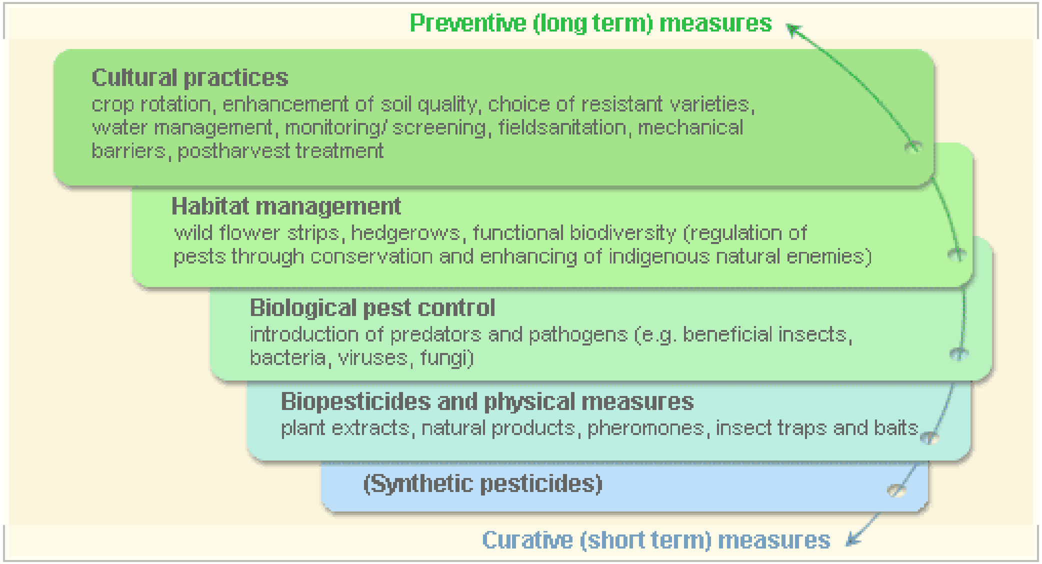
Male of the cassava green mite. *(Mononychellus tanajoa)*, real size 0.8 mm.

Major species of spider mites in Africa:

- **The common/two-spotted spider mite (*Tetranychus urticae*)**
- **The tobacco red spider mite (*Tetranychus evansi*)**
- **The carmine red spider mite or common red spider mite (*Tetranychus cinnabarinus*)**
- **The cassava green mite (*Mononychellus tanajoa*)**
- **The coffee red mite (*Oligonychus coffeae*)**
- **The cotton red mite (*Oligonychus gossypii*)**

Pest and Disease Management

Pest and disease management: General illustration of the concept of *infonet-biovision*



These illustration shows the methods promoted on infonet-biovision. The methods shown at the bottom have a long-term effect, while methods shown at the top have a short-term effect. In organic farming systems, methods with a long-term effect are the basis of crop production and should be used with preference. On the other hand methods with a short-term effect should be used in emergencies only. On infonet we do not promote synthethic pesticides.

Further below you find concrete preventive and curative methods against Spider mites.

Cultural practices

Monitoring

Inspecting your field regularly is very important, since the population build up of the mites is very rapid. At the beginning of the infestation the distribution of mites is very patchy. Control must start early. It is very difficult to control the mite population once they are established. A recommended monitoring method for mites on tomato is:

Select randomly 20 tomato plants and access the level of damage caused by the mites of three leaflets/plant by using a damage leaf index ranking from 1 to 5 (one is few yellow spots, five is leaf totally covered with spots, dry patches occur). Once the average damage level exceeds the first rank, control measures should start.

Less experienced farmers sometimes have difficulties with early identification of the mites, since the symptoms resemble a nutrient

deficiency or plant disease. Close inspection of the underside of affected leaves shows mites as tiny moving specks (red or yellow-greenish depending on the species) and whitish particles (shed skins of mites).

Further cultural practices are:

- **Site nurseries away from infested crops and avoid planting next to infested fields.**
- **Grow healthy crops; avoid water and nutrient stress. Apply mulch and incorporate organic matter into the soil to improve the water holding capacity and reduce evaporation.**
- **Keep perennial hedges such as pigeon peas, they are said to encourage predatory mites, which predate on spider mites.**
- **Uproot and burn infested plants. This can be successful during the early stages of infestation when the mites concentrate on a few plants.**
- **Keep the field free of weeds.**
- **Remove and burn infested crop residues immediately after harvest**
- **Mites favour dry and hot conditions. Influencing the microclimate by reducing the planting distance is reported to repress spider mite populations. However, this could also enhance fungal diseases, so care**

should be taken.

- **When moving through the crop for weeding, pruning, harvesting or any other field work, always leave the infested area until last in order to minimise the spread of mites on clothing or farm tools**

Biological pest control

Natural enemies

A range of natural enemies attacks spider mites. The most important are predatory mites, predatory beetles such as small staphilinidae (*Oligota* spp), and ladybird beetles, lacewings, predatory thrips, anthocorid bugs (*Orius* spp), mirid bugs, and predatory flies such as cecydomyiid and hoverflies.

Naturally occurring predators are in most cases capable of controlling infestations of the two-spotted spider mite and the carmine red spider mite, provided natural enemies are not disturbed by the severe use of broad-spectrum pesticides, and the crop is irrigated properly.

This is not the case for spider mites that have been accidentally introduced from other continents. Thus, few natural enemies are known to

feed on the tobacco spider mite in Africa. In contrast, natural enemies keep this mite under control in his home region (Brazil). Icipe has recently conducted experimental releases of a predatory mite (*Phytoseiulus longipes*) introduced from Brazil into Kenya (personal communication, Markus Knapp, icipe).

The cassava green mite has been effectively controlled by predatory mites (mainly *Typhlodromalus aripo* and *T. manihoti*) introduced from South America, the home of the cassava green mite (Yaninek and Hanna, 2003).

Tetranychus predators -

Several natural enemies of spider mites are commercially available worldwide. The most common is the predacious mite *Phytoseiulus persimilis*. This predatory mite, widely used for control of the two-spotted spider mite, is present in Kenya and it is commercially available. Suitable release rates and timings vary with the crop. In areas where the mite has been

predatory mites (orange-red individuals)(*Phytoseiulus persimilis*) in a colony of the two-spotted spider mite *(Tetranychus urticae)*. Spider mites are very tiny, they rarely exceed a size of 0.5 mm.

© Warwick HRI, University of Warwick.

Adult of the predatory beetle *Oligota* sp. a natural enemy of mites.

established, augmentative releases are required to maintain control. For more information on [natural enemies click here.]

© F. Haas, icipe

According to RealIPM newsletter of Jan 2008, the horticultural export company Oserian has now been spider mite free for 1 1/2 years using *Phytoseiulud persimilis* and integrated management saving large amounts on money on acaricides and getting much better quality roses. The same predatory mite is also effective for spider mites on french beans both in green house and field conditions. Available from Real IPM and Koppert(Ltd). See contacts below.

Biopesticides and physical methods

Neem

Neem products, in particular oil formulations give reasonable control of spider mites. Though neem does have some systemic effect in plants, spray it as you would other contact insecticides, ensuring thorough spray coverage and targeting the undersides of the leaves where spider mites tend to cluster. Neem commercial products are available in Kenya. Use as

recommended. For information on Neem click here.

Soap spray

Apply on the infested plants thoroughly, including the undersides of the leaves. Spray early in the morning or late afternoon.
Precaution:
Soap spray may injure foliage. Test these sprays on few leaves before applying to the entire plant. It may take two days for damage symptoms to appear. For the recipe of soap spray click here.

Pyrethrum

Spray of natural commercial Pyrethrum extracts such as "Flower DS" (Kenya) control spider mites when applied on very early outbreaks (farmer experience, Kenya). Take care of beneficial insects, which are also killed by pyrethrum.
For more information on pyrethrum click here.

Flour preparations

Flour mixed in water is said to be very effective against aphids and spider mites. It should be applied in the morning taking care to spray underside of leaves. As the heat of the sun increases, the mixture dries out and the insects are left encrusted in flour, shrivel and die. The coating of flour falls off the leaves so that their ability to photosynthesise is not essentially affected (Gabriele Stoll, 1988). For information on flour preparations click here

Glues

Any water-soluble glue, particularly those obtained from plants, for example glue (starch) obtained by boiling potatoes and cassava in water. Spray a weak solution to suffocate the insects. The strength of mixes varies greatly according to the glue available but the diluted solution should leave a thin skin coating the plant when the solution has dried (H. Elwell et. al, 1995).

Others

The above mentioned and other natural control methods against spider

mites are currently being tested in several Eastern and Southern African countries. Thus, the Mashare ADI (Agricultural Development Institute) in the Kavango Region in Namibia is carrying out tests with chilli, garlic and soap extracts, and a mixture of buttermilk and flour. The results are not available yet, however for the latest information, contact the Horticultural Section at Mashare ADI or the Kavango Horticultural Production and Marketing Project (KHPMproject@mweb.com.na). Botanicals such as Neem and *Tephrosia* sp. are currently being evaluated in Malawi, Zimbabwe and Kenya.

Lachlan Kenya Ltd currently markets an organically certified botanical product called Bio-cure, which according to Real IPM is much more effective against spider mites than pyrethrum. See reference addresse below.

Water

- **Overhead irrigation or hosing with a strong jet of water knocks off mites and destroys their webs. Be sure to include the underneath of the leaves. However, this should be done early in the day to allow the foliage**

to dry. Wetness of the foliage for an extended period is conducive to development of fungal diseases.

- **Apply water to pathways and other dusty areas at regular intervals.**

Information Source Links

- **CABI. (2005). Crop Protection Compendium, 2005 Edition. © CAB International Publishing. Wallingford, UK. www.cabi.org**
- **EPPO. European and Mediterranean Plant Protection Organization www.eppo.org**
- **Henry Elwell & Anita Maas. Natural Pest & Disease Control. Natural Farming Network, Zimbabwe, P.O.Box 301, Causeway, Harare 1995. ISBN: 0-7974-1429-0**
- **Keizer, M. and Zuurbier, J. Red Spider Mite. Namibian crop pests. www.larsen-twins.dk**
- **OISAT. Online Information Service for Non-Chemical Pest Management in the Tropics. www.oisat.org**
- **Seif, A.A., A.M. Varela, Loehr, B. and S. Michalik (2001). A Guide to IPM in French Beans Production with Emphasis on Kenya. pp. 88. ICIPE**

Science Press, Nairobi, Kenya. (ISBN: 92 9064 142 8).

- Stoll, Gabriele (1988). Natural Crop protection on the tropics. AGRECOLE. c/o ÖKOZENTRUM, CH-4438 Langenbruck, Switzerland.
- Varela, A. M., Seif, A.A., and B. Loehr (2003). A Guide to IPM in Tomato Production in Eastern and Southern Africa. ICIPE Science Press, Nairobi, Kenya. ISBN: 92 9064 149 5.
- Varela, A. M., and A.A., Seif. (2004). A Guide to IPM and Hygiene Standards in Okra Production in Kenya. ICIPE Science Press, Nairobi, Kenya ISBN: 92 9064 161 5

Contact Links

- Dr Henry Wainwright The Real IPM Company (K) Ltd P O Box 4001, Madaraka, Thika - 01002, Kenya + 254 (0)20 2113228 + 254 (0)722 655983 wainwright@realipm.com www.realipm.com
- Koppert Biological Systems (K) Ltd. 2nd Floor, Baobab House Westlands Office Park , Waiyaki Way P.O. Box 41852 - 00100, NAIROBI , KENYA . Tel. +254 20 2021918/ 4453780/1/2 Fax +254 20 4453783 Cell:+254 724 256524 Tlkm. wireless:+254 20 3597844 Web: www.koppert.com
- Lachlan Kenya Limited, P.O.Box 49470, Nairobi 00100. Old Airport

Road, off Mombasa road. Tel: +254 20 2073 912/3/4. Fax: +254 2060 260. E-mail: stonewigg_lachlan@griculture.co.ke. Website: www.griculture.co.ke

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

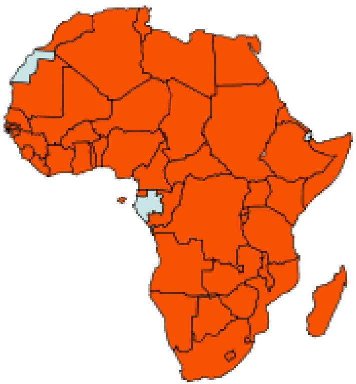
Aphids

Aphids
Scientific name: *Aphis* spp., *Acyrthosiphum pisum, Brevicoryne brassicae, Cinara cupressi, Diuraphis noxia, Lipaphis erysimi, Melanaphis sacchari, Myzus persicae, Pentalonia nigronervosa, Ropalosiphum maidis, Toxoptera* spp., etc.
Family: Hemiptera: Aphididae
Type: pest (insect/mite)
Host plants: African Nightshade Amaranth Bananas Beans Cabbage/Kale, Brassicas Citrus plants Cocoa Cotton Cowpea Cucumber Eggplant Green gram

Groundnut Maize Mango Okra Papaya Passion fruit Peas Peppers Pigeon pea Potato Pumpkin Sesame Sorghum Soybean Spider plant Spinach Sweet potato Tea Tomato Wheat Zucchini/Courgette Apple trees

General Information on Pest and Damage

Geographical distribution



Geographical Distribution of Aphids in Africa (red marked)

Introduction

Major species of aphids attacking crops in Africa:

- **Banana aphid *(Pentalonia nigronervosa)***
- **Black bean aphid *(Aphis fabae)***
- **Cabbage aphid *(Brevicoryne brassicae)***
- **False cabbage aphid *(Lipaphis erysimi)***
- **Citrus aphid *(Toxoptera citricidus*, *T. aurantii)***
- **Green peach aphid *(Myzus persicae)***
- **Groundnut aphid *(Aphis craccivora)***
- **Cotton aphid *(Aphis gossypii)***
- **Russian wheat aphid *(Diuraphis noxia)***

- **Cypress aphid *(Cinara cupressi)***
- **Mango aphid *(Toxoptera odinae)***
- **Maize aphid *(Ropalosiphum maidis)***
- **Pea aphid *(Acyrthosiphum pisum)***
- **Sorghum aphid *(Melanaphis sacchari)***

Some images of these aphid species are found under 'more images' and under the specific crop pages.

Damage

Both adults and nymphs pierce plant tissues to feed on plant sap. Their feeding may cause rolling, twisting or bending of leaves. Heavily attacked leaves can turn yellow and eventually wilt. Aphids feeding on flower buds and fruits may cause malformed flowers and fruits. Aphids excrete a sugary, sticky liquid called honeydew that accumulates on leaves and branches. Sooty moulds (a fungal growth) grow on honeydew deposits turning leaves and branches black. Heavy coating with honeydew and sooty moulds may reduce photosynthesis, affecting plant growth and

yield.

Honeydew is a favourite food of some ant species. Thus, black ants are commonly found on plants with aphid infestations. These ants protect the aphids from natural enemies and are therefore considered indirect pests. Ants may even transport aphids from plant to plant. Many species of aphids have been implicated as major vectors of plant viral diseases.

Affected plant stages
Seedling stage, vegetative growing stage and flowering stage.

Affected plant parts
Growing points, stems, leaves, inflorescences, fruits and whole plant.

Symptoms on affected plant part
Curled leaves, abortion of flowers, stunted growth and dieback. Sooty black mould becomes evident in heavy infestations. Black ants are very common in plant with aphid infestations. However, sooty moulds and ants are also associated with other honeydew-producing insects such as

mealybugs, softscales and whiteflies.

Biology and Ecology of Aphids

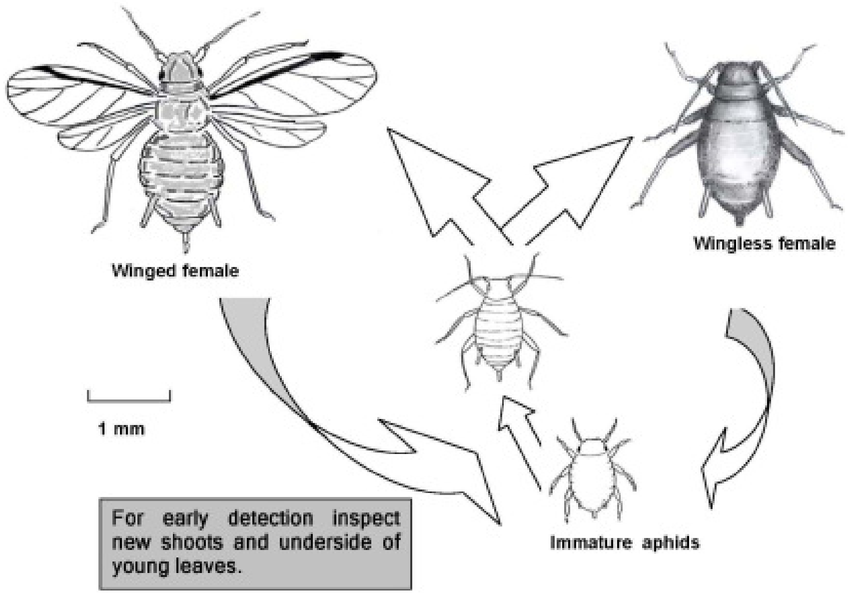
Eggs are very tiny, shiny-black, and are found in the crevices of bud, stems, and barks of the plant. Aphids usually do not lay eggs in warm parts of the world.

Nymphs (immature stages in image below) are young aphids, they look like the wingless adults but are smaller. They become adults within 7 to 10 days.

Adults are small, 1 to 4 mm long, soft-bodied insects with two long antenna that resemble horns. Most aphids have two short cornicles (horns) towards the rear of the body. The mouthparts are needle-sharp, resembling tiny straws. Their body colour varies from black, green, red, yellow, pink, white, brown, greyish, or purple. Adults of the same species may be wingless or winged (with two pair of wings). Winged aphids are usually dark in colour. Wingless forms are the most common; winged aphids are produced when they need to migrate, for example under overcrowded conditions or when environmental changes indicate them

that is time to move.

Aphids lifecycle



© A. M. Varela, icipe

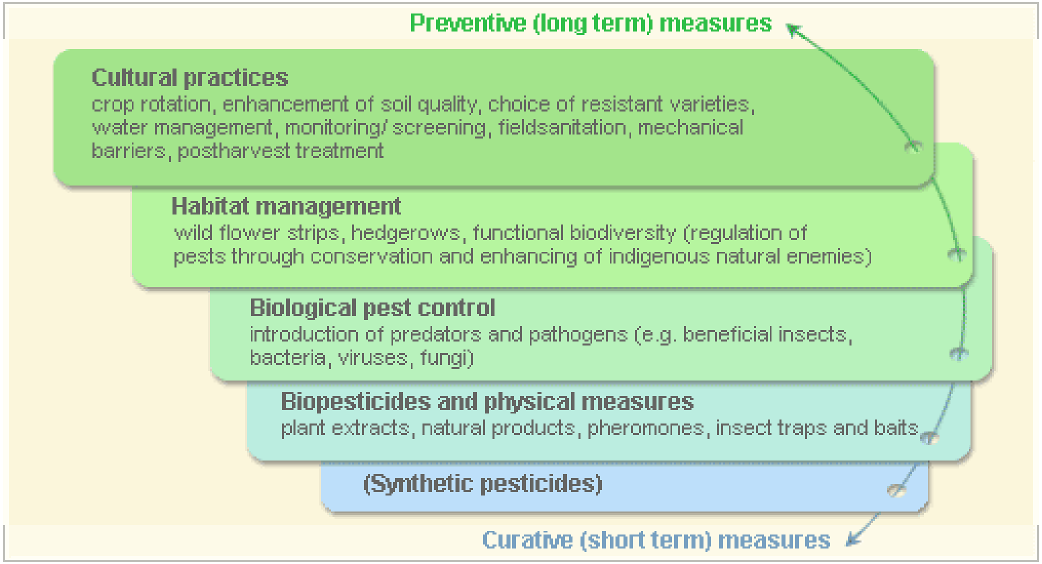
Aphids have complicated life cycles. Females can reproduce with or

without mating. Female aphids may lay eggs or give birth to wingless offspring, known as nymphs. In the warm parts of the world, as in the tropics, no male aphids are produced and female aphids do not lay eggs but give birth to small nymphs. A female can produce from 20 to over 100 nymphs. Young aphids grow quickly, becoming adult in about one week and start to reproduce. Thus the numbers increase rapidly under favourable conditions. Aphids live in clusters (known as colonies) on leaves and stems. Initially they are present on tender parts of the plant (young shoots and leaves), but as their number increases they can cover the whole plant. As the colony grows winged aphids are produced which fly away looking for new plants to start a new colony.

Warm and dry weather is particularly favourable for rapid increase of aphid numbers.

Pest and disease Management

Pest and disease Management: General illustration of the concept of *infonet-biovision*



These illustration shows the methods promoted on infonet-biovision. The methods shown at the bottom have a long-term effect, while methods shown at the top have a short-term effect. In organic farming systems, methods with a long-term effect are the basis of crop production and animal husbandry and should be used with preference. On the other hand methods with a short-term effect should be used in emergencies only. On infonet we do not promote synthethic pesticides.

Further below you find concrete preventive and curative methods against Aphids.

Cultural practices

Monitoring

It is particularly important to scout crops during the critical periods of seedling and shoot growth and during flowering and fruiting. To monitor aphid populations, examine the undersides of the leaves and the bud areas for groups or colonies of aphids. Presence of ants may indicate presence of aphids. Early detection of aphids is important as they can multiply rapidly. Therefore, the crop should be scouted regularly. Yellow traps are useful for monitoring the arrival of winged aphids to the crop. The presence and abundance of natural enemies should also be recorded.
For more information on monitoring traps click here.

Economic Threshold Levels

Economic threshold levels have been developed for some few aphid species. One example is the threshold level for cotton aphid *(A. gossypii)* on cotton in Sudan: if 30% of the plants are infested during the first 2

months of the season, treatments are recommended (Stam et al., 1994). However, damage thresholds depend on many factors (crop stages, crop age, economic and climatic conditions).

Instead of trying to use threshold levels, the growth of the aphid population within 3 to 5 days should be monitored. If a rapid growth of the number of aphids per plant is observed, and no or only few predators are present, treatments should be planned. Most plants can tolerate moderate numbers of aphids without great damage. However, even small numbers may need to be controlled in cases where aphids transmit virus diseases. Prompt control is necessary when numbers build-up and natural control is not satisfactory.

Field sanitation and management

Grow healthy plants. Healthy plants are able to protect themselves better from pests and diseases than weak plants. Growers are strongly recommended to use compost in preference to manures, including liquid manures. Excess use of manures and mineral (artificial) fertilisers, particularly nitrogenous fertilisers, produce fleshy plant tissue attractive

to aphids. Therefore their use should be avoided as far as possible.

Practice crop rotation. This may help to reduce aphid infestations, particularly of aphid species that are host specific (they feed and develop only on one or few plant species).

Grow crops in mixed cropping. This involves plant diversity by growing diverse plants on the same land, at the same time. Common mixed cropping include use of companion planting and intercropping. The mixture of plants needs to be carefully chosen. For instance, intercropping poses a problem when the minor crop harbours a disease or pest of the primary crop. Mixed cropping is in general beneficial to natural enemies, since it provides food and shelter. Depending on the plants used and the pattern of cropping, mixed cropping may help disrupt the lifecycle of pests and maintain their population below the economic threshold level.

Use trap crops: some crops are particularly attractive to pests and can be used to trap them and protect the main crop. Monitoring of the trap crops is very important. They should be destroyed when they become severely

infested, and before they are killed by the pest, or have completed their lifecycle, as the pest may move from the trap plants to the main crop. They can be removed and buried. Trap crops can be planted around the field to be protected, or interspersed among the rows.

Farmer experiences

Following some examples of crop mixtures that are reported to help on managing aphid infestations:

- **Trap crops such as dill, nasturtiums, and timothy grass near the main crop are reported to avoid aphid infestations in the main crop (The Bug Lady, 2004).**

- **Anise, chives, garlic, onions, radish, and parsley are reported as good companion crops (Elwell and Maas, 1995; KIOF). Onion, chives, garlic and Mexican marigold repel aphids. The Kenya Institute of Organic Farming (KIOF) recommends leaving a few plants of Mexican marigold between the crop.**

- **Intercropping beans with maize is a common practice in East Africa. It has been shown that infestations of black bean aphid in common beans were greatly reduced when intercropped with older and taller maize plants in a study in Kenya (Ogenga-Latigo et al., 1993).**

- **Numbers of the aphid *Aphis gossypii* decreased in potatoes that were intercropped with onions *(Allium cepa* or *Allium sativum)*. To achieve this reduction, the onions had to be planted within 0.75 m of potato plants (Potts MJ, Gunadi N, 1991).**

Biological pest control

Natural Enemies

The most important aphid predators are predatory bugs (e.g. *Anthocoridae, Miridae, Nabidae*), carabid beetles (*Carabidae*), soldier beetles (*Cantharidae*), predatory gall midges(*Cecidomyiidae*), lacewings (*Chrysopidae*), ladybird beetles (*Coccinellidae*) and hoverflies (*Syrphidae*).

In addition, parasitic wasps (parasitoids) are often involved in the control of aphid populations (mummified aphids). Parasitised aphids can be easily recognised. They turn brown and hard and remain stuck to the plant surface. They are known as ?mummies?.

Depending on climatic conditions and crops fungi that cause diseases of insect pests (entomopathogenic fungi) can contribute to a rapid decline of aphid populations. Natural aphid enemies usually appear with a certain delay because they react to the presence of aphids.

It is important to help natural enemies to establish and improve their effectiveness (conservation biocontrol). This can be done through:

- **Habitat management. For instance, leaving or growing flowering plants at the boarder of the crops or as companion plants within the crops attracts beneficial insects.**
- **Avoiding use of pesticides toxic to natural enemies. If pesticides must be used, selective biopesticides that target specific pests should be preferred to broad-spectrum pesticides (that kill a wide range of insects**

including natural enemies)

Controlling ants feeding on honeydew produced by aphids. They disturb natural enemies giving protection to the aphids. Ploughing and flooding the field destroy ant colonies and expose eggs and larvae to predators and sunlight (Elwell and Maas, 1995). Ploughing and flooding the field destroy ant colonies and expose eggs and larvae to predators and sunlight (Elwell and Maas, 1995).

For more information on [natural enemies click here]

See some images below:

Carabid beetle (*Agonum dorsale*) (6 to 8 mm long). An important predator of many aphid pests and the eggs of several dipterous (fly) pests.

© D.A. Kendall

Ladybird beetle larva of *C. sexmaculata* feeding on aphids.

Ladybird beetle (*Coccinellidae sexmaculata*) adult feeding on aphids. The adults are pink and black.
© M. Shepard / Coastal Research Center Charleston

Brown lacewing (*Micromus timidus*)

Hover fly adult

© Jonny N.Dell, retired, Courtesy of Bugwood.org

Hover fly larva

© R.J. Reynolds Tobacco Company, Bugwood.org

Biopesticides and physical methods

Neem

Neem extracts can control early infestations of some aphids, but they are not efficient against all aphid species. For a reliable and satisfying control neem extracts must be applied at an early stage of aphid attack. Usually repeated spot sprays of affected plants are necessary to achieve control. Neem has a slow mode of action, and usually effects are not visible before 10 days after application. Some neem extracts may be phytotoxic. Therefore, test the extract on few plants before going into full scale spraying.

Neem products have in general no or low negative effect on natural enemies. However, products based on neem oil have stronger effects on some natural enemies.

For more information how to prepare Neem water extract click here

Botanicals

Other botanical sprays reported to be effective against aphids include:

Chilli pepper
Cut half a kg of hot chilli peppers in small pieces and boil them in four litres of water for 20 minutes. Add equal amount of soapy (bar soap) water, cool and spray (KIOF). or
Pulverise 100g chillies in a mortar, shake vigorously with one litre of water and filter through a cloth. Dilute one part of this mixture with five parts of soapy water before spraying (G. Stoll, 1988).
Chilli also repels ants.

Castor oil plant: As a general spray soak green leaves and seeds in water for 24 hours, filter and spray (Elwell and Maas, 1995).

Pyrethrum: Commercially available pyrethrum sprays are effective against aphid infestations, but also kill predators. It is therefore recommended to inspect plants regularly and control early outbreaks, before the insect becomes a big problem. Use spot sprays on infected plants. For more information on how to prepare Pyrethrum extract click here

Traps

Yellow sticky traps and yellow water traps are mainly used to monitor winged aphids. As the yellow colour attracts many insect species, including beneficial insects, use these traps only where necessary.

Water traps
Half-filled yellow pans or basins with soapy water are placed close to the plant but exposed enough so that aphids are attracted by the yellow colour. Water traps are mainly used to monitor winged aphids. As the yellow colour attracts many insect species, including beneficial insects, use water traps only where necessary.

Sticky board traps
To make your own sticky trap, spread petroleum jelly or used motor oil on yellow painted plywood, 6 cm x 15 cm in size and up. Place traps near the plants but far apart enough to avoid leaves sticking to the board. Sticky yellow traps are mainly used to monitor winged aphids. As the yellow colour attracts many insect species, including beneficial insects, use water traps only where necessary.

For more information on [traps click here]

Soap (fatty acids) spray

Spray with insecticidal soaps or with a soap and water solution. This control aphids and does not seriously affect natural enemies.

- **Mix 1 tablespoon of dishwashing soap or 3 tablespoons soap flakes (non detergent) with 4 litres of water.**
- **Add soap to water. Use mild soap or potash-based soap.**
- **Start with a lower concentration and make adjustments of the strength after testing on few infested plants.**
- **Always try on few infested plants before going into full scale spraying. Soaps can cause burnt leaves (phytotoxicity) on sensitive plants, like brassica crops and certain ornamentals. Make 2 or 3 treatments in a 3 to 4 days interval for a better efficacy.**
- **Apply on the infested plants thoroughly, including the undersides of the leaves. Spray early in the morning or late afternoon to avoid phytotoxic effects on crops.**

Precaution:
Soap spray may injure foliage. Test these sprays on few leaves before

applying to the entire plant. It may take 2 days for damage symptoms to appear. For more information on soap sprays click here.

Others

Flour preparation

For a description of flour preparation click here.

Ash

Ash can be used to effectively control aphids in vegetables. Ash should be dusted evenly onto infested parts of vegetables. Also aphids can be controlled by spraying wood ash mixed with soapy water and or lime (Elwell and Maas, 1995).

Information Source Links

- **Aphids. www.ent.uga.edu/**
- **Blackman, R. L. and Eastop, V. F. (2000). Aphids on the world's crops.**

An identification and information guide. John Wiley & Sons, Ltd. ISBN 0 471 85191 4.

- **CABI. (2004): Crop Protection Compendium, 2004 Edition. © CAB International Publishing. Wallingford, UK. www.cabi.org**
- **Digital diagnostics. Database of Insects and Plant Diseases. Oklahoma State University. entoplp.okstate.edu/ddd**
- **Gabriele Stoll: Natural Crop protection on the tropics. AGRECOL 1988. c/o OKOZENTRUM, CH-4438 Langenbruck, Switzerland.**
- **Gordon's aphid page. www.earthlife.net**
- **Henry Elwell & Anita Maas: Natural Pest & Disease Control. Natural Farming Network, Zimbabwe, P.O.Box 301, Causeway, Harare 1995. ISBN: 0-7974-1429-0**
- **KIOF - Kenya Institute of Organic Farming, Nairobi.**
- **Ogenga-Latigo MW, Baliddawa CW, Ampofo JKO, 1993. Factors influencing the incidence of the black bean aphid, *Aphis fabae* Scop., on common beans intercropped with maize. African Crop Science Journal, 1(1):49-58.**
- **Potts MJ, Gunadi N, 1991. The influence of intercropping with *Allium* on some insect populations in potato (*Solanum tuberosum*). Annals of**

Applied Biology, 119(1):207-213.

- Stam PA, Abdelrahman AA, Munir B, 1994. Comparisons of control action thresholds for *Heliothis armigera*, *Bemisia tabaci* and *Aphis gossypii* on cotton in the Sudan Gezira and Rahad regions. Crop Protection, 13(7):503-512; 20 ref.

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

African bollworm

African bollworm
Scientific name: *Helicoverpa armigera* (Synonym: *Heliothis armigera*)
Family: Lepidoptera: Noctuidae
Type: pest (insect/mite)
Common names: African bollworm, Fruitworm, Podborer, Corn earworm, Tomato grub, Tobacco budworm
Host plants: Beans Cotton Cowpea Green gram

Maize Okra Peas Peppers Sorghum Tomato Wheat Sunflower

General Information on Pest and Damage

Geographical Distribution of the African bollworm in Africa (red marked)

Geographical distribution: The African bollworm is reported to be present in all African countries (CABI Compendium 2006).

