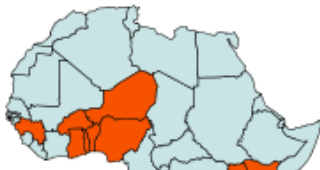
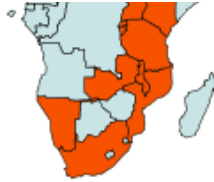

Information of www.infonet-biovision.org

Larger grain borer**Larger grain borer****Scientific name: *Prostephanus truncatus*****Family: Coleoptera: Bostrichidae****Local names: Kenya: Osama, Tanzania: Dumuzi (Mwezi language/Kisuaheli), Scania****Type: pest (insect/mite)****Host plants: Cassava Maize****General Information on Pest and Damage****Geographical distribution**

The larger grain borer was accidentally introduced from Central America into Tanzania in the late 1970s, and spread to other countries in the region. In West Africa it was first found in Togo in the early 1908s. It has now spread to many African countries becoming the most destructive pest of stored maize in both West and East Africa. Up to date it has been reported in Benin, Burkina Faso, Burundi, Ghana, Guinea Conakry, Kenya, Malawi, Mozambique, Namibia,





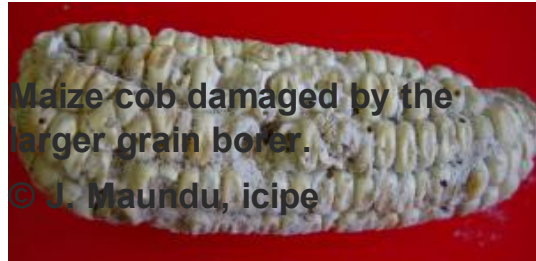
Niger, Nigeria, Rwanda, South Africa, Tanzania, Togo, Uganda and Zambia. In some of these countries it has become a serious pest of stored maize and dried cassava.

Geographical Distribution of the Larger grain borer in Africa (red marked)

Damage

The larger grain borer is a serious pest of stored maize and dried cassava roots, and will attack maize on the cob, both before and after harvest. Adults bore into the cassava or maize husks, cobs or grain, making neat round holes and tunnelling extensively producing large quantities of grain dust as they tunnel. The adults prefer grain on cobs to shelled grain, thus damage on unshelled maize is greater than on loose, shelled maize.

When infesting stored maize cobs with husk intact, the adults frequently begin their attack by boring into the maize cob cores, and eventually gain access to the grain at the apex of the cob by



Maize cob damaged by the larger grain borer.

© J. Maundu, icipe

crawling between the cob and husk. They may also bore directly through the husk. They cause considerable losses in stored maize; weight losses as high as 35% have been observed after only 3 to 6 months storage in East Africa. Losses in dry cassava can be very high too; the dried roots may be readily reduced to dust by boring adults. Average losses of 19% have been recorded after 6 months storage and as much as 30% in some cases.

The larger grain borer is spread over longer distances almost entirely through the import and export of infested grain. Local dispersal is through the local movement of infested maize and dried cassava and by flight activity of the adult beetles.

Although the larger grain borer develops best at high temperature and relatively high humidity, it tolerates dry conditions, and may develop in grain at low moisture in contrast to many other storage pests, which are unable to increase in number under low moisture conditions. For this reason, infestations of the larger grain borer usually found together with other storage pests, is the predominant storage pest under dry conditions.

Attack by the larger grain borer is sporadic. Pest incidence may be low for several

years and then suddenly increase in a "bad" year.

Symptoms

Adults tunnel through stored maize grain or other starchy products, such as dried cassava chips, creating large quantities of dust.

Host range

The larger grain borer is reported to breed only in maize and cassava. The adults can, however, live in and damage many stored products such as bulrush millet sorghum, yam, and wheat, as well as structural wood and wooden utensils.

Adults also bore into a wide range of foodstuffs and other materials such as bamboo, gourds, plastic and soap. In heavy infestations, wooden storage structures may be become damaged and act as reservoirs of infestation from which the new harvest may be attacked. The larger grain borer also occurs in the natural environment, it is able to breed on dead, dry wood of a range of trees, as well as dried stems of cassava and maize plants. Studies of this pest using pheromone traps showed that it was widespread in the natural vegetation in the Tsavo National Park, Kenya (Nang'ayo et al., 1993, 2002, Nansen et al., 2004).

Symptoms by affected plant part

Seeds: holes, large quantities of dust.

Affected plant stages

Post-harvest.

Affected plant parts

Seeds.

Biology and Ecology of the Larger Grain Borer

Eggs are laid in tunnels and chambers bored by the females in the food source.

Larvae hatch from the eggs after three to seven days

The larvae are white, fleshy and sparsely covered with hairs and have three pairs of legs. They develop within the grain or in the flour that accumulates by the feeding action of the adults. They pupate inside the food source.

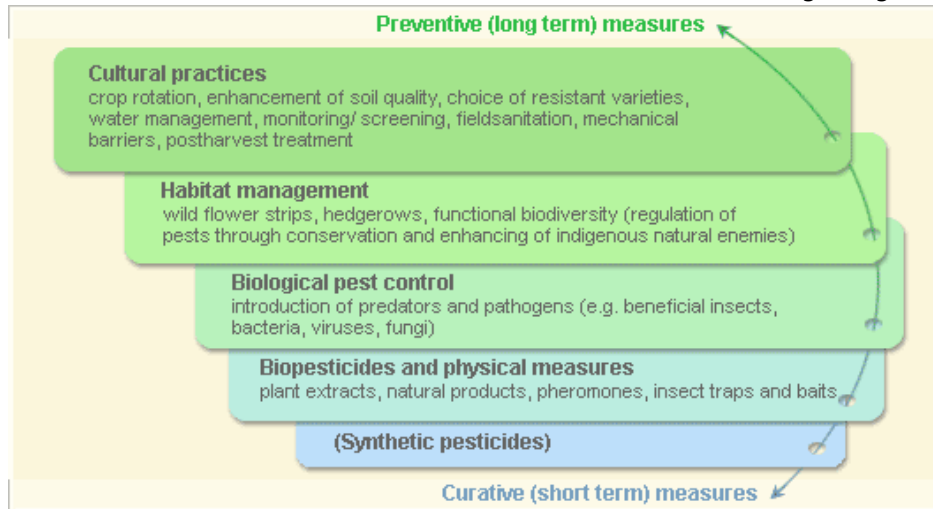
The adult beetle is 3 to 4.5 mm long and dark brown in colour. It has a cylindrical body shape, when viewed from above the rear of the insect is square shaped. The thorax bears rows of teeth on its upper front edge and the head is turned down underneath the thorax so that it cannot be seen from above. The female lays 30 to 50 eggs into the produce (maize, cassava, etc).

The lifecycle can be completed within 25 to 26 days at optimum conditions - this is high temperature (about 30°C) and relatively high humidity (about 70% r.h, + 13% grain moisture content). Development takes longer under cooler or drier conditions.

The larger grain borer develops more rapidly on maize grain than on cassava.

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 Larger grain borer.

Cultural practices

Detection and inspection methods

Except when populations are very high is not possible to detect the pest by visual inspection. The immature stages develop within the food source, and therefore they are not normally seen. Traps baited with the chemical attractant (pheromone) produced by the male beetle are useful to detect and monitor adult beetles. This pheromone is synthesised in the laboratory and loaded into plastic capsules, which then release the pheromone slowly through their walls. A pheromone capsule is then placed in a suitable trap.

Flight traps, such as funnel, delta or wing traps baited with the pheromone are considered the best for monitoring the larger grain borer. These traps are suspended about 1 to 2 m from the ground outside the store or the standing maize crop; they should be placed at least 100m from stores or from the field to avoid attracting the beetles to these food sources. The traps are useful for researchers and for plant protection authorities; it is an important tool for phytosanitary purposes and for warning farmers about impending attack by the larger grain borer. However, small populations already feeding on maize or cassava in a store cannot be detected by pheromone traps because the pest does not react to the pheromone until dispersing from its food source. Only when the population has increased to an extent whereby the infestation is obvious and the beetles are starting to disperse will the traps catch beetles. Presently, the only means of

assessing infestations in store is by manual sampling of the produce.

A detailed leaflet giving recommendations on the use of pheromone traps to monitor the larger grain borer has been prepared by Hodges and Pike (1995). Although the traps and pheromones are available commercially, they are expensive and not easy to get. See under reference addresses.

Store hygiene

Good store hygiene is very important in limiting infestation.

- **Clean store thoroughly between harvests**
- **Remove and burn infested residues before the new stock is stored**
- **Immerse used sacks in boiling water to eliminate residual infestations**
- **Eliminate residual infestation in the wooden structure of the store by removing timber or by fumigating the whole store under a gas-tight sheet**

For more information on [storage pests click here](#)

Harvest timely

When maize is ready for harvest, do not leave it for too long in the field; the larger grain borer or other storage pests could attack it. Studies in Benin have shown that maize harvested 3 weeks after physiological maturity gave better economic

returns when stored for 8 months than maize harvested one or seven weeks after physiological maturity.

Leaving the maize in the field for extended periods after physiological maturity resulted in severe grain losses after eight months of storage, mainly due to damage by the larger grain borer; early harvested maize had a higher proportion of mouldy grain (Borgemeister et al., 1998).

Post harvest

In locations where the larger grain borer is a problem, shell infested cobs as soon as possible before storing and dry completely to below 12% moisture (safe for bagging); when the kernels are too hard to bite through with the teeth they are usually dry enough for bagging. Treat the grain with a botanical pesticide.

Traditional varieties with good husk cover are much less likely to be attacked, thus when storing these varieties on the cob, reject any cobs with damaged or open sheathing leaves. (Meikle et al, 2002; Borgemeister, et al, 2003).