Introduction

The African bollworm is a pest of major importance in most areas where it occurs. It damages a wide variety of food, fibre, oilseed, fodder and horticultural crops. It is a major pest due to its high mobility, its ability to feed on many species of plants, its high fecundity and reproductive rate, and its capacity to develop resistance to pesticides. The habit of feeding inside the fruiting parts of the plant during most of its development makes bollworms less vulnerable to insecticides. Pesticides should be applied before the caterpillars bore into the fruits/pods. The African bollworm has a strong ability to develop resistance to insecticides. Currently there is a widespread occurrence of resistance to popular synthetic pyrethroids in Africa and elsewhere.

Moreover, its preference for the harvestable flowering parts of high-value crops including cotton, tomato, sweet corn, and cut-flowers makes it responsible for huge economic losses and socio-economic costs. Crop losses at farm level in Kenya has been estimated at over 50% on cotton and pigeon pea, over 20% on sorghum and millet, and over 2 million stems on cut flowers (Kibata, 2002). In addition, the African bollworm is a quarantine pest. This is important for export crops. If a caterpillar of this

pest is detected in a consignment of an export commodity (e.g. flowers, vegetables, etc) shipped to Europe, the whole consignment may be rejected.

Damage

The severity of the damage varies between crops, regions and locations, and between seasons.

Caterpillars of the African bollworm feed on leaves, buds, growing points, flowers and fruit. Leaf damage reduces leaf area, which can slow plant growth. Feeding on flowers and fruit causes the main damage. Flower feeding can prevent fruit formation. Caterpillars usually bore clean, circular holes through fruits/pods. Excrements (faeces / waste) of the feeding caterpillars are placed away from damaged plant parts. The holes serve as entry points for secondary infection by diseases causing fruit decay. One caterpillar can damage several fruits/pods. Once they burrow into the fruits/pods they are difficult to reach and control with

insecticides. Often caterpillars feed with the head and forepart of the body inside the fruit/pod and the rest of the body outside.

Moreover, its preference for the harvestable flowering parts of high-value crops including cotton, tomato, sweet corn, and cut-flowers makes it responsible for huge economic losses and socio-economic costs. Crop losses at farm level in Kenya has been estimated at over 50% on cotton and pigeon pea, over 20% on sorghum and millet, and over 2 million stems on cut flowers (Kibata, 2002). In addition, the African bollworm is a quarantine pest. This is important for export crops. If a caterpillar of this pest is detected in a consignment of an export commodity (e.g. flowers, vegetables, etc) shipped to Europe, the whole consignment may be rejected.

Host range

The African bollworm has been reported on 35 crops and 25 wild host plants in eastern and southern Africa (Greathead and Girling 1989). The

severity of the damage varies between crops, regions and locations, and between seasons. In eastern Africa, attacked crops include cotton, french beans, dry beans, okra, peas, legumes, maize, sorghum, sunflower, tobacco and tomato. Among these crops, the African bollworm is considered a key pest of cotton, chickpea, pigeon pea and tomato (Sithanantham et al., 2002). In South Africa crops attacked include peas, beans, wheat, cotton, maize, grain sorghum, oats, barley, sunflower, tobacco, citrus, cucurbits, potato, tomato, lucerne, sunnhemp, cape gooseberry, chickpea and groundnuts (Cherry et al., 2003). *Amaranthus* spp., *Cleome* sp. and *Acalypha* sp. are important wild host plants in Africa.

Symptoms

Larvae feed on leaves, flower buds, flowers, grains, and bore into pods and fruits. Excrements (faeces / waste) of the feeding caterpillars are evident on damaged plant parts.

Affected plant stages

Vegetative growing stage, flowering stage and fruiting stage.

Affected plant parts

Leaves, growing points, inflorescence and fruits/pods.

Biology and Ecology of the African Bollworm

The eggs are tiny (about 0.5 mm in diameter), round and yellowish-white in colour. They darken before hatching. They are deposited singly on tender parts of the plant. Egg-laying generally coincides with early flowering of host crops.

African bollworm eggs are tiny (about 0.5 mm in diameter).

© A.M. Varela, icipe

Young caterpillars (larvae) are generally yellowish-white to reddish brown. They have a dark brown to black head and several rows of black bumps with short hairs along their backs, which give them a spotted appearance. Fully-grown caterpillars are 35 - 40mm long. Older caterpillars vary in colour from almost black, brown or green to pale yellow with dark grey yellow stripes along the sides of the body. However, all caterpillars have a typical light stripe along each side of the body. The head is brown or green and mottled. The fully-grown caterpillars drop from the plant and burrow into the soil to pupate.

African bollworm on French

beans. Fully grown caterpillars are 3-4 cm long.

© A.M. Varela, icipe

The pupa is shiny brown, about 16 mm long, with smooth surface, with two short parallel spines at the posterior tip of the body. Pupation takes place in the soil.

The African bollworm pupa is shiny brown, about 16 mm long

© A.M. Varela, icipe

The adult moth is fleshy, yellowish-brown with a

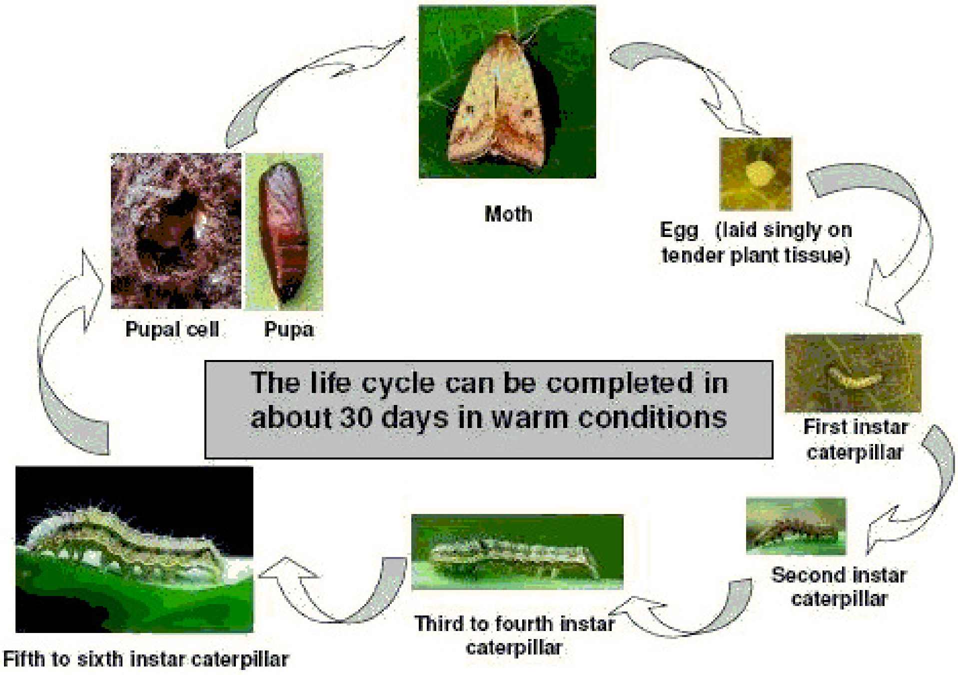
Adult moths of African bollworm are about 14 to 18 mm long with a wingspan of 35 to 40 mm.

© A.M. Varela, icipe

dark speck, greyish irregular lines and a black kidney-shaped mark on the forewings. The hindwings are whitish with a black patch along the outer margin. The moth is about 14 to 18 mm long with a wingspan of 35 to 40 mm. They are relatively strong fliers, dispersing widely within areas where the host plants are found. They can also be carried by strong winds. Moths are strongly attracted to plants that provide honeydew or nectar.

The life cycle of African bollworm

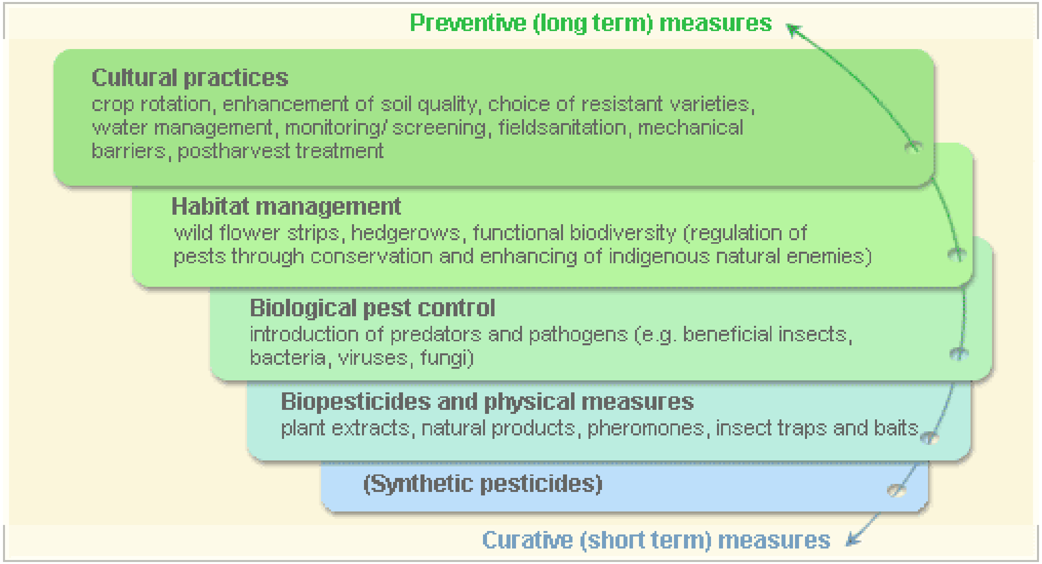
Moths lay a large number of eggs, and the life cycle may be completed in a short time under warm conditions. Eggs hatch in 3 to 5 days. Larval and pupal periods last 17 to 35 and 17 to 20 days, respectively. The life cycle is completed in 25 to 60 days depending on temperature.


Moth
Egg (laid singly on tender plant tissue)
First instar caterpillar
Second instar caterpillar
Third to fourth instar caterpillar
Fifth to sixth instar caterpillar
Pupal cell
Pupa
The life cycle can be completed in about 30 days in warm conditions

Life cycle of African bollworm
© A.M. Varela, icipe

Pest and disease management

Pest and disease Management: General illustration of the concept of *infonet-biovision*



This illustration shows the methods promoted on infonet-biovision. The methods shown at the bottom have a long-term effect, while methods

shown at the top have a short-term effect. In organic farming systems, methods with a long-term effect are the basis of crop production and animal husbandry and should be used with preference. On the other hand methods with a short-term effect should be used in emergencies only. On infonet we do not promote synthethic pesticides.

Further below you find concrete preventive and curative methods against African bollworm

Cultural practices

Monitoring and Decision Making

Look out for eggs and small caterpillars. Early detection of eggs, or young caterpillars before they bore into the fruits or pods is very important. Once the caterpillars have entered the fruit/pod they are difficult to control and by then they have caused damage. Early detection can be achieved by regular scouting of the crop. Monitoring moth population by using pheromone traps reduces crop inspection time considerably and leads to timely intervention. Check also for natural enemies. Parasitised

eggs are easy to recognise, since healthy eggs are whitish yellow in colour, and they turn black when parasitised.

Action thresholds have been developed for high value crops (e.g. tomato, cotton, pulses and tobacco). In these crops the tolerance for insect damage is low; therefore, economic damage thresholds are low. The following thresholds are given as examples.

Cotton: In Malawi and Zimbabwe, thresholds based on egg numbers have been used successfully in cotton since 1961. Spraying was recommended at an average of one egg per two plants in twice-weekly counts. In the Sudan Gezira, over two eggs or caterpillar per 18 plants, and in Australia two eggs per metre of row were used as thresholds (CABI, 2004). It has been argued that control thresholds based on damage are easier to use and more economical than those based on pest density. In the case of cotton, damaged buds are easier to detect and sample than either eggs or small caterpillars. Studies in Tanzania indicate that spraying at damage threshold of 10 to 20% would give adequate protection to the crop. Further fine-tuning of damage thresholds should be concentrated during

the first four weeks of flowering when most of the damage by this pest occurs. (Kabissa, 1989).

Tomato: It has been recommended to randomly select 30 tomato plants and examine the leaves immediately below the topmost open flowers to look for eggs of African bollworm (AVRDC, 2000).

The decision to make an intervention to manage this pest should be based on an analysis of the situation (stage of the crop, presence of natural enemies, economic return (based on market value of the crop and the value of the intervention) etc.

Sanitation (Clean cultivation)

- **Remove and destroy plant residues immediately after harvesting.**
- **Plough the soil after harvesting. This exposes pupae, which may then be killed by natural enemies or through desiccation by the sun.**

Mechanical control

- **Handpick and destroy eggs and small caterpillars. This is feasible in** small plots or when infestations are low. For instance, it has been reported that in Ethiopia when pest damage in sorghum is minor, farmers shake the plant to induce the caterpillar to drop from the sorghum head and pick them by hand (Negash and Abate, 2002). It is very important to detect small caterpillars before they enter the fruits.

- If African bollworms are detected in the field, sort out the harvested crop very thoroughly and remove the caterpillars manually. This is particular important for export crops to minimise/avoid rejection in the importing country.

Habitat Management

Intercropping and trap crops

Moths of the African bollworm prefer to lay eggs on certain crops (e.g. pigeon pea, chick peas, crotalaria, maize, tobacco, African marigold, sorghum and sunflower), especially during the flowering period. These crops may be utilised to distract moths from crops that are more vulnerable to African bollworm damage. If trap crops are planted in strips or around the field, the moths will lay eggs on them instead of the main crop. A careful choice of the trap crops and planting dates might ensure

the maximum effectiveness of trap crops. Heavy infestations of the African bollworm on the trap crops need to be controlled to prevent build-up of the pest populations.

Trap cropping and planting diversionary hosts have been widely applied, although with variable results. Some examples are given below:

- **Intercropping of cotton with chickpea, cowpea, onion, pearl millet, crotalaria, pigeon pea and marigold in strips is reported to divert the populations of sucking pests and the African bollworm from cotton (Dejen and Tesfaye, 2002).**
- **It has been shown that flowering sunflower, sorghum and maize are much more attractive to African bollworm moths for egg-laying than cotton. For this reason, maize has been commonly used as a trap crop. Preference for maize has been observed to be so strong that cotton plots remained almost clear of eggs when bordered with a few rows of maize. However, this attractiveness appears to be inconsistent. This may be due to differences between varieties of the host plant or differences between African bollworm populations (van den Berg, 1993).**
- **Studies of this pest and its natural enemies in cotton, sunflower,**

maize and sorghum in Kenya showed that survival of the African bollworm is low in maize and sorghum. Therefore, it is suggested that they could be used to divert African bollworm infestation. The selection of the variety is important. In the case of sorghum, studies in Tanzania showed that mortality of the African bollworm was high in sorghum varieties with open panicles, which give little protection from natural enemies. In contrast, pest mortality in compact head sorghum varieties with dense and semidense panicles was low; cotton grown adjacent to compact head varieties suffered a rapid build-up of the African bollworm as the sorghum crop reached maturity (Nyambo, 1989). Moreover, when using maize or sorghum as trap crops to protect cotton, these trap crops would have to be planted at regular intervals since there is only a short period (flowering) when maize and sorghum are attractive to moths, whilst on cotton, moths lay eggs over a extended period of time (three months in Kenya) (van den Berg, 1993). This would be feasible if irrigation is available but impractical for rainfed crops.

- **Castor, sunflower, black gram, and cowpea are also recommended as traps crops for cotton. These plants attract bollworm as well as provide habitat for natural enemies, which feed on bollworms. It has been**

recommended to grow a row of castor as border crop, or to sow the other crops in every five rows of cotton (CIKS, 2000).

- **Research in Ethiopia indicated that lupin, pigeon pea, hyacinth bean, maize and sunflower attracted significantly higher numbers of this pest and diverted them from the main crop haricot beans (Dejen and Tesfaye, 2002). It has been reported that maize grown as a strip crop at 10 m intervals reduced pod damage by the African bollworm in haricot beans (Ahmed and Damte, 2002).**
- **Intercropping chickpeas with wheat, barley, linseed, mustard and safflower are reported to reduce attack by the African bollworm on chickpeas in India. On the other hand, intercropping chickpeas with lentils and field peas have led to a higher pest infestation in chickpeas (Negash and Abate, 2002)**
- **African marigold has been used as trap crop in tomato. Marigold planted after every eight rows of tomato helps attract most of the African bollworms moths to marigold (Negash and Abate, 2002).**

The following procedure has been recommended to minimise infestation of the African bollworm on vegetable crops in Ghana (Youdeowei, 2002):

- **Obtain a suitable trap crop to plant with the main crop**
- **Plant the trap crop around the vegetable field in strips 10 to 15 cm apart; pigeon peas can be planted as a hedge around the main crop**
- **Plant the trap crop so that it starts flowering earlier than the main crop and remains flowering thorough the development cycle of the main crop; in this way, the bollworms will lay eggs and thrive only on the trap crops**
- **Regularly observe the populations of bollworms on the trap crop and, if necessary, spray them with a suitable pesticide to control them.**

Crop rotation

Avoiding planting crops after each other that are susceptible to bollworm like cotton, maize, sorghum, tobacco, soybean, and tomato may help to reduce/prevent build up of bollworm populations. However, to be effective crop rotation should be done over large areas, since the moths can fly long distances (Dobson et al. 2002). Some crops not susceptible to bollworm that could be planted in rotation with susceptible crops are small grains like wheat, rice, and plants of the onion family.

In countries with two distinct seasons (wet and dry), it has been recommended to plant rice followed by beans during the rainy season, and cotton or small grains in the second cropping (Hasse, 1986,1987).

However, it should be noted that the African bollworm also attacks many other plants commonly found in the field (e.g. weeds), for instance Cleome in Tanzania. Therefore, crop rotation alone is not likely to be effective in managing this pest.

Biological pest control

Natural enemies

In Africa, a wide variety of natural enemies have been recorded attacking the African bollworm. The most important are egg parasitoids (e.g. *Trichogramma* spp.), larval parasitoids (wasps and flies that parasitise caterpillars), and predators such as ants, assassin bugs, minute pirate (anthocorid) bugs, lacewings and ladybird beetles. Over 170 parasitoids and a large number of predators have been reviewed and catalogued,

most of them from southern and East Africa (Cherry et al, 2003). Conserving and encouraging these natural enemies should be part of any strategy to manage this pest.

The distribution and importance of natural enemies vary within and between region, between crops and seasons. For example parasitism of eggs by *Trichogramma* wasps is higher and by more species on sorghum than on other crops. Studies in Kenya showed that predators, mainly anthocorid bugs and ants, were the most important natural enemies of the African bollworm on sunflower, maize, sorghum and cotton (van den Berg, 1993; Cherry et al. 2003), while in northern Tanzania, parasitism and diseases were the major cause of mortality on sorghum, cotton and a weed (*Cleome* sp.) (Nyambo, 1986; 1990; van den Berg, 1993).

Spraying practices can harm natural enemies. This is particularly detrimental early in the season since natural enemies that may otherwise have built up and suppressed the pest are killed. Substitution of broad spectrum pesticides with selective biopesticides such Bt, nuclear polyhedrosis viruses (NPVs) and botanicals (e.g. neem), for control of this

and other pests may permit early establishment of natural enemies and contribute to the control of pests. To achieve better results this should be a joint effort involving neighbours and farmer communities in a regional scale.

Plant crops that are attractive to natural enemies
The impact of natural enemies can be improved through intercropping or adjacent planting of crops that are attractive to them. In cotton, the African bollworm infests the crop before flowering; this is earlier than the immigration of anthocorid bugs into the fields. It is suggested that if crops with distinct flowering periods that attract African bollworm moths and anthocorid bugs at the same time, are planted adjacent or intercropped with young cotton, they would attract anthocorid bugs and other predators early in the season, and at the same time distract moths from cotton. Sorghum seems to be a better 'natural control' plant than maize because it is equally or more attractive to African bollworm, and attracts more anthocorid bugs during flowering. Moreover, sorghum varieties are better adapted than maize to the dry climatic conditions where cotton is commonly grown (van den Berg, 1993).

Ants are important predators of the African bollworm. Ant activity on the crops can be encouraged by changing crop composition, by weed management and by provision of alternative food sources. Plants that offer alternative food sources on the canopy, such as plant exudates or honeydew producing insects, are more attractive to ants. Ants could also be attracted to crops by providing crushed sugar cane, or sprayed sugar solution. Ants would then complete their diet with protein by preying on insects, including caterpillars of the African bollworm. A good example is the BioRe project in Tanzania, where sunflower is used as a trap crop in and around organic cotton fields. Cannibalism and predation by ants (in particular the bigheaded ants *Pheidole* spp.) on sunflowers causes high mortality among bollworm caterpillars (Cherry et al, 2003).

Chicken can help by eating caterpillars and pupae at certain time of crop development in small fields. They can be allowed to roam freely on lands not yet planted or where hardy crops are growing. However, they should not be allowed near seedlings or plants with fruit since they may cause damage by scratching and pecking (Dobson et al, 2002; Elwell and Maas,

1995).

Birds that eat pests can be encouraged to visit crop fields. Some changes will encourage them to nest and stay in the area, and this can lead to a permanent increase in local predatory bird populations. For example, groundnut plants are close to the ground and birds cannot use them as vantage points for spotting insect prey. From a perch, however, birds can easily identify prey and swoop down to devour them. Bird perches are resting places for predatory birds to rest and to look for preys such as insect pests of cotton, peanuts, and cowpeas. 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 have been found to be attractive to predatory birds. Much larger populations of birds (mynas, finches and blackjays) were recorded in fields with bird perches, and these contributed to a significant suppression of the insect pests. In cotton field, plant *Setaria* in

every 9th or 10th row of cotton. Once the birds are on the fields, they prey on cotton bollworms and other insects (NCIPM).

For more information on natural enemies click hier

Biopesticides and physical methods

Botanicals

Several plants are reported to be useful in the management of the African bollworm on several crops. Garlic is reported to be effective against African bollworm on cotton and maize. For information on how to make your own biopesticide with garlic click here.

Experiments for screening effective botanicals for control of tomato pests, in Western Kenya, indicated that pepper and marigold were effective against pests of tomatoes including African bollworm (Magenya, 2002).

Neem (*Azadirachta indica*)

There are several reports of use of neem products for control of the African bollworm on several crops. It is important to control the small caterpillar before they enter the fruit, as any later treatment would be ineffective. For more information on how to make your own biopesticide with neem click here.

Bt (*Bacillus thuringensis*)

Bt is widely used in Africa for control of caterpillars, including the African bollworm. In particular *B.t.* subspecies *kurstaki* and *B.t. aizawai* control this pest (Cherry et al, 2003; Kibata, 2002). Commercial Bt products for control of caterpillars currently available in Kenya include Dipel®, Thuricide HP® (both Bt var. kurstaki), Florbac 70 DG® and XenTari® (both *B.t.* var. *aizawai*). For more information on Bt click here.

Farmer experience

In Kenya, farmers at the Coast use extracts from neem leaves and seeds, and commercial neem products on vegetable crops. They also use extracts from hot pepper or mixtures of plant extracts such as Lantana, chillies and Tephrosia (Kega, 2002; Pole and Kimani, 2002).

Physical methods

- **Handpick damaged fruits and collect those that fall down. Destroy the damaged fruits by cutting into small pieces, or place them in sealed sacks and dry under the sun. Putting them immediately in a compost pit or burying them will enable the matured caterpillars to pupate into the soil.**
- **Handpick and destroy eggs and caterpillars. It is very important to detect small caterpillars before they enter the fruits. This is feasible at low infestations and in small plots.**
- **Weed if necessary. Destruction of weeds that may harbour caterpillars is important to prevent African bollworm infestation.**
- **Plough the field to expose the pupae to predators and weather.**

Information Source Links

- **AVRDC. Tomato fruitworm. www.avrdc.org/LC/tomato/fruitworm.html**
- **Ahmed, S. and Damte, T. (2002). African bollworm: A key pest in pulses production in Ethiopia. In African Bollworm Management in Ethiopia. Status and needs. Proceedings of the National Workshop held**

at the Plant Protection Research Centre Ambo, Ethiopia. April 2002. pp 27-36.

- **Bessin, R. Tomato IPM guidelines. University of Kentucky Entomology. www.ca.uky.edu**
- **CABI. (2004). Crop Protection Compendium, 2004 Edition. © CAB International Publishing. Wallingford, UK. www.cabi.org**
- **CIKS. (2000). Bollworm control in cotton. Center for Indian Knowledge Systems. Chennai, India. Pesticide Post. Vol. 8, No 6.**
- **Cherry, A., Cock, M, van den Berg, and Kfir, R (2003). Biological control of *Helicoverpa armiguera* in Africa. In Biological Control in IPM Systems in Africa. Neuenschwander, P., Borgemeister, C and Langewald. J. (Editors). CABI Publishing in association with the ACP-EU Technical Centre for Agricultural and Rural Cooperation (CTA) and the Swiss Agency for Development and Cooperation (SDC). pp. 329-346. ISBN: 0-85199-639-6.**
- **Dejen, A. and Tesfaye (2002). Cultural control of the African bollworm, *Heliothis armiguera* (Hb.). In African Bollworm Management in Ethiopia. Status and needs. Proceedings of the National Workshop held at the Plant Protection Research Centre Ambo, Ethiopia. April 2002. pp 99-105.**

- **Dobson, H., Cooper, J., Manyangariwa, W., Karuma, J. and Chiimba, W. (2002). Integrated Vegetable Pest Management- Safe and Sustainable Protection of Small-scale Brassicas and Tomatoes. Natural Resources Institute, University of Greenwich. 179 pp. ISBN: 0-85954-536-9.**
- **Elwell, H and Maas, A. (1995). Natural Pest & Disease Control. Natural Farming network, Zimbabwe. The Plant Protection Improvement Programme and the Natural Farming Network.**
- **Greathead, D.J. and Girling, D. J. (1989). Distribution and economic importance of *Heliothis* and of their natural enemies and host plants in southern and eastern Africa. In King, E. C. And Jackson, R. D. (eds) Proceedings of the Workshop on Biological Control of *Heliothis*: Increasing the Effectiveness of Natural Enemies. November 11-15 1985. New Delhi, India. Far Eastern Regional Research Office, United States Department of Agriculture. New Delhi, India. pp 329-345.**
- **Haggis MJ, 1982. Distribution of *Heliothis armigera* eggs on cotton in the Sudan Gezira: spatial and temporal changes and their possible relation to weather. Proceedings of the International Workshop on *Heliothis* Management. ICRISAT Center, Patancheru, India, 15-20 November 1981, 87-99; [5 fig.].**

- **Hasse, V. (1986): Introducing plant protection to cotton farmers in the Philippines. Second International Conference on Plant Protection in the Tropics. Malaysian Plant Protection Society, Kuala Lumpur.**
- **ICIPE, A Guide to IPM in Brassicas/Tomato Production www.icipe.org**
- **ICIPE. (2003). Development of biocontrol-based management of *Helicoverpa armigera* in eastern and southern Africa. 2000-2003 ICIPE Scientific Report. International Center for Insect Physiology and Ecology, Nairobi, Kenya.**
- **Kabissa JCB, 1989. Evaluation of damage thresholds for insecticidal control of *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) on cotton in eastern Tanzania. Bulletin of Entomological Research, 79(1):95-98.**
- **Kega, V. M. (2002). Research Status and Future Needs for Sustainable Management of the African Bollworm in Kwale District of Coastal Kenya. In *Helicoverpa* management in Kenya. Research Status and Needs. Proceedings of the KARI-ICIPE Workshop on Biocontrol-based IPM of the African Bollworm in Kenya. 16th November, Nairobi, Kenya. S. Sithanantham, C. Kairuki and J, Baya. (Editors). pp. 79-82.**
- **Kibata, G. N. (2002). The status of the African bollworm, *Helicoverpa***

***(Heliothis) armigera* Hübner (Lepidoptera: Noctuidae) and future research needs for its management in Kenya. In *'Helicoverpa* managment in Kenya. Research Status and Needs. Proceedings of the KARI-ICIPE Workshop on Biocontrol Based IPM of the African Bollworm in Kenya. S. Sithanantham, C., Kariuki and J. Baya. (Editors). pp. 11-15.**

- **Magenya, O. E. V.(2002). Present knowledge and potential options for control of the African Bollworm in Southwestern Kenya. In *Helicoverpa* management in Kenya. Research Status and Needs. Proceedings of the KARI-ICIPE Workshop on Biocontrol-based IPM of the African Bollworm in Kenya. 16th November, Nairobi, Kenya. S. Sithanantham, C. Kairuki and J, Baya. (Editors). pp. 67-71.**
- **Matthews GA, Tunstall JP, 1968. Scouting for pests and the timing of spray applications. Cotton Growers' Review, 45:115-127**
- **NCIPM (2000). Annual report 1999-2000. National Centre for Integrated Pest Management, Indian Council for Agricultural Research, Lal Bahadur Shastri Building, Pusa Campur, New Delhi - 110 012, India**
- **Negash, T. and Abate, S. (2002). African bollworm management in the southern Region of Ethiopia. In African Bollworm Management in Ethiopia. Status and Needs. Proceedings of the National Workshop held**

at the Plant Protection Research Centre Ambo, Ethiopia. April 2002. pp 59-62.

- **Nyambo, B. (1986). Studies in the bollworm *Heliothis armigera* Hübner, the key cotton pest in Tanzania, as a basis for improved integrated pest management. Thesis. Department of Pure and Applied Biology, Imperial College of Science and Technology. Silwood Park. U.K.**
- **Nyambo, B. (1990). Effect of natural enemies on the cotton bollworm *Heliothis armigera* Hübner (Lepidoptera: Noctuidae) in Western Tanzania. Tropical Pest Management. 36, 50-58.**
- **OISAT: Organisation for Non-Chemical Pest-Management in the Tropics www.oisat.org**
- **Pole, T. M. and Kimani, A. I. (2002). Research Status and Future Needs for Sustainable Management of the African Bollworm in Kilifi Region, Coastal Kenya. In '*Helicoverpa* management in Kenya. Research Status and Needs'. Proceedings of the KARI-ICIPE Workshop on Biocontrol-based IPM of the African Bollworm in Kenya. 16th November, Nairobi, Kenya. S. Sithanantham, C. Kairuki and J, Baya. (Editors). pp. 75-78.**
- **Seif, A. A, Varela, A. M., Michalik S. and Löhr B. (2001): A Guide to IPM in French Beans Production with Emphasis on Kenya. ISBN: 92 9064 142**

8.

- **Sithanantham, S., Baumgartner, J. and Matoka, C. (2002). Ecosystem Approach for Management of *Helicoverpa armiguera* in Eastern Africa. In African Bollworm Management in Ethiopia. Status and needs. Proceedings of the National Workshop held at the Plant Protection Research Centre Ambo, Ethiopia. April 2002. pp 129-134.**
- **Stoll, G. (1986). Natural Crop Protection in the Tropics. AGRECOL. ISBN: 3-8236-1113-5.**
- **van den Berg, H. (1993). Natural control of *Helicoverpa armigera* in smallholder crops in East Africa. Thesis Wageningen.ISBN: 90-5485-107-4**
- **Varela, A. M., Seif, A. A. and Löhr B. (2003). A Guide to IPM in Tomato Production in Eastern and Southern Africa. ISBN: 92 9064 149 5**
- **Varela, A. M., and Seif, A. A. (2004). A Guide to IPM and Hygiene Standards in Okra Production in Kenya. ISBN: 92 9064 161 5**
- **Youdeowei, A. (2002). Integrated pest management practices for the production of vegetables. Ministry of Agriculture (MOFA) Plant Protection and Regulatory Services Directorate (PPRSD), Ghana, and the German Development Cooperation (GTZ). ISBN: 9988-0-1088-5.**

Information of www.infonet-biovision.org

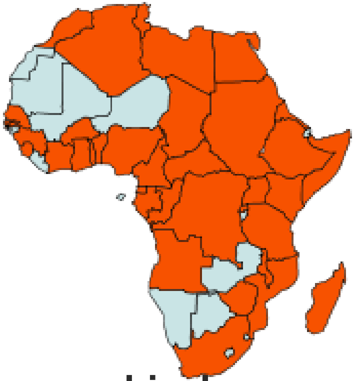
Information of www.infonet-biovision.org

Whiteflies

Whiteflies
Family: Homoptera: Aleyrodidae
Type: pest (insect/mite)
Host plants: Beans Cabbage/Kale, Brassicas Cassava Citrus plants Cotton Cucumber Eggplant Green gram Mango Okra Papaya Peppers Pigeon pea Pumpkin Sesame Sweet potato Tomato

General Information on Pest and Damage

Geographical distribution



Geographical Distribution of Whiteflies in Africa *(red marked)*

Damage

Whiteflies cause direct damage to plants by sucking plant sap and removing plant nutrients, thereby weakening the plants. Damage may be more severe when plants are under water stress. In addition, they often produce large quantity of honeydew

that leads to the growth of sooty mould on the lower leaves, blocking or reducing the photosynthetic capacity of the plants. The honeydew also contaminates the marketable part of the plant, reducing its market value or making it outright unsaleable. Infested plants may wilt; turn yellow in colour, become stunted or die when whitefly infestations are severe or of long duration.