In the case of cassava, leave roots in the ground for as long as possible to reduce the storage period in order to minimise losses. After harvest, sun dry the cassava and immediately transfer it to sealed containers.

Storage

- **Store only clean produce. Carefully inspect the store before the newly harvested maize or cassava is placed inside and sort out infested cobs or roots for immediate use**
- **Store the grain in a suitable container. The larger grain borer easily attacks grains stored in gunny bags or guards. Moreover, this pest also damages guards. The most suitable containers are those that can be sealed such as metallic containers, old oil drums or mudded cribs or baskets. They provided a very effective barrier to pest attack and can be used provided the stock is sufficiently dried so that ventilation is not required**
- **Use brick stones to construct the granaries; wood and grass would encourage breeding and multiplication of the larger grain borer**
- **Prefer iron sheet roof for the stores to avoid harbouring the pest. If using grass thatched, it should be a thick layer and cone shaped; the roofing should be replaced after a certain interval period to minimise leaking**

Sell the maize stock within 3 months

since the extent of large brain borer infestation during the first 3 months of storage is generally low. Alternatively split the maize harvest into two portions. One portion, destined for consumption by the families, should not be kept longer than three months in the store. The other portion to be kept longer in the store should be treated if larger grain borer was observed the previous year. If not, the stock should be regularly inspected; if the pest is found subsequently then grain shelling and treatment either with a botanical or with an inert dust is required.

Biological pest control

Natural enemies

The beetle *Teretrius* (formerly *Teretriosoma) nigrescens*, which is a specific predator of the larger grain borer in Central America, has been introduced into Africa. The adult and the immature stages of this predatory beetle fed on eggs and larvae of the larger grain borer.

The predatory beetle has been released in Benin, Ghana, Guinea-Conakry, Kenya, Malawi, Tanzania Togo and Zambia. It became well established and spread in most countries. However, despite the successful introductions, there are still regular outbreaks of the larger grain borer and farmers still suffer losses. Nevertheless this predator has a role to play in the management of the larger grain borer, as it

is able to reduce the density of the pest.

Biopesticides and physical methods

Effect of Neem on storage pests

Several plants have been reported to control the larger grain borer. See table below:

Plant	Plant part	Product/ concentration	Effect on damage
Castor beans	Seed	10% ethanolic extract	-
Neem	Seed	5-10% slurry	< 10% damage
Neem	Oil	1.5% (vol/vol)	< 16% damage
Pyrethrum	Flower	0.5% powder (w/w)	Highly effective
Velvet leaf	Leaf, root	2.5-10% slurry	< 10% damage

(Source: Modified from G. Stoll, 2003)

Using plant material in the form of slurry has given better results than plant powders. The slurry can be prepared by weighing out powder into 150 ml containers and adding sufficient water to give a 10% concentration (w/w), and stirring until a smooth paste is obtained. Then, the grain is poured into prepared

slurries and stirred with a rod until all grains are coated (Tierto, as cited by GTZ, and Stoll, 2003).

Neem shows considerable potential for controlling pests of stored products. Jute sacks are also treated with neem oil or neem extracts to prevent pests - in particular, weevils and flour beetles- from penetrating for several months. However, neem products are not as effective for protection of maize grain against the larger grain borer as against grain weevils. Pyrethrum is much more effective. Since these two pests are usually found together, a mixture of neem and pyrethrum known as ("Nimpyr") seems as a better option to protect stored maize. Trials in Tanzania showed much lower grain damage in maize treated with "Nimpyr" (0.5 - 6% kernel infested) compared to untreated maize (17% to over 90%) 6 months after treatment.

But there are some shortcomings to the use of this mixture, namely:

- A relatively large amount of the mixture is needed to protect grain (2 to 3 kg/ 100 kg grain)**
- The labour input needed to manufacture "Nimpyr" is considerable**
- The active principles of pyrethrum deteriorates relatively rapid on exposure to heat and/or light**
- Pyrethrum has an unpleasant odour, whilst neem has a bitter taste (although**

this can be eliminated by soaking and washing the grains in water for a sufficient period) and

- **The mixture is unlikely to give protection in maize stored in cobs, since the pests are protected under the shucks.**

How to prepare and use "Nimpyr"

- **Collect ripe neem fruits; tease out the seed kernel, wash and dry in the shade for three to five days. Then pound the kernels into a fine pulp, dry for a further one to two days, crush with the fingers and sieve. Pound and sieve again until a fine powder is obtained. Do not use the same mortar as for food processing because of the bitter taste of the neem seeds.**
- **Pluck the dry florets of pyrethrum, pound in a mortar and sieve. Florets and powder quickly lose their effect in the sunlight. Therefore, store florets away from the light if they cannot be processed immediately. Use powder straight away**
- **To treat 100 kg of grain, mix 1.5 to 2 kg of neem seed powder with 0.5 to 1 kg of pyrethrum floret powder. When the grain is well dried, distribute this preparation over it and mix in carefully. Store without delay.**
- **Grain intended for consumption must be soaked and washed in abundant water before use to eliminate any unpleasant odour or taste.**

(Source: GTZ- Plant derived products as protectans against the larger grain borer

and other stored-food pests).

Neem oil is an extremely effective and cheap protection for stored beans, cowpeas, and other legumes. It keeps them free of bruchidbeetle infestations for at least 6 months, regardless of whether the beans were infested before treatment or not. This process may be unsuited for use in large-scale food stores, but it is potentially valuable for household use and for protecting seeds being held for planting. The treatment in no way inhibits the capacity of the seeds to germinate.

Neem has also been used in India to protect stored roots as well as tubers against the potato moth. Small amounts of neem powder are said to extend the storage life of potatoes 3 months. (OIA 1992).

For more information on [neem in pest control click here](#).

Ash/chilli mixture

Ash/chilli mixture and a thick layer of paddy husk ash covering the stock is reported to be effective in preventing larger grain borer attack.

How to prepare an ash/chilly mixture to protect Maize from LGB:

- **Dry the chillies and pound them to a fine powder**
- **Sieve cold wood ash from the fireplace**

- **Mix 2 kg of wood ash with 1 tablespoon of of chilli powder. Make sure they are properly mixed**
- **Mix 1 part ash/pepper mixture with 4 parts of dried maize grain**
- **Store**

(Source: D. Wanjama, KIOF; ICIPE; Borgemeister et al, 2003)

Diatomite

The use of diatomite earth for control of grain boring insects during storage has in many cases been successful. Mix diatomite powder with grain before storing in bags or dust newly harvested dry cobs before storing them with diatomite. Use 1 kg Diatomite per bag of maize or grain.

Some confusion exists on the use of diatomite earth, as finer ground diatomite products commonly used for sifting beverages is not effective as insect control. However unprocessed products such as 'Kensil Lagging' work on the same principles as laterite mentioned below, by dehydrating the insects and by destroying the insects' articulations.

Laterite

The common red soil of the arid tropics, when finely crushed protects stored grains and beans. In family grain stores or in sealed clay pots, the dust deters

insects from boring into or laying their eggs on the dusted grains. Laterite rubs the waterproof waxy coating off the insect bodies and they dehydrate and die.

In sealed storage pots insects suffocate because enough dust is poured in with grain to exclude air also trapped insects dehydrate and die as their outer coating is damaged by abrasion.

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Reference addresses:

- Supplier of pheromone traps: Agrisense BCS Ltd. Treforest Industrial Estate, Pontypridd. Mid-Glamorgan, CF37 5SU. UK. Telephone: (0433) 841155. Fax UK

(0433) 841152 (GASGA 1993).

- **A grain injury model for LGB infesting farm stored maize in West Africa has been developed at the International Institute of Tropical Agriculture. It can be used in conjunction with predictive models of pest population dynamics to guide the development of integrated pest management strategies (Holst et al., 2000a). The models are conveniently displayed, together with information on sampling routines <http://www.agrsci.dk/plb/bembi/africa/project.htm>**

Contact Links

- **Daniel Wanjama, Consultant, KIOF, Kenya**
- **ICIPE, International Centre of Insect Physiology and Ecology; Kenya**
- **KIOF, Kenya Institute of Organic Farming, Kenya**

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Spotted stemborer**Spotted stemborer****Scientific name: *Chilo partellus* (Swinhoe)****Family: Crambidae****Type: pest (insect/mite)**

Common names: Spotted sorghum stemborer / Spotted stalk borer

Host plants: Maize Millet Rice Sorghum

General Information on Pest and Damage

Geographical distribution



***Chilo partellus* is found in Ethiopia, Sudan, Somalia, Kenya, Tanzania, Uganda, Mozambique, South Africa, Swaziland, Lesotho, Zimbabwe, Zambia, Malawi and Botswana.**

Geographical Distribution of the Spotted stemborer in Africa (red marked)

Introduction

The spotted stemborer is one of the most important stemborers in East and Southern Africa. This pest is not native to Africa, but was accidentally introduced from Asia. It is essentially a pest of hot lowland areas, and it is seldom found above an altitude of 1500m. Since its appearance on the African continent, it has continuously expanded its distribution in the warm, low-altitude regions of eastern and southern Africa; it is now the most economically important stemborer in many areas. In Africa, the spotted stemborer is a major pest of maize and sorghum pearl millet.

Damage

Young caterpillars of spotted stemborer feed on the tender leaves of the plants. They later feed at the growing point into the stem. Seriously attacked plants dry-up entirely or partly showing the so-called 'dead heart' symptom. Early attacked plants are stunted in growth and the ears are poorly developed. Stem tunnelling by older



caterpillars interferes with transference of nutrients to the grain. Stemborer damage results in plant stunting, lodging, stem breakage, and direct damage to ears. Infestations by stemborers increase the incidence and severity of stalk rots and may increase the contamination of the grains with toxin-producing fungi like *Aspergillus flavus*.