Tomato plant infected with Tomato Yellow Leaf Curl. Note upward and inward rolling of the leaf margins.

Whiteflies are also serious indirect pests as vectors of virus diseases. *Bemisia tabaci* transmits serious virus diseases on cassava, cotton, tobacco, tomato, beans, chillies, and sweet potatoes. Whitefly transmitted viruses are among the most serious virus diseases on plants; virus infection often results in total crop losses. This whitefly is the vector of a range of leaf curl disease-inducing virus, in Eastern and

Southern Africa, including the Tomato Yellow Leaf Curl Virus, the Cassava Mosaic Virus, the Cowpea Mild Mottle Virus, the Watermelon Chlorotic Stunt Virus among others. It also transmits one of the most important factors limiting cassava production in Africa. In sweet potatoes *B. tabaci* transmits the Sweet potato Chlorotic Stunt virus, which together with the aphid-transmitted Sweet potato Feathery Mottle Virus causes the Sweet Potato Virus Disease, the most important disease constraint to sweet potato production in Sub-Saharan Africa (Legg et al., 2003).

Major species of whiteflies in Africa:

- **The greenhouse whitefly (*Trialeurodes vaporariorum*)**
- **The tobacco whitefly or sweet potato whitefly (*Bemisia tabaci*)**
- **The spiralling whitefly (*Aleurodicus dispersus*)**
- **The citrus woolly whitefly (*Aleurothrixus floccosus*)**
- **The cabbage whitefly (*Aleyrodes proletella*)**

For more information on whiteflies on different crops click on the crop name:

- **Cassava**

- **Tomato**
- **Cotton**
- **Sweet potato**
- **Beans**

Host Range

The tobacco whitefly (*Bemisia tabaci*) and the greenhouse whitefly (*Trialeurodes vaporariorum*) attack a very wide range of wild and cultivated plants. *Bemisia tabaci* is the dominating whitefly in the region. Its host range includes cotton, tobacco, vegetables (tomatoes, eggplant, okra, bell peppers, cucurbits, etc.), legumes (beans, soybeans, cowpeas and groundnut), tuber and root crops (sweet potato, cassava, potato) among others. The host range of *Trialeurodes vaporariourm* is similar to the one for *Bemisia tabaci*, but the former usually occurs at higher altitudes and cooler climates than *B.tabaci*. *Trialeurodes vaporariorum* attacks many plants grown under protected conditions (greenhouses) in temperate countries, the most severely affected crops are aubergine, cucumber, beans, sweet peppers, tomatoes and a large number of ornamentals. The status of this whitefly in field grown crops in the region

is not clear.

The cabbage whitefly (*Aleyrodes proletella*) is a pest of Brassicas but rarely reaches levels that require intervention.

The citrus woolly whitefly (*Aleurothrixus floccosus*) is found mainly on citrus plants, but also attacks coffee (arabica), guava, eggplant, aubergine, mango, and several wild plants.

The spiralling whitefly (*Aleurodicus dispersus*) feed on many plants. In West Africa, it has been observed causing damage on many food crops, including cassava, soybean, pigeon pea, citrus, papaya and others. This whitefly has also not been recently found in East Africa.

Symptoms

Feeding of whiteflies causes yellowing of infested leaves. Whiteflies excrete honeydew, a clear, sugary liquid. This honeydew covers the lower leaves and supports the growth of black sooty mould, which may coat the entire plant. Where plant viruses are transmitted plants show the typical

symptoms of the virus diseases. Presence of whiteflies can also be recognised by a cloud of tiny whiteflies flying up when the plants are shaken. The whiteflies resettle soon on the plants.

Affected plant stages

Seedling, vegetative growing and flowering stage

Affected plant parts

Leaves.

Symptoms by affected plant part

Leaves: honeydew or sooty mould.

Biology and Ecology of Whiteflies

Eggs are tiny (about 0.2 mm long) and pear-shaped. They stand upright on the leaves, being anchored at the broad end by a short stalk inserted into the leaf. They are laid usually in arcs or circles, on

Eggs of spiralling whitefly
© A.M.Varela, icipe

the undersides of young leaves. Eggs are whitish in colour when first laid, but gradually turn brown. Some whiteflies deposit large quantity of wax around the eggs in the form of a loose spiral like a fingerprint. Hatching occurs after 5 to 10 days at 30°C depending on species, temperature and humidity.

On hatching, the first instar or crawler is flat, oval, very small (barely visible evn with a hand lens) and and greenish-white in colour. It is the only mobile immature stage. It moves to a suitable feeding location on the lower leaf surface where it settles. It moults, loosing the legs and antennae, and cannot move throughout the remaining immature stages. They pass through two additional feeding stages, known as nymphs. The nymphs are usually oval or oval-elongate in shape, and are simple in appearance like small scale insects. Nymphs of many species produce waxy secretions around the margins and the dorsal

surface of their body.

The last (fourth) immature stage is known as puparium. In this stage the metamorphosis to adult occurs. The red eyes of the adult developing inside are visible through the skin (integument). As the other larval instars it is greenish in colour and is scale-like, but becomes more bulky shortly before the adult emerge. They are usually found on mature leaves. The adult emerges about six days after pupation. It usually emerges through a T-shaped split in the dorsal surface of the pupal case.

The total nymphal (immature) period last 2 to 4 weeks according to temperature. Large populations may develop within three weeks under optimum conditions, and the lower leaf surfaces may be almost covered by immature stages.

Adults are small (1 to 3 mm long), with two pairs of wings that are held roof-like over the body. They resemble very small moths. Their body is pale yellow. The

The tobacco whitefly *Bemisia tabaci* adult (bottom right) about 1 mm long, beside two *Trialeurodes vaporariorum* adults.

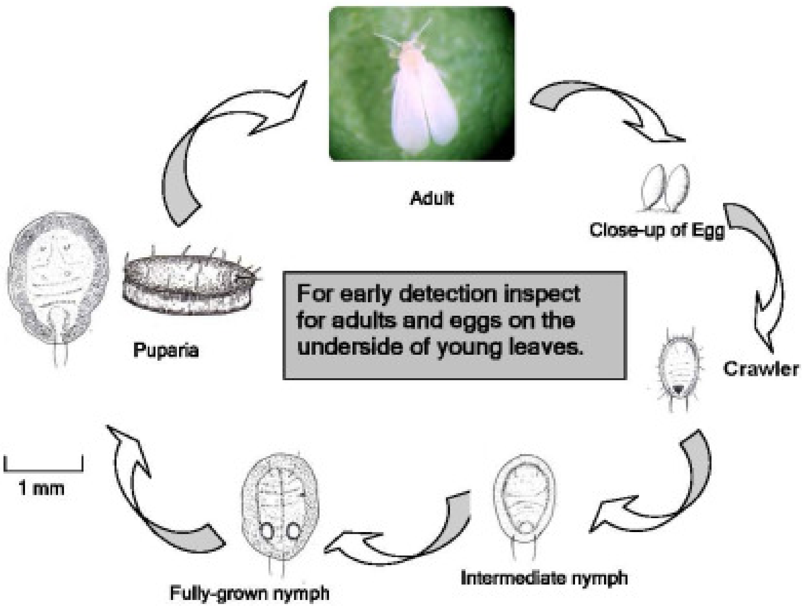
© Ian D. Bedford. Reproduced from Crop Protection Compendium, 2004 Edition. © CAB International Publishing. Wallingford, UK.

body and wings are covered with a powdery, waxy coating. Whiteflies are mostly white, but can also be yellowish and some species have dark or mottled wings. They have sucking mouthparts. They are often found clustered in groups on the underside of young leaves and readily fly away when disturbed. A female may live for 60 days; life of the male is generally much shorter (9 to 17 days).

Means of movement and dispersal

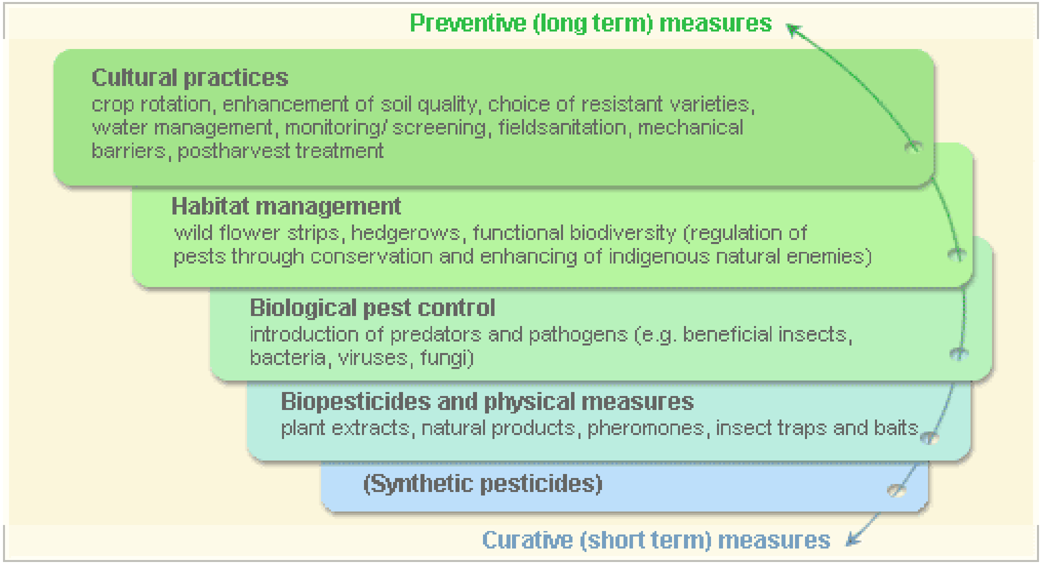
Whiteflies adults do not fly very efficiently, but once airborne can be transported long distances by the wind. All stages of the pest, but particularly the immature stages (which are small and easily overlooked) are likely to be carried on plant materials.

Whiteflies life stages



Pest and Disease Management

Pest and disease management: General illustration of the concept of *infonet-biovision*



These illustration shows the methods promoted on infonet-biovision. The

methods shown at the bottom have a long-term effect, while methods shown at the top have a short-term effect. In organic farming systems, methods with a long-term effect are the basis of crop production and should be used with preference. On the other hand methods with a short-term effect should be used in emergencies only. On infonet we do not promote synthethic pesticides.

Further below you find concrete preventive and curative methods against Whiteflies.

Cultural practices

Monitoring and decision making

For early detection inspect for adults and eggs. They are usually found on young leaves. Watch out for whiteflies flying up when the crop is disturbed. It is important to identify the whitefly and the type of damage caused, as well as the stage of the crop for making decision. Small numbers of whiteflies do not cause major direct plant damage to healthy, mature plants and therefore do not justify any chemical intervention. Control measures can be justified if large numbers of whiteflies are

present during the early stages of the crop. However, where virus transmission is involved, as is the case of the tobacco whitefly on tomatoes, sweet potato or cassava, even small numbers of whiteflies may need to be controlled.

Yellow sticky traps can be used to monitor the presence of whiteflies for timing of interventions. See more on section on traps below.

The following description helps to distinguish the most important whitefly species in Africa: However, for authoritative identification contact the Entomology Department of the National Museums of Kenya.

Adults of the tobacco whitefly (*B. tabaci*) have wings all white in colour, and hold them tent-like over the body, giving a narrow, triangular, appearance while other whiteflies usually hold their wings flatter, which give them a flattened appearance.
The larval stages and puparium of this whitefly are naked (not covered with waxy white material). They appear as pale yellow oval specks to the naked eye. On a closer look they are oval and flat with a rounded outside

margin, tapering toward the leaf surface as viewed from the side. In contrast, the pupae of the greenhouse whitefly have distinctly ridged outside margins with flat, vertical surfaces surrounded by short threads.

Adult of the greenhouse whitefly

© M. Billah, A. M. Varela, icipe

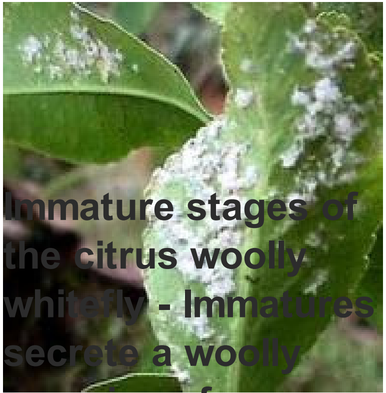
The wings of the greenhouse whitefly (*Trialeurodes vaporariorum*) are completely

white, while the cabbage whitefly (*Aleyrodes proletella*) has dark flecks on the wings.

The cabbage whitefly. Larvae are yellow-white scales, 0.3-0.6 mm long. Adult are about 1mm long.

© A.M. Varela, icipe

Adults of the citrus woolly whitefly (*Aleurothrixus floccosus*) have wings all white in colour. Eggs are in a circle or half a circle. The immature stages are covered by abundant, dirty-looking, flocculent white wax, which gives them a woolly appearance. They usually form large dense colonies covered with cotton-like secretions on the lower leaf surface.



Immature stages of the citrus woolly whitefly - Immatures secrete a woolly covering of flocculent white wax.

© B. Loehr, icipe

Adult of the spiralling whitefly (*Aleurodicus dispersus*) are white, although pale or dark spots may occasionally occur on the forewings. Eggs are laid on the lower leaf surface in characteristic spiral patterns, resembling fingerprints of white material secreted by the female. Nymphs and adults produce considerable amount of white wax. When the adults move around they leave behind a trace of waxy material. They usually form dense colonies on the lower leaf surfaces.

Providing conditions for growing healthy plants

Ensure adequate growing conditions for the crop such as good soils, adequate water supply, proper feeding (avoid application of high doses of nitrogen fertiliser, since it favours development of the pest), proper spacing and good nursery management to start the crops with healthy, vigorous plants. If the plants are to be raised in a seedbed and later transplanted like many vegetables, keep the seedlings protected under a

fine meshed insect netting until they are ready for transplanting. Make sure the netting is always properly closed.

Mixed cropping systems

Selection of crops for intercropping can be used to manage whitefly populations. For instance, interplanting tomatoes with capsicum or cucumber has reduced whiteflies numbers when compared with tomatoes alone or tomatoes planted with eggplant or okra.
Planting of border rows with coriander and fenugreek, which are non-host of *B. tabaci*, will serve as windbreaks, and are favourable for natural enemies and also repellent to whiteflies.
Growing African marigolds and nasturtiums has been reported to discourage whiteflies (Dobson et al).

Planting date

Avoid the season when whiteflies are more likely to occur.

Host plant resistance

Growing resistant varieties is particularly useful for the management of diseases caused by viruses transmitted by whiteflies, in particular, *B. tabaci*. Outbreaks of cassava mosaic virus (CMV) in East Africa are associated with the varieties grown and are less devastating in areas where many different varieties are grown. The outbreak of CMV in East Africa has been contained by farmers adopting resistant varieties introduced from Nigeria (IITA) or those selected by the National Agricultural Research Organisations from the available local varieties. Resistant varieties introduced from Nigeria include SSA, Nase 1, Nase 2, and Nase 3 (or Migyera) (OFDA-CMD Project). For more information on cassava mosaic virus click here.

Tomato varieties resistant to TYLC virus are also available from AVRDC and can be bought in Tanzania and Kenya. For instance the varieties Fiona and Tyking are resistant to TYLCV in Tanzania. For more information on tomato yellow leaf curl virus (TYLCV) click here.

Sanitation

Weeds play an important role in harbouring whiteflies between crop

plantings. They also often harbour whitefly-transmitted viruses. Therefore, weeds should be removed in advance of planting. Fields should also be kept weed free.

Biological pest control

Natural enemies

Whiteflies are attacked by a large number of natural enemies: parasitic wasps (e.g. *Eretmocerus* spp., *Encarsia* spp.), predatory mites (*Amblyseius* spp. and *Typhlodromus* spp.), predatory thrips, lacewings, rove beetles and ladybird beetles. The dusty lacewing *Conwentzia africana* is considered to be one of the most important predators of *B. tabaci* in East and southern Africa (Legg, 2003).

Parasitised pupae can be recognised by the black colour of the puparium, and later, when the parasitic wasp has emerged, by an irregular round hole on the puparium, which is chewed by the emerging wasp. The whitefly adult usually leaves a T-shaped split in the pupal case after emerging. Parasitic wasps are very important for control of whiteflies. *Encarsia formosa* in particular, has been widely used for control of

whiteflies worldwide.

Two parasitic wasps *Encarsia guadaloupe* and *Encarsia haitiensis* have provided control of the spiralling whitefly an introduced pest in West Africa (Neuenschwander, 1998; James, et al, 2000).

The citrus woolly whitefly, accidentally introduced into East Africa, is now under control by the parasitic wasp *Cales noacki*, introduced and released in the region in the late 90s. For more information on the citrus woolly whitefly and the parasitic wasp click here

Several fungi (e.g. *Verticillium lecanii, Beauveria bassiana, Paecilomyces fumosoroseus*) attack whiteflies and can be useful control agents in situations where the crop is grown in high humidity conditions. Commercial preparations are available.

Natural enemies commercially available in Kenya include the parasitic wasp *Encarsia formosa*, produced by Dudutech and registered as Encartech®, and the pathogen *Beauveria bassiana* sold under the trade

name Bb plus® by Juanco SPS Ltd.

Mortality of whiteflies by natural enemies is particularly important in crops where feeding damage is the cause of losses, rather than virus transmission. In cases where the whiteflies are vectors of virus diseases, control provided by natural enemies is generally not sufficient to prevent virus spread and transmission.

Biopesticides and physical methods

Neem (*Azadirachta indica*)

Neem-based pesticides are reported to control young nymphs, inhibit growth and development of older nymphs, and reduce egg laying by adult whiteflies. They also reduce significantly the risk of Tomato Yellow Leaf Curl Virus transmission. Efficacy of neem-based pesticides can be enhanced by adding 0.1 to 0.5% of soft soap.
For more information on Neem click here.

Physical methods

Yellow sticky traps usually used to monitor the presence of whiteflies for timing of interventions, have also been used as a control method for low density infestations in enclosed environments.

- **Yellow plastic gallon containers mounted upside down on sticks coated with transparent automobile grease or used motor oil. These should be placed in and around the field at about 10 cm above the foliage. Clean and re-oil when traps are covered with flies.**
- **Yellow sticky boards. 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 from the 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 up. Place traps near the plants but faraway enough to prevent the leaves from sticking to the board. Traps when hung should be positioned 60-70 cm above the plants.**
- **Yellow plastic trapping sheets. A 2 m long x 75 cm wide yellow plastic sheet coated with motor oil, both ends attached to bamboo or wooden poles and carried by 2 persons through the field to mass capture adult flies**

- **Yellow plastic drinking cups coated with adhesives and stapled on stakes above plant canopies to trap flies**

For more information on traps click here

Flour/Starch preparation has been listed by several authors as successful against whiteflies. Ensure the spray reaches the underside of the leaves, where the whiteflies like to hide. For more information on Flour spray click here.

Plastic covers and mulches. Preventing physical contact of the whiteflies with the plant can prevent the transmission of virus diseases. This can be done by using plastic covers and mulches and by cultural methods. Several cover crops (forage, peanut, weeds) and inert covers (silver, yellow, and white/black plastic mulches) have been shown to reduce whitefly damage in tomatoes. However, when using plastic covers, care should be taken to avoid sunscald (see also on tomato page).
This is effective as long as the plants are young and do not cover the mulch; the whiteflies will be more attracted by the colour of the plastic mulch. The heat of the plastic kills the whiteflies. The protection can last

for 10 to 20 days after transplanting and about 30 days after direct seeding.

Covering tomato seedling nurseries with nylon nets or use of tunnels for 3 to 5 weeks protects seedlings from whiteflies infestation. These methods have been reported to reduce the transmission of the Tomato Yellow Leaf Curl Virus in several countries.

Spraying with soap and water reportedly control whiteflies. However, care should be taken, since the use of strong soaps, or soft soaps at high concentrations can scorch the plants.
For more information on Soap spray click here.

Information Source Links

- **CABI. (2005). Crop Protection Compendium, 2005 Edition. CAB International Publishing. Wallingford, UK. www.cabi.org**
- **Legg, J., Gerling, D., Neuenschwander, P. (2003). Biological Control of Whiteflies in Sub-Saharan Africa. In Biological Control in IPM System in Africa. CAB International. ISBN: 0-85199-639-6.**

- **Mound, L.A. and Halsey, S.H. (1978). Whitefly of the World. British Natural History Museum.. ISBN: 0-471-99634-3.**
- **Tropical Whitefly IPM Project Description http://www.tropicalwhiteflyipmproject.cgiar.org/project-profile03.jsp**
- **Tropical Whitefly IPM Project http://www.tropicalwhiteflyipmproject.cgiar.org/**
- **Tropical Whitefly IPM Project: Book 'Whitefly and Whitefly-Borne Viruses in the Tropics: Building a Knowledge Base for Global Action' http://www.tropicalwhiteflyipmproject.cgiar.org/WF-book.htm**
- **Tropical Whitefly IPM Project: Video 'The white plague' http://www.tropicalwhiteflyipmproject.cgiar.org/videos.jsp**
- **United States Department of Agriculture, Whitefly Knowledgebase: http://whiteflies.ifas.ufl.edu/wfly0019.htm**

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

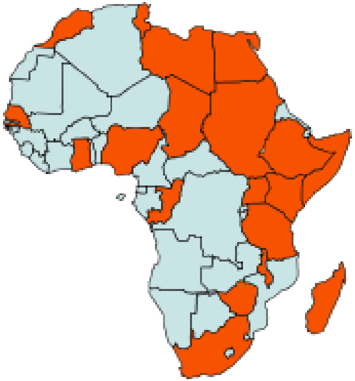
Thrips

Thrips

Scientific name: ***Thrips tabaci***
Family: Thysanoptera: Thripidae
Type: pest (insect/mite)
Host plants: Avocados Bananas Beans Cabbage/Kale, Brassicas Cashew Citrus plants Cocoa Coffee Cowpea Eggplant Green gram Groundnut Mango Okra Onion Passion fruit Peas Peppers Pigeon pea Pineapple Tea Tomato Wheat

General Information on Pest and Damage

Geographical distribution



Geographical Distribution of Thrips in Africa (red marked)

Damage

Thrips feed on the lower surface of leaves, buds, flowers and fruits. Both larvae and adults feed by piercing the plant tissue and sucking up the released plant juices. A heavy infestation causes premature wilting, delay in leaf development and distortion of leaves and


Thrips damage on tomato
© A. M. Varela, icipe

young shoots. Under heavy infestations, when buds and flowers are attacked, abortion usually occurs. Thrips attack may also result in premature fruit shed. Thrips may also cause cosmetic damage to plants. Thrips feeding causes scarring of flowers and skin blemishes and distortion of fruits (scarring, russeting, fruit cracking or splitting), which affects fruit quality. In addition, egg-laying spots may be surrounded by slightly raised, light coloured areas, which may lead to rejection of banana, tomato or peas grown for the export market.

Thrips may also cause cosmetic damage to plants by laying eggs. The egg laying spots may be surrounded by slightly raised, light coloured areas, which may lead to rejection of banana, tomato or peas grown for the export market.

Thrips also cause indirect damage as vectors of disease-causing virus, fungi

and bacteria. Several species of thrips are vectors of the tomato spotted wilt virus group in a wide range of crops (bell pepper, lettuce, pea, tobacco, potato, tomato, groundnut and a large number of ornamental plants). In addition, injuries caused by thrips feeding may serve as entry point for bacterial or fungal pathogens. For example infection by fusarium ear rot on maize is facilitated by the western flower thrips, and purple blotch in onions by the onion thrips.

Scarred eggplants due to thrips damage.

© A. M. Varela, icipe

The stage of growth when an infestation occurs seems to determine the extent of yield loss. Direct feeding damage is most harmful in dry climate and conditions, when heavily attacked plants lose moisture rapidly. Young plants are particularly susceptible, and there may be total losses at the seedling stage in onions, cabbages and cotton.

Major species of thrips attacking crops in Africa:

- **African bean flower thrips (*Megalurothrips sjostedti*)**
- **Coffee thrips (*Diarthrothrips coffeae*)**
- **Blossom or Cotton bud thrips (*Frankliniella schultzei*)**
- **Black tea thrips (*Heliothrips haemorrhoidales*)**
- **Banana thrips (*Hercinothrips bicinctus*)**
- **Citrus thrips (*Scirtothrips aurantii*)**
- **Cacao or red banded thrips (*Selenothrips rubrocinctus*)**
- **Tomato thrips (*Ceratothripoides brunneus*)**
- **Cereal thrips (*Haplothrips* spp)**
- **Tea thrips (*Scirtothrips kenyensis*)**
- **Onion thrips (*Thrips tabaci*)**
- **Western flower thrips (*Frankliniella occidentalis*)**

Host range

Thrips attack a wide number of vegetables, fruit and flower crops and cereals. Some species are specific to particular host plants while other feed on many host plants. Both onion thrips and western flower thrips attack a wide range of plants including cereals and broadleaves crops.

Symptoms

The characteristic symptom of attack is a silvery sheen of the attacked plant tissue, and white or silvery patches and streaks on leaves, fruits and pods. Affected tissue will dry up when the damage is severe. A further indicating of attack by thrips is small black spots of faecal material on the infested parts of the plant. However, small dark spots can also be observed on plants attacked by other insects such as lace bugs. Damaged leaves may become papery and distorted. Infested terminals lose their colour, roll, and drop leaves prematurely. Feeding on fruits leaves a roughened silvery texture on the skin.

Thrips damage on cabbage

© A. M. Varela, icipe

Affected plant stages

Flowering stage, post-harvest, seedling stage and vegetative growing stage.

Affected plant parts

Growing points, inflorescence and leaves.

Symptoms by affected plant part

Growing points: dead heart.
Inflorescence: lesions; abnormal colour; abnormal forms.
Leaves: lesions; abnormal colours; abnormal forms.

Biology and Ecology of Thrips

Eggs are very tiny, a single egg is 0.25 mm long and 0.1 mm wide. They are white when freshly laid and turn pale yellow toward maturation. Eggs are usually laid singly inside the plant tissue, and are therefore not visible. Some thrips (e.g. *Haplothrips* spp) lay eggs singly or in clusters attached to the

plant surface.

Larvae. The first and second instar larvae are very small (0.5 to 1.2 mm), elongated, slender, and vary in colour from pale-yellow, orange or red according to the species. They have piercing-sucking mouthparts. They resemble a miniature version of the adults but do not have wings.

Thrips on onion. Thrips are 1 to 1.5 mm small.

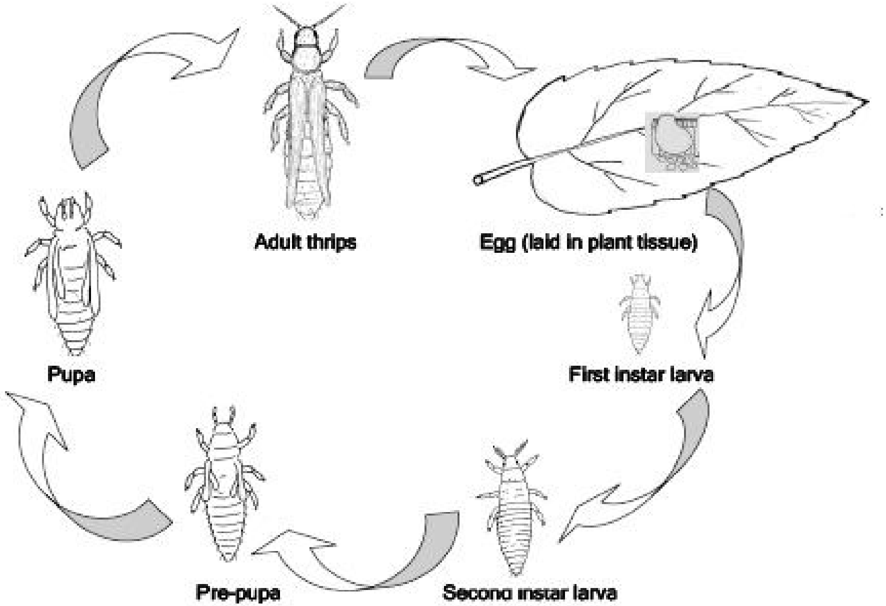
Prepupa and pupae. These two or three instars are intermediate forms between the nymph and the adult. They have short wing buds but no functional wings. During these stages thrips are inactive and do not feed and therefore they do not do cause any damage to the plant. Pupation may occur on a plant or in the soil beneath, depending on species.

Adult thrips are small (usually 1 to 1.5

Close-up of thrips (*Megalurothrips sjostedti* (black) and *Frankliniella occidentalis* (yellow). Real size 1 to 1.5 mm.

mm), slender and usually winged. The wings are long, narrow and fringed with long hairs, and at rest, are tied on the back along the body. Their colour varies according to the species. Most species are black, brown or yellow

The life cycle takes about two to three weeks under warm conditions, which gives them a enormous capacity for increase. Thrips migrate actively between different hosts.

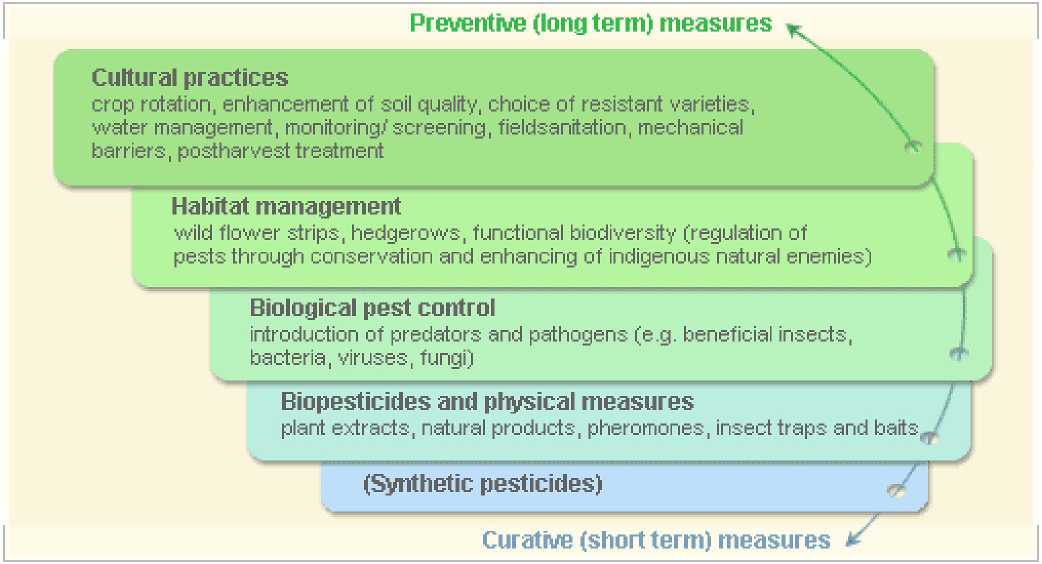


Thrips life cycle

© A.M. Varela, icipe

Pest and Disease Management

Pest and disease management: General illustration of the concept of *infonet-biovision*



These illustration shows the methods promoted on infonet-biovision. The methods shown at the bottom have a long-term effect, while methods shown at the top have a short-term effect. In organic farming systems, methods with a long-term effect are the basis of crop production and should be used with preference. On the other hand methods with a short-term effect should be used in emergencies only. On infonet we do not promote synthethic pesticides.

Further below you find concrete preventive and curative methods against Thrips.

Cultural practices

Monitoring and decision-making

Monitor the crop regularly. Early detection of thrips is important to determine an appropriate control strategy. In the case of onions, randomly sample plants and evaluate thrips numbers and damage under leaf folds. Sample at least five plants from four separate areas of the field. (For more information on monitoring and damage thresholds click here to see datasheet on onions). In other crops pay particular attention to flower buds and flowers. Thrips can be easily detected by shaking leaves and flowers on a white piece of paper.

Adult thrips can be monitored by mass trapping with coloured (blue, yellow or white) sticky traps or water traps in the nursery or field.

The type of crop damage needs to be taken into consideration when deciding on the need for control measures and the appropriate strategy.

This is particularly important in the case of thrips-transmitted virus diseases. The prevention of these diseases is difficult since relatively small numbers of vector thrips can result in high rates of pathogen spread. In general, transmission of the plant pathogen occurs so quickly that the thrips are not killed before they have transmitted the virus to the plants. In these cases, the best strategy is to keep the crop free of thrips at least during the most vulnerable period of the crop.

Irrigation

Provide good growing conditions for the plants to ensure rapid growth. Environmental stress that weakens plants makes them more susceptible to thrips attack. In particular, plants under water stress are very susceptible to direct thrips damage. Adequate irrigation is a critical factor in minimising damage.

Tillage

Ploughing and harrowing, and solarisation can kill pupae in the soil from previously infested crops.

Planting date

Well-established crops can withstand attack better than newly planted ones, therefore early planting is desirable particularly in rainfed crops. This is especially beneficial in light, dry soils, where it is common for plants to suffer from water shortage as the growing season progresses.

Intercropping

In some cases intercropping has been found to reduce thrips infestation. The effects are probably caused through shading of the lower crop by the taller intercrop, which influences the abundance and activity of the thrips. However, thrips reduction is not necessarily translated in yield increase. The effect of intercropping on thrips numbers and damage depends, among other factors, on the selection of plants. In some cases intercropping does increase the numbers of thrips in susceptible crops. Thus, populations of the onion thrips increase on potatoes when intercropped with shallot and garlic, as does *Caliothrips indicus* on groundnuts intercropped with pigeon pea and mung bean. A mixed cropping habitat is likely to encourage thrips predators, as has been

shown for the minute pirate bugs (*Orius tristicolor*) (Parella and Lewis, 1997)

In Egypt, intercropping onion and garlic with tomato reduced infestations of the onion thrips by almost 80% percent, but the yield of both crops declined. In England infestation of the onion thrips (*Thrips tabaci*) on onions was halved when intercropped with carrots. The effect was greater with closely alternating single rows of each. Infestation of the onion thrips on cabbage was reduced tenfold by growing clovers (*Trifolium repens* or *T. subterraneum*) between rows (Parella and Lewis, 1997).

In Kenya, populations of the African bean flower thrips (*Megalurothips sjostedti*) and *Hydatothrips adolfifriderici* on cowpea buds were almost halved by intercropping the cowpea with sorghum and maize (Parella and Lewis, 1997)

Crop rotation

Avoidance of successive planting of susceptible crops helps reduce the impact of thrips. Identification of the thrips involved is important to know

the host range of crops adequate for crop rotation. Thus, in the case of onions, they should not be planted near grain fields.

Biological pest control

Natural enemies

Natural enemies, in particular predators are often found feeding on thrips. They include predatory thrips, predatory mites (e.g. *Amblyseius* spp.) anthocorid bugs or minute pirate bugs (*Orius* spp.), ground beetles, lacewings, hoverflies, and spiders. They are important in natural control of thrips. The parasitic wasp *Ceranisus menes* is an important natural enemy. The farmer can increase the number of these natural enemies by providing protective habitats for them. For more information on natural enemies click here.

Pathogens such as the fungi *Entomophthora, Verticillium lecanii, Beauveria bassiana* and *Metarhizium anisopliae* are also important in natural control of thrips. Spray formulations of *Beauveria bassiana* are used for the control of thrips. This microorganism is most effective when used early before large thrips populations have built up.

The natural enemies *Beauveria bassiana, Orius jeanneli*and *Amblyseius californicus* are commercially available in Kenya (reference addresse see below)

Biopesticides and physical methods

Spinosad

Spinosad, a microbial insecticide, is very effective in controlling thrips. This biopesticide is derived from the fermentation of an Actinomyces bacterium, commonly found in the soil. In Kenya, this microbial pesticide is sold as Tracer 480 SC®.

Neem

Neem-based pesticides are reported to control young nymphs, inhibit growth and development of older nymphs, and reduce egg-laying by adult thrips. Adding 0.1 to 0.5% of soft soap enhances efficacy of neem-based pesticides.
For more information on Neem click here

Other botanicals and measures

Other botanical pesticides that have been recommended for management of thrips include garlic, rotenone, ryania, pyrethrum and sabadilla. A homemade botanical spray of garlic and pepper has been recommended for organic growers in USA (ATTRA, 2004). The garlic/pepper mixture is made by liquifying two bulbs of garlic and two cayenne or habanero (hot) peppers in a blender 1/3 full of water. Solids are strained out, and enough water is added to make one gallon of the concentrate. The spray solution is prepared by mixing ¼ cup of the concentrate with two tablespoons of vegetable oil and enough water to make 1 gallon (ATTRA, 2004). For more information on garlic recipe click here.

For more information on pyrethrum recipe click here.

Sulphur, insecticidal soaps and diatomaceous earth have demonstrated efficacy in suppressing thrips in several crops. Three applications of superfine sulphur at monthly intervals are recommended in fruit crops. Lime sulphur has also been recommended as an alternative. However,

care should be taken when using sulphur as it has been reported to harm some predatory mites.

Flour/starch preparations have been recommended for control of thrips. For more information on Flour preparation click here.

Coloured sticky traps (blue, yellow or white) or water traps are useful for monitoring and in some cases reducing thrips by mass trapping them in the nursery or field. Research in California has shown that hot-pink sticky cards attract more thrips than blue-coloured traps. The colour spectrum of the boards is important for the efficacy of the sticky traps. Bright colours attract more thrips than darker ones. For more information on sticky traps click here.

Overhead irrigation and rainfall reduce thrips numbers. Irrigation by flooding fields has been found to reduce thrips damage. It destroys a large proportion of pupae in the soil.

Ultraviolet-absorbing plastics, used to build walk-in field tunnels have

proved effective in protecting crops from western flower thrips.

Reflective mulches deter thrips. Aluminium-surfaced mulch (e.g. coated plastic mulch) has considerably decreased thrips and virus infection in tomato, pepper and tobacco. The effectiveness of the mulch decreases with increased shading by lower leaves (Lewis, 1997).

Information Source Links

- **ATTRA. 2004. Thrips Management Alternatives in the Field. By George Kuepper. NCAT agriculture specialist. ATTRA publication #IP132. http://attra.ncat.org/attra-pub/PDF/thrips.pdf**
- **Crop Protection Compendium, 2005 Edition. CAB International, Wallingford, UK, 2005 www.cabi.org**
- **Lewis, T. (1997). Field and Laboratory Techniques. In Thrips as crop pests (1997). Edited by T. Lewis. CAB International. Institute of Arable Crops Research-Rothamsted, Harpenenden, Herts, UK. Pages 435-475. ISBN: 0-85199-178-5.**
- **OISAT: Organisation for Non-Chemical Pest Management in the Tropics. www.oisat.org**

- **Parella, M. P. and Lewis, T. (1997). IPM in Field Crops. In Thrips as crop pests. (1997).. Edited by T. Lewis. CAB International. Institute of Arable Crops Research-Rothamsted, Harpenenden, Herts, UK. Pages 595-614. ISBN: 0-85199-178-5.**
- **UC Pest Management Guidelines: How to Manage Pests. Onion and Garlic Thrips. UC IPM Online. Statewide Integrated Pest Management Program. University of California. Agriculture and Natural Resources. http://www.ipm.ucdavis.edu/PMG/selectnewpest.onion-and-garlic.html**
- **Varela, A.M., Seif, A., and Löhr, B. (2003). A Guide to IPM in Tomato Production in Eastern and Southern Africa. ICIPE, Nairobi, Kenya. ISBN: 92 9064 149 5 www.icipe.org**

Local Reference Addresses for Natural Enemies

- ***Amblyseius californicus* (Amblytech®), *Orius jeanneli* (Oritech®) are available at Dudutech Kenya Ltd., email: dudtech@kenyaweb.com**
- ***Beauveria bassiana* (Bb plus ®) is available at Juanco SPS Ltd. http://www.juenacogroup.com.**

Information of www.infonet-biovision.org

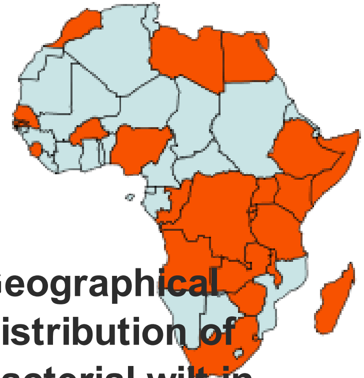
Information of www.infonet-biovision.org

Bacterial wilt

Bacterial wilt
Scientific name: *Ralstonia solanacearum* (=*Pseudomonas solanacearum*)
Family: Burkholderiales: Ralstoniaceae
Type: disease (bacterial)
Common names: brown rot, moko disease (banana), slime disease (potato), southern bacterial blight (tomato), seedling rot
Host plants: African Nightshade Bananas Eggplant Groundnut Peppers Potato Tomato Tobacco

General Information on Disease and Damage

Geographical distribution



Geographical Distribution of Bacterial wilt in Africa (red marked)

Symptoms

The disease causes rapid wilting and death of the entire plant without any yellowing or spotting of leaves. All branches wilt at about the same time. When the stem of a wilted plant is cut across, the pith has a darkened, water-soaked appearance. There is a greyish slimy ooze on pressing the stem. In later stages of the disease, decay of the pith may cause extensive hollowing of the stem. Bacterial wilt causes no spotting of the fruits. Affected roots decay, becoming dark brown to black in colour. If the soil is moist, diseased roots become soft and slimy.

Water test: To distinguish this wilt from others, take a thin slice or sliver of the brown stem tissue and place it on the inside of a glass of water at the water level. If bacterial wilt is present, a milky bacterial stream (strands) flows from the lower cut surface of the sliver within seconds.

Water test for detection of bacterial wilt. Note

bacterial strands oozing from infected tissue.
© A. M. Varela and A. A. Seif, icipe

Bacterial wilt of potato: The infested leaves wilt during the (sunny) day and sometimes recover during cool hours. The wilting is similar to the result of lack of water. During the rapid development of the disease, the entire plant wilts quickly without yellowing. Other symptoms could be wilting of only a part of the stem, or one side of the leaf/stem. The stem wilts or dries up completely and the remainder of the plant remains healthy. When the diseased tuber is cut, it shows a browning of the vascular ring and the immediate surrounding tissues On the cut surface, a creamy fluid usually appears on the vascular ring.

Bacterial wilt of tomato/eggplant: Bacterial wilt of tomato/eggplant: The initial symptom is a wilting of the terminal leaves, which after 2 to 3 days becomes permanent when the whole plant wilts due to the active development of the disease. Then the whole plants wilt and die suddenly.

Total collapse of the plant usually occurs when temperatures reach 32°C and above. Plant wilts while still green. In the case of a slow development of the disease, the plant stunts and produces large numbers of adventitious roots on the stem. Bacterial wilt diagnosis in the field can be done easily. Cut a piece of the stem 2 to 3 cm long from the base. Suspend the cut stem in clear water in a glass container. Hold the stem with an improvised tong to maintain a vertical position. Within a few seconds, milky bacterial threads are discharged from the cut stem.

Moko disease of banana: Initially one of the youngest three leaves turns pale-green or yellow in color and breaks down at the petiole and the pseudostem. Later all the other leaves collapse around the pseudostem. An infected finger or fruit shows dry and rotted pulp that is colored brown or black, and the presence of bacterial discharges.

Affected plant stages

Vegetative growing stage.

Affected plant parts

Leaves, roots, seeds, fruits, stems, vegetative organs and whole plant.

Symptoms by affected plant part

Growing points: wilting.
Leaves: wilting.
Roots: rot.
Stems: internal discoloration; creamy exudates; wilt.
Vegetative organs: internal discoloration.
Whole plant: plant death; dwarfing.

Biology and Ecology of Bacterial Wilt

Source of infection and spread

The bacterium is soil borne and can survive in soil for long periods. However, some soils are conducive to bacterial wilt and other suppressive. Important soil factors affecting the occurrence and persistence of the pathogen are soil moisture and antagonistic microorganisms. Soil type influences soil moisture and population of antagonistic microorganisms, which in turn affect the survival of *R. solanacearum* in soil.

Bacterial wilt (*R. solanacearum*) has a very wide host range and infects all nightshade plants (members of Solanaceae). Weed hosts include black nightshade, lantana and Jimson weed. It infects plants through roots. As the roots of wilted plants decay, the bacteria are released back into the soil. Infestation by root-knot nematodes aggravates the disease. The bacterium is especially destructive in moist soils at temperatures above 24° C. It is sensitive to high pH (alkaline soils), low soil temperature, low soil moisture and low fertility levels. Spread is effected by running water, movement of infested soil and also diseased seedlings.

Bacterial wilt can also be spread on vegetative propagating material. Therefore, plant quarantine of potentially infested plant material is very important to avoid long-range dispersal.

(Hayward 1991)

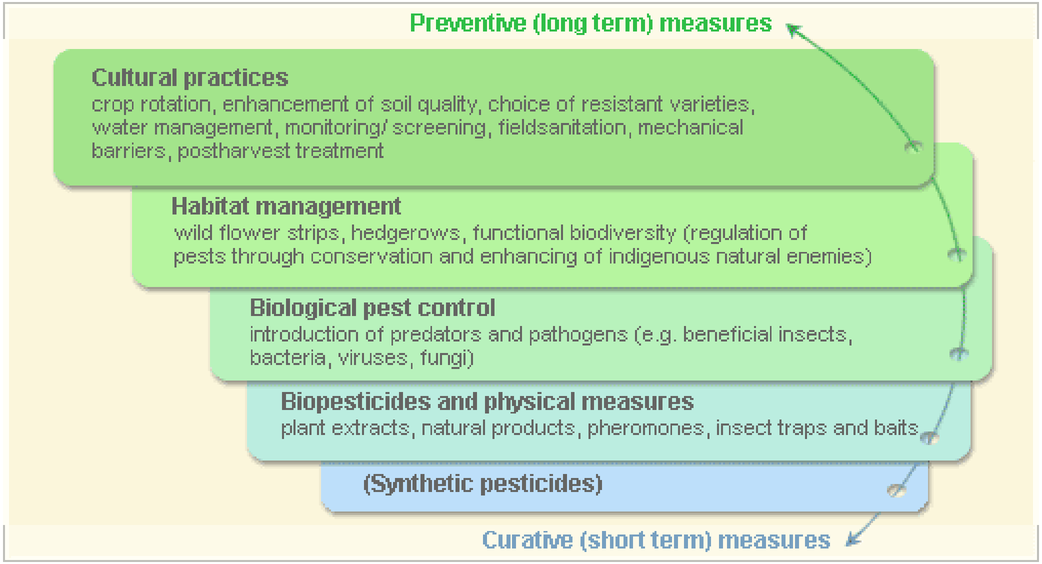
Conditions that favour disease development

1. **Crop residues infected by *Ralstonia solanacearum* left in the field .**
2. **Injured roots caused by farm tools or by soil pests**

3. **Warm temperature and high soil moisture**
4. **Slightly acidic soils**
5. **Poor and unfertile soil**
6. **Infestation by root-knot nematodes**

Pest and disease Management

Pest and disease Management: General illustration of the concept of *infonet-biovision*



These illustration shows the methods promoted on infonet-biovision. The methods shown at the bottom have a long-term effect, while methods shown at the top have a short-term effect. In organic farming systems, methods with a long-term effect are the basis of crop production and animal husbandry and should be used with preference. On the other hand methods with a short-term effect should be used in emergencies only. On infonet we do not promote synthethic pesticides.

Further below you find concrete preventive and curative methods against Bacterial wilt.

Cultural practices

- **Crop rotation is not effective as the pathogen can survive for a long period (several years) in the soil and also attack a wide range of crops and solanaceous weeds**
- **Use plant varieties that are tolerant / resistant to bacterial wilt. In Kenya, the following tomato varieties have been claimed to be resistant to bacterial wilt: "Fortune Maker", "Kentom", and "Taiwan F1".**
- **Do not grow crops in soil where bacterial wilt has occurred.**
- **Rogue out wilted plants from the field to reduce spread of the disease**

from plant to plant

- Control root-knot nematodes since they could facilitate infection and spread of bacterial wilt
- Where feasible, extended flooding (for at least 6 months) of the infected fields can reduce disease levels in the soil
- Soil amendments (organic manures) can suppress bacterial wilt pathogen in the soil

Good results have been encountered in Australia, the US and the Philippines by using "Biofumigation" as soil treatment for bacterial wilt.

Disease avoidance

Since high soil temperatures and soil moisture enhance bacterial wilt development, damages can be minimized by changing the date of planting, considering seasons that are less favorable for disease development.

Intercropping

In some developing countries intercropping has been used as a means of reducing pathogen populations in the soil and root-to-root transmission.

In Burundi, growing potato with bean showed a lower incidence of bacterial wilt, indicating that a bean intercrop, which has a dense root system and grows quickly, was better than a crop such as maize, which develops slower and has a more dispersed root system.

(Hayward 1991)

Information Source Links

- **Beije C.M, Kanyagia S.T., Muriuki S.J.N., Otieno E.A., Seif A. and Whittle A.M. (1984). Horticultural Crops Protection Handbook. National Horticultural Research Station. Thika, Kenya.**
- **CAB International (2005). Crop Protection Compendium, 2005 edition. Wallingford, UK www.cabi.org**
- **Dobson H., Cooper J., Manyangarirwa W., Karuma J. and Chiimba W. (2002). Integrated Vegetable Pest Management. Natural Resources Institute (UK) ISBN: 0-85954-536-9**
- **Hayward, A.C. (1991). Biology and Epidemiology of Bacterial Wilt caused by *Pseudomonas Solanacearum*. Annual Reviews Phytopathol. 29: 65-87.**
- **OISAT: Organisation for Non-Chemical Pest Management in the**

Tropics www.oisat.org

- Varela, A.M., Seif, A. and Löhr, B. (2003). A Guide to IPM in Tomato Production in Eastern and Southern Africa. ICIPE. ISBN: 92 9064 149 5

Information of www.infonet-biovision.org

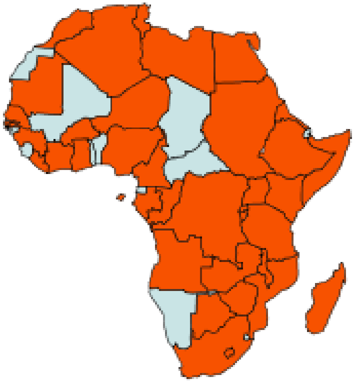
Information of www.infonet-biovision.org

Root-knot nematodes

Root-knot nematodes
Scientific name: ***Meloidogyne*** **spp. (*M. incognita, M. hapla, M. javanica, M. arenaria*)**
Family: Tylenchida: Meloidogynidae
Local names: Eelworms
Type: disease (nematodes)
Host plants: Bananas Beans Carrot Citrus plants Coffee Cotton Cowpea Cucumber Eggplant Groundnut Okra Papaya Passion fruit Peas Peppers Pigeon pea Pineapple Potato Rice Soybean Sweet potato Tea Tomato Lettuce

General Information on Pest and Damage

Geographical distribution



Geographical Distribution of Root-

knot nematodes in Africa *(red marked)*

Introduction

The root knot nematode species, *M. incognita*, is the most widespread and probably the most serious plant parasitic nematode pest of tropical and subtropical regions throughout the world. It occurs as a pest on a very wide range of crops.

Damage

Root-knot nematodes

Affected plants appear in patches.
Estimates of vegetable crop losses due to *Meloidogyne* species, mainly *M. incognita* and *M. javanica*, have ranged from 17 to 20% for aubergine (*Solanum melongena*), 18 to 33% for melon and 24 to 38% for tomato.
Losses of potatoes due to *Meloidogyne* species, mainly *M. incognita*, are estimated

at 25% or more.

Root-knot nematodes (*Meloidogyne incognita* / *M. javanica*) Roots of severely attacked (left) and healthy plant (right). Affected plants are normally stunted and eventually wilt and die. The most characteristic symptom is formation of root galls (knots) and these can be seen with the naked eye. Affected roots rot.
© A. M. Varela, icipe

Host range

Root-knot nematodes affect a wide range of crops, particularly vegetables. *M. incognita* is a major economic pest of food legumes in the tropics and subtropics. Common bean (*Phaseolus vulgaris*) is very badly damaged by *Meloidogyne* species in the tropics. Cowpea (*Vigna unguiculata*) is another very susceptible host crop of *M. incognita*. Many

crops grown as vegetables are susceptible to the nematode particularly tomato, aubergine, okra, cucumber, melon, carrot, gourds, lettuce and peppers. Table I shows susceptibility of various commonly grown crops to root-knot nematodes.

Table 1. Crop susceptibility to root-knot nematodes (after AfFOResT)

Susceptible	Tolerant	Resistant
Bambara nut	Brassicas	Cassava
Beans	Chilli pepper	Garlic
Beetroot	Radish	Leek
Carrot	Sweet potato	Maize
Celery	Turnip	Millet
Cowpea		Rhodes grass
Cucumber		Sesame
Eggplant		Sorghum
Gourd		Sudan grass

Irish potato		**Sweet corn**
Lettuce		
Melon		
Okra		
Parsley		
Peas		
Pumpkin		
Squash		
Sweet pepper		
Swiss chard		
Tomato		

(Source: Dobson *et al.* 2002)

Symptoms

Affected plants are stunted and yellow and have a tendency to wilt in hot weather. Very heavily infested plants are killed. Affected plants appear in patches. If infested plants are pulled from the soil, the roots are severely distorted, swollen and have lumps known as galls or root knots. The galls range in size from smaller than a pinhead to 25mm or more in diameter.

Affected plant stages

Flowering stage, fruiting stage, seedling stage and vegetative growing stage.

Affected plant parts

Leaves, roots and whole plant.

Symptoms on affected plant part

Leaves: wilting.
Roots: galls; reduced root system; swollen roots.
Whole plant: dwarfing; wilting

Biology and Ecology of Root-knot Nematodes

There are four species of root-knot nematodes (*M. arenaria, M. hapla, M. incognita)* and *M. javanica*) that are capable of attacking vegetables. These species occur in Kenya (National Horticultural Research Station, 1984) and are particularly serious in irrigated fields. Important environmental factors that influence development of *Meloidogyne* are moist soils and relatively warm temperatures. Some plant penetration by root-knot nematodes occurs between 10 and 35°C, with the optimum at about 27°C depending on the species. No eggs are laid at temperatures lower than 14.2 or higher than 31.7°C. Under average conditions a female produces 300 to 800 eggs. A new generation can arise within 25 days, but under less favourable conditions, the time may be prolonged to 30 to 40 days. All species, with exception of *M. hapla* are killed by freezing.

Root-knot nematodes measure about 0.5 mm to 1.5 mm in length.

Juveniles (young nematodes) penetrate the root tips and occasionally invade roots in the zone of root elongation. Invaded nematodes initiate the development of giant cells in the root tissues and galling of roots occurs.

Root knot nematodes are soil inhabitants. They are spread by transplanting infested seedlings, or from soil washed down slopes or sticking to farm implements and farm workers. They may also be spread by irrigation water.

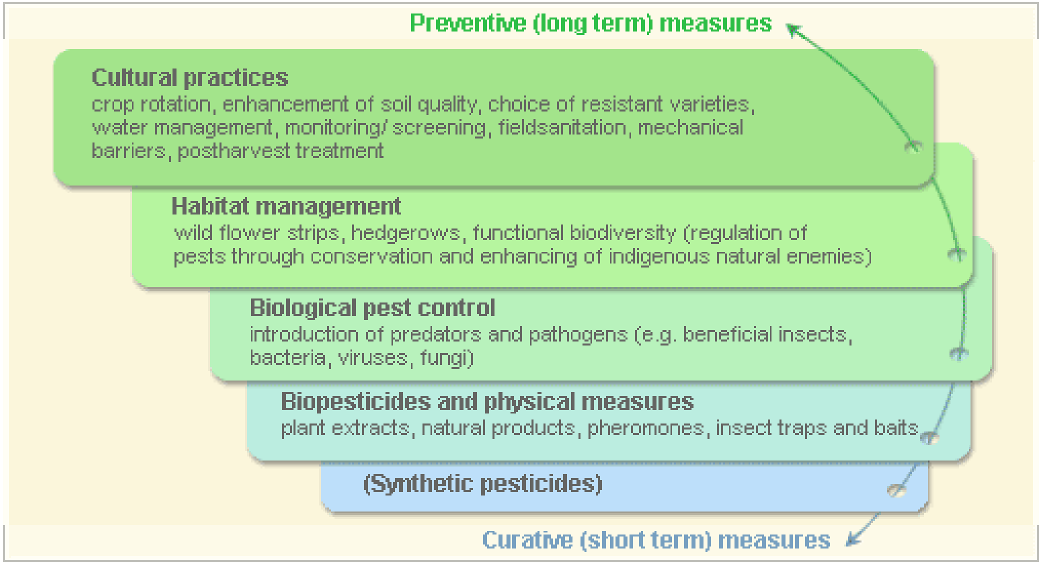
The disease is most serious on light, sandy soils and in furrow irrigated areas. Attack by nematodes may greatly increase the severity of bacterial, *Fusarium* and *Verticillium* wilt diseases

Conditions that favour development:

- **Infected volunteer plants**
- **Monocultures**
- **Weeds in fields**
- **Warm temperatures and moist but well-aerated sandy soils**
- **Continuous growing of susceptible crops (no rotation)**

Pest and Disease Management

Pest and disease management: General illustration of the concept of *infonet-biovision*



These illustration shows the methods promoted on infonet-biovision. The methods shown at the bottom have a long-term effect, while methods shown at the top have a short-term effect. In organic farming systems, methods with a long-term effect are the basis of crop production and should be used with preference. On the other hand methods with a short-term effect should be used in emergencies only. On infonet we do not promote synthethic pesticides.

Further below you find concrete preventive and curative methods against Root-knot nematodes.

Cultural practices

Prevention and control

- **Do not locate seedbeds where vegetables have been grown previously. After preparation of the seedbed, burn the topsoil using dry leaves or other waste plant material.**
- **Solarise seedbeds if possible.**
- **Use biofumigation where possible (for more information on biofumigation click here). Different mustards (e.g. *Brassica juncea* var. *integrifoliaor Brassica juncea* var. *juncea*) should be used as intercrop on infested fields. As soon as mustards are flowering they are mulched and incorporated into the soil. While incorporated plant parts are decomposing in a moist soil, nematicidal compounds of this decomposing process do kill nematodes. Two weeks after incorporating plant material into the soil a new crop can be planted or sown.**
- **Maintain high levels of organic matter (manure and compost) in the soil.**

- **Incorporate neem cake powder into the soil if it is available.**
- **Fields should be ploughed deep and the followed by a dry fallow.**
- **Uproot entire plants from the field after harvest and destroy crop debris.**

Crop rotation

Rotate with onions, baby corn, sweet corn, maize, millet, sorghum, sesame, cassava or Sudan grass.

A rotation system called "STRong" is recommended for management of root-knot nematodes. The system was developed by, African Farmers' Organic Research and Training (AfFOResT), a NGO in Zimbabwe. It involves planting in rotation of a susceptible crop (e.g. tomatoes), followed by a tolerant crop (e.g. cabbage) and then a resistant crop (e.g. onions) before a return to a susceptible crop (e.g. tomatoes). Crop susceptibility of various commonly crops is given in Table 1.

Use trap crops such as marigold (*Tagetes* spp.) and Indian mustard. (A trap crop is a crop planted to attract a pest and is then destroyed together

with the pest). Mixed cropping with marigold can also minimise root-knot nematode damage.

Resistant varieties

Use resistant tomato varieties (e.g. 'Caracas', 'Kentom', 'Meru', 'Piersol', 'Roma VFN', 'Tengeru 97', 'Zest F1', 'Star 9001', 'Star 9003'). Tomato varieties carrying 'VFN' label are tolerant to root-knot nematodes. Most of these varieties are commercially available in the region.

Information Source Links

- **Additional information about nematodes: Genome Sequencing Center: http://www.nematode.net**
- **Beije C.M, Kanyagia S.T., Muriuki S.J.N., Otieno E.A., Seif A.A. and Whittle A.M. (1984). Horticultural Crops Protection Handbook. National Horticultural Research Station.**
- **Crop Protection Compendium, 2005 Edition. © CAB International, Wallingford, UK, 2005 www.cabi.org**
- **Dobson, H., Cooper, J., Manyangarirwa, W., Karuma, J., Chiimba, W.**

(2002). Integrated Vegetable Pest Management. Natural Resources Institute, University of Greenwich, UK. ISBN: 0-85954-536-9

- OISAT. Organisation for Non-Chemical Pest Management in the Tropics www.oisat.org
- Varela, A.M., Seif, A., and Löhr, B. (2003). A Guide to IPM in Tomato Production in Eastern and Southern Africa. ICIPE, Nairobi, Kenya. ISBN: 92 9064 149 5
- Varela, A.M.and Seif, A. (2004). A Guide to IPM and Hygiene Standards in Okra Production in Kenya. ICIPE, Nairobi, Kenya. www.icipe.org

---

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Powdery mildew

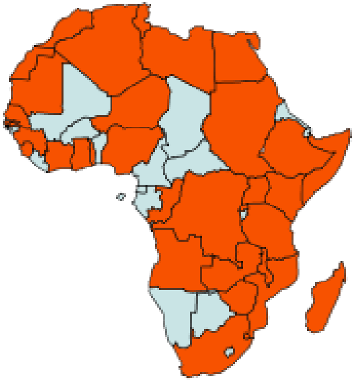
Powdery mildew

Scientific name: *Phyllactina* spp. / *Leveillula* spp. / *Erysiphe* spp. / *Uncinula* spp. / *Blumeria* spp. / *Golovinomyces* spp. / *Podosphaera* spp. / *Sphaerotheca* spp.

Family: Erysiphaceae
Type: disease (fungal)
Host plants: Beans Cabbage/Kale, Brassicas Carrot Cashew Cowpea Cucumber Eggplant Green gram Mango Okra Papaya Peas Peppers Pigeon pea Pumpkin Sesame Tomato Zucchini/Courgette

General Information on Disease and Damage

Geographical distribution



Geographical

Distribution of Powdery mildew in Africa *(red marked)*

Damage

Infected leaves curl and become distorted. Diseased flowers fail to open and drop from the panicle without fruit forming. Mildew causes skin cracking on fruits that have started to form. The diseased fruit drops. Infected seedlings will eventually die. Mature leaves and fruit are not susceptible to mildew.

Powdery mildew on cabbage.

© A.M. Varela, icipe

Host range

Individual species of powdery mildew fungi typically have a very narrow host range. Hosts include cereals, grasses, vegetables, ornamentals,

weeds, shrubs, fruit trees, and forest trees. Notable exceptions include maize, celery and carrots.

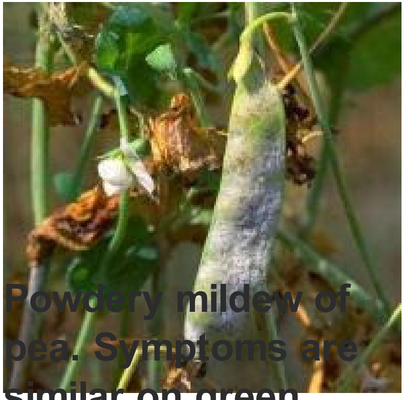
Genera of powdery mildew fungi and their host plants:

- ***Phyllactina*** **spp. (*Ovulariopsis*) attack trees and shrubs**
- ***Leveillula*** **spp. (*Oidiopsis*) attack Solanaceae**
- ***Erysiphe*** **spp. (*Oidium*) attack cereals and legumes**
- ***Uncinula*** **spp. (*Oidium*) attack trees and shrubs**
- ***Blumeria*** **spp. (*Oidium*) attack grasses**
- ***Golovinomyces*** **spp. (*Oidium*) attack cucurbits and Compositae**
- ***Podosphaera*** **spp. (*Oidium*) and *Sphaerotheca* spp. (*Oidium*) attack Rosaceae**

Symptoms

Even though there are several types of powdery mildew fungi, they all produce similar symptoms on

plant parts. Powdery mildews are characterized by spots or patches of white to greyish, talcum-powder-like growth. Tiny, pinhead-sized, spherical fruiting structures that are first white, later yellow-brown and finally black may be present singly or in a group. These are the cleistothecia or over-seasoning bodies of the fungus.

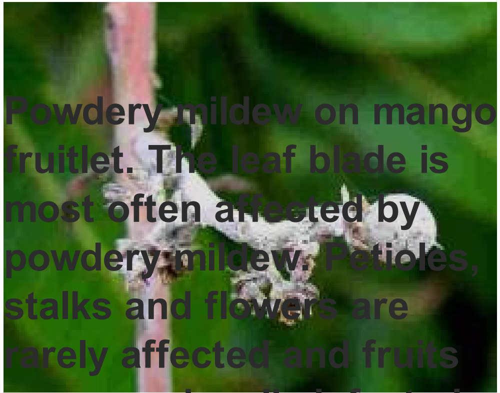


Powdery mildew of pea. Symptoms are similar on green gram.

© AgrEvo (Reproduced from CABI 2006)

The disease is most commonly observed on the upper sides of the leaves. It also affects the lower sides of leaves, young stems, buds, flowers and young fruit. Infected leaves may become distorted, turn yellow with small patches of green, and fall prematurely.

Infected buds may fail to open.



Powdery mildew on mango fruitlet. The leaf blade is most often affected by powdery mildew. Petioles, stalks and flowers are rarely affected and fruits are occasionally infected.

Affected plant stages

Seeding, vegetative, and reproductive stages.

Affected plant parts

Leaves, petioles, stems, and sometimes fruits.