© Stemborer
team, icipe



**Early attack by
the spotted**

**stemborer on
maize. Note
damage
(window pane)
on leaves
© Stemborer
team, icipe**

Host Range

The spotted stemborer is an important pest of cultivated cereals, especially maize, sorghum and pearl millet (*Pennisetum glaucum*). It has also been recorded from wild grasses and mainly wild sorghum.

Symptoms

Leaves show irregular scars, holes and windows caused by the feeding of young caterpillars. Seriously attacked plants, especially young plants dry-up entirely or partly showing the so-called 'dead heart' symptom, due to the death of central leaves. The longitudinal dissection of the stalks reveals the caterpillars. In older plants the upper part of the stem usually dies due to the boring of the caterpillars in the stem. Older caterpillars tunnel extensively in stems and in maize cobs, weakening the stems, which may break. Damage to inflorescences may interfere with grain formation, causing chaffy heads in sorghum. Similar symptoms are

produced by other species of cereal stemborer.



Stem damaged by stemborers

**© D. Cugala, stemborer team,
icipe**

Damage by stemborer caterpillars

© D. Cugala, stemborer team, icipe



Stemborer caterpillar in maize cob

© D. Cugala, stemborer team, icipe

Affected Plant Stages

All stages.

Affected Plant Parts

Ear/head, growing points, leaves, stems.

Symptoms by affected plant part

Ear/head: internal feeding; external feeding.

Growing points: internal feeding; boring; dead heart.

Leaves: external feeding; internal feeding.

Stems: internal feeding; deadheart.

Biology and Ecology of the Spotted Stemborer



Eggs are flat and oval, creamy-white and about 0.8 mm long. They are laid in overlapping batches on the underside of a leaf near the midrib. They hatch after 4 to 10 days.

Eggs of the spotted stemborer (*Chilo partellus*)

© icipe



Caterpillar of the spotted stem borer (*Chilo partellus*)

© Stemborer team, icipe

Caterpillars are up to 25 mm long when fully grown, with a prominent reddish-brown head. The body is creamy-white to yellowish-brown, with four purple-brown longitudinal stripes and usually with very conspicuous dark-brown spots along the back, which give them a spotted appearance. Young caterpillars initially feed in the leaf whorl. Older caterpillars tunnel into stems, eating out extensive galleries. In warm conditions larval development is completed in about 15 to 20 days. Caterpillars pupate in damaged stems.

Pupae are up to 15 mm long, slender, shiny and light yellow-brown to dark red-brown in colour. Adults emerge 5 to 12 days after pupation.

Adults are relatively small moths with wing lengths ranging from 7 to 17 mm and a wingspan of 20 to 25 mm. The forewings are dull, generally light yellow-brown with some darker scale patterns. The hindwings



are white. Adults emerge from pupae in the late afternoon or early evening. They are active at night and rest on plants and plant debris during the day. They are seldom seen, unless disturbed.

Life cycle

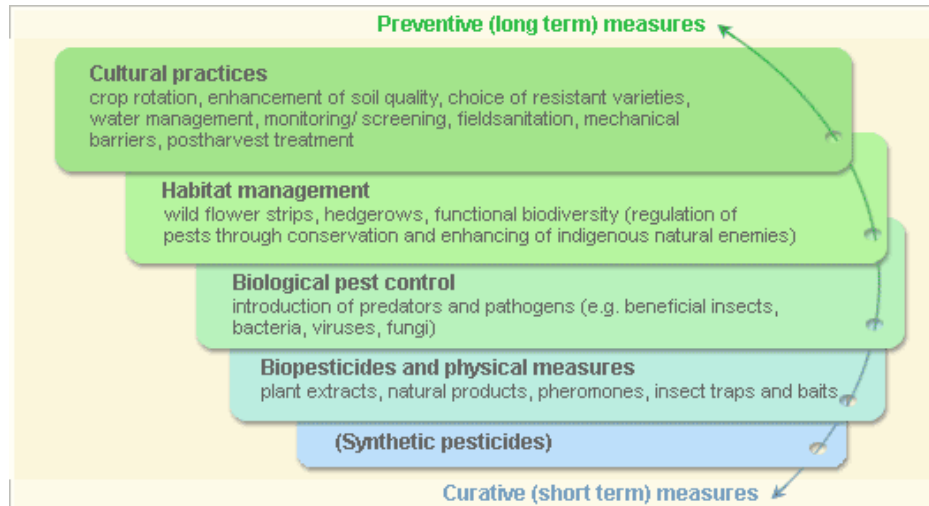
The whole life cycle takes about 3 to 4 weeks, sometimes longer in colder months, and shorter in hot ones. Five or more successive generations may develop in favourable conditions. In regions where there is sufficient water and an abundance of host plants, *Chilo partellus* normally develops continuously all year-round. In other regions with long dry periods in winter or in summer, the spotted stemborer, as with many other cereal stemborer, pass the winter or dry season as fully-grown caterpillars in a resting period (diapause) in stems and stubbles in the field. They may remain inactive for up to six months, before pupating and completing their development early in the following growing season.

In Kenya, the spotted stemborer diapauses for several months in the dry season; however, populations without a resting period were reported from the Coast

Province of Kenya and Uganda. In the coastal areas of Kenya, in periods between cropping seasons, some stemborers diapause in maize stubble, whereas others remain active, feeding in wild grasses such as wild sorghum.

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 synthetic pesticides.

Further below you find concrete preventive and curative methods against Spotted stemborer.

Cultural practices

Monitoring

Infestations of stemborers are detected by walking through young crops looking for characteristic feeding marks on funnel leaves, the presence of dead hearts and holes in tunnelled stems. Samples of affected stems are then dissected to retrieve caterpillars and pupae.

As other stemborers cause similar symptoms, retrieval of caterpillar or pupae and confirmation of their identity by rearing adults for identification by a taxonomic specialist is essential to ensure a correct diagnosis.

The presence of this species in older crops and in crop residues may be detected by taking random samples of stems or stools for dissection.

Crop sanitation

Practise good crop hygiene, this includes the destruction of crop residues (stems and stubbles). Remove volunteer crop plants and/or alternative hosts. This reduces carryover of stemborers from one growing season to the next, and will help to limit the most damaging attacks on young crops early in the growing season.

Disease avoidance

Manipulation of sowing dates may also be used to avoid periods of peak adult activity. However, this is not practical in situations where lack of water is a major constraint as farmers often plant after first rains.

Manipulation of sowing dates may also be used to avoid periods of peak adult activity.

Improvement of soil fertility

Studies on several stemborers in Africa showed that soil nutrient levels, such as nitrogen, greatly influenced nutritional status of the plant, and the plant's tolerance to stemborer attack. Although an increase in nitrogen is related to higher pest loads and tunnel damage, there is also an increase in plant vigour with a net benefit to the plant reflected in lower yield losses (Setamu et al., 1995).

Trials in Tanzania to evaluate the effect of nitrogen fertilisation (0,50,70,100 kg N/ha) on pest abundance, plant damage and yield loss of maize due to stemborers showed the beneficial effect of nitrogen on the maize plant's abilities to compensate for damage by the spotted stemborer. Yield loss decreased with an increase in nitrogen application and the effect was stronger under high than low borer infestation levels (icipe, 2005; Mgoo et al., 2006).

Intercropping and habitat management

The importance of plant biodiversity in maize agroecosystems for reducing borer's infestation on maize has been recognised in Sub-Sahara Africa. Studies have shown that intercropping maize with cowpea is an effective way of reducing damage by the spotted stemborer caterpillars migrating from neighbouring plants. The effect is variable, if the crop to be protected is not planted after the companion crops.

Intercropping maize with molasses grass (*Melinis minutiflora*), which is a non-host for stemborers, significantly reduced stemborer infestation on maize. A significant increase of parasitism of stemborers by the wasp *Cotesia sesamiae* was also observed. Molasses grass produces volatile agents, which repel stemborers but attract the parasitic wasp. In addition, the molasses grass is an effective cover

crop and provides good fodder for livestock. Greenleaf desmodium (*Desmodium intortum*) repels egg-laying stemborer moths, and in addition, when intercropped with maize, suppresses and eliminates Striga.

Trap crops

Planting an outer encircling row of some highly preferred hosts as trap plants is another useful diversionary tactic for management of stemborers. Examples of trap plants are Napier grass (*Pennisetum purpureum*) and Sudan grass (*Sorghum vulgare sudanense*), common fodder plants in Africa. Napier grass is highly attractive to egg laying moths, but only few caterpillars complete their lifecycles, since when they enter the stem the plant produces a gummy substance that kills the caterpillars. Sudan grass provides natural control of stemborers by acting as a trap crop (attracting moths) and as a reservoir for its natural enemies.

"Push-Pull"- Strategy

A simple habitat management strategy has been developed combining use of intercropping and trap crop systems. The strategy is known as "Push-Pull", whereby farmers use Napier grass and Desmodium legume (*silverleaf* and *greenleaf desmodium*) as intercrops. For more information [on push-pull click here](#) or refer to www.push-pull.net (click to follow link).

Biological pest control

Natural enemies

Two parasitic wasps that attack stemborers were introduced from Asia into East Africa: *Cotesia flavipes* and *Xanthopimpla stemmator*.



Parasitic wasps (*Cotesia flavipes*)

© D. Cugala, stemborer team, icipe

Somalia) (Omwega et al. 2006; Kfir et al, 2002). Studies of the impact of this parasitic wasp in coastal Kenya showed that it has caused a 70% decrease in stemborer densities.