Biology and Ecology

Source of infection and spread

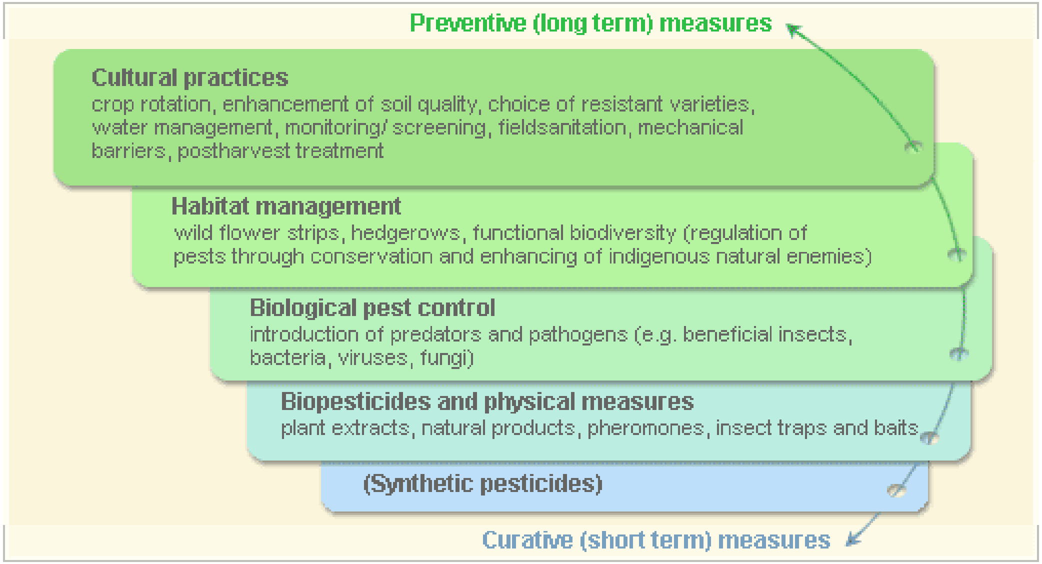
The white powdery growth consists of large numbers of fungal spores, which are spread by wind. The disease can spread very rapidly. It is more prevalent in dry weather when humidity is high and nights are cool. The fungus survives from season to season in dormant buds. The flowering is the most critical stage for infection.

Conditions that favour development

The severity of the disease depends on many factors: variety of the host plant, age and condition of the plant, and weather conditions during the growing season.
Powdery mildews are severe in warm, dry climates. This is because the fungus does not need the presence of water on the leaf surface for infection to occur. However, the relative humidity of the air does need to be high for spore germination. Therefore, the disease is common in crowded plantings where air circulation is poor and in damp, shaded areas. Incidence of infection increases as relative humidity rises to 90 percent, but it does not occur when leaf surfaces are wet (e.g. in a rain shower). Young, succulent growth usually is more susceptible than older plant tissues.

Pest and Disease Management

Pest and disease management: General illustration of the concept of *infonet-biovision*



These illustration shows the methods promoted on infonet-biovision. The methods shown at the bottom have a long-term effect, while methods shown at the top have a short-term effect. In organic farming systems, methods with a long-term effect are the basis of crop production and

should be used with preference. On the other hand methods with a short-term effect should be used in emergencies only. On infonet we do not promote synthethic pesticides.

Further below you find concrete preventive and curative methods against Powdery mildew.

Cultural practices

Several practices will reduce or prevent powdery mildews. Many plants, such as roses, vegetables and Kentucky bluegrass, are developed to be resistant or tolerant to powdery mildew. Choose appropriate cultivars that grow in cool, dry areas. For example, mango varieties vary in susceptibility to powdery mildew: 'Apple', 'Alphonse', 'Boribo', 'Kent', 'Ngowe' and 'Zill' are highly susceptible; 'Haden' and 'Keitt' are moderately susceptible; and 'Sensation' and 'Tommy Atkins' are resistant. Inquire about resistant varieties before a purchase. If resistant varieties are unavailable, do not plant in low, shady locations.

Once the disease becomes a problem:

- **Avoid late-season applications of nitrogen fertilizer to limit the production of succulent tissue, which is more susceptible to infection.**
- **Avoid overhead watering to help reduce the relative humidity.**
- **Remove and destroy all infected plant parts (leaves, etc.). For infected vegetables and other annuals, remove after harvest as much as possible of the plant and its debris. This decreases the ability of the fungus to survive to next season. Do not compost infected plant debris. Temperatures often are not hot enough to kill the fungus.**
- **Selectively prune overcrowded plant material to help increase air circulation. This helps reduce relative humidity and infection.**

Biopesticides and physical methods

Sprays of powdered kelp, sodium bicarbonate or sulphur based products will often control the disease.

Information Source Links

- **CABI. (2005). Crop Protection Compendium, 2005 Edition. © CAB International Publishing. Wallingford, UK. www.cabi.org**
- **Heffer, V., Johnson,K.B., Powelson, M.L. and Shishkoff, N. (2006).**

Identification of Powdery Mildew Fungi anno 2006. The Plant Health Instructor. DOI: 10.1094/PHI-I-2006-0706-01
http://www.apsnet.org/education/LabExercises/PowderyMildew/Top.html

---

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Cowpea seed beetle

Cowpea seed beetle
Scientific name: *Callosobruchus* spp. (*Callosobruchus maculatus, Callosobruchus chinensis*)
Family: Coleoptera: Bruchidae
Type: pest (insect/mite)
Common names: Cowpea weevil, cowpea seed weevil, spottet cowpea bruchid / Chinese bruchid, Adzuki bean beetle
Host plants: Cowpea Green gram Pigeon pea Soybean

General Information on Pest and Damage

Geographical distribution

Geographical

Distribution of Cowpea seed beetles in Africa *(red marked)*

Damage

***Callosobruchus* beetles are important pests of pulses. Infestation commonly begins in the field, where eggs are laid on maturing pods. As the pods dry, the pest's ability to infest them decreases. Thus, dry seeds stored in their pods are quite resistant to attack, whereas the threshed seeds are susceptible to attack throughout storage. Infestation may start in the pods before harvest and carry over into storage where substantial losses may occur.**

Levels of infestation in storage are strongly influenced by the type of storage structure employed and the variety of seed. Storage structures that maintain high levels of moisture in seeds are more prone to high levels of infestation. The value of dried pulses is strongly affected by levels of bruchid attack. In Nigeria, it has been estimated that 3% of the annual production in 1961/62 was lost due to attack by *Callosobruchus*

***maculatus*.**

Host range

Cowpea bruchids are major pest of cowpeas, pigeon peas, soybean, green gram and lentils.

Symptoms

In the early stages of attack the only symptoms are the presence of eggs glued to the surface of the pulses. As development occurs entirely within the seed, the immature stages can normally not be seen. However, they can be detected after pupation takes place; although the seed coat of the bean is still intact, a round 1 to 2 mm window is apparent at the location where the beetle is pupating. The adults emerge through these windows leaving round holes in the grain that are the main evidence of damage.

Affected plant stages

Fruiting stage and post-harvest.

Affected plant parts

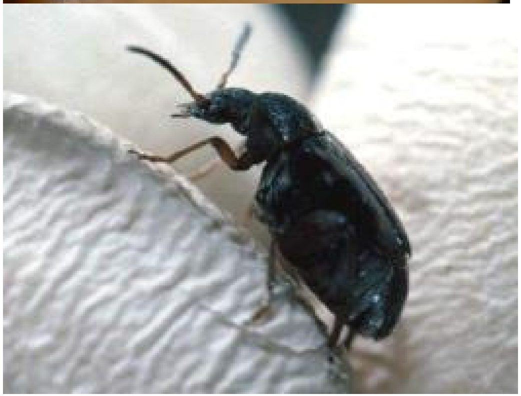
Seeds.

Biology and Ecology of Cowpea Seed Beetles

Eggs are small (0.75mm long), clear, shiny and smooth, and oval or spindle shaped. They are firmly glued to the surface of pods and pulses. If the pods have opened, eggs are laid directly onto the seeds. Eggs are small, smooth, have domed structures with oval, flat bases. When newly laid they are translucent grey and inconspicuous. Upon hatching the empty eggs shells are white, and clearly visible to the naked eye. Eggs hatch within 5-6 days of oviposition.

The larvae are whitish and somewhat C-shaped with small heads. Upon hatching, they bite through the base of the eggs and bore into the seeds where they spend the whole lifecycle feeding on the seed. The larvae pupates inside the seed.

Pupation takes place in a chamber just under the testa of the seed. Pupation takes about seven days to complete.



Cowpea seed weevil (*C. maculatus*) on cowpea. Adults are 2-3.5 mm long.

© Peter Credland, Reproduced from CABI

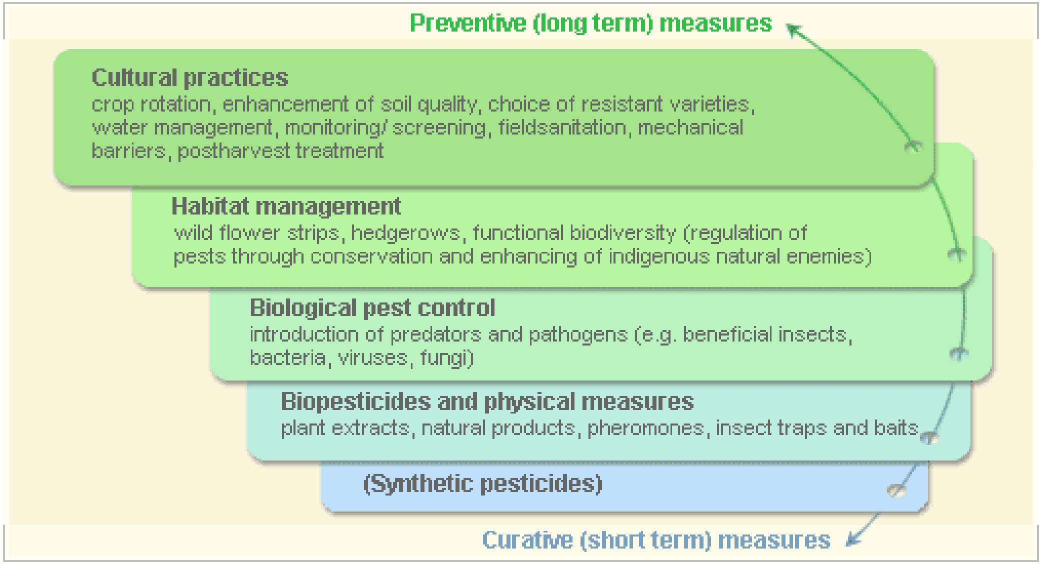
Adult beetles are small, about 2 to 3 mm long and somewhat teardrop and slightly elongate. They are pale to reddish brown with black and grey patches and two black spots near the middle on the wing cases. The posterior part of the abdomen is not covered by the wing cases. They do not feed on stored produce. They are very short-lived; usually they do not live longer than 12 days. During this time the females lay up to 115 eggs. The optimum temperature for egg-laying is about 30 to 35° C.

The whole lifecycle takes about 4 to 5 weeks.

2006

Pest and Disease Management

Pest and disease management: General illustration of the concept of *infonet-biovision*



These illustration shows the methods promoted on infonet-biovision. The methods shown at the bottom have a long-term effect, while methods

shown at the top have a short-term effect. In organic farming systems, methods with a long-term effect are the basis of crop production and should be used with preference. On the other hand methods with a short-term effect should be used in emergencies only. On infonet we do not promote synthethic pesticides.

Further below you find concrete preventive and curative methods against Cowpea seed beetle.

Cultural practices

Intercropping

Intercropping maize with cowpeas, and not harvesting crops late significantly reduced infestation by several species of cowpea seed beetles (*C. maculatus, C. rhodesianus, C. chinensis* and the bean bruchid *Acanthoscelides obtectus*) in Kenya (Olubayo and Port, 1997).

Sanitation

Good store hygiene plays an important role in limiting infestation by cowpea seed beetles.

Remove infested residues from last season's harvest.
General hygiene is also very important.

Solarisation

Solarisation (sun drying and heating) can be used to control infestations without affecting seed germination. When small lots are stored, sun-drying the beans can give substantial protection. Sun-dry the beans periodically in a thin layer for periods of up to 4 hours. Solar heaters or transparent bags of seeds left in the sun can provide excellent control of infestations (Ntoukam et al., 1997; Ghaffar and Chauhan, 1999). For more information on solarisation click here.

Resistant varieties

During the last few decades, researchers in Africa have been looking for pest resistance in cowpeas. The varieties 'Mouride' and 'CRSP Niebe' are reported to be resistant to cowpea seed beetle (IITA, CRSP).

Ashes

Farmers often mix cowpea grains with ash to control the cowpea seed beetle. To be efficient, it be should used at least five percent of ash (Gómez, C).

For more information on management of storage pests click hier

Information Source Links

- **Bean/Cowpea Collaborative Research Support Program (CRSP). www.isp.msu.edu/crsp**
- **Beck, C. W. and Blumer, L. S. (2007). A handbook on Bean Beetles, Callosobruchus maculates. The National Science Foundation, DUE-0535903. www.beanbeetles.org**
- **CABI. (2005). Crop Protection Compendium, 2005 Edition. © CAB International Publishing. Wallingford, UK. www.cabi.org**
- **Ghaffar, M.A., Chauhan, Y.S. (1999). Solarization to protect pigeonpea seeds from bruchid damage during storage. International Chickpea and Pigeonpea Newsletter, No. 6:50-52.**
- **Gómez, C. CHAPTER XXXII - COWPEA: Post-Harvest Operations. FAO. www.fao.org**
- **IITA, www.iita.org**

- **Murdock, L.L. and Fatokun, C. The Bean/Cowpea CRSP and IITA: Collaboration, Cooperation and Complementarity. http://www.isp.msu.edu**
- **Ntoukam, G., Kitch, L.W, Shade, R.E. and Murdock, L.L. (1997). A novel method for conserving cowpea germplasm and breeding stocks using solar disinfection. Journal of Stored Products Research, 33(2):175-179.**
- **Olubayo, F.M. and Port, G.R. (1997). The efficacy of harvest time modification and intercropping as methods of reducing the field infestation of cowpeas by storage bruchids in Kenya. Journal of Stored Products Research, 33(4):271-276.**

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

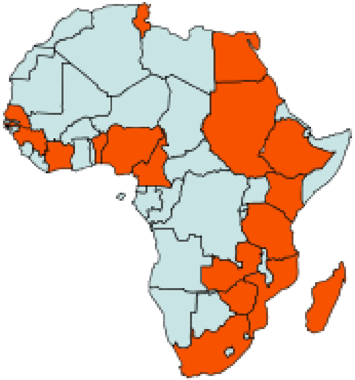
Leafmining flies (leafminers)

Leafmining flies (leafminers)
Scientific name: *Liriomyza* spp.
Family: Diptera: Agromyzidae

Type: pest (insect/mite)
Host plants: Amaranth Beans Cabbage/Kale, Brassicas Okra Onion Passion fruit Peas Peppers Rice Tomato

General Information on Pest and Damage

Geographical distribution



Leafmining flies are serious pests of vegetables and ornamental plants worldwide.

Geographical Distribution of Leafmining flies in Africa (red marked)

Introduction

Major species of leafmining flies in Africa are:

- **The serpentine leafminer (*Liriomyza trifolii*)**
- **The vegetable leafminer (*L. sativae*)**
- **The cabbage leafminer (*L. brassicae*)**
- **The pea leafminer (*L. huidobrensis*)**

Leafmining flies are serious pests of vegetables and ornamental plants worldwide. They are occasional pests of brassicas. *Liriomyza brassicae* is cosmopolitan. In Africa it is reported from Egypt, Ethiopia, Kenya, Mozambique, Zimbabwe, Cape Verde and Senegal. Host plants are primarily crucifers.
Two species of serpentine leafmining fly, *L. trifolii* and *L. sativae*, are considered serious pests of tomatoes. Both species are cosmopolitan.

***Liriomyza sativae* is a typical American pest, whereas the typical leafmining fly in Europe is *L. bryoniae*. *Liriomyza trifolii* is common on tomato in America and Europe, and *L. huidobrensis* is occasionally reported on tomato in America but damage has been recorded mainly on ornamentals. Leafmining flies *L. trifolii* and *L. sativae* are closely related with similar appearance and overlapping host ranges.**

In Africa, *L. trifolii* has been reported in several countries, including Kenya, Mauritius, Reunion, Senegal, South Africa and Tanzania. In Kenya, *Liriomyza trifolii* was introduced to Kenya in the late 1970s through chrysanthemum cuttings from Florida (USA). Since then, *Liriomyza* species have been found throughout the country, attacking vegetables and ornamental plants. *Liriomyza. huidobrensis* is currently a serious pest of ornamentals and passion fruits. *Liriomyza sativae* was recently recorded in Kenya.

***L. brassicae* has also been reported for many years as a pest on brassicas and legumes, but in general, the damage done to mature crops is largely superficial.**

Damage

Female flies puncture leaves and in some instances also fruits (peas) with their ovipositor to feed and to lay eggs. These punctures can serve as entry point for disease-causing bacteria and fungi, but in most cases they are not of economic importance. However, they can be a problem for export products such as on snow- and ornamentals. Eggs are laid inside the plant tissue, and they cannot be removed through washing; this may lead to rejection of the produce when their presence is detected during import inspection.

Damage by maggots feeding in the plant tissue is economically more important than the feeding punctures of adult flies. Maggots feed between the upper and lower surface of the leaf making tunnels or mines as they move along. Although individual mines on leaves do not produce much damage, heavy attacks, especially on seedlings, may result in dying off

Leaf of okra seedling showing attack by leafmining flies. Note pupa on leaf.

of young plants. Heavy attack leads to large-scale necrosis of leaf tissue, eventual shrivelling of the whole leaf and may result in complete defoliation of crops. Defoliation of tomato plants may also expose fruits to sunburn and thus affect their market value.

Leafmining flies damage on tomato leaf. Note maggot ready to pupate (yellow) and pupa (brown). A. M. Varela,

Heavy infestation reduces the photosynthetic capacity of the plant and affects the development of flowers and fruits. However, mature plants of most crops such as tomato and cabbage can withstand considerable leafmining, especially on the lower or outer leaves. In other crops, where feeding occurs on the marketable part of the crop, even slight damage may lead to rejection of the crop. This is particularly important for export crops, as most Liriomyza species are considered quarantine icipe.jpg

© A. M. Varela, icipe

pests in the EU and there have been rejections of produce exported to Europe.

Host range

Leafminers are able to colonise a wide range of plants (primarily although not exclusively *Solanaceae, Leguminosae* and *Asteraceae*). Liriomyza flies have become important pests of horticultural crops and potatoes in the tropics and subtropics. The most common species, *L. sativae*, *L. trifolii* and *L. huidobrensis*, feed on a wide range of plants. Main host plants include cabbage and other brassicas (cruciferous crops), okra, onion, pigeon pea, bell pepper, cucumber, pumpkin, cowpea, potato, passion fruit, tomato and common bean.

In East Africa, these leafmining flies are recorded from most export vegetables with sometimes extremely heavy damage on French and runner beans, okra, eggplant, passion fruit and peas. Severe infestations have also been recorded on cut flowers. *Liriomyza brassica* attacks mainly crucifers. It has no economic importance in the region.

Affected plant stages

Seedling and vegetative growing, flowering and fruiting stages.

Affected plant parts

Leaves and pods.

Symptoms by affected plant part

Feeding and egg-laying by female flies result in white puncture marks on leaves. These punctures are easily seen and are the first signs of attack.

Feeding by maggots leaves irregular mines on the leaves, with occasional thread-like black frass inside the mine. Severely mined leaves may turn yellow, disfigured, and drop.

Biology and Ecology of Leafmining Flies

Eggs are very tiny (about 1.0 mm long and 0.2 mm wide), greyish or yellowish white and slightly translucent. They are laid

inside the leaf tissue, just below the leaf surface. In some instances eggs are laid below the epidermis of fruits (e.g. peas). Eggs hatch in about three days.

Larvae are small yellow maggots (about 2 to 3 mm long when fully-grown). They are found feeding inside the leaf tissue, leaving a long, slender, winding, white tunnels (mines) through the leaf. They pass through three larval stages. After five to seven days the maggots leave the mines and pupate either on the leaf surface or - more commonly - in the soil. In some cases, maggots pupate within the mines.

Legless maggot of the leafmining fly *(Liriomyza brassica)* with no separate head capsule, transparent when newly hatched but colouring up to a yellow orange in later instars, up to 3 to 4 mm long.

The pupae are very small, about 2 mm long and 0.5 mm wide) oval, slightly flattened

ventrally with variable colour varying from pale yellow-orange to golden-brown. They have a pair of cone-like appendages at the posterior end of the body. Adults emerge four to five days after pupation.

Leafminer (*Liriomyza sativae*) pupa within tunnel of onion. They are oval, slightly flattened and about 1 - 2 mm long.

Leafmining adult flies are small, about 2 mm long. They are greyish to black with yellow

markings. Female flies are slightly larger than males.

Insect Images (www.insectimages.org)

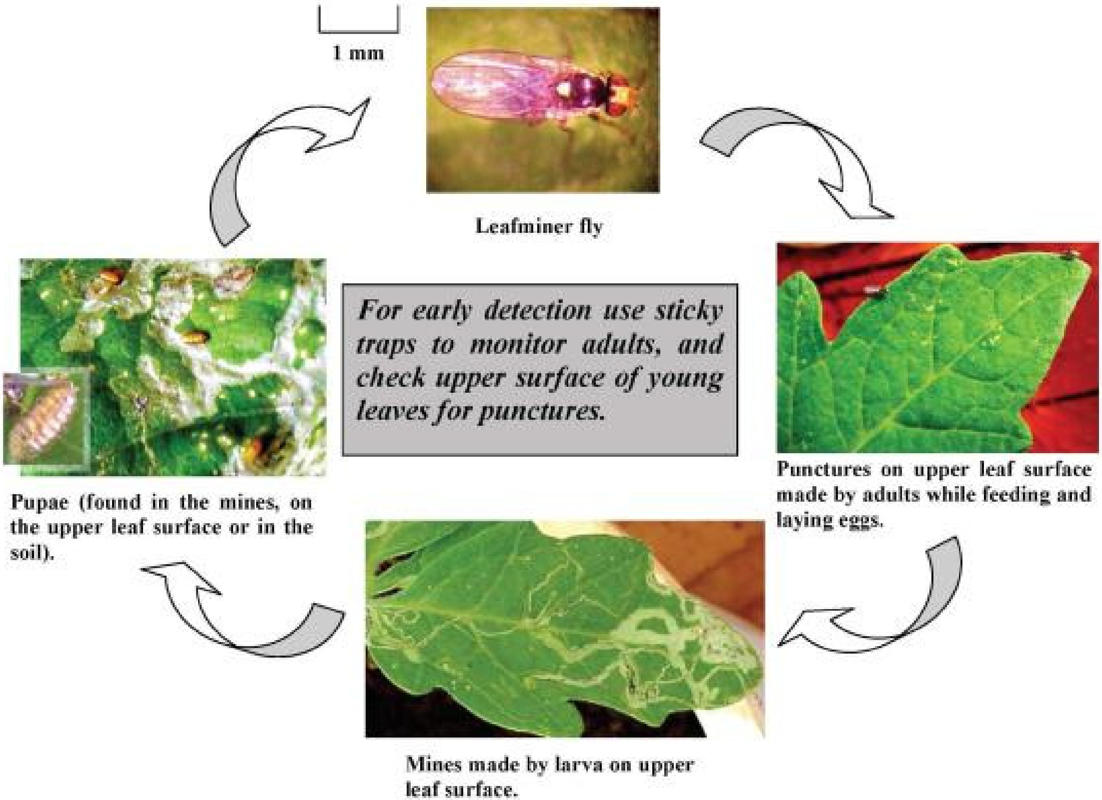
Leafmining fly on okra leaf

© A.M.Varela, icipe

Life cycle

The life cycle varies with host and temperature. The average life cycle is approximately 21 days in warm conditions, but can be as short as 15 days.

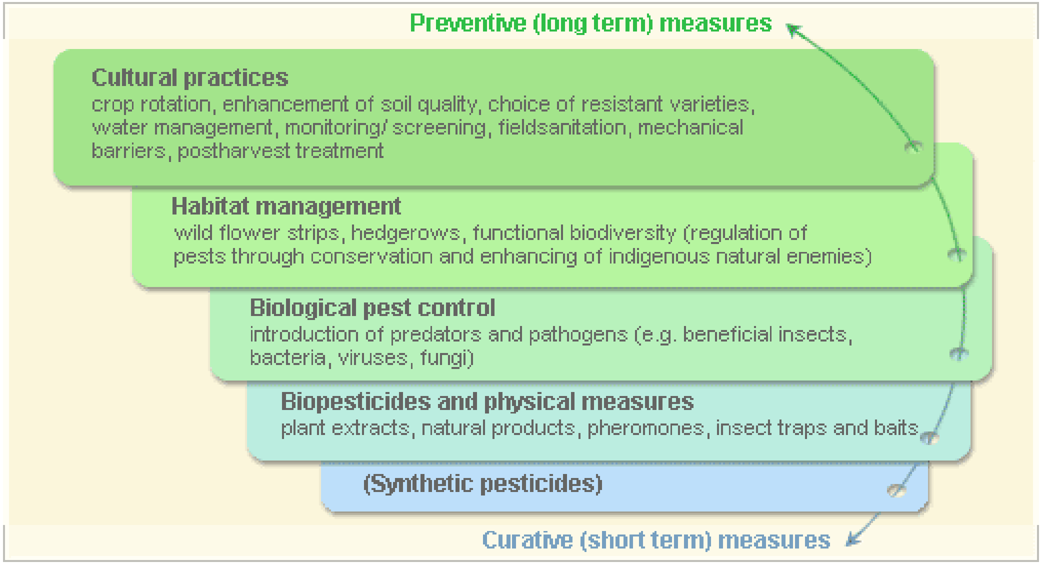
Thus, populations can increase rapidly.



Leafminer life cycle

Pest and Disease Management

Pest and disease management: General illustration of the concept of *infonet-biovision*



These illustration shows the methods promoted on infonet-biovision. The methods shown at the bottom have a long-term effect, while methods shown at the top have a short-term effect. In organic farming systems, methods with a long-term effect are the basis of crop production and

should be used with preference. On the other hand methods with a short-term effect should be used in emergencies only. On infonet we do not promote synthethic pesticides.

Further below you find concrete preventive and curative methods against Leafminers.

Cultural practices

Monitoring and inspection methods

Small black and yellow flies may be detected flying closely around the crop or on the leaves. Inspection of the leaf surface will reveal punctures of the epidermis and the greenish-white mines in the leaves. Feeding maggots will be found at the end of the mine. When the maggots have already left the mine to pupate, the mine will end with a small convex slit in the epidermis. Occasionally the pupae may be found on the leaf surface, although in most cases they pupate in the soil.

A monitoring technique for leafminers used in fresh market tomatoes in USA is to place plastic trays beneath plants at several randomly chosen

places in the field. Mature larvae that drop from foliage accumulate on the trays and pupate there, providing a measure of leafminer activity. Visual rating systems to assess the total number of leafminers on tomato have also been developed. The flies can also be monitored by using yellow sticky traps.

It is also important to monitor the presence and activity of natural enemies. Absence of pupae on leaves or in trays placed beneath plants, even if new mines are present, is an indication that natural enemies are keeping leafminers controlled.

The economic importance of damage by *Liriomyza* leafminers depends on the plant stage and on the crop. These factors must be considered when determining whether to implement control. Young plants can withstand less damage than older ones. On leafy crops such as spinach, lettuce, and chard, a 5 percent threshold level is often used. Much more damage can be tolerated in crops where the leafminers affect the leafy, non-marketable parts of the plant than in crops where the marketable part is attacked, particularly in high value crops such as snow peas, or cut-flowers and

ornamentals.

Leafminers can also be monitored by foliage examination for the presence of mines and larvae and by trapping adult flies with yellow sticky traps. Yellow sticky traps used for mass trapping can effectively control the pest at low densities. Visual rating systems to assess the total number of leafminers on tomato have been developed in the USA.

Cultural control

Normal agricultural hygiene can play an important part in controlling leaf miner damage:

- **Hand-picking and destroying of mined leaves**
- **Destroying all infected leaves and other plant material after harvest**
- **Destroying pupae before planting a new crop: ploughing and hoeing can help reduce leafmining flies but exposing pupae, which then would be killed by predators or by desiccation. Flooding the soil followed by hoeing could kill or release much of the buried pupae**
- **Where new stock is obtained as seedlings rather than seed, check careful and destroy infected plants before planting to prevent**

introduction of pests including leafminers

- **Solarisation can kill pupa in the soil. For more information on [solarisation click here]**

Biological pest control

Natural enemies

Leafmining flies have a wide range of natural enemies, mainly parasitic wasps, which normally keep them under control. However, the indiscriminate use of pesticides disrupts the natural control resulting in major leafminer outbreaks.

The three major species present *(L. sativae*, *L. trifolii* and *L. huidobrensis)* in Kenya have been accidentally introduced. Local parasitic wasps now attack these leafmining flies, but the only afford satisfactory control when they are present early in the crop cycle.

Fortunately, one of the most efficient parasitic wasps for control of leafmining flies, *Diglyphus isaea*, is now present in Kenya, and it is giving satisfactory control on some crops.

However, this parasitic wasp often comes too late to prevent early damage and farmers resort to pesticides too early, thus preventing population build-up of this natural enemy affecting its efficiency. This parasitic wasp is now being reared locally and is commercially available in Kenya, but smallholder growers have no access to the parasitic wasps; therefore it is important to conserve this and other naturally occurring natural enemies.


Parasitic wasp *Diglyphus isaea*

© A.M.Varela, M.Billah, icipe

For more information on natural enemies click here.

Biopesticides and physical methods

Neem

Neem-based pesticides are used for control of leafmining flies. Neem products reduce fecundity and longevity of flies and disrupt the development of the maggots. They can be applied as drench or as foliar sprays.
Weekly applications of aqueous neem seed extracts (ANSE) at 60 g/l and neem oil (2.5 to 3%) reduced leafminer damage on tomato (Ostermann and

Dreyer, 1995).

Weekly foliar sprays with a commercial neem product (Neemros®) at rates of 25 and 50 g/l water and a spray volume of about 900 l/ha controlled leafmining flies on experimental tomato fields in Kenya. Five applications were done starting 20 days after transplanting. Emergence of leafmining flies decreased with increased dosage (icipe).

In Kenya, the integration of neem products in the management of leafmining flies in high value crops (e.g. snow peas, French beans and cut flowers) resulted in the increase of the beneficial wasp *Diglyphus isaea*, a considerable reduction of pesticide use, and of rejection of the produce due to leafminer damage (icipe).

For more information on [Neem click here]

Spinosad

Spinosad, a bacterium derivative, used mainly for control of caterpillars, thrips, and fruit flies, controls Liriomyza leafminers as well. Spinosad does

not significantly affect beneficial organisms including ladybugs, green lacewings, minute pirate bugs, and predatory mites. Its use is now accepted in organic production. It is commercially available in Kenya (e.g. Tracer®).

Traps

Yellow sticky traps used for mass trapping and monitoring can effectively control the pest at low densities.

For further information on sticky traps click here.

Information Source Links

- **Varela, A.M., Seif, A. and Loehr, B. (2003). A Guide to IPM in Tomato Production in Eastern and Southern Africa. ICIPE. www.icipe.org. ISBN 92 9064 149 5.**
- **CABI. (2004). Crop Protection Compendium, 2004 Edition. © CAB International Publishing. Wallingford, UK. www.cabi.org**
- **Ostermann, H. and Dreyer, M. (1995). Vegetables and grain legumes. In The Neem Tree- Source of Unique Natural Products for Integrated Pest Management, Medicine, Industry and Other Purposes. H.**

Schmutterer (ed.). pp 392-403.ISBN: 3-527-30054-6.

Information of www.infonet-biovision.org

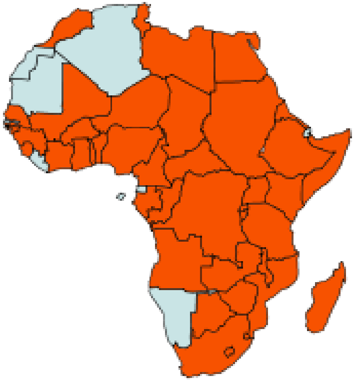
Information of www.infonet-biovision.org

Anthracnose

Anthracnose
Scientific name: *Colletotrichum* spp. / *Gloeosporium* spp. / *Glomerella* spp. / *Sphaceloma* (*Elsinoe*) spp.
Type: disease (fungal)
Common names: anthracnose, brown blight (of coffee and tea), tear stain, dieback (citrus), fruit rot, stem canker, black spot of fruit, ripe rot of pepper, anthracnose tear-stain.
Host plants: Avocados Bananas Beans Cashew Cassava Citrus plants Cotton Cowpea Cucumber Eggplant Green gram Mango Onion Peppers Pumpkin Sorghum Soybean Spinach Tomato Wheat Yam Zucchini/Courgette - (Anthracnose has a very

wide host range including also Cucurbits, Cereals, Legumes and Spinach)

General Information on Disease and Damage



Anthracnose caused by the pathogen (*Colletotrichum gloeosporioides*) is found worldwide, although it is more abundant in the tropics and subtropics than in temperate regions. The map shows its distribution that has been documented in the literature since 1973.