***Cotesia flavipes* is a small wasp that attacks caterpillars of the spotted stemborer in Asia. This wasp was imported, mass reared in the 90's, and subsequently released in East and Southern Africa. *Cotesia flavipes* locates the stemborers while the stemborers are feeding inside the plant stems. The wasp lays about 40 eggs into a stemborer. Upon hatching the larvae of the parasitic wasp feed internally in the stemborer, and then exit the stemborer and spin cocoons.**

This parasitic wasp is now established in several countries (Kenya, Tanzania, Mozambique, Uganda, Ethiopia, Zambia, Zimbabwe, Zanzibar, Malawi,

***Xanthopimpla stemmator*, a wasp attacking pupa of stemborers, has been recently imported, and released in several countries.**

Local natural enemies such as earwigs and ants are also important for control of stemborers included the spotted stemborer.



Parasitised spotted stemborer caterpillar. Note cocoon of the parasitic wasp *Cotesia flavipes*.

© D. Cugala, Stemborer team,

icipe

Biopesticides and physical methods

Neem

Simple neem products are effective for control of stemborers, including the spotted stalkborer. It is recommended that a small amount of neem powder (ground neem seeds) mixed with dry clay or sawdust at a rate of 1:1 is placed in the funnel of the plant.

One kg powder should be sufficient to treat 1500 to 2000 plants. In this method rainwater dissolves the active substances in neem powder as it gathers in the funnel and washes out the powder. Where rainfall is irregular a liquid neem seed extract can be sprayed into the funnel.

The treatment should be repeated every 8 to 10 days during the sensitive growing phase. Thus, roughly three treatments are required per crop.

This recommendation applies only for young plants before flowering and not for older plants.

A mixture of ground neem kernels and sawdust (1:1) applied as granules at weekly and biweekly intervals reduced the number of maize plants attacked by the spotted semborer by 60% and 40% respectively in field trials.

In experiments in Somalia, pulverised neem kernel and kernel cake (0.5 g and 1 g per plant) alone or a mixture with clay, markedly reduced stalk borer damage and increased the yield in comparison with the check plots by over 100% (Hellpap, C. 1995).

For more information [on neem click here](#)

Information Source Links

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- **CABI (2005). Crop Protection Compendium, 2005 Edition. © CAB International Publishing. Wallingford, UK. www.cabi.org**
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Africa. Annual Review of Entomology. 47: 701-731.

Contact links

ICIPE and her partners: 'Push-Pull' Technology for the Control of Stemborers and Striga weed. www.push-pull.net

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Fruit flies



Fruit flies

Scientific name: *Ceratitis* spp., *Dacus* spp., *Bactrocera* spp.

Family: Diptera: Tephritidae

Type: pest (insect/mite)

Host plants: Avocados Bananas Citrus plants Cocoa Coffee

Cucumber Mango Papaya Passion fruit Peppers Pumpkin

Zucchini/Courgette

General Information on Pest and Damage

Geographical distribution



Fruit flies (diverse species) have been recorded in all African countries. The Mediterranean fruit fly is the most widely distributed.

**Geographical
Distribution of the
Fruit fly in Africa
(red marked)**

Damage

Fruit flies cause direct damage by puncturing the fruit skin to lay eggs. During egg laying bacteria from the intestinal flora of the fly are introduced into the fruit. These bacteria cause rotting of the tissues surrounding the egg. When the eggs hatch, the maggots feed on the fruit flesh making galleries. These provide entry for pathogens and increase the fruit decay, making fruits unsuitable for human consumption. Generally the fruit falls to the ground as, or just before the maggots pupate. In fruits for export, fruit flies cause indirect losses resulting from

quarantine restrictions that are imposed by importing countries to prevent entry of fruit flies. Nearly all fruit fly species are quarantine pests.

Major species of fruit flies attacking crops in Africa:

- **African invader fly (*Bactrocera invadens*)**
- **Melon fly (*Bactrocera cucurbitae*)**
- **Pumpkin fly (*Dacus bivittatus*)**
- **Jointed pumpkin fly (*Dacus vertebratus*)**
- **Mediterranean fruit fly or medfly (*Ceratitis capitata*)**
- **Natal fruit fly (*Ceratitis rosa*)**
- **Mango fruit fly or Marula fruit fly (*Ceratitis cosyra*)**

Host Range

Fruit flies attack soft, fleshy fruits of a wide variety of fruit and vegetable crops. The Mediterranean fruit fly *Ceratitis capitata* feeds and causes damage to a very wide range of crops.

Major host plants of *Ceratitis cosyra* include mango, guava, sour orange, marula, wild custard apple and wild apricot.

***Ceratitis rosa* is recorded from over 100 plant species. In Africa it attacks mango, papaya, guava and custard apple. It is also a common pest of arabica coffee in**

eastern Africa.

***Ceratitis fasciventris* is a major pest of mango, guava and coffee in eastern and western Africa.**

***Bactrocera invadens*, a new species recently introduced into East Africa, attacks primarily mango, although it has been reared from several other plants (e.g. tomato, banana, guava, marula, avocado).**

***Bactrocera cucurbitae*, *Dacus bivittatus*, *D. ciliatus* and *D. frontalis* are pests mainly of cucurbit crops.**

Symptoms

Damage symptoms vary from fruit to fruit. Attacked fruit usually shows punctures (made by females while laying eggs). Around these a necrosis may occur. Small holes on the fruits are visible when the maggot leaves the fruit. The affected part of the fruit becomes soft and colours prematurely.

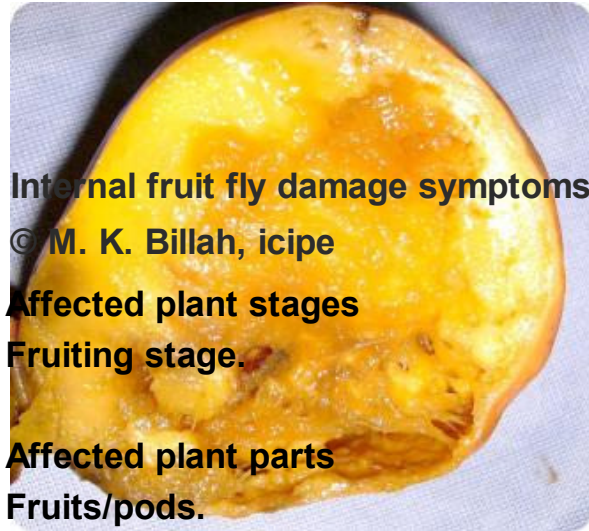
17/10/2011

www.infonet-biovision.org - Large...



Internal fruit fly damage symptoms on courgette

© M. K. Billah, ic



Internal fruit fly damage symptoms on mango

© M. K. Billah, icipe

Affected plant stages

Fruiting stage.

Affected plant parts

Fruits/pods.

Symptoms by affected plant part

Fruits/pods: internal feeding; lesions; abnormal exudates; visible mould; discoloration; odour.

Biology and Ecology of Fruit Flies

The morphology of the various fruit fly species is similar.

Eggs of fruits flies are small, white, and slender. They are laid under the skin of fruits in groups of 3 to 8 eggs, depending on the species. The flies lay eggs on

mature green and ripening fruit. Some species may lay eggs in unripe fruitlets. Eggs hatch within 1 to 2 days.

The larvae are whitish maggots. They feed on the fruit flesh causing the fruit to rot. After 4 to 17 days the maggots leave the fruit, making holes in the skin, and drop to pupate in the soil.



The pupae are white, brown or black and 4 to 12 mm long. They are found in the soil 2 to 5 cm beneath the host plant. the flies emerge from the pupae 10 to 20 days after pupation depending on climatic conditions.

**Larvae of the
Mediterranean fruit fly
(*Ceratitidis capitata*)
pupate in the soil.**

**© Coutin R./OPIE,
Courtesy of Ecoport
(www.ecoport.org)**

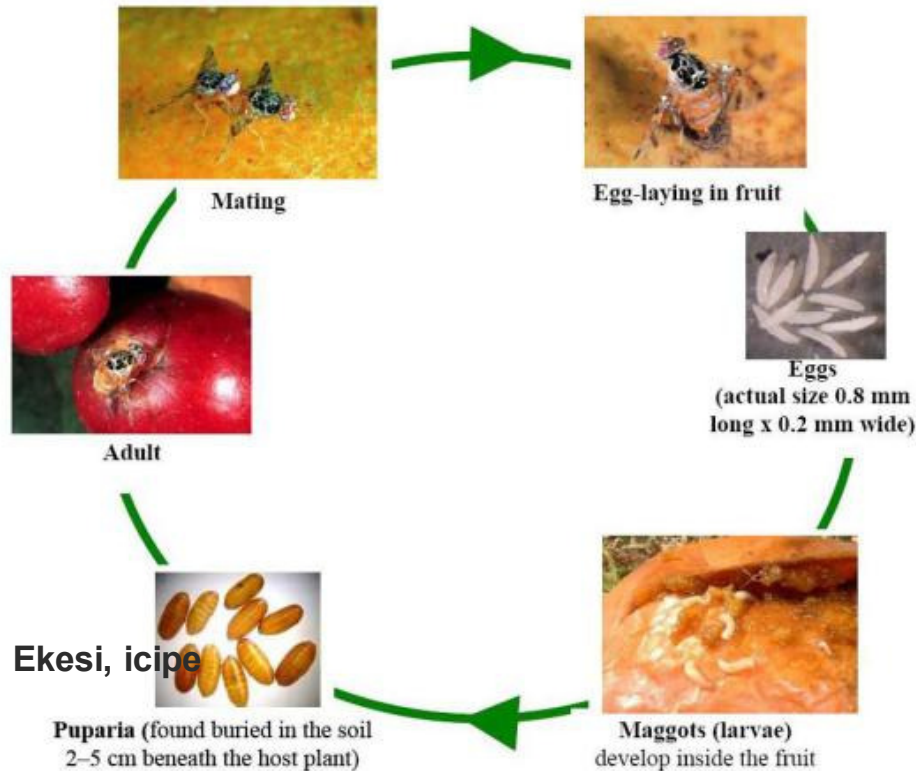


Adult fruit flies are 4 to 7 mm long, brightly coloured, usually in brown-yellow patterns. The wings are spotted or banded with yellow and brown margins.