Geographical Distribution of Anthracnose in Africa (red marked)

Introduction

Anthracnose are diseases of the foliage, stems, or fruits that typically appear as dark-coloured spots or sunken lesions with a slightly raised rim. Some cause twig or branch dieback. In fruit infections, anthracnose often has a prolonged latent stage. In some fruit crops, the spots are raised and have corky surfaces. Anthracnose diseases of fruit often result in fruit drop and fruit rot. Anthracnoses are caused by fungi that produce conidia within black fungal fruiting bodies called acervuli. Colletotrichum species are responsible for most anthracnose diseases. They are found in nature mostly in their conidial stage (asexual) and can overwinter as mycelium or conidia in foliage, stems, twigs and infected crop debris.

Colletotrichum* diseases are the most common anthracnoses and are very similar, if not identical, to the diseases caused by Glomerella. The latter is probably the sexual stage of most or all species of *Colletotrichum

(Gloeosporium). **Anthracnose diseases, particularly those caused by *Colletotrichum (Gloeosporium)* or *Glomerella* fungi, are very common and destructive on numerous crop and ornamental plants. Although severe everywhere, anthracnose diseases cause their most significant losses in the tropics and subtropics. The diseases are favoured by wet, humid, warm conditions. They are spread by infected seed, rain splash and moist wind.**

Damage

Anthracnose diseases, particularly those caused by *Colletotrichum (Gloeosporium)* or *Glomerella* fungi, are very common and destructive on numerous crop and ornamental plants. Although severe everywhere, anthracnose diseases cause their most significant losses in the tropics and subtropics. Pre- and post-harvest losses of many high-value crops are substantial in the tropics because of various diseases caused by *C. gloeosporioides*.

Flower infection on mangoes (blossom blight) can destroy flowers and young fruit and cause complete crop failure. Fruit infection may cause premature fruit drop, but major fruit losses occur during ripening when quiescent infections break out and cause spreading black lesions. Anthracnose of other fruits also causes major post-harvest losses. Heavy infections cause rapid rotting, and even light infections which cause mainly cosmetic damage will shorten fruit storage life. Because of variability between seasons and locations, overall figures for losses are difficult to give, but it is clear that in many mango-growing areas losses of up to 50% of the crop to the various stages of the disease would not be uncommon.

Of the foliage diseases caused by *C. gloeosporioides*, yam anthracnose can be one of the most economically damaging and may prevent significant growth of tubers if the disease strikes early.

Anthracnose infected vegetables (e.g. beans, brinjals, peas, pepper and cucurbits) and fruits (e.g. avocado, mangoes and bananas) are not acceptable for export market.

Host range

C. gloeosporioides is a fungi which causes Anthracnose, it is by far the most predominant and major *Colletotrichum* pathogen on a wide range of cultivated crops, particularly tropical perennial crops (Waller, 1992). However, because it is also a common saprophyte and secondary invader of damaged tissue, it has been implicated as a pathogen more often than is justified after closer investigation. Disease is favoured by wet/humid, warm conditions. It is spread by infected seed, rain splash and moist wind.

Symptoms

Anthracnose diseases attack all plant parts at any growth stage. The symptoms are most visible on leaves and ripe fruits. At first, anthracnose generally appears on leaves as small and irregular yellow, brown, dark-brown or black spots. The spots can

Anthracnose *(Colletotrichum gloeosporioides)* on avocado fruit. This fungal disease is primarily a post-harvest problem when fruit is at maturity stage.

© A. A. Seif, icipe

expand and merge to cover the whole affected area. The colour of the infected part darkens as it ages. The disease can also produce cankers on stems. Infected fruit has small, water-soaked, sunken, circular spots that may increase in size up to 1 cm in diameter. As it ages, the center of an older spot becomes blackish and emits gelatinous pink spore masses.

Affected plant stages
Flowering stage, fruiting stage, post-harvest, seedling stage, and vegetative growing stage.

Anthracnose *(Colletotrichum orbiculare)* damage to pumpkin leaf *(Cucumis sativus)*. On cucurbits, leaf spots are often large, about 10 mm in size and pale-brown to gray in color, with distinct margins. The lesions on fruit appear as brownish discolorations, often 20-30 mm diameter that become sunken, wrinkled and dark, with concentric rings of fungal fruiting bodies.

Affected plant parts
Leaves, stems, fruits/pods, and inflorescence.

Biology and Ecology of Anthracnose

Anthracnose is a common name of plant diseases characterised by black lesions, usually sunken, caused by certain imperfect fungi that produce spores, e.g. *Colletotrichum*, *Gloeosporium* and some closely-related *Sphaceloma* species.

The lifecycle of anthracnose diseases involves essentially production of spores on susceptible hosts, dispersal of spores, penetration of host tissue, initiation of an infection process within the cells, development of lesions, formation of bristly spores and dispersal usually by water-splash, air currents, insects or other forms of contact.

The anthracnose pathogen reaches its most serious dimensions at high moisture and warm temperature. For example *C. gloeosporioides* has an optimum of 25-29°C but it will also survive at temperatures as low as 4°C. Spore germination, dispersal and infection require relative humidities near

100%. However, in drier situations disease expression can occur when latent infections are activated through aging or tissue damage.

The anthracnose diseases are primarily transmitted through seed, but also through infected plant parts. Rainsplash will also disperse spores within crop canopy. The pathogen persists on and in seed, crop residues, and weed hosts.

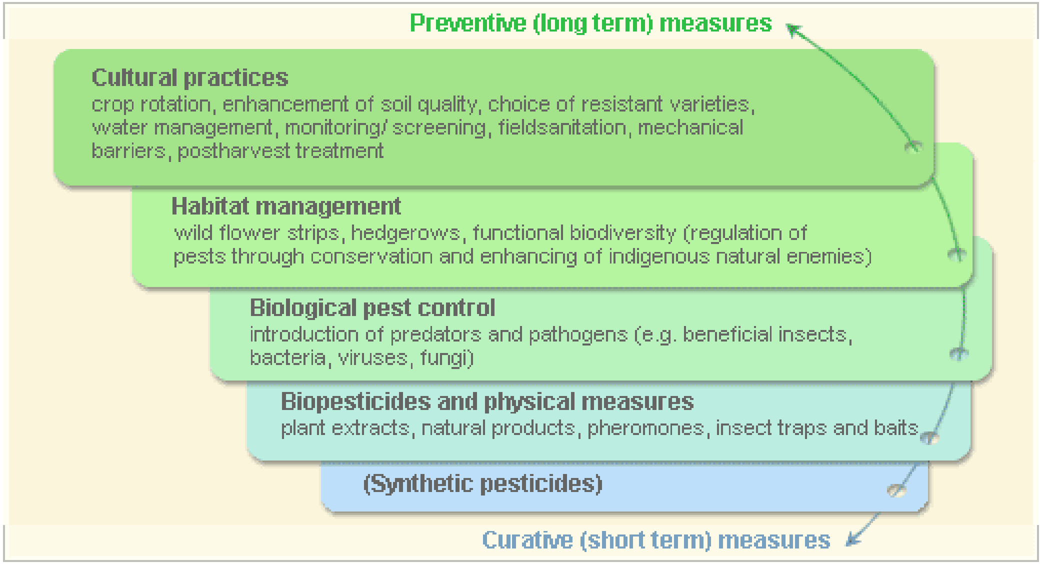
Major species of anthracnose fungi affecting crops in Africa:

- **Anthracnose of avocado (*Glomerella cingulata*)**
- **Anthracnose of cotton (*C. gossypii*)**
- **Anthracnose of cucurbits (*C. lagenarium*)**
- **Anthracnose of grapes((*Sphaceloma (Elsinoe) ampelina*)**
- **Anthracnose of lime (*Gloeosporium limtticola*)**
- **Anthracnose of spinach (*C. spinacicola*)**
- **Anthracnose of tomato (*C. coccodes, C. phomoides*)**
- **Banana anthracnose (*C. musae*)**
- **Bean anthracnose (*C. lindemuthianum (Glomeralla cingulata)*)**
- **Cereal anthracnose (*C. graminicola*)**

- **Coffee anthracnose (*C. coffeanum*)**
- **Common scab of citrus (*Sphaceloma (Elsinoe) fawcettii)*)**
- **Mango anthracnose (*C. gloeosporioides*)**
- **Onion smudge (*C. circinans*)**
- **Pea anthracnose (*C. pisi*)**
- **Pepper anthracnose (*C. capsici*)**
- **Red rot of sugarcane (*Glomerella tucumanensis (C. falcatum)*)**
- **Watermelon anthracnose (*C. lagenarium*)**

Pest and disease Management

Pest and disease Management: General illustration of the concept of *infonet-biovision*



These illustration shows the methods promoted on infonet-biovision. The methods shown at the bottom have a long-term effect, while methods shown at the top have a short-term effect. In organic farming systems, methods with a long-term effect are the basis of crop production and animal husbandry and should be used with preference. On the other hand methods with a short-term effect should be used in emergencies only. On infonet we do not promote synthethic pesticides.

Further below you find concrete preventive and curative methods against Anthracnose.

Cultural practices

Field sanitation

Field sanitation is an important and highly effective farm practice to keep most diseases under control.

1. Properly select healthy plants for transplanting.
2. Keep weeds under control at all times. Keep the surroundings of your farm free of weeds, unless they are maintained and intended as habitat for natural enemies.
3. Make yourself 'clean'. Always bear in mind that you might be the carrier of the diseases while you move from one plant to another
4. Pull out plants that are heavily infected.
5. Prune the plant parts where insect pests are found congregating and those that show heavy symptoms of disease infection.
6. Properly dispose of all the infected plants.
7. Pick rotten fruits and collect those that have dropped and bury in a pit.
8. Plow-under the crop residues and organic mulches. This improves soil

condition and helps to disrupt the pest's lifecycle. The pest is exposed to extreme temperature, mechanical injury, and predators.

9. Maintain cleanliness on the irrigation canals.

10. If possible, remove all the crop residues after harvest. Add these to your compost pile.

11. Make your own compost. Your compost pile is where you can place your plant trimmings and other plant debris.

12. Clean your farm tools. Wash plows, harrows, shovels, trowels and pruning gears after use. Lightly oil pruning gears.

Hot water seed treatment

Certified disease-free seed: Always use healthy seed as anthracnose is seed-borne. When using own seed, treat the seed with hot water. For more information on hot-water treatment of seeds click here.

Pruning

Pruning is the selective removal of specific plant parts like shoots and branches. It is particularly important for fruit trees. Pruning done in a regular basis as part of plant care achieves the following:

- **makes the plant less dense**
- **improves the air circulation and sunlight penetration that decrease the incidence of diseases and the conditions that promote fungal growth. It also allows better spray penetration and coverage**
- **improves the appearance and health of plants**
- **gets rid of the disease infected parts**
- **allows the natural enemies to find their preys easily**
- **controls the size of a plant**
- **trains the young plants**
- **influences flowering and fruiting (proper pruning of flower buds encourages early vegetative growth)**

Reminders for crops that in their management need pruning

- **Pruning is done best during dry weather as it minimizes the spread of the pathogens that cause diseases**
- **Always use sharp pruning tools to have clean and smooth cuts angled**

to shed water and absorb sunlight

- Dip your pruning tools into container with 10% bleach solution and wash your hands and pruning tools between pruning the diseased plants
- After pruning, disinfect your pruning tools with 10% bleach solution
- Ask for assistance from your local agriculturist for the proper pruning techniques on fruit trees

Biopesticides and physical methods

Copper

There are many copper compounds that are used as fungicides. The most common are derived from copper hydroxide and copper oxychloride. These products are cheap and are readily available in most African countries. It is accepted in organic farming provided that the number of applications is strictly followed and a proper soil amendment is observed to prevent copper accumulation in the soil.

In organic culture it is advised to consult your organic certification body. Also as copper products constitute propriety products, users are advised to comply with product label instructions on dosage, frequency of

application, pre-harvest intervals and product safety (proper handling, storage, and disposal). Most available copper products include KOCIDE 101®, KOCIDE DF® and copper oxychloride.

When handling and/or applying pesticides observe the following:

- **Read and follow the label instructions carefully.**
- **Ask for assistance from your local agriculture office when using copper for the first time.**
- **Monitor plants regularly and spray only when necessary as copper can accumulate in the soil.**
- **Spray in the early morning or late afternoon.**
- **Wear protective clothing when handling and/or applying any pesticide (including copper)**
- **Wash your hands after handling / pesticides**

For more information on copper click here.

Information Source Links

- **CABI. (2004). Crop Protection Compendium, 2004 Edition. © CAB International Publishing. Wallingford, UK. www.cabi.org**
- **OISAT (Online Information Service for Non-Chemical Pest Management**

in the Tropics) www.oisat.org

- **Waller, JM. (1992). Colletotrichum diseases of perennial and other cash crops. In: J.A.Bailey and M.J. Jeger (Editors). Colletotrichum: biology, pathology and control. CABI, Wallingford , ISBN 978-0851987569**
- **Wheeler, B.E.J. (1969). An Introduction to Plant Diseases. John Wiley & Sons Ltd. ISBN: 0 471 93752 5**

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Late blight

Late blight
Scientific name: *Phytophthora infestans*
Family: Pythiales: Pythiaceae
Type: disease (fungal)
Common names: Late blight / potato blight
Seriousness: It is very destructive in cool, moist conditions
Host plants: Eggplant Potato Tomato

General Information on Disease and Damage

Geographical distribution

Geographical

Distribution of Late blight in Africa (red marked)

Host range

Late blight is a fungal disease that can affect many vegetables of the *Solanum* species, mainly potatoes and tomatoes, but also eggplants. Late blight of potatoes or tomatoes can be devastating with dramatic and disastrous economic consequences. It is known as the most devastating disease of potatoes.

When conditions favour development of late blight and there are no steps taken to suppress the disease, it can completely destroy the above-ground parts of plants (stems, leaves, tomato fruits) and can also affect potato tubers.

Symptoms

Late blight symptoms can develop on leaves, stems, branches, and in case of tomatoes on both green and ripe fruits. In potatoes, tubers can also be infected. On leaves, pale green to brown spots, sometimes with a

purplish tinge, appear on the upper surface of leaves. Leaf spot margins often are pale green or water-soaked. The spots may enlarge rapidly until entire leaflets are killed. In moist conditions, a downy white greyish mould usually develops near the margin of leaf spots on the underside of leaves. In dry weather, affected foliar parts may appear dry and shriveled. Stems can also develop elongated, greyish watery brown lesions.

Late blight on tomatoes. Note scorched appearance of leaves, stems and fruits.

© B. Loehr, icipe

On tomato fruit, grey green watery spots can develop on the upper half of the fruit, which later spread and turn greasy brown and bumpy. In moist weather, a white downy fungal growth may appear on the affected fruit-rot surface. Infected potato tubers exhibit wet and dry rots.

Late blight symptoms can be mistaken for several other diseases. Late blight is sometimes confused with early blight (*Alternaria solani*). Early blight symptoms are more circular, larger and darker than late blight marking and have a definite concetric (zonate) margins. Active late blight spots are not zonate and typically do not have definite concentric rings.

Patches of infected plants have a characteristic odour as a result of the rapid breakdown of plant material.

Affected plant stages

All stages.

Affected plant parts

All parts.

Symptoms by affected plant part

Fruits/pods: spots.
Leaves: spots; abnormal colours; wilting; fungal growth.
Vegetative organs: dry rot.
Whole plant: seedling blight; unusual odour.

Biology and Ecology of Late Blight

Late blight of potato and tomato is caused by the fungus *Phytophthora infestans*. Although late blight can occur at any time during the growing season, it is more likely to be seen during cool wet seasons. The disease can spread rapidly during cool, rainy weather, killing plants within a few days. Daytime temperatures between 15 - 21° C, night temperatures between 10 - 15°C, and relative humidity near 100% create ideal conditions for infection and spread of the disease. The fungus becomes inactive during dry periods.

The late blight fungus survives in infected potato tubers in the ground or in cull piles and in infected tomato fruits and crop debris. The fungus can also survive in perennial weeds, such as nightshade. As infected tubers and perennial weeds germinate and grow, the fungus becomes active and reproduces on the young plants.

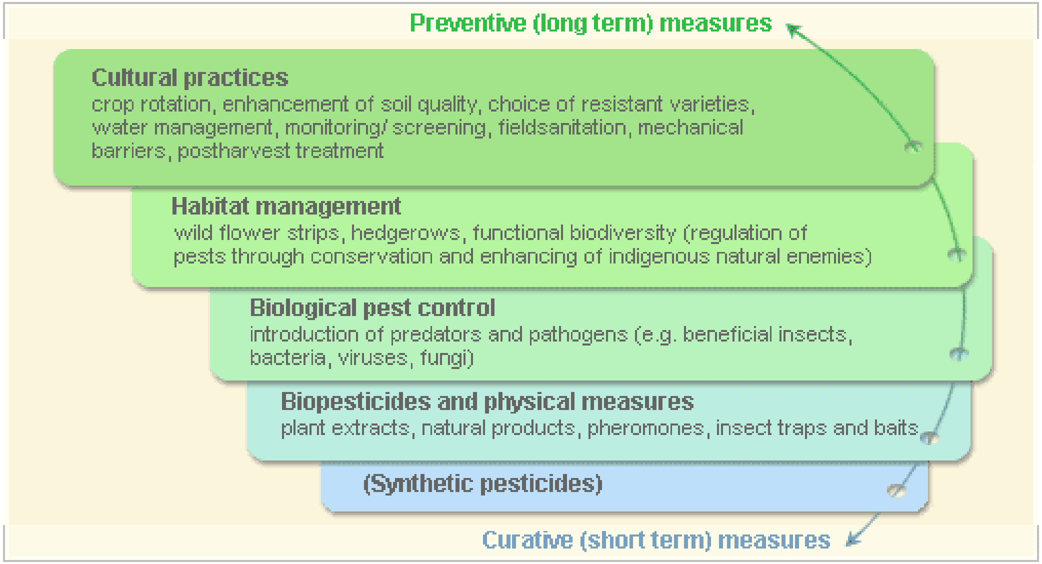
Disease transmission

Spores are the mechanism for the rapid and devastating spread of late blight when conditions are cool and moist. Splashes of water can transfer

the spores from plant to plant and wind can carry the spores much greater distances. If Irish potatoes have been grown in a field, tubers remaining in the soil after harvest can be a source of the disease for crops that follow.

Pest and Disease Management

Pest and disease management: General illustration of the concept of *infonet-biovision*



These illustration shows the methods promoted on infonet-biovision. The methods shown at the bottom have a long-term effect, while methods shown at the top have a short-term effect. In organic farming systems, methods with a long-term effect are the basis of crop production and should be used with preference. On the other hand methods with a short-term effect should be used in emergencies only. On infonet we do not promote synthethic pesticides.

Further below you find concrete preventive and curative methods against Late blight.

Cultural practices

Controlling blight once it has taken over is very difficult. The most important way of controlling late blight is to prevent its spread. At this point, there is no biological control of known efficacy for use in suppressing late blight. Cultural techniques can help to reduce the risk of late blight outbreaks. Stake tomato plants to keep them off the soil, mulch to reduce water splashes, and remove or deeply dig in old crops after harvest. Pruning of indeterminate tomato varieties will increase air movement and allow good spray penetration if bio-pesticides are to be

used. Irrigating in the heat of the day should allow the crop to dry before nightfall and reduce disease transmission and development.

Further cultural measures are:

Use healthy seeds / planting material
Use only tomato seeds / transplants and potato tubers that are certified or disease free. Growing healthy plants helps to prevent disease in crops. Adding compost or well decomposed animal manure, and sowing green manures help to improve soil structure and nutrient content to produce a healthier crop that can tolerate / or resist blight.

Field sanitation
Eliminate all early inoculum by destroying potato cull piles, preventing growth of volunteer potatoes, and planting tomatoes as far as possible from potatoes. Remove crop residues after harvesting.

Crop rotation
Rotation away from tomatoes and potatoes for 3 to 4 years helps to break

the disease cycle. Do not plant potato near tomato or other solanaceous crops when disease has occurred, as the disease can easily spread from one to the other. Rotation will only be effective if it is done in cooperation with neighbouring farmers since the fungal spores of late blight can wind travel quite large distances.

Proper plant spacing
Allow proper aeration among the plants and proper sunlight penetration. Indeterminate tomato varieties should be pruned. Ask for assistance from your local agriculture office.

Resistant varieties
In some agro-ecosystems, cultivars with tolerance are available and these could significantly reduce late blight damage. In Kenya the potato varieties 'Asante' (red) and 'Tigoni' (white) are fairly resistant to late blight. CIP (The International Potato Centre) is testing other resistant potato varieties in the region, expecting to release more resistant varieties in the future. ICIPE is testing tomato varieties for resistance to late blight (Dr. A.A. Seif, personal communication). Ask your agricultural extensionist for

information on recommended varieties for your locality.
In Tanzania, the following commercial tomato varieties have been claimed to be resistant to late blight: "Meru", "Tengeru 97" and "Shengena".

Tool hygiene
Clean tools thoroughly before using in a different area of crops to stop the disease spreading. It is advisable to start field operations in clean fields and end-up in diseased fields. This would reduce spread of the disease in the farm.

Solarisation
High temperatures have been used to control *Phytophthora* in many ways. Steam heat to kill *Phytophthora* in contaminated soil in greenhouses was used many years ago in the developed / first world countries. Although the industry now uses soil-less media, homeowners can still use this technique. Solar heating in the field by laying out clear polyethylene tarps helps pasteurize the soil. This method has been useful in places with a large proportion of cloudless days. For further information on solarisation click here

Weather forecasts
Listen to weather forecasts on the possible late blight outbreaks (where such forecasts are broadcasted) or ask for updates from your local agriculturists. The temperature-humidity rule is one of the methods used to forecast the late blight epidemic. Late blight fungus will sporulate (produce spores) when there is a cool and warm temperature that is not less than 10° C, and the relative humidity is over 75% and lasts for 2 consecutive days.

Potato: use healthy seed tubers

Late blight has not been reported as seed-borne on true seeds of potato. However, it is seed-borne on tuber seed pieces. For potatoes, it is therefore important to plant certified disease free tubers.

How to select healthy potato tubers
First plant parts to be inspected should be the seed tubers. Lesions can be readily seen on clean tubers with smooth white skins. Lesions are more

difficult to detect on russeted or pigmented tubers. External inspection should be followed by observation of the flesh just underneath the potato tuber skin. Late blight causes a corky, 'granular', apparently discontinuous dry rot. Don't use these potato tubers for propagation.

If you are not sure whether you have a healthy potato there is a small test:
Take the potato tubers out in the field or keep in a warm place for about 15 - 20 days before planting. Let them sprout at a temperature of 15 - 20º C for 10 - 15 days. Diseased potato tubers will rot in high temperatures. Remove the rotten ones and dispose of them properly, and properly select the healthy sprouted potatoes as planting materials.

Planting potato
Good soil coverage provides better protection for the potato tubers. Sow tubers in holes more than 15 cm deep to protect them from easy infection. Hilling up the plant rows after germination will also reduce tuber infestation.

Post-harvest treatment of potato tubers

Before harvesting potatoes, the tops should be cut and left to dry completely. Harvest potato when the vines are completely dead because the fungi-causing blight will not survive in dead vegetation. Dry tubers and remove infected ones before storing to reduce additional losses from soft rot diseases.

Tomato: seed-treatment

You can dry tomato seeds for 3 days at about 22°C or oven-drying them for 6 hours at 29.5-37.7°C. Sun drying is also recommended. After this time the Late blight pathogen is eliminated and you can use the seed for propagation.
For more information on heat treatment of seeds click here.

Farmers experiences - avoiding crop losses

Avoiding disease can be an effective disease management strategy:

1. Farmers in the Andes plant susceptible potatoes at high altitudes where low temperatures reduce late blight pressure. However, this strategy is

frequently used in such a way that farmers trade off yield potential for decreased risk of disease. One survey in Ecuador estimated that between 30 and 40% of potato production in a province in central Ecuador was done in the dry season to avoid late blight. Yields in the dry season are considerably lower.

2. Similarly, much of the potato production in the highlands of Ethiopia occurs during a period known as the "short rains". Yields are low during this period because of limited water supply, but the risk of losses due to blight is also reduced. Overall production in this country could be increased by the introduction of potato cultivars with tolerance/ resistance to late blight that could be planted in the main rainy season.

3. Traditional farmers in Kenya use a mixture of Mexican marigold, nettle and *Piectranthus barbatus* (beautiful blue flowered shrub commonly used for hedging and said to have particular fungicidal properties) (Kikuyu name:Maigoya) to prevent outbreaks of late blight.

Biopesticides and physical methods

Copper

There are many copper compounds used as fungicides. Recommended are copper products based on either copper hydroxide or oxychloride. Copper fungicides are formerly accepted in organic farming provided that the number of applications is strictly followed and a proper soil amendment is observed to prevent copper accumulation in the soil, and can still be accepted with permission from the certifying authority (other fungicides based on Sulphur (e.g. Thiovit) are being tested by CIP).

In wet weather fungicide sprays should be applied as soon as the disease is observed or as soon as local experience suggests that weather conditions are favourable for disease development.

Crop scouting should be used as a guide in making a decision on whether to apply a fungicide. And when applying fungicides, safety procedures in application must be complied with, particularly, in use of protective clothing. Observe right dosage and prescribed pre-harvest intervals. Ask your local agricultural extentionist on locally registered fungicides.
For further information see also standard procedures for application of

copper (click here).

Information Source Links

- CABI (2004). Crop Protection Compendium, 2004 Edition. © CAB International Publishing. Wallingford, UK. www.cabi.org
- CIP - International Potato Centre. P.O.Box25171, Nairobi 00603, Kenya. www.cipotato.org
- GILB. Global Late Blight Initiative. http://gilb.cip.cgiar.org/
- HDRA. Henry Doubleday Research Association, UK. www.gardenorganic.org.uk/pdfs/international_programme/TDC1-Late_blight.pdf
- Kuepper, G. and Sullivan, P. (2004). Organic Alternatives for Late Blight Control in Potatoes. Pest Management Technical Note. ATTRA. www.attra.org/attra-pub/lateblight.html
- Oisat. Online Information Service for Non-Chemical Pest Management in the Tropics. www.oisat.org
- Pscheidt, J. Diagnosis and control of Phytophthora diseases. An online guide to plant disease control. Oregon State University Extension. http://plant-disease.ippc.orst.edu/article_index.cfm
- University of Minnesota. Late blight of tomato and potato.

www.extension.umn.edu/projects/yardandgarden/ygbriefs/p230lateblight-pot-tom.html

- **Varela, A.M, Seif, A.A. and Löhr, B. (2003). A Guide to IPM in Tomato Production in Eastern and Southern Africa. pp. 144. ICIPE Science Press, Nairobi, Kenya. ISBN: 92 9064 149 5**

Information of www.infonet-biovision.org

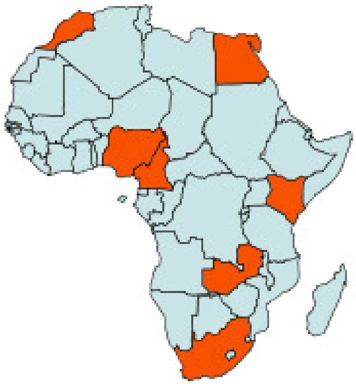
Information of www.infonet-biovision.org

Early blight

Early blight
Scientific name: *Alternaria solani*
Type: disease (fungal)
Common names: Early blight / Alternaria blight / dry blight / leaf spots / seedling blight / damping-off / collar rot / hard-rot of fruits
Host plants: African Nightshade Eggplant Okra Potato Tomato

General Information on Disease and Damage

Geographical distribution



Geographical Distribution of Early blight in Africa (red marked)

Early blight occurs in all continents and is widespread in the tropics, subtropics and temperate zone.

Introduction

Early blight is one of the most common and serious diseases of potato and tomato. It is of particular importance in warm dry areas. Infection first

occurs during periods of warm, rainy, humid weather. Increased damage may occur by secretions of toxins by pathogens.

Symptoms of Early blight

All above ground parts of the plant can be affected. In seedbeds, pre- and post-emergence damping-off occurs. On young seedlings, collar rot may develop - it is characterized by girdling of the stem at the base of the plant. Affected seedlings are stunted and may wilt and die. When older seedlings are infected, stem lesions (spots) usually are restricted to one side of a stem and become elongated and sunken on stems and leaf petioles.

Affected leaves exhibit brown spots with concentric rings. Leaf spotting first appears on the oldest leaves and progresses upward

on the plant. Entire plant could be defoliated and killed.

Early blight on tomato leaf. Leaf spots of early blight are circular, up to 1.2cm in diameter, brown, and often show a circular pattern, which distinguishes this disease from other leaf spots on tomato.

© A.M. Varela, icipe

Typical fruit spots occur at the stem-end as a rot that radiates out from the area of attachment between the calyx and the fruit. The spot is usually brown to black, firm, depressed and has distinct concentric rings.

Early blight is sometimes confused with Late blight. Late blight lesions are lighter, smaller and they do not have the circular ridged bands that early blight has.

Early blight symptoms on

tomato fruit
© A.A. Seif, icipe

Affected plant stages

all growth stages

Affected plant parts

all parts except roots

Symptoms by affected plant parts

Fruits/pods: spots. leaves: spots.
Stems: external discoloration.

Biology and Ecology of Early Blight

Early blight is caused by the fungus, *Alternaria solani*, which survives in infected leaf or stem tissues diseased potato tubers on or in the soil and in infected tomato fruits. This fungus is universally present in fields where susceptible crops have been grown. It can also be carried on tomato seed and in potato tubers.
Spores are formed on infected plant debris at the soil surface or on active

lesions over a fairly wide temperature range, especially under alternating wet and dry conditions.

Infection occurs in warm, humid weather with heavy dews or rain. Periods of warm rainy weather, with temperatures between 21-24°C favour outbreaks of early blight.
Seriousness of early blight is dependant on weather conditions and crop variety. Early blight can develop quite rapidly under humid warm conditions and is more severe when plants are stressed by poor nutrition, drought, nematode attack or a heavy fruit load. Tomato plants become more susceptible with age particularly at fruiting. In tomato seedbeds collar rot may appear almost simultaneously on many plants indicating contamination of seeds or soil. Infection of potato tubers occurs through natural openings on the skin or through injuries. Tubers may come in contact with spores during harvest and lesions may continue to develop in storage.

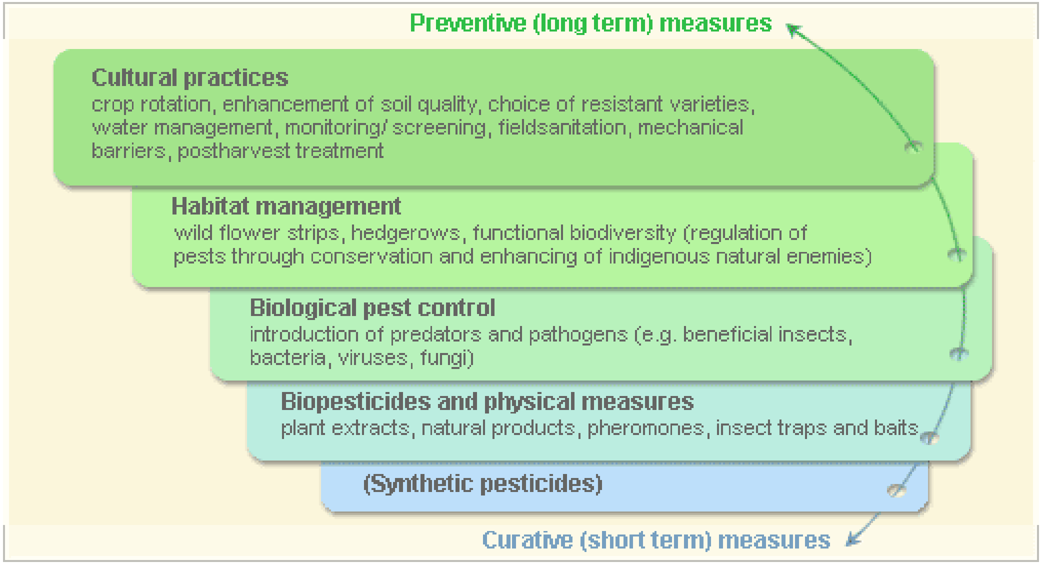
Disease transmission

Early blight can be seed-borne, resulting in damping-off. Infected plant

residues in the soil can carry the disease to the following season, particularly if the soil is dry. The spores are formed on the surface of infected tissue and can be spread by the wind and splashes of water.

Pest and Disease Management

General illustration of the concept of *infonet-biovision*



These illustration shows the methods promoted on infonet-biovision. The

methods shown at the bottom have a long-term effect, while methods shown at the top have a short-term effect. In organic farming systems, methods with a long-term effect are the basis of crop production and should be used with preference. On the other hand methods with a short-term effect should be used in emergencies only. On infonet we do not promote synthethic pesticides.