**Mediterranean fruit fly
(*Ceratitidis capitata*)**

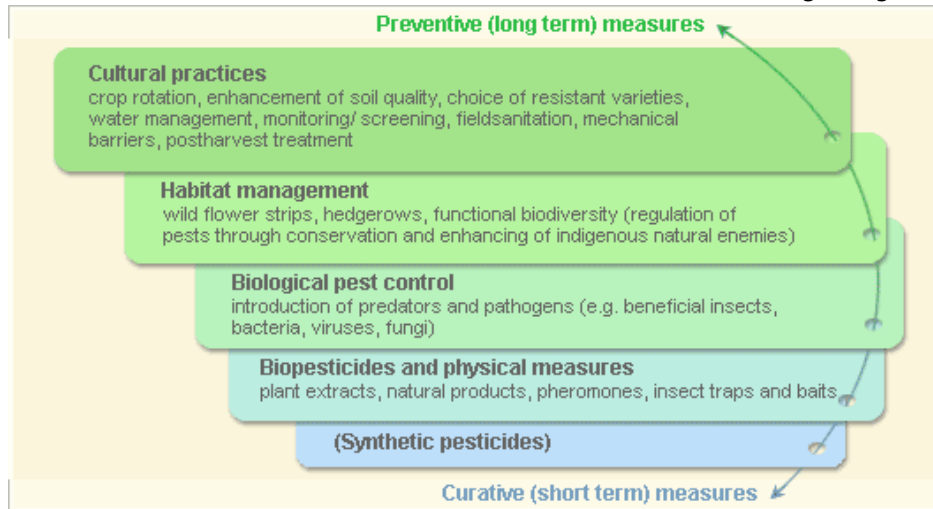
**© Scott Bauer, USDA
Agricultural Research
Service,
www.insectimages.org**

Life cycle of tephritid fruit flies



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 Fruit flies.

Cultural practices

Monitoring

Monitoring fruit flies is important to determine when they arrive in the orchard and to decide when treatment is needed.

Monitoring can be done using bait traps such as the Lynfield or bucket trap (described in this datasheet under biopesticides and physical methods)

For effective monitoring it is important that farmers are able to identify fruit flies from among other insects trapped.

Orchard sanitation

Poorly managed or abandoned orchards can result in build up of fruit fly populations. Remove fruits with dimples and oozing clear sap. This method, although laborious, is more effective than picking rotten fruits from the ground, as the maggots may have left the fruits to pupate. To be effective this has to be done regularly (twice a week for the entire season). Kill the maggots by burning, burying or tying collected fruits in black plastic bags and exposing them to the heat of the sun for a few hours to kill the maggots. Alternatively, feed fruits to pigs or poultry. When burying fruits, ensure that the fruits are buried at least 50 cm (about two feet) deep to prevent emerging adult flies from reaching the soil surface.



Destruction of fallen fruits infested by fruit flies by putting them in black plastic bags, tying the bags and exposing them to the sun.

© M. K. Billah, icipe

Early harvesting

Harvesting crops early when mature green helps protect some crops from fruit fly damage. Fruit flies cannot develop in certain fruits such as papaya, banana and sapodilla when they are green. Only ripe fruits are good hosts. However, in other crops, such as mango this practice is not effective as some fruit fly species like *Bactrocera invadens* and *Ceratitis cosyra* are capable of infesting even immature or green mangoes.

Biological pest control

Natural enemies

Several natural enemies can contribute to the suppression of fruit flies. Major natural enemies are parasitic wasps (parasites the maggots of fruit flies) and predators such as rove beetles, weaver ants, spiders, and birds and bats. In particular weaver ants have been shown to be very efficient in protecting fruit trees from pests, including fruit flies. These ants prey on fruit flies, but most important their presence and foraging activity hinders the fruit flies from laying eggs, resulting in reduced fruit fly damage, as shown in mango orchards in Benin (Van Mele et al., 2007).

Although natural enemies alone do not give satisfactory control of fruit flies, efforts should be made to protect them, and to complement their effect on fruit flies with other management options.

Parasitoids

Tiny wasps (e.g. *Bracon* spp.) parasitise the maggots of fruit flies. Eggs and larvae of these parasitoids are found inside the bodies of the maggots. The parasitoid larvae are tiny, cream-colored grubs that feed in or on other insects. Adult wasps

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



The image shows a braconid wasp parasiting a caterpillar.

For more information on [natural enemies click here.](#)

Braconid wasp

© Scott Bauer,

USDA

Agricultural

Research

Service,

Bugwood.org

Biopesticides and physical methods

Pyrethrum

To control fruitflies, a spray with a pyrethrum solution can be used. It will kill bees if they are sprayed directly, but it does not leave poisonous residues, so, the best is to use it in the evenings after most of the bees are back in their hives (after 6 pm).

There is a product commercially available called Flower-DS (available at the Hygrotech Company, contact-addresses below). This product is made of natural pyrethrum and is acceptable in organic certified systems. Artificial pyrethroids will work as well if you are not concerned about organic certification, but they are stronger and will leave residues on the fruits and leaves, which are poisonous to other animals, to useful insects and to humans.

- Precautions: Be careful to spray late in the evening, follow the spraying instructions. Wear masks and skin protection. All insect poisons are also poisonous to humans even if coming from natural sources.**
- Frequency of spraying: start shortly after beginning of flowering, and repeat approx every 5 days or according to counts.**
- Please check the insect trap information to count your fly population. If no flies are trapped - there is no need to spray.**

Neem

Frequent applications of neem can keep fruit fly attack to a minimum. For more information on [neem click here.](#)

Fruit fly trap (Lynfield or bucket trap)

The Lynfield trap is cheap and easy to make. It is made of a cylindrical plastic container with 4 holes evenly spaced on its sides, a lid, a wire hanger and a bait basket (if it is to be used with a dry attractant). Similar traps can be made locally using 'Kimbo' or 'Blue Band' tubs or similar plastic containers or plastic bottles.

They can be used with either specific attractants such as methyl eugenol or food baits such as protein hydrolysates or yeast or a piece of fruit (banana, mango). Also vinegar is a very good attractant. (Methyl eugenol attracts males of *Bactrocera* species and of a few *Dacus* species). Food baits attract both males and female fruit flies, they are not species specific, and also attract other insects, including natural enemies.

Several types of commercial fruit fly baits exist but are not locally available or registered.

Use food baits that attract a whole range of fruit fly species in the orchard such as protein hydrolysate (for example, Nulure®, Buminal®, Solbait®). An alternative is waste brewers' yeast at a rate of 45 ml per litre water. Use about 250 ml of the mixture in each trap. Add one tablespoonful of borax (di-sodium tetraborate) to each trap to prevent rotting of the flies caught.

A simple fruit fly trap is made as follows:

- **Take a plastic bottle**
- **As bait, use 1/2 cup vinegar, mix with water**
- **add 4-6 drops liquid dish soap (it heavies down the wings and the fruit flies drown), don't stir**
- **Then take a pen or pencil and poke 4 to 5 holes in the plastic, just big enough for a fruit fly to fit into, about 7mm. Once a fruit fly crawls in, it can't get out. You would think they would just fly back out through the holes, but they won't! If you see fruit flies crawling around on the surface of**



Homemade fruit fly trap

© A.M.Varela, icipe

**your plastic container but not going inside,
make the holes larger**

- **Hang the bottle in an area where you have seen the most fruit flies. Depending on the amount of fruit flies you have, you can expect to start seeing the bottle fill up within just a few hours.**

The trap is filled with bait and hanged on the tree about 2 to 4 m above the ground within the canopy layer, in a semi-shaded spots, preferably in the upwind part of the canopy. The trap should be hanged in such a manner that branches and leaves are nearby, but not touching the trap. Traps should be hanged 10 to 50m apart, depending on the bait used. Collect catches weekly and sieve them.



Fruit fly trap

© A.M. Varela and A.A. Seif, icipe

Fruit bagging

Bagging prevents fruit flies from laying eggs on the fruits. In addition, the bag provides physical protection from mechanical injuries (scars and scratches). Although laborious, it is cheap, safe, and gives a more reliable estimate of the projected harvest. Bagging not only protects fruit from fruit fly damage but protect the fruit from physical damage improving the market appearance of fruits. However, it is only practicable on small trees.

How to make a bag?

Cut old newspapers measuring 15 x 22 cm or 12.5 x 27.5 cm for mango and for fruits of similar size. Double the layers, as single layers break apart easily. Fold and sew or staple the sides and bottom of the sheets to make a rectangular bag.

How to bag a fruit?

Blow in the bag to inflate it. Remove some of the fruits, leaving one on each cluster. Insert one fruit per bag then close the bag using coconut midrib or firmly tie top end of bag with string or wire. Push the bottom of the bag upwards to prevent fruit from touching the bag. Use a ladder to reach as many fruits as possible. Secure the ladder firmly on the ground and for bigger and higher fruits trees, secure or tie the ladder firmly on big branches.



Reminders

Bagging works well with melon, bitter gourd, mango, guava, star fruit, and banana. Whole banana bunches may be bagged inside banana leaves. Start bagging the mango fruit 55 to 60 days from flower bloom or when the fruits are about the size of a chicken egg.