Further below you find concrete preventive and curative methods against Early blight.

Cultural practices

Prevention and control: Controlling early blight once it has established is very difficult. The most important way of controlling early blight is attempting to prevent its establishment and further spread.

Use clean seed: Make sure that seeds/tubers for sowing and planting are certified and not taken from plants that were previously infected by the early blight. If possible, use potato and tomato varieties that are resistant to the disease.

Use tolerant or resistant varieties: Use plant varieties that are tolerant or resistant to early blight. Examples of tolerant / resistant tomato varieties in Kenya: 'Floradade', 'Hytec 36', 'Julius F1', 'Rio Grande', 'Rossol', 'SummersetF1', 'Zeal F1' and 'Zest F1'.

Destroy crop debris after harvest: Plough under all the crop residues after harvest to physically remove the inoculum (infection) source from the topsoil. Remove also weeds as they may serve as alternate hosts. Burn the infected material and plant debris.

Crop rotation: Fields should not be planted with tomato, Irish potato, or eggplant for at least 2 cropping seasons, since they are hosts to early blight. Also avoid planting new plots of these vegetables alongside old ones. Rotations with small grains, maize or legumes are preferable.

Avoid injury to potato tubers during harvesting and handling: Harvest potato tubers when the soil is not wet and when the vines are dry.

Practise proper plant spacing and staking: Prevent tomato plants from soil

contact and prune and stake indeterminate varieties to promote good air circulation. Mulch determinate tomato varieties.

Water management: If possible avoid over-head irrigation. Otherwise, irrigate early in the morning so that the canopy would dry in the evening. In case of Irish potatoes, furrow irrigation should not be used especially after tuber formation.

Soil management: Use plenty of compost or well decomposed animal manures. Maintain soil fertility at optimal levels. Nitrogen and phosphorus deficiency can increase susceptibility to early blight. Also excess nitrogen could induce early blight infection.

Biopesticides and physical methods

Hot water treatment of seeds

Hot water treatment of seeds, where own seeds are used, could help reduce the incidence of seed-borne infection by early blight. It will also take care of other seed borne problems caused by pathogens such as

***Phoma* spp., *Septoria* spp. and bacterial pathogens.**

Specified temperatures and recommended time for treatment should be strictly followed in order to maintain seed viability. Use a good thermometer or better ask for assistance from qualified personnel from your local extension office.

To make sure that the seed is not damaged it is advisable to test the germination of 100 heat-treated and 100 untreated seeds.

For more information on hot water treatment of seeds click here

Botanical fungicides

Botanicals are are derived from plants. Many plant products are said to have fungicidal properties. They are natural products and most of them break down quickly on the leaves or in the soil. However, there is very little information on their effective dose rates, their impact on beneficial organisms or their toxicity to humans.

Fermented Marigold extract:
Ingredients: Whole flowering plant, soap and water. Fill-in a drum with 1/2-3/4 full of flowering plants. Leave to stand for 5-10 days. Stir occasionally. Strain before use. Dilute the filtate with water at a ratio of 1:2. Add 1 teespoon of soap in every litre of the extract (Stoll, 2000: p. 132).

Onion bulb extract:
Ingredients: 50 g of bulb onion and 1 litre distilled water. Finely chop the onion. Add to water. Mix well. Strain. Spray thoroughly on the infected plant, preferably early in the morning or late afternoon (Stoll, 2000: p. 223).

For more information on plant extracts, including standard procedures for the preparation and application of plant extracts click here

Sulphur

Sulphur sprays are permitted as preventive fungicides in organic farming. The commercial product 'Thiovit' can be used and has been reported by some farmers to have preventive effect on early blight (farmer experience in Kenya), albeit very harmfull to predatory mites.

Copper

If the problem of blight is serious, fungicide spraying may be required. Ensure that persons dealing with fungicides are trained on safe use and handling of pesticides.

There are many copper compounds that are used as fungicides. Most copper products are either based on copper oxychloride or copper hydroxide and are readily available in the market. Copper is accepted in organic farming provided that the number of applications is strictly followed and a proper soil amendment is observed to prevent copper accumulation in the soil

Note: Excessive use of copper based products can be detrimental to the soil. Constantly shake the sprayer while in the process of application of copper to prevent the solution from clogging. It is advisable to use dry flowable copper products now available in the Kenya pesticide market. For more information on standard procedures for application of Copper and sulphur click here.

Information Source Links

- CABI. (2004). Crop Protection Compendium, 2004 Edition. © CAB International Publishing. Wallingford, UK. www.cabi.org
- Cornell University. Resource guide for organic insect and disease management. ISBN: 0-9676507-2-0. www.nysaes.cornell.edu/pp/resourceguide/index.php
- Ellis, B., Bradley, F. (1996). The organic gardener's handbook of natural insect and disease control. Rodale Press. Emmaus, Pennsylvania. ISBN: 0875967531
- HDRA. Henry Doubleday Research Association, UK. www.organicgardening.org.uk/pdfs/international_programme/TNP2-Mexican_marigold.pdf www.gardenorganic.org.uk/pdfs/international_programme/TDC2-Early_blight.pdf
- ICIPE (2003). Varela, A.M, Seif, A.A. and Lohr, B. (2003). A Guide to IPM in Tomato Production in Eastern and Southern Africa. pp. 144. ICIPE Science Press, Nairobi, Kenya. ISBN: 92 9064 149 5
- Nega, E., Ulrich, R., Werner, S. und Jahn, M. (2003). Hot water treatment of vegetable seed: an alternative seed treatment method to

control seed borne pathogens in organic farming. Journal of Plant Diseases and Protection 110(3):pp. 220-234. orgprints.org/7672/

- Ohio State University. Early blight of potato and tomato. Factsheet. ohioline.osu.edu/hyg-fact/3000/3101.html
- Oisat www.oisat.org
- Sridhar, S.; Arumugasamy, S.; Saraswathy, H.; Vijayalakshmi, K. (2002). Organic vegetable gardening. Center for Indian Knowledge Systems. Chennai.
- Stoll, G. (2000). Natural protection in the tropics. Margraf Verlag, Weikersheim. ISBN: 3-8236-1317-0
- TAMU. A guide to the identification of common problems: Tomato disorders. aggie-horticulture.tamu.edu/tomatoproblemsolver/index.html
- University of Minnesota Extension. Early blight of potato and tomato. www.extension.umn.edu/projects/yardandgarden/ygbriefs/p256earlyblight-pot-tom.html
- Vijayalakshmi, K.; Subhashini, B.; Koul, S. (1999). Plants in Pest Control: Garlic and onion. Centre for Indian Knowledge Systems, Chennai, India.

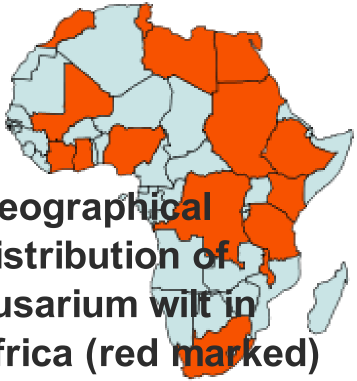
Information of www.infonet-biovision.org

Fusarium wilt

Fusarium wilt
Scientific name: ***Fusarium oxysporum***
Family: Fungi: Hypocreales
Type: disease (fungal)
Host plants: Bananas Beans Cotton Cowpea Cucumber Eggplant Millet Okra Passion fruit Peas Peppers Pigeon pea Sesame Spinach Sweet potato Tomato Yam

General Information on Disease and Damage

Geographical distribution



Geographical Distribution of Fusarium wilt in Africa (red marked)

Important *Fusarium* species:

- **Banana wilt (Panama disease) (*F. oxysporum* f.sp. *cubense*)**
- **Cabbage yellows (*F. oxysporum* f.sp. *conglutinans*)**
- ***Fusarium* wilt of common beans (*F. oxysporum* f.sp. *phaseoli*)**
- ***Fusarium* wilt of cotton and okra (*F. oxysporum* f.sp. *vasinfectum*)**
- ***Fusarium* wilt of peas (*F. oxysporum* f.sp. *pisi*)**
- ***Fusarium* wilt of pigeon pea (*F. odum*)**
- ***Fusarium* wilt of tomato (*F. oxysporum* f.sp. *lycopersici*)**

Symptoms on banana

An infected plant is characterised by a strong yellowing of the leaves that remain erect for 1 to 2 weeks. Some of the leaves may then collapse at the leaf stalk and hang down at the pseudostem. The leaves fall in order, from the oldest to the youngest, until they hang about the plant like a skirt, and dry up.

The fungus grows in the vascular system causing the plant to wilt. A lengthwise cut on the pseudostem will show numerous brown and black lines running in all

***Fusarium* wilt symptoms (*Fusarium oxysporum* f.sp. *cubense*) on banana leaves. Banana cultivar 'Bluggoe' with**

directions.Infected suckers growing out of diseased corms (rhizomes) produce plants that wilt and eventually die. Leaf symptoms appear after the fungus has spread through the corm (rhizome). In younger plants, the first signs of infection are to be found on the unfurling leaf which turns yellow and dies off.

yellowing symptoms on lower leaves

Symptoms on cotton and okra (*F. oxysporum* f.sp. *vasinfectum*)

The affected plants are stunted. The leaves turn yellow, wilt and are later shed. Usually the lower leaves are the first affected. When a stem or the main root is cut crosswise, brown discoloration is usually found in the ring just beneath the bark. Wilting of plants is mostly gradual.

Wilting of okra plant due to *Fusarium* wilt

Symptoms on tomato

The lower leaves of the plant usually turn

yellow and die. One or more branches may show definite symptoms. Leaflets on one side of a petiole may be affected, while those on another side remain without symptoms. Diseased leaves readily break away from the stem. Sometimes the affected leaves may dry up before wilting is detected.

When affected stems just above the ground level and petioles are cut diagonally, a brown discoloration of the water conducting tissue inside the stem will be seen.

***Fusarium* wilt (*Fusarium oxysporum* f. sp. *lycopersici*) symptoms on tomato plant in field crop.**

Symptoms on beans

Fusarium wilt on beans

© A.M. Varela, icipe

Infestation often occurs on medium-aged or older plants. It begins as a yellowing and wilting of the lower leaves. The infection progresses up the plant until the entire plant turns yellow. Plants become stunted when infected at a younger age.

To be sure that the plant is infected by *Fusarium* wilt, you make a lengthwise cut on the stem at the soil line, near the base. The cut has a dark-brownish vascular tissue below the bark. If an infected plant is uprooted, the roots are partially or totally reddish-brown in colour.

Affected plant stages

Cotton and Okra: Seedling stage and vegetative growing stage.
Banana: Flowering stage, fruiting stage and vegetative growing stage.
Tomato: Flowering stage, fruiting stage and seedling stage.
Beans: Vegetative growing stage.

Affected plant parts

Cotton and Okra: Leaves, whole plant, and roots
Banana: Growing points, leaves, roots and stems.
Tomato: Leaves, stems, whole plant, and roots.
Beans: Leaves and roots.

Symptoms on affected plant part

Cotton and Okra: Leaves: yellowing lesions; abnormal colours. Whole plant: dwarfing.
Banana: Growing points: dead heart. Leaves: lesions; yellowing; wilting; Roots: rot. Stems: internal discolouration; stem splitting.

Tomato: Leaves yellowing. Stems: internal discolouration. Whole plant: wilt.
Beans: Leaves: yellowing; wilting.

***Fusarium* wilt on passionfruit.**
Note browning of water

conducting tissues
© A.M. Varela, icipe

***Fusarium* wilt on passionfruit. Close-up of a cut stem showing brownish water-conducting tissues.**

Biology and Ecology of Fusarium Wilt

Source of infection and spread

The fungus is both seed-borne and soil-borne. It may become established in many types of soil, but it is likely to cause most damage on light, sandy soils. It is most active at temperatures between 25 and 32° C. Since the fungus produces resting spores (chlamydospores), it can survive in the soil indefinitely even when no host plants are grown. It can also survive in fibrous roots of weeds such as *Amaranthus*, *Digitaria* and *Malva*. It can spread by movement of infested soil or infected transplants. Acidic soils (pH 5.0 to 5.6) and ammonium nitrogen (ammonium nitrate and urea) promote disease development. Infestation by root-knot nematodes enhances the disease.

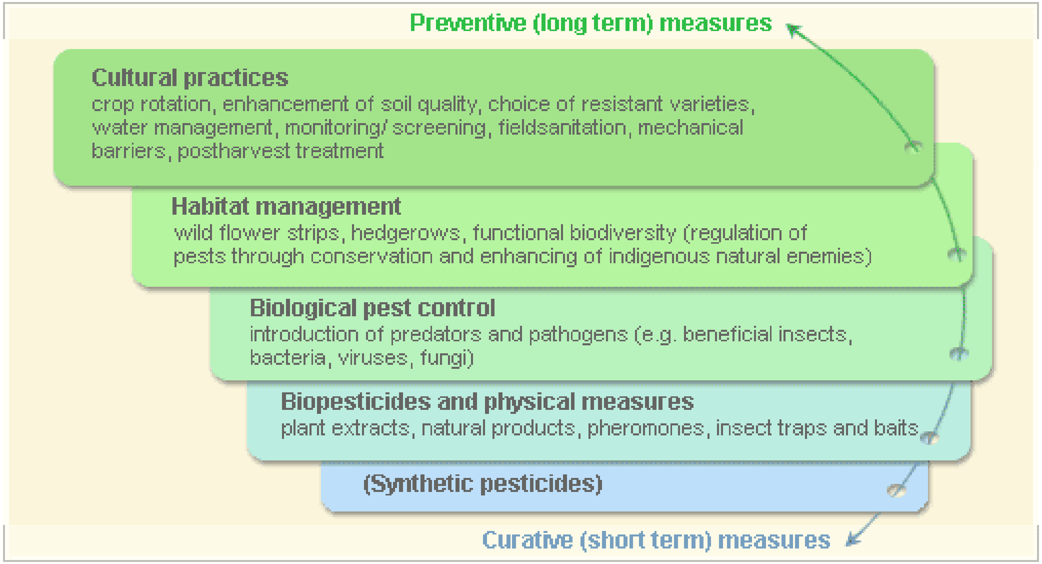
Conditions that favor development

- **High soil temperatures**
- **High nitrogen levels in the soil**
- **Soil moisture stress**

- ***Fusarium* infested soil**

Pest and disease Management

Pest and disease Management: General illustration of the concept of *infonet-biovision*



These illustration shows the methods promoted on infonet-biovision. The methods shown at the bottom have a long-term effect, while methods shown at the top have a short-term effect. In organic farming systems,

methods with a long-term effect are the basis of crop production and should be used with preference. On the other hand methods with a short-term effect should be used in emergencies only. On infonet we do not promote synthethic pesticides.

Further below you find concrete preventive and curative methods against Fusarium wilt.

Cultural practices

Disease prevention and management:

Spraying with fungicide will not control this disease

- **Because *Fusarium* persist several years in soil, a long crop rotation (4 to 6 years) is necessary.**
- **Avoid using any solanaceous crop (potato, tomato, pepper, eggplant) or other host plants in the rotation. Rotate with cereals and grasses wherever possible.**
- **Avoid fields with a long history of *Fusarium* wilt.**
- **Deeply plough the fields and leave them fallow for 2-3 months, where**

feasible

- **Use certified, disease-free seeds**
- **Use resistant varieties, e.g. tomatoes: 'Diego', 'Duke', 'Floridade', 'Fanny', 'Fortune Maker', 'Napoli', 'Radja', 'Roma VF', 'Roma VFN' and 'Tengeru 97'. Graft tomato plants on resistant root stocks where available.**
- **Raise soil pH by applying lime or farmyard manure where soil is acidic. Do not use chicken manure, which is very acidic.**
- **Control root-knot nematodes. To find out more on root-knot nematodes click here**
- **Keep fields weed-free**
- **Regularly irrigate the crop**

Information Source Links

- **CABI. (2005). Crop Protection Compendium, 2005 Edition. © CAB International Publishing Wallingford, UK. www.cabi.org**
- **OISAT: Organisation for Non-Chemical Pest Management in the Tropics www.oisat.org**
- **Reddy, M.V., Raju, T.N., Sharma, S.B., Nene, Y.L. and McDonald, D.**

(1993). Handbook of Pigeonpea Diseases. Information Bulletin N. 42. ICRISAT. ISBN: 92-9066-277-8

- Varela, A.M. and Seif, A. (2004). A Guide to IPM and Hygiene Standards in Okra Production in Kenya. ICIPE. Kenya. ISBN: 92 9064 161 5
- Varela, A.M., Seif, A. and Löhr, B. (2003). A Guide to IPM in Tomato Production in Eastern and Southern Africa. ICIPE. Kenya. ISBN: 92 9064 149 5

Information of www.infonet-biovision.org

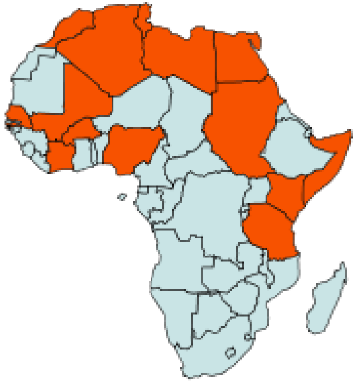
Information of www.infonet-biovision.org

Tomato Yellow Leaf Curl Virus Disease (TYLCV)

Tomato Yellow Leaf Curl Virus Disease (TYLCV)
Family: Geminiviridae: Begomovirus {GEM2}
Type: disease (viral)
Host plants: Tomato

General Information on Disease and Damage

Geographical distribution



Geographical Distribution of Tomato Yellow Leaf Curl Virus Disease in Africa *(red marked)*

The disease is widely spread and extremely severe in Somalia.

Damage

The virus affects yields by greatly reducing the number of fruit produced.

Fruit developing at the time of infection remain on the plant, but very few fruit will set once infection has occurred.

Symptoms

The disease can be easily recognized when tomato plants are infected at the seedling stage. TYLCV causes severe stunting of young leaves and shoots, resulting in bushy growth of infected seedlings. Tomato plants infected early in the season are normally stunted and excessively branched. Such plants have terminal and axillary shoots erect while leaflets are reduced in size and abnormal in shape.
Affected leaves are curled upwards or inwards. Flower drop is common, and therefore infected plants have a reduced number of flowers and fruit. If infection takes place at a later stage of growth, fruits

already present develop normally. There are no noticeable symptoms on fruits derived from infected plants. Generally, table tomatoes are severely affected by the disease, especially when infection occurs before the flowering stage.

Tomato yellow leaf curl virus. Note thickened shoots.

Host range

Although TYLCV has a broad host range, it is primarily known as one of the most damaging viruses to infect tomatoes. Beans (*Phaseolus vulgaris*) are also hosts of TYLCV and show severe symptoms after infection by whiteflies. The virus has been reported from non-solanaceous plants like sesame (*Sesamum indicum*), asthma weed (*Euphorbia geniculata*), fleabane (*Conyza stricta*) and oxalis (*Oxalis corniculata* and *O. acetosella*).

Affected plant stages

Seedling stage, generative and vegetative growing stage.

Affected plant parts

Leaves, stems and whole plant.

Symptoms on affected plant part

Leaves: stunting, bushy growth; reduced size; abnormal forms.
Flowers: drop.
Stems: abnormal growth.
Whole plant: dwarfing.

Biology and Ecology of the Tomato Yellow Leaf Curl Virus Disease

Source of infection and spread

The tomato yellow leaf curl virus is not seed-borne and is not transmitted mechanically. The disease is spread by whiteflies (*Bemisia tabaci*). Whiteflies have a wide host range. New plant growth attracts whiteflies, which feed on the lower leaf surface. It takes about 15-30 minutes for the whitefly to become infected by the virus. The incubation period is 21-24 hours, and the transmission period at least 15 min.

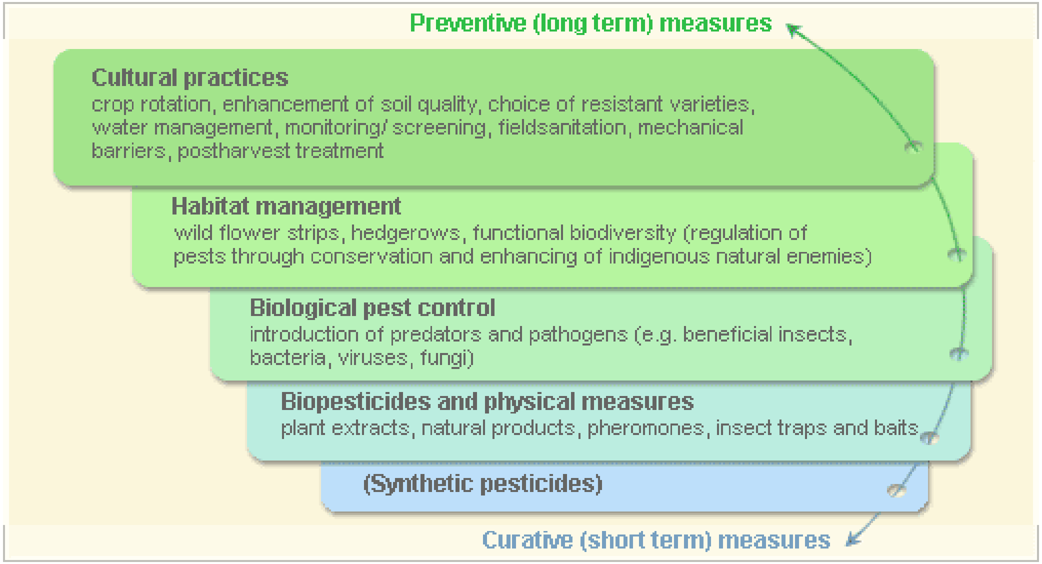
Factors that favour development:

- **High temperatures, and low or no rainfall**
- **Presence of whiteflies**
- **Infected transplants**
- **Weedy fields**

Pest and Disease Management

Pest and disease management: General illustration of the concept of

infonet-biovision



These illustration shows the methods promoted on infonet-biovision. The methods shown at the bottom have a long-term effect, while methods shown at the top have a short-term effect. In organic farming systems, methods with a long-term effect are the basis of crop production and should be used with preference. On the other hand methods with a short-term effect should be used in emergencies only. On infonet we do not promote synthethic pesticides.

Further below you find concrete preventive and curative methods against TYLVC.

Cultural practices

Following find a list of cultural practices for management and prevention of TYLCV:

- **Avoid continuous growing of tomato. Practice crop rotation by planting crops that are not susceptible to whitefly.**
- **Use resistant/ tolerant varieties, e.g. 'Amareto', 'Peto 86', 'Fiona F1', 'Perlina', 'Denise', 'Cheyenne (E448)', 'Rover'.**
- **Mulch the seedbeds.**
- **Protect seedbeds with a white nylon net (40 mesh).**
- **Pull out diseased seedlings.**
- **Protect seedlings from whiteflies (for more information on whiteflies click here)**
- **Plant barrier crops like maize around tomato fields. These crops should be sown a month or two before transplanting of tomato.**

- **Mulch tomato fields with sawdust or straw.**
- **Immediately remove infected-looking plants and bury them.**
- **Do not plant cotton near tomato and/or other crops susceptible to whiteflies or vice versa.**
- **Eradicate weeds.**
- **Plough-under all plant debris after harvest or burn them when possible**

Information Source Links

- **CABI (2005). Crop Protection Compendium, 2005 Edition. © CAB International Publishing. Wallingford, UK. www.cabi.org**
- **Dobson, H., Cooper, J., Manyangarirwa, W, Karuma, J. and Chiimba, W. (2002). Integrated Vegetable Pest Management - Safe and sustainable protection of small-scale brassicas and tomatoes. Natural Resources Institute, University of Greenwich, UK. ISBN: 0-85954-536-9**
- **Food and Fertilizer Technology Centre for Asian and Pacific Region (1986). Plant Virus Diseases of Horticultural Crops in the Tropics and Subtropics. FFTC Book Series No. 33, Taiwan, Republic of China**
- **OISAT. Organisation for Non-Chemical Pest Management in the**

Tropics. www.oisat.org

- Varela, A.M., Seif, A. and Löhr, B. (2003). A Guide to IPM in Tomato Production in Eastern and Southern Africa. ICIPE, Nairobi, Kenya. ISBN: 92 9064 149 5 www.icipe.org

---

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

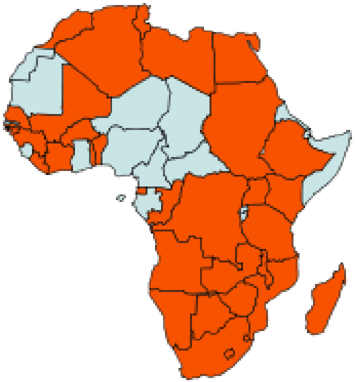
Cutworms

Cutworms
Scientific name: ***Agrotis*** **spp. (*Agrotis segetum* and *A. ipsilon*)**
Family: Lepidoptera: Noctuidae
Type: pest (insect/mite)
Common names: The common cutworm, turnip moth (*Agrotis segetum*); the greasy cutworm, black cutworm, tobacco cutworm (*Agrotis ipsilon*)
Host plants: Amaranth Beans Cabbage/Kale, Brassicas Carrot Coffee Cotton Eggplant Maize Okra Peas

Peppers Pigeon pea Potato Sesame Sorghum Tea Tomato

General Information on Pest and Damage

Geographical distribution



Cutworms (*Agrotis* spp.) occur in Africa from the Cape to the Mediterranean Coast. *Agrotis ipsilon* is one of the most widely distributed species of the cutworm complex. It is generally considered to be worldwide in distribution. Distribution of *Agrotis segetum* is limited by temperature; in Africa this cutworm is absent in the inner Sahel since the climate is too harsh.

Geographical Distribution of Cutworms in Africa (red marked)

Damage

Young caterpillars feed on leaves and later on stems. Mature caterpillars cause the most damage. They are capable of eating or destroying the entire plant. They girdle and cut-off young seedlings at ground level during the night, dragging them into the tunnel in the soil and feed on them during the day.

- **In beans, caterpillars feed on leaves, buds, flowers, and pods. Larger caterpillars tunnel into and destroy the bean pod and seeds.**

Okra seedling damaged by cutworm

- **In maize, caterpillars will feed on leaves, silk, and ears.**

caterpillar (right). Note healthy seedling on the left. Close-up of cutworm (inset) © A.M. Varela, icipe

- **On tubers and root crops, cutworms feed on tubers and roots, boring a wide shallow hole.**

- **Thick-stemmed vegetables such as lettuce and brassicas may have the stem below the ground completely hollowed out. Attacked plant wilt and die.**

The nature of the soil has a large influence on the rate of infestation. Cutworms tend to be more frequent in soil with plenty of decaying organic material or where organic manure has been applied. Damage is worse where cutworms are present in large number before planting. Cutworms often reoccur in the same field, coming with crop residues and dense stands of weeds.

Host Range

Cutworms attack cultivated plants belonging to more than 15 families. Common host plants include okra, cabbage, cauliflower, rutabaga, bell pepper, tomato, potato, maize and cotton.

Symptoms

External feeding on leaves by young caterpillars results in the presence of very tiny round 'windowpanes'. Feeding on leaves, stalks and stems results in falling leaves, small holes in the stems or cut stems respectively. Feeding on tubers and roots results in a variety of holes, ranging from small and superficial to very large deep ones.

Feeding by medium to large caterpillars is easier to recognise because whole leaves may fall off the plant after being cut through at the base of the stalk. Alternatively, small holes may be found on the stems and roots at the soil surface. A further sign of activity is the presence of leaf pieces partly pulled down into the soil.

The activity of the fully-grown caterpillars is very obvious. Whole plants

fall over and on root crops deep holes become visible at and above the soil surface. Damage to underground tubers (e.g. potatoes) may be difficult to recognise before harvest.
Damage is far more severe under very dry conditions and occurs deeper below the surface (Thygesen, 1971; Esbjerg, 1990).

Affected Plant Stages

Seedling stage and vegetative growing stage.

Affected Plant Parts

Leaves, roots and stems.

Symptoms by affected plant part:

Leaves: "windowpane" holes on leaves; abnormal leaf fall.
Roots: Holes ranging from small and superficial to very large deep ones.

Biology and Ecology of Cutworms

The eggs are ribbed, globular and small (about 0.5 mm in diameter). When

newly laid they are cream coloured turning reddish-yellow to blackish before hatching. Eggs are laid singly or in small groups on moist soil, on weeds or on the stem and lower leaves of host plants or on low growing vegetation. A single female may lay up to 2000 eggs. Preferred substrates are densely growing plants relatively low to the ground and fine-textured plant debris in untilled fields. Damp, low-lying areas within untilled fields are particularly attractive for egg-laying moths. Eggs hatch in 10 to 28 days.

Young caterpillars are pale, yellowish-green with a blackish head. Older caterpillars have a plump body; their colour varies from grey, dark green to brown or black with shiny, greasy-looking skin. Fully-grown caterpillars are 4 to 5 cm long. Newly hatched caterpillars feed on the leaves and later on the stems.

Older caterpillars feed at the base of

Black cutworm (*Agrotis ipsilon*). Early instars are about 7 to 12 mm long. Fully grown caterpillars are 3.5 to 5 cm long.

© Ooi P., Courtesy of Ecoport (www.ecoport.org)

plants or on roots or stems underground. They are nocturnal and hide in the soil or under stones and plant debris during the day. At night they move up to the soil surface to feed. Caterpillars construct burrows or tunnels in the soil about 2.5 to 5 cm deep near the host plant. They pupate in an earthen cell in the soil.

Black cutworm (*Agrotis ipsilon*). Pupae are brown

The pupae are about 1.7 to 2.5 cm long, smooth and shiny reddish-brown with two dark spines at the tip of the abdomen. They appear almost black in colour just befor the moth emerges.

to dark brown and approximately 1.7 to 2.5 cm in length and 5 mm in width.
© Ooi P., Courtesy of Ecoport (www.ecoport.org)

Turnip moth (*Agrotis segetum*). The adult moth is about 2 cm long and has a

The adult is a medium-sized moth, about 2 cm long with a wingspan of 4 to 4.5 cm. The forewings are greyish-brown with black lines or kidney-shaped markings along the side margins. The hindwings are pearly white with dark brownish margins and veins. They are active at night.

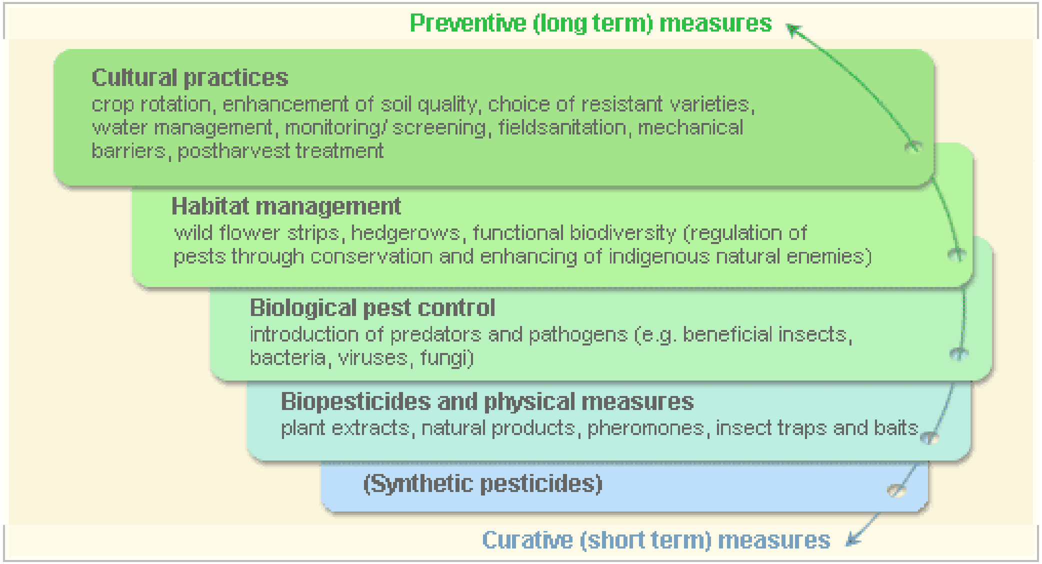
The life cycle can be completed in 6 weeks under warm conditions.

wingspan of 4 to 4.5 cm.

© Ooi P., Courtesy of Ecoport (www.ecoport.org)

Pest and Disease Management

Pest and disease Management: General illustration of the concept of *infonet-biovision*



These illustration shows the methods promoted on infonet-biovision. The

methods shown at the bottom have a long-term effect, while methods shown at the top have a short-term effect. In organic farming systems, methods with a long-term effect are the basis of crop production and should be used with preference. On the other hand methods with a short-term effect should be used in emergencies only. On infonet we do not promote synthethic pesticides.

Further below you find concrete preventive and curative methods against Cutworms.