When using plastic bags, open the bottom or cut a few

Mango fruit bagging in an orchard in Kenya to prevent infestation by fruit flies.

© M. K. Billah, icipe

small holes to allow moisture to dry up. Moisture trapped in the plastic bags damage and/or promotes fungal and bacterial growth that caused diseased fruits. Plastic also overheats the fruit. Bags made of dried plant leaves are good alternatives to plastic.

Remove the bags during harvest and dispose of them properly.

Information Source Links

- **For more information on fruit bagging see: Secretariat of the Pacific Community, (2001). Fruit fly control methods for Pacific Island Countries and Territories. Pest Advisory Leaflet No. 40. Plant Protection Service, Secretariat of the Pacific Community. www.spc.int**
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- **Organisation for Non-Chemical Pest Management in the Tropics (OISAT)**

www.oisat.org

- **Van Mele, P., Vayssières, JF., Van Tellingen, E. and Vrolijk, J. (2007). Effects of an African Weaver Ant, *Oecophylla longinoda*, in Controlling Mango Fruit Flies (Diptera: Tephritidae) in Benin. Journal of Economic Entomology. 100(3): 695-701.**

Contact Links

- **For information on small scale farming techniques, seeds, equipment and insecticides (e.g. pyrethrum solution).**

HYGROTECH EAST AFRICA, LTD

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Information of www.infonet-biovision.org

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Mealybugs

Mealybugs



Scientific name: *Phenacoccus* spp., *Planococcus* spp., *Pseudococcus* spp., *Rastrococcus* spp., *Ferrisia virgata*, *Dysmicoccus brevipes*, *Saccharicoccus sacchari*

Family: Homoptera: Pseudococcidae

Type: pest (insect/mite)

Host plants: Cashew Cassava Citrus plants Cocoa Coconut
Coffee Mango Millet Papaya Passion fruit Pineapple
Sugarcane Yam

General Information on Pest and Damage

Geographical distribution



Geographical Distribution of

Mealybugs in Africa *(red marked)*

Damage

Mealybugs damage plants by sucking sap from roots, tender leaves, petioles and fruit. They excrete honeydew on which sooty mould develops. Severely infested leaves turn yellow and gradually dry. Severe attack can result in shedding of leaves and inflorescences, reduced fruit setting and shedding of young fruit. The foliage and fruit may become covered with sticky honeydew, which serve as a medium for the growth of sooty moulds.

Honeydew, sooty mould and waxy deposits may cover leaves reducing photosynthetic efficiency and may lead to leaf drop. Contamination of fruit with honeydew and with sooty mould reduces its market value. The honeydew attracts ants, which collect the honey and protect indirectly mealybugs from natural enemies. Some mealybugs inject toxic substances while feeding causing deformation of the plant (e.g. the cassava mealybug). Some species transmit viruses (e.g. the pineapple mealybug).



Mealybugs on citrus. Mealybugs excrete honeydew, which leads to the growth of sooty mould on fruit and leaves.

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Host range

The most important species of mealybugs and their major host crops in Africa are:

- The cassava mealybug (*Phenacoccus manihoti*) attacks cassava
- The citrus mealybug (*Planococcus citri*) attacks a wide range of crops such as cocoa, bananas, tobacco and coffee and wild trees such as *Ceiba pentandra* and *Leucaena*.
- The long-tailed mealybug (*Pseudococcus longispinus*) is widespread and common on many crops but it is usually not a serious pest. Major hosts plants of the long-tailed mealybug are citrus, taro, avocado, guava, eggplant and grapevine.
- The mango mealybugs (*Rastrococcus iceryoides* and *R. invadens*) have been reported on a number of economically important plants, but there are reports of economic damage only on mango and citrus
- The pineapple mealybug (*Dysmicoccus brevipes*) attacks pineapple, and other crops including avocado, banana, celery, citrus, clover, cocoa, coconut, coffee, custard apple, figs, ginger, guava, maize, mango, oil palm, orchids, groundnut, peppers, plantain, potato and sugarcane.
- The Kenya mealybug (*Planococcus kenyae*) attacks coffee and a large number of wild and cultivated plants including yam, pigeon pea, passion fruit, sugarcane and sweet potato

- **The pink sugarcane mealybug (*Saccharicoccus sacchari*) is found primarily on sugarcane and its wild relatives (*Saccharum* spp.). It has been recorded occasionally on sorghum, rice and other grasses**
- **The striped mealybug (*Ferrisia virgata*). It is widespread and common on many crops but it is usually not a serious pest.**

Symptoms

Mealybug infestations of above-the ground plant parts start with the appearance of crawlers (the first-instar nymphs) on the underside of the leaves on terminal shoots, stems and other plant parts. Heavy mealybug attack appears as white, waxy masses of mealybugs on stems, fruits and along the veins on the underside of leaves. Heavy infestations usually result in coating of adjacent stems, leaves and fruits with honeydew and sooty mould. Severely infested plants may wilt due to sap depletion; leaves turn yellow, gradually dry and ultimately fall off. Feeding on fruit results in discoloured, bumpy, and scarred fruit, with low market value, or unacceptable for the fresh fruit market.



Mealybugs on pineapple. Severe infestation of pineapple mealybug on the

Mealybugs injecting toxic substance while feeding cause plant fruit deformation. This is the case of the cassava mealybug; feeding of this mealybug on cassava plants causes stunting, leaf distortion, shortening of the internodes and loss, dieback and weakening of stems used for crop propagation. Mealybugs attacking roots, as is the case of the citrus mealybug on coffee and the pineapple mealybug, cause stunted roots, rotting of roots and subsequent wilting of the plants. Roots of coffee plants attacked by the citrus mealybug are often encased in a thick case of greenish-white fungal tissue; if the fungal coat is peeled off the white mealybugs can be seen.

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De Villiers EA
(Courtesy of
EcoPort,
www.ecoport.org)

Affected plant stages

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

Affected plant parts

Growing points, leaves, roots, stems and whole plant.

Symptoms by affected plant part

Growing points: deadheart, abnormal forms.

Leaves: abnormal colours, abnormal forms, abnormal leaf fall, wilting, yellowed or dead, honeydew or sooty mould.

Roots: reduced root system, fungal growth (coffee).

Stems: abnormal forms, abnormal growth, dieback.

Fruits: scarring, discolouration, honeydew, sooty mould.

Wholeplant: wilting, plant dead, dieback, dwarfing.

Biology and Ecology of Mealybugs

Mealybug eggs are very small and are laid under a white, loose woolly wax, which remains attached to the abdomen of the females. A female may lay between 50 to 600 eggs.

Nymphs. Very small nymphs are flat, oval and yellow. Older nymphs of some species are covered with fluffy, white wax. Older female nymphs resemble the adults, but older male nymphs secrete a tiny, fluffy cocoon, within which they develop into winged adults. Upon hatching young mealybugs, known, as crawlers, are extremely mobile and may disperse over large distances. Older nymphs are more or less sessile.

Adult female mealybugs are soft-bodied, elongated, oval insects with well-developed legs. They are about 3 to 5 mm

long. Their body is usually covered with a mealy waxy secretion, often extended into lateral and terminal filaments. They are wingless and do not move unless disturbed. They usually remain clustered around the terminal shoots, leaves or fruits. They live for several months (depending on the species).

The short-lived males are up to three mm long. Male adults have one pair of wings and several pairs of eyes but no mouthparts. Males fly about seeking females to mate with. In many species of mealybugs there are no males and females reproduce without mating. Some species lay eggs, and others give birth to living young.

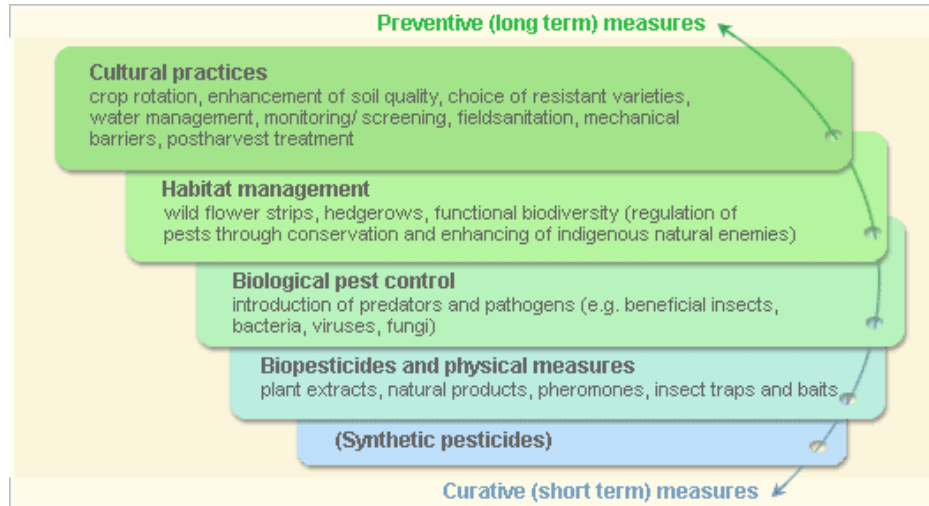


Female mealybugs on passionfruit leaf. Female mealybugs are 3 to 5 mm long and their body is usually covered with a waxy secretion.

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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 synthetic pesticides.

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

Cultural practices

Monitoring

Early detection of mealybugs is necessary for effective control. Check plants for crawlers; pay special attention to the new growth (tender issues), the undersides of leaves and around leaf joints.

Mealybugs can be controlled by:

- **Removing mealybugs by rubbing or picking mealybugs from affected plants. This is practicable when infestation is low**
- **Pruning and destroying affected parts. This is particularly useful at the initial stage of infestation.**
- **Removing and destroying heavily infested plants**
- **Spraying a steady stream of water (reasonably high pressure) on the host plant to knock-off mealybugs. Once on the ground, the fallen ones will be available to ground predators and this will also make their return to the plant difficult. Make sure that there are no ants tending mealybugs, otherwise they will be brought back to the host plants.**

- **Ensuring soil fertility.** In most cases healthy plants are able to withstand some mealybug attack. Moreover, improvement of soil fertility can enhance biological control activity as shown in the case of the cassava mealybug. It was observed that cassava grown in poor soils (pure sand and no mulch cover) had high mealybug infestations even after the release of the parasitic wasp *Apoanagyrus lopezi*. In experiments conducted in Benin use of manure or other fertilisers resulted in a reduction in the cassava mealybug population; improved plant nutrition resulted in the production of larger mealybugs, which in turn resulted in a higher proportion of female parasitic wasps with higher fertility levels. Mulch and fertiliser use also enhanced the antibiotic properties of cassava against mealybug infestation (Schulthess, et al., 1997; Neuenschwander, 2003).

Biological pest control

Natural enemies

Mealybugs are attacked by numerous natural enemies, which usually keep them under control. Most common natural enemies include parasitic wasps, ladybird beetles, hover flies and lacewings. However, if many ants are present, or when broad-spectrum pesticides kill the natural enemies, mealybugs become a problem.

Mealybugs can also cause severe damage when introduced to new areas where

efficient natural enemies are absent. In this case, importation of natural enemies associated with the mealybugs in the area of origin (classical biological control), have usually given satisfactory control. Thus, several natural enemies, mainly parasitic wasps and ladybird beetles, were introduced from South America into Africa for control of the cassava mealybug. The most effective has been the parasitic wasp (*Apoanagyrus (=Epidinocarsis) lopezi*), which has kept this mealybug at low levels, resulting on a significant reduction of yield losses in most areas in Africa.

Another example is the mango mealybug *Rastrococcus invadens*, which was brought under control in West and Central Africa by two parasitic wasps (*Gyranusoidea tebygi* and *Anagyrus mangicola*) introduced from India. Another mango mealybug *Rastrococcus iceryoides* is a major pest of mango in East Africa, mainly Tanzania and coastal Kenya. Although several natural enemies are known to attack this mealybug in its aboriginal home of southern Asia none have been introduced so far into East Africa.

The Kenya mealybug, which was a major pest of arabica coffee in the East Rift Area of Kenya between 1923 and 1939, has been reduced to a minor pest after the release of natural enemies from Uganda in 1938.

Conservation of natural enemies is important to reduce mealybug outbreaks. This can be done by:

- **Limiting insecticidal sprays against other mealybugs or/and other pests and diseases, and avoiding use of broad-spectrum pesticides.**
- **Controlling ants to facilitate build-up of natural enemies. Ant control may be either indirect, by excluding ants from the tree (for example, by applying a barrier around the stems or trunks of the trees) or direct, by destroying the ant nests. However, it should also be taken into consideration that some ants may be beneficial as predators by deterring pests such as plant-feeding bugs.**
- **Keeping flowering plants at the border of the crops or as companion plant within the crops may help to attract natural enemies.**

For more information on [natural enemies click here](#)

Biopesticides and physical methods

Neem

Neem products have a repellent effect on some mealybugs (Saxena, 2002). For example, a 1% hexane extract of neem seeds repelled the citrus mealybug in a choice test (Jacobson et al., 1978).

Young cassava mealybugs are sensitive to neem kernel water extract (NKWE). Thus, crawlers (first instar nymphs) of the cassava mealybug were repelled by

leaves treated with a 10% neem kernel water extract, and those that settled and started feeding died in the second instar. Treatment of cassava plants with neem extracts (NKWE) at concentration of between one and 25% provided good protection against the cassava mealybug. However, some phytotoxicity manifested as yellow spots on the leaves, was observed on plants treated with neem extracts. Phytotoxic damage was slight in plants treated with lower concentrations (one and 10%), but plants treated with neem extracts at 25% showed severe phytotoxic symptoms on some of the leaves (Mourier 1997).

For more information on [neem click here.](#)

Soap spray

When necessary, spray with soapy solutions (1 to 2%) or insecticidal soaps. Spraying with a soap and water solution is reported to control mealybugs. Whenever possible, spray only infested plants (spot spraying).

Oils

Oils such as vegetable oils (e. g. rape oil, neem oil) and mineral oils are useful for control of mealybugs.

Application of soap and oil: Good spray coverage and good timing is important

when using soapy solutions and oils. To be effective they must come in contact with the mealybugs. Crawlers are the easiest to kill, since they are more susceptible and are more exposed than eggs, older nymphs and adults. As they grow, the wax covering their bodies becomes thicker, rendering them more resistant to insecticides. Use with caution soapy solutions and oils. These products may be toxic to some plants causing discoloration or burning of foliage. Prior to applying them extensively, apply to a small, inconspicuous branch or to a few plants and after 48 hours check for adverse reactions. Apply them when the air temperature is cool. Make sure your plants were watered well the day before you apply your control - never spray wilted plants.

For more information on [soap spray click here.](#)

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Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

African armyworm



African armyworm

Scientific name: *Spodoptera exempta* or also *Laphygma exempta*

Family: Lepidoptera: Noctuidae

Local names: Ethiopia: Geiry, Temch. Kenya: Keenyu, Kungu, Ng'Urrto, Ngonga. Uganda: N'Kugula, Omor. Sudan: El-Afrigia, El-Dudah, El-Zafha. Somalia: Diirta afrikaana. Mozambique: Nyanja. Malawi: Nchembere, Zandonda, Chipakusu, Kapuchi

Type: pest (insect/mite)

Common names: Mystery worm, Barnosay

Host plants: Carrot Maize Millet Rice Sorghum Sugarcane

Sweet potato Teff Wheat

General Information on Pest and Damage



Geographical distribution: The African armyworm is found in Africa, on the Arabian Peninsula, and in South-East Asia, Australasia and Oceania (including Hawaii, USA). The African armyworm is widespread in Africa south of the Sahara, being most prevalent in the east and eastern central regions of the continent.

**Geographical
Distribution of the
African armyworm in
Africa (red marked)**

Introduction

The African armyworm is a migratory moth, the larvae (caterpillars) of which are important pests of pastures and cereal crops, predominantly in Africa south of the Sahara, Yemen, and certain countries of the Pacific region.

Normally, only small numbers of this pest occur, usually on pastures. However, periodically the populations increase dramatically and mass migration of moths occur, covering many thousands of square kilometres and traversing international boundaries. They travel from field to field in great numbers, hence the name "armyworm".

Outbreaks follow the onset of wet seasons when dry grasslands produce new growth and cereal crops are planted. The severity and extent of outbreaks are increased by extended drought followed by early season rainstorms, which concentrate egg-laying moths and provide flushes of new grass as food for newly hatched caterpillars, and dry and sunny periods during the caterpillar development, which promote survival and rapid development. Therefore, major upsurges occur in seasons of sporadic rainstorms and long sunny periods throughout the outbreak period.

Caterpillars are major pests in outbreak years, causing significant losses on a local, national and regional scale. During outbreaks, caterpillars occur in such high numbers that they have to travel in masses from one field to another in search of food to complete their development, devastating crops as they move. Significant losses are most consistently reported from eastern and southern Africa. However, in recent decades, the frequency of reports from West Africa has

increased, possibly due to the extension of suitable grassland habitats following forest and bush clearance for agriculture.

The economic importance of the African armyworm is due to its rapid development (short life cycle), high reproductive capacity, and mobility by migration. Moreover, there is little time to react as infestations frequently go unnoticed, since young caterpillars are difficult to detect. When caterpillars become conspicuous (at the fourth instar), they cause a lot of damage in a very short time.

Damage

The degree of damage to crops depends on:

- **Stage of development of the crop**
- **Prevailing weather conditions**
- **Density of caterpillars present and area affected**

In areas with high and localised rainfall during armyworm seasons, plants can regenerate provided the growing tips are not damaged, with little or no yield reduction. In contrast, in areas of erratic rainfall, farmers may lose their crop completely.

The degree of damage by armyworms varies from year to year. In East Africa, a

severe outbreak can cover several square kilometres at very high densities, while in non-outbreak years, caterpillar density is often low, and the size of attacked areas are negligible. The first armyworm outbreaks appear in Tanzania and Kenya, and are serious in nine years out of ten, causing up to 90 per cent losses of crops and pasture in bad years. They covered 157,000 hectares of crops and pasture in 2001. In major outbreak years the moths subsequently migrate to cause extensive damage in Uganda, Ethiopia, Somalia, Eritrea and may travel as far as Yemen, or south to Malawi, Mozambique and Zambia.

Grasslands, even maturing crops can be totally destroyed. If drought conditions follow an outbreak, plants may not recover from defoliation and replanting may fail to produce a crop.

Damage to cereal crops results principally from attack on young plants by young caterpillars hatching or dispersing into the crop from adjacent wild grasses. Weed-free maize crops taller than 50 cm are unlikely to become infested by newly hatched caterpillar because the leaves are too tough to allow them to establish. However, when older caterpillars moving from heavily infested grasslands invade fields, even maturing crops can be totally destroyed. Reported yield losses caused by defoliation in maize range from nine percent in plants attacked at the early whorl (four leaves) stage to 100% in those damaged at the pre-tassel stage. The

ability of young maize plants to recover from armyworm damage depends on the position of the growing point at the time of attack and the amount of root development when the caterpillars stop feeding. Damage is always serious if the growing point is affected but, as it remains at the base of the plant until near to the pre-tassel stage, it may be below ground during the outbreak and remain undamaged.