Cultural practices

Monitoring and decision making

Early detection helps to prevent serious damage. Check fields for cutworm before sowing or transplanting.
Monitor damage by counting damaged and freshly cut leaves, freshly cut young plants, and holes in leaves and in stems.
Monitoring of cutworm caterpillars should be done at dawn.
Monitoring of cutworm moths can be done by pheromone traps (not available locally).
Control before thinning is advisable where high numbers of cutworms are

present. Control is normally not needed when plants are about 25 to 30 cm tall, but heavy attacks can even kill taller plants. Bigger seedlings are more tolerant to damage.

Control options

- **Ploughing exposes caterpillars to predators and to desiccation by the sun.**
- **Fields should be prepared and vegetation and weeds destroyed 10 to 14 days before planting the crop in the field. If the field is planted soon after land preparation some cutworms may be alive and attack the new crop.**
- **Delaying transplanting slightly until the stems are too wide for the cutworm to encircle and/or too hard for it to cut may reduce cutworm damage.**
  Hand picking of caterpillars at night by torch or very early morning before they return into the soil is useful at the beginning of the infestation.
- **Flooding of the field for a few days before sowing or transplanting can help kill cutworm caterpillars in the soil.**

Biological pest control

Natural enemies

Cutworms are attacked by a large range of natural enemies. The most important are parasitic wasps and flies, and some predators. The parasitic wasp *Cotesia (Apanteles) ruficrus* has been used in biological control programmes. The most common predators include ground beetles, lacewings, praying mantis, ants, and birds. Hens are useful because they dig out and eat cutworms present near the soil surface. They are very effective when confined on garden beds prior to planting.

Parasitoids:

1. Braconid: *Snellenius manilae* is a small Braconid wasp species. It looks like *Cotesia* except that it has a triangular closed cell on its front wing and has hairy eyes. This parasitoid wasp is host specific. It only parasitizes cutworm larvae. A female wasp lays 3-5 eggs in a cutworm larva. The parasite eats the body fluids and the larva for its development. Cocoons are formed next to the host's body. Lifecycle takes about 4-8 days. A wasp lives for about 1 week.
2. *Cotesia*

3. Tachinid fly

For more information on natural enemies click here.

Biopesticides and physical methods

Neem (*Azadirachta indica*)

Experiments in Sudan showed that spraying aqueous neem seed and neem leaf extracts three times at weekly intervals, starting directly after tuberisation reduced early infestation by cutworms on potato leaves. To prepare the extracts, leaf and seed powder were soaked in water at a rate of 1kg/40 l of water, stirred thoroughly and left overnight, and passed through a sieve before spraying (Siddig,1987).

For information on Neem click here.

Bait traps

Baits consisting of flour and water and containing Bt, or other insecticides (e.g. pyrethrum) are recommended. Baits are more effective when other

food is limited.

How to make baits:

1. Mix 100g bran or maize flour, 10 g sugar (1 small tablespoon), 5 g pyrethrum powder with 200ml water thoroughly together.
2. Sprinkle mixture closely around the plants in the affected areas.
The cutworms will eat the bait and die.

or
1. Mix equal quantities of hardwood sawdust, bran and molasses with enough water to make the mixture sticky.
2. Spread around the plants in the evenings.
The bait attracts the cutworms and as they try to pass through it they get stuck and die.

Pheromone traps

Pheromone traps are used to monitor and catch moths of cutworms. However, pheromones for cutworms are not available in the region.

How to make:

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, to allow moths to enter.

2. Heat a small piece of metal to make the holes easily.

3. Put a wire from the cover to suspend the bait.

4. Secure the pheromone dispenser aligns with the entrance holes inside the trap.

5. Make a rectangular opening into the lower part of the container for removing the moths caught.

How to use?

1. Half-fill the trap 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 container.

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.

Reminders while using pheromone traps:

- **Buy the pheromone that lures the pest you want to control.**
- **Always label the trap. The name of the species you are trapping, the date the bait was placed, and the name of the bait if you are using several.**
- **Change bait according to manufacturer's recommendation.**
- **Dispose properly the bait wrappers. The tiny amount of pheromone left near the traps will compete with your bait.**
- **Wash your hands between handling baits. Minute traces of other chemicals can render the baits completely ineffective.**
- **Always remove all captured adults during each visit. Discard them away from the field. Put live ones into a bucket with soap solution to drown.**

Protective collars

Protective collars made of plastic or paper cups, cardboard tubes from paper towels or toilet paper, plastic drink bottles with ripped-out bottom, sturdy cardboard, and milk cartons. Place the collar around the young plant just after planting and push into the soil to prevent the cutworm from attacking the stem.

Sticky substances

Such as molasses, diatomite earth, saw dusts, or crushed eggshells placed around the base of each plant. When cutworm emerges to feed, it will come in contact with the trap, get stuck, harden, and die.

Ashes

Ashes are reported to deter cutworms when spread on seedbeds, around plants, or mixed with the soil in the planting holes. The ash layer must be

renewed repeatedly.

Stick

A thick dry stick inserted on the side of the seedlings can act as a mechanical barrier, reducing loss of plants by cutworms.

Information Source Links

- **CABI (2005). Crop Protection Compendium, 2005 Edition. © CAB International Publishing. Wallingford, UK. www.cabi.org**
- **Elwell, H. and Mass, A. (1995). Natural Pest and Disease Control. Published by the Natural Farming Network. Harare, Zimbabwe.**
- **Esbjerg, P. 1990. The significance of shelter for young cutworms (*Agrotis segetum*). Entomologia Experimentalis et Applicata, 54(2):97-100.**
- **Hill, S. D. (1983). Agricultural insect pests of the tropics and their control. Second edition. Cambridge University Press. ISBN: 0-521-24638-5**
- **OISAT: Organisation for Non-Chemical Pest Management in the**

Tropics www.oisat.org

- Seif, A., Varela, A. M., Michalik, S. and Löhr, B. (2001). A guide to IPM in French beans production with emphasis on Kenya. ICIPE Science Press. ISBN: 92-9064-142-8
- Siddig, S. A. (1987). A proposed pest management program including neem treatments for combating potato pests in the Sudan. Proc. 3rd Int. Neem Conf. (Nairobi, Kenya, 1986). pp. 449-459.
- Thygesen, Th. 1971. On the correlation between cutworm attacks, light trapping and weather conditions. Danish Journal of Plant and Soil Science, 75:807-815.
- Varela, A. M. and Seif, A. (2004). A guide to IPM and hygiene standards in okra production in Kenya. ICIPE Science Press. ISBN: 92-9064-161-5.

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Diamondback moth (DBM)

Diamondback moth (DBM)
Scientific name: *Plutella xylostella*

Family: Lepidoptera: Plutellidae
Local names: Tanzania: Nondo mgongo-almazi (Kishwaheli); Kenya: Kimbaru twa (Kikamba), Kihuruta (Kikuyu), Kirinyo (Kimeru)
Type: pest (insect/mite)
Host plants: Cabbage/Kale, Brassicas broccoli, Brussels sprouts, cauliflower, Chinese cabbage, kale, kohlrabi, mustard, rape, savoy, swede, turnip

General Information on Pest and Damage

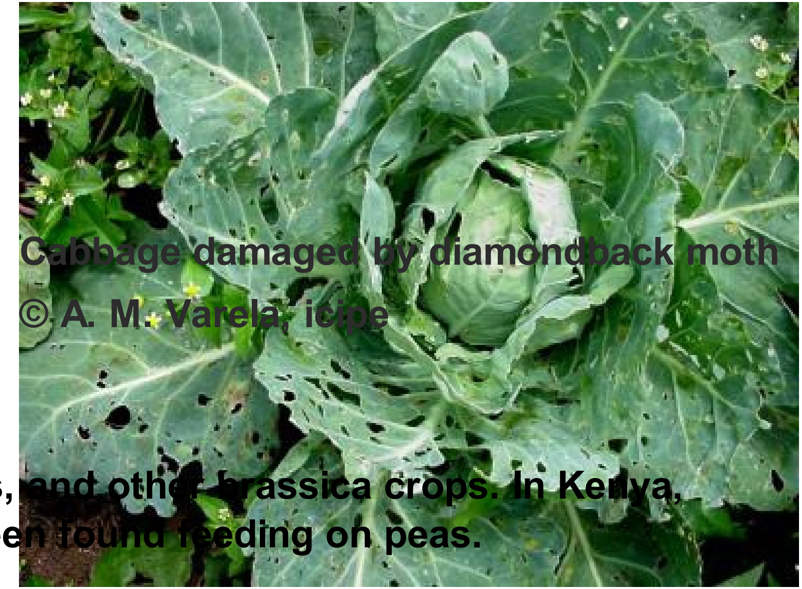
Geographical distribution

Geographical Distribution of the Diamondback moth in Africa (red marked)

Damage

Throughout the world diamondback moth is considered the main insect pest of brassica crops, particularly cabbages, kales, broccoli and cauliflowers. The economic impact of diamondback moth is difficult to assess since it occurs in diverse small scale and large-

scale production areas, but it has been known to completely destroy cabbage and kale crops. It is considered a major pest in all countries of the eastern and southern African region.



Cabbage damaged by diamondback moth

© A. M. Varela, icipe

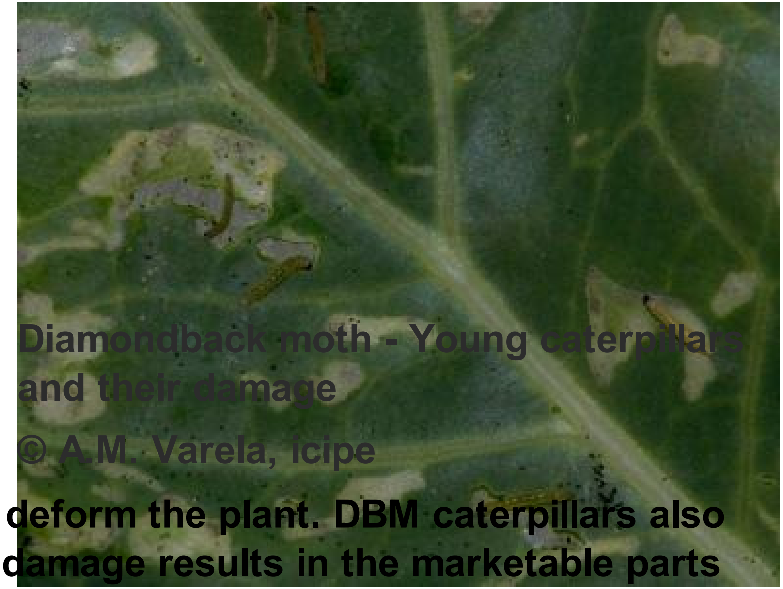
Host Range

Broccoli, cabbage, cauliflowers, and other brassica crops. In Kenya, diamondback moth has also been found feeding on peas.

Symptoms

Newly hatched DBM caterpillars feed as leafminers inside the leaf tissue. Older caterpillars feed on all plant parts. They feed on the leaf tissue leaving the upper leaf surface intact.

This type of damage is called "windowing", since it gives the appearance of translucent windows on the leaf. In cases of severe infestation entire leaves could be damaged. Caterpillar and pupae are found on damaged leaves. Older caterpillars are often found around the growing bud of young plants. Their feeding can deform the plant. DBM caterpillars also feed on stems and pods. Heavy damage results in the marketable parts contaminated with excrement, which makes the produce unsaleable.



Diamondback moth - Young caterpillars and their damage

© A.M. Varela, icipe

Affected plant stages

Seedling stage, vegetative growing stage, flowering stage and fruiting stage.

Affected plant parts:

Fruits/pods, growing points, inflorescence, leaves and stems.

Diamondback moth caterpillars feeding on kales

© A. M. Varela, icipe

Biology and Ecology of the Diamondback Moth

Eggs of the diamondback moth are tiny, flat and oval in shape, they are yellowish and less than 1 mm in size.

© F. Haas, icipe

Eggs are tiny (less than one mm), flat and oval in shape, and yellowish in colour. They are laid singly or in groups of 2 to 3 along the veins on the upper and lower leaf surfaces. The eggs hatch in 3 to 8 days depending on the environmental conditions.

Caterpillars are pale yellowish-green to green covered with fine, tiny scattered, erect hairs. Mature caterpillars are cigar-shaped and about 12 mm long. They have chewing mouthparts.

Diamondback moth feeding on kales. A fully-grown caterpillar is about one cm long. Head capsule is pale to pale-greenish or pale-brown, mottled with brownish and black-brown spots.

The caterpillars go through four instars and complete their development and pupate in 10 to 28 days. Diamondback moth (DBM) caterpillars are easily identified because they wriggle violently when disturbed, drop from the plant suspended by a silken thread and finally climb their way back up and continue feeding.

Pupae are 5 to 6 mm long. Pupae are initially light green and turn brown as the

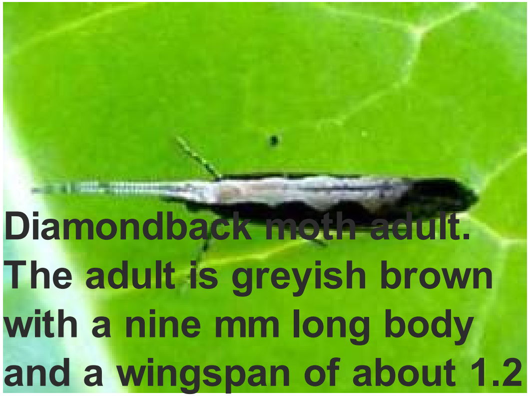
Diamondback moth pupal colour changes to brown before adult emergence. The developing moth can be seen through the cocoon. The pupa is 5 to 6 mm long.

© A. M. Varela, icipe

adult moths become visible through the cocoon. They are covered with a loosely spun net-like cocoon that is attached to the leaves, stems or seedpods of the host plant. Cocoons are about nine cm long.

The moths emerge 3 to 15 days after pupation depending on the environmental conditions.

The adult is a small greyish-brown moth, approximately 8 to 9 mm long with a wingspan of 12 to 15 mm. It has diamond-shaped markings on the back when the wings are folded, which gives the common name to this insect. The moth folds its wings over the abdomen in a tent-like manner when

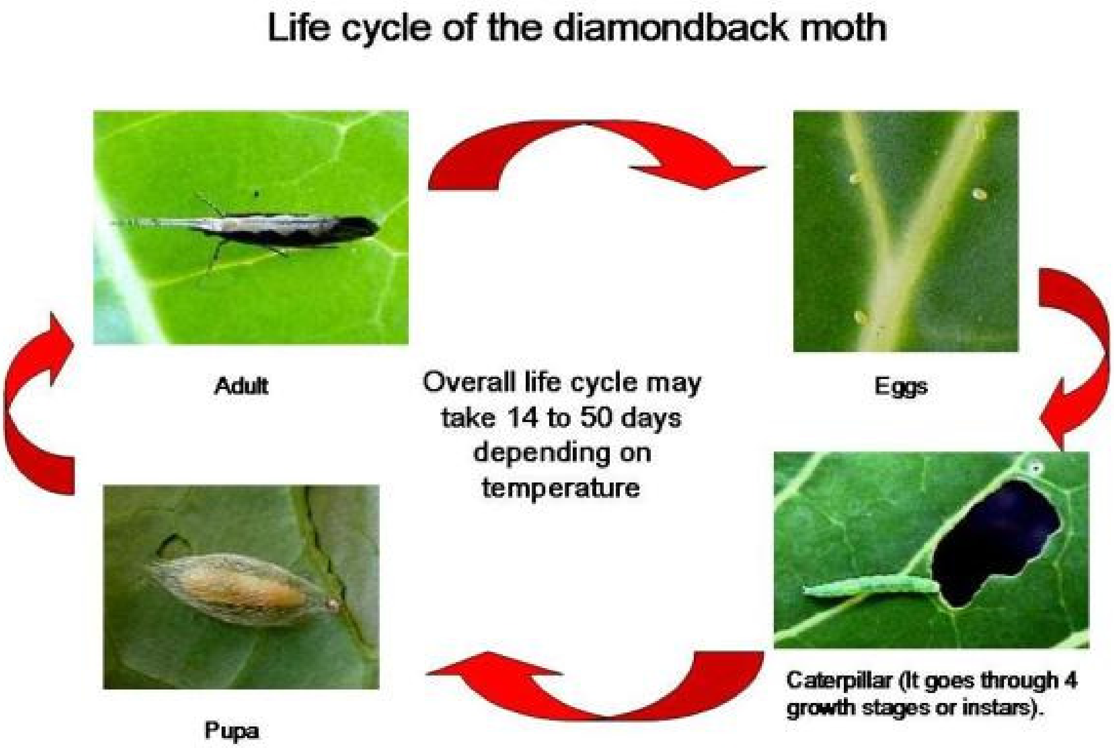


Diamondback moth adult. The adult is greyish brown with a nine mm long body and a wingspan of about 1.2 to 1.5 cm

© A. M. Varela, icipe

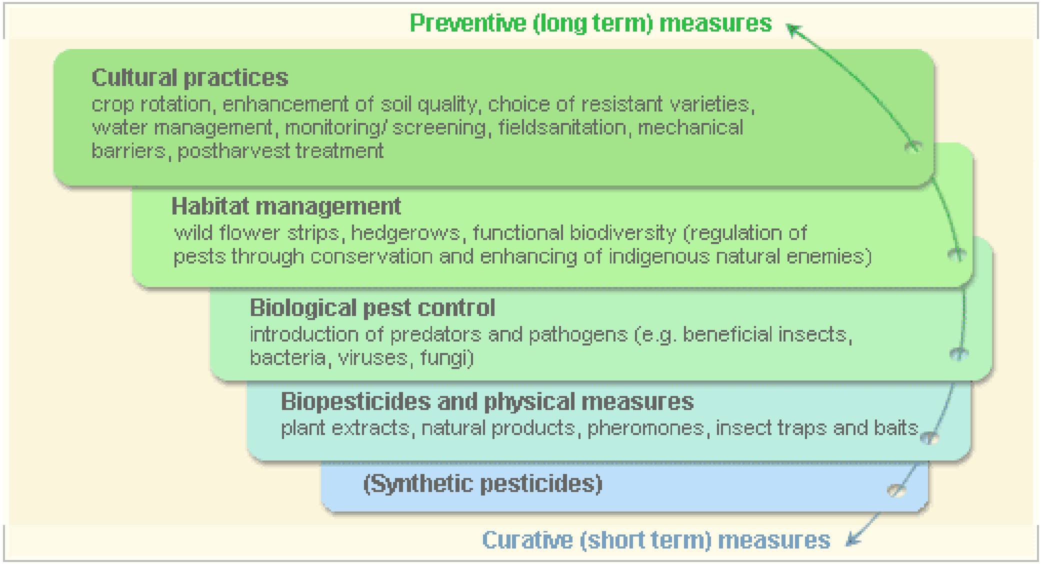
resting. The wing tips are fringed with long hairs. Adult females can lay an average of 160 eggs during their lifespan of about 16 days. Moths lay eggs at night. The greatest number of eggs is laid the first nights after emergence, egg laying continues for about 10 days. In the field, moths will fly up out of the plant canopy when disturbed.

Diamondback moth infestations tend to be serious in the dry months. Heavy rains may reduce populations dramatically, thus this pest is less likely to be a problem in wet years and during rainy seasons. Diamondback moth populations can increase rapidly at temperatures above 26°C.


Life cycle of the diamondback moth
Adult
Eggs
Overall life cycle may take 14 to 50 days depending on temperature
Caterpillar (It goes through 4 growth stages or instars).
Pupa

Pest and Disease Management:

Pest and disease Management: General illustration of the concept of *infonet-biovision*



These illustration shows the methods promoted on infonet-biovision. The methods shown at the bottom have a long-term effect, while methods shown at the top have a short-term effect. In organic farming systems, methods with a long-term effect are the basis of crop production and should be used with preference. On the other hand methods with a short-term effect should be used in emergencies only. On infonet we do not promote synthethic pesticides.

Further below you find concrete preventive and curative methods against Diamondback moth (DBM).

Cultural practices

Monitoring

Inspect the crop regularly. Diamondback moth populations can increase rapidly in warm conditions. Therefore, it is important to scout for Diamondback moth regularly, at least twice a week. Diamondback moth caterpillars are detected by visual observations of the plant. (Adults can be detected by the use of pheromone traps though they are not yet available in East Africa.)

Scouting should begin when the plants are young; the earlier the pest is discovered, the easier it is to control. Plants should be checked thoroughly. Growing points should be carefully examined. Caterpillars that are inside the cabbage head are difficult to detect unless outer leaves are pulled back. When scouting, it is important to record presence of parasitic wasps and parasitised caterpillars. Please also refer to section on natural enemies under Biological Pest Control further down on this page.

Examples of economic thresholds

Economic thresholds for the diamondback moth have been developed in several countries. For example, in small cabbage plots (0.25 ha) in Honduras, it is recommended to sample at least 60 plants and the action threshold is one caterpillar per plant. Broccoli and cauliflower at the vegetative stage can support 30% defoliation. At harvest time, an infestation level of one caterpillar per head is the action threshold (Rueda and Shelton, 1995). In the Midwest (USA), the treatment threshold for caterpillars (including DBM) attacking cabbage is given as 10% of infested pants in the seedbed, 30% infested plants from transplant to cupping stage, 20% infested plants from cupping to early heading, and 10% infested plants at the and early heading to mature head stages. For processing cabbage, which will be trimmed and shredded, more injure is tolerable; treatment is advised at 75% infestation. The treatment thresholds for broccoli and cauliflower are: 10% plant infestation in the seedbed, 50% plant infestation from transplant to first flower, and 10% infestation from first flower to maturity (Foster and Flood, 1995).

These thresholds are given as examples. However, note that economic thresholds depend on many factors (crop stage, crop age, and economic and climatic conditions) and cannot be adopted without taking into consideration local conditions.

Sanitation

- **Start with a healthy crop. Place seedling beds away from production fields to minimise attack by the diamondback moth. Transplant only healthy seedlings, which are free of eggs, caterpillars and pupae of the diamondback moth and other pests.**
- **Remove and destroy or plough down crop residues in seedling beds and production fields.**
- **Remove and destroy or plough down crop residues in seedling beds and production fields. These practices will prevent build-up of the diamondback moth and migration to nearby fields**

Pest avoidance

Planting cabbage at the beginning of the rainy season can help to avoid problems with the diamondback moth. Heavy rains reduce flight activity and mating of moths and wash off caterpillars and pupae from plant leaves. However, in the rainy season the plants will be more prone to diseases such as black rot, downy mildew and ring spot.

Crop rotation

Crop rotation can be effective in controlling the diamondback moth in semi-arid environments as there are only very few wild host plants. A significant reduction in the numbers of caterpillars can be achieved by having a break of 6 weeks or more where no brassica crops (cabbage, broccoli, cauliflower among others) are grown at all.

It is important that all farmers in a locality, or at least close neighbours, follow crop rotation simultaneously. This break will disrupt the pest's breeding cycle. Therefore, brassica crops planted after this break will be safe from the pest for sometime. However, this does not work in the highlands where large numbers of wild host plants are present in the surroundings of the fields throughout the year.

Intercropping, trap cropping

Planting rows of tomatoes alternately with rows of cabbage is reported to reduce damage but it does not prevent the attack completely. KIOF recommends this method as effective. In addition, cabbages would repel the tomato bollworm, making this practice serve a double purpose.

Intercropping with chillies is said to repel diamondback moth adults (Dobson et al, 2002).

Trap crops such as mustard and rape can also be useful to reduce diamondback moth attacks. Fifteen rows of cabbage followed by mustard rows have been shown to be most effective (HDRA, 2000). Bold seeded Indian mustard could also be sown densely all around the area 10 days before the crucifers are planted. The plants attract up to 80% diamondback moths (IPM Bulletin of Pest Management, Undated). However, trap crops should be frequently monitored so as to control this pest before it can move to the main crop. Once the trap crop is infested it can be ploughed in or removed. Unattended trap crops can generate large

populations of diamondback moth.

Care is needed to manage intercrops in order to use them as part of a control practice (Shelton *et al*., 1995).

Irrigation

As with rain, frequent overhead irrigation disrupts moth activities and washes off caterpillars from the plants. However, use of sprinkler irrigation may lead to increase of diseases such as black rot and downy mildew.

Habitat Management

Habitat management

Managing the habitat or the way a crop is grown helps to prevent or reduce pest and disease. Mix cropping brassica crops with some other crops or plants (intercropping, trap crops, strip cropping) has been shown to reduce infestation by the diamondback moth. The plants to be grown

together with the brassica crops need to be carefully selected.

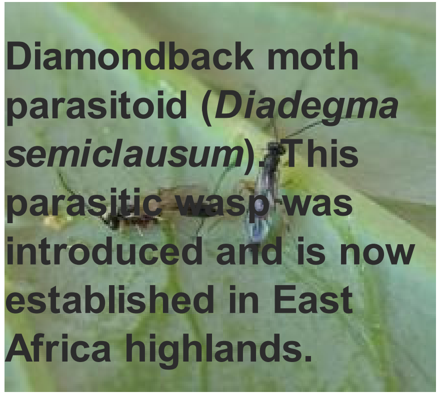
Maintaining natural surroundings, including trees and shrubs help to conserve natural enemies by providing shelter and plenty of breeding places for them. Maintaining strips of local flowering plants in the vicinity of the brassica crops is useful for beneficial insects. Trap cropping with flowering mustard can also augment the number of beneficial insects in the trap crop and the neighbouring crops.

Biological pest control

Natural enemies

Natural enemies (local and imported) can help to keep the pest at acceptable levels if they are conserved and their activity encouraged. Habitat management and avoidance of broad-spectrum insecticides early in the season, when the diamondback moth is present in low numbers may preserve natural enemies that can help keep

diamondback moth and aphid populations under control later in the season.



Diamondback moth parasitoid (*Diadegma semiclausum*). This parasitic wasp was introduced and is now established in East Africa highlands.

© A. M. Varela, icipe

Many natural enemies prey on the diamondback moth at different stages of its life cycle. Birds and spiders feed on moths; ants, lacewings, wasps, and parasitic wasps among others attack the caterpillars.

Numerous parasitic wasps attack diamondback moth. The most common are wasps of the genus *Cotesia*, *Diadegma*, *Diadromus* and *Oomyzus*. These wasps are also known from Africa and some are reported to effect excellent control of the diamondback moth elsewhere.

Unfortunately, the locally existing wasps do not provide satisfactory control of the diamondback moth in eastern and southern Africa. For this reason, two species of wasps (*Diadegma semiclausum* and *Cotesia plutellae*) were imported and released by ICIPE in Kenya, Uganda and

Tanzania. The former has provided almost complete control of this pest in highland growing conditions while the second is specific to mid-altitude, semi-arid areas where it also provides good control.

Diamondback moth parasitoid (*Cotesia plutellae*)

© A. M. Varela

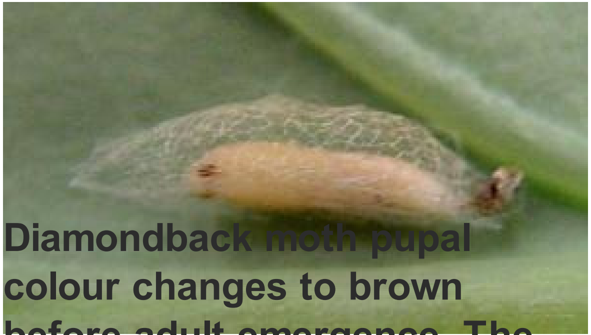
It is important to distinguish parasitised diamondback moth caterpillars from

Coccon of the parasitic wasp *Diadegma semiclausum*. The wasp larva spins a brown, rounded cocoon within the silk cocoon of diamondback moth.

© A. M. Varela, icipe

healthy ones. Caterpillars parasitised by *Diadegma semiclausum* can be distinguished at the pupal stage. The larva of this parasitic wasp eats the diamondback moth caterpillar from inside and pupates inside the diamondback moth cocoon. The pupa of the parasitic wasps appears as a round elongated brown capsule within the diamondback moth cocoon. In contrast, it is possible to see the developing moth through the cocoon of a healthy pupa.

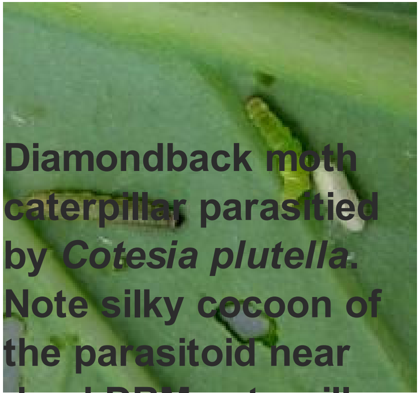
The larva of *Cotesia plutellae* feeds inside the diamondback moth caterpillar and emerges from the caterpillar to pupate in a silky cocoon on the leaves near the dead diamondback moth caterpillar.



Diamondback moth pupal colour changes to brown before adult emergence. The developing moth can be seen through the cocoon. The pupa is 5 to 6 mm long.

© A. M. Varela, icipe

Pathogens including fungi, bacteria and viruses are naturally found causing diseases to the diamondback moth in the field. However, they generally occur during rainy seasons when problems with this pest are not very pronounced. There are some commercially available pesticides based on disease-causing microorganisms



Diamondback moth caterpillar parasitied by *Cotesia plutella*. Note silky cocoon of the parasitoid near dead DBM caterpillar. The wasp larva emerges from the caterpillar and spins a white cocoon from which the adult wasp emerges.

© A. M. Varela, icipe

(microbiological pesticides). A well-known example is *Bacillus thuringiensis* (Bt).

For more information on natural enemies click here.

Biopesticides and physical methods

Bt (*Bacillus thuringiensis*)

***Bacillus thuringiensis* var. *aizawai* and Bt var. *kurstaki* are very effective in controlling infestations of the diamondback moth. Bt var. *kurstaki* is widely used at a weekly interval and a rate of 0.5/ha. This type of strategy provides effective control of this pest. However, continuous use of Bt can induce development of resistance. Bt kills the diamond back moth and does not harm beneficial insects. Bt insecticides should be applied when the newly hatch caterpillars appear. Sprays may need to be applied at intervals of 5 to 7 days when populations are high. Because Bt insecticides are UV-degraded treat crops in the late afternoon. For more information on Bt click here.**

Farmers experience

Farmers in some countries produce their own homemade biopesticides by collecting diseased diamondback moth caterpillars (fat and white or yellowish or with fluffy mould on them), crushing them and mixing them with water in a blender. Large tissue clumps are filtered out and the liquid is sprayed onto the crop (Dobson et al, 2002).

Neem (*Azadirachta indica*)

Neem-based products give a good control of the diamondback moth and are relatively harmless to natural enemies and non-toxic to warm-blooded animals. Since the action of neem is relatively slow, caterpillars may survive for a few days after application, but their growth and feeding is inhibited and they do not cause further damage to the crop. For more information on [Neem click here.]()

Information Source Links

- **CABI. (2004). Crop Protection Compendium, 2004 Edition. © CAB International Publishing.Wallingford, UK.[www.cabi.org]()**
- **Cornell International Institute for Food, Agriculture and Development. Global Crop Pests. Rueda and Shelton. Diamondback moth (DBM). [www.nysaes.cornell.edu]()**
- **Foster R. and Flood, B. (1995). Vegetable insect management with emphasis on the Midwest. Purdue Research Foundation. Meister Publishing Company, Willoughby, Ohio. ISBN: 0-931682-52-2.**
- **HDRA (2000). Diamondback moth, *Plutella xylostella*. Pest Control No.**

TPC3. Tropical Advisory Service, HDRA,UK. www.gardenorganic.org.uk/pdfs/international_programme/TPC3-Diamondback_moth.pdf

- **ICIPE www.icipe.org**
- **Natural Resources Institute, University of Greenwich, UK (2002): Integrated Vegetable Pest Management. Safe and sustainable protection of small-scale brassicas and tomatoes. By Hans Dobson, Jerry Cooper, Walter Manyangarirwa, Joshua Karuma and Wilfred Chiimba. ISBN: 0-85954-536-9.**
- **Oisat. Organisation for Non-Chemical Pest Management in the Tropics. www.oisat.org**
- **Rushtapakornchai, W., Vattanatangum, A. and Saito, T. (1992). Development and implementation of sticky trap for diamondback moth control in Thailand. In: Talekar NS, ed. Diamondback Moth and Other Crucifer Pests: Proceedings of the Second International Workshop. Shanhua, Taiwan: Asian Vegetable Research and Development Center, 523-528. www.avrdc.org/pdf/90dbm/90DBM58.pdf**
- **Shelton, A.M., Turner, A., Giga, D. Wilkinson, P., Zitzanza, E. and Utete, D. (1995). Diamondback moth. Zimbabwe Horticultural Crops Pest**

Management. NYSAES, Geneva NY. 2pp.

- Talekar, N. S. and Shelton, A. M. (1993). Biology, Ecology and Management of Diamondback Moth. Annual Review of Entomology, Volume 38. http://www.nysaes.cornell.edu/ent/dbm/review.html

---

Information of www.infonet-biovision.org