Replanting maize after armyworms have destroyed the first-sown plants is frequently unsatisfactory, as the optimum planting dates will have been missed. Yield losses of 6% have been estimated for each day's delay after the optimum planting date in high-rainfall areas in Kenya. Late planting may result in much higher losses in areas with less rainfall; yield losses of up to 92% have been recorded in such areas in Malawi and Kenya. If drought conditions follow an outbreak, plants may not recover from defoliation and replanting may fail to produce a crop.

In sorghum, millet, rice and teff, armyworm damage may stimulate growth of tillers (lateral shoots on or just under the surface of the ground), which can increase yield in favourable conditions. If subsequent rainfall is adequate for crop growth and development, yield losses may be limited, providing the damage occurs before the critical grain-initiation stage has been reached.

Damage to pasture and rangeland can be extensive and severe. Good rainfall after infestation is an important factor in pasture recovery. In Kenya, vegetation changes in infested pastures have been reported to persist for many years before good grass cover has been restored by management of dicotyledonous weeds.

Indirect losses to livestock due to armyworm outbreaks in pastures are sometimes severe, due to a combination of starvation and poisoning. The latter occurs when cattle graze on pastures recently infested with armyworm. Deaths among cattle grazing recently infested pasture have been reported by herdsman in southern Ethiopia, Somalia (where 100 cattle were reported to have died on one occasion), and Kenya, as well as in southern Africa. Speculations as to the causes of death include high cyanide levels induced in *Cynodon* grasses by armyworm damage, and ingestion of caterpillars or fungal mycotoxins on armyworm faeces.

Host Range

The plants attacked are mainly cereals, grasses and sedges (Poaceae and Cyperaceae families). Major economically important hosts are: barley, pearl millet, African millet, maize, oat, rice, sorghum, sugarcane, teff, wheat and pasture

grasses, especially *Cynodon* and *Pennisetum* species. Caterpillars exhibit strong host preferences within the *Poaceae* (cereals and grasses); there are major differences between varieties of cereal crops in their susceptibility to attack. Armyworm has once been found causing serious damage to coconut seedlings and once to young tea and, during high-density outbreaks, non-host plants including tobacco and cotton may be eaten, though not extensively.

Primary hosts: *Sorghum bicolor* (sorghum), *Saccharum officinarum* (sugarcane), *Panicum miliaceum* (millet), *Oryza sativa* (rice), *Eragrostis tef* (teff), *Zea mays* (maize), *Hordeum vulgare* (barley), *Avena sativa* (oats), *Triticum spp.* (wheat) and *Zingiber officinale* (ginger).

Secondary hosts: *Palmae* (plants of the palm family), *Rosaceae*, *Cyperus* (flatsedge).

Wild hosts: *Eleusine coracana* (Koracan), *Poaceae* (grasses), *Cyperaceae* (Sedges), *Cynodon dactylon* (Bermuda grass), *Panicum maximum* (Guinea grass), *Pennisetum clandestinum* (Kikuyu grass), *Cynodon spp.* (Quickgrass) and *Pennisetum glaucum* (Pearl millet).

Symptoms

The symptom of African armyworm attack is gross feeding damage to foliage, growing points and young stems. Young caterpillars scrape out the tissue of one side of the leaves creating a 'window' effect; leaves may dry up and assume a scorched appearance. Older caterpillars feed on leaves starting at the margins and moving inwards, leaving the leaves with a ragged appearance. They may eat whole leaves leaving only the midrib.

Severe infestation results in total defoliation or destruction of the plant to ground level. Older caterpillars drop to the ground if disturbed. With large populations the ground may be literally covered with the gregarious band of caterpillars.

Affected Plant Stages

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

Affected Plant Parts

Growing points, leaves and stems.

Symptoms by affected plant part

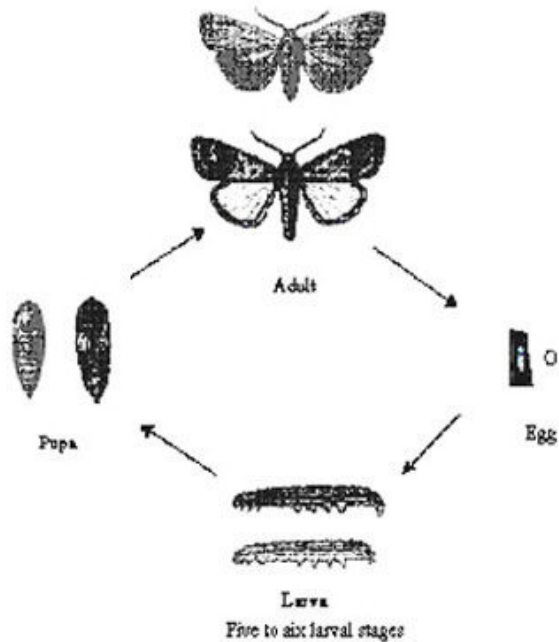
Growing points: external feeding.

Leaves: external feeding, windowing, ragged leaves.

Stems: external feeding.

Biology and Ecology on the African Armyworm

African armyworm lifecycle



Lifecycle of armyworm. 10 to 300 eggs are laid by an adult female moth, on the leaves. The eggs are white and become dark brown just before hatching (about 0.5 mm in diameter). Depending on temperature the eggs hatch after 2 to 5 days.
© IRRI Rice doctor

Eggs: (2 to 5 days), Larvae: (14 to 22 days), Pupae: (7 to 15 days), Moth: (5 to 16 days). In East Africa the lifecycle lasts about 25 days at an average temperature of 26°C.

Individual eggs are almost spherical, slightly flattened, and about 0.5 mm in diameter. They are whitish yellow in colour when newly laid, but darken just before hatching.

Female moths lay eggs at night in batches of 10 to 300 eggs in one or more layers on the leaves of the host plants, or sometimes on other surfaces (e.g. dry grasses, leaves of tall plants, twigs of bushes and trees, or on buildings). The egg mass is covered with black hairs from the female. The eggs hatch after 2 to 5 days, depending on temperature.

Caterpillars have a marked colour variation depending on density; thus, crowding of caterpillars results in changes in both their colour

and behaviour, creating what appears to the 'untrained eye', to be two different species. They occur in two principle forms: the gregarious form characteristic of high-density populations and the solitary form found at low caterpillar densities.

Young caterpillars are green.

Gregarious caterpillars (caterpillars growing crowded) become blackish as they grow. Fully-grown caterpillars are about 40 mm in length; they are velvety-black on the upper body surface with green, black, yellow and white lateral stripes. The underside of the body is green or yellow and the larvae do not have hairs on the body. The head is shiny-black. Gregarious caterpillars are very active, feed on the upper part of the plant avoiding shade.

Solitary caterpillars (caterpillars growing singly) are coloured in a variety of shades of green-brown or pink, with a pale speckled head. They appear fat, and are extremely sluggish, actively avoiding the sun and sheltering and feeding at the base of grasses.



African armyworm. Mature larvae measure up to 4 cm. This is the gregarious form (caterpillars growing crowded).

© University of Arkansas

Armyworm caterpillars usually feed on cloudy days and at night. When armyworms are numerous and the food supply becomes depleted, caterpillars march in great numbers to find a new food source. During this time they may also be seen feeding during the day. Mature caterpillars burrow into the soil to pupate.

The pupae are brown in colour right after pupation turning darker brown and finally almost black. They are 10 to 14 mm long, with a smooth, shiny surface, and are enclosed in a delicate cocoon of soil particles held together by silk.



Adult African armyworms are stout-bodied moths, 1.4 to 1.8 cm long and with a wingspan of about 3 cm. Forewings are dark-brown with distinctive grey-black markings. Hindwings are white with dark veins.

Armyworm, adult male moth *S. exempta* (museum set specimen). 1.4 to 1.8 cm long and with a wingspan of about 3

cm.

© Georg Goergen/IITA Insect
Museum, Cotonou, Benin.
Reproduced from the Crop
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Edition.

Life stages of Beet armyworm (*Spodoptera exigua*)

A related species, *Spodoptera exigua* (Lesser armyworm or beet armyworm) feeds not only on Gramineae but also on many other crops, including cotton, tobacco, tomato, groundnut and beans. Unlike *S. exempta*, this species does not migrate over long distances, but the caterpillars are gregarious and move in swarms. They are about 1.2 cm long with a wingspan of 2.5 cm. They are light grey with a small, round, light orange spot and a small, kidney-shaped spot on the forewing. Newly hatched caterpillars are light green with black heads. The fully grown caterpillars are about 3 cm long, light green to dark brown with conspicuous stripes along the sides of the body.



Figure 1: Adult moth
© A.M. Varela, ICIPE



Figure 2: Egg mass on upper leaf surface: note eggs under characteristic woolly cover

© A.M. Varela, ICIPE

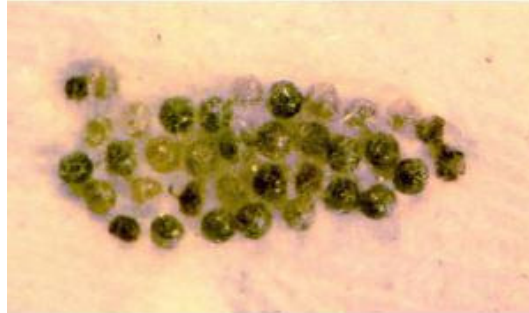


Figure 3: Eggs at 'pinhead stage' (about to hatch).

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Figure 5: Advanced larval stage.

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Figure 4: First instar larvae.

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Figure 6: Fully grown larva.

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A female moth (Figure 1) can lay 500 - 600 eggs, in clusters of 50 - 150, covered with scales and hairs, which gives them a woolly appearance (Figure 2). Eggs are greenish cream coloured when freshly laid turning dark in colour before hatching (Figure 3). The eggs hatch after 2-4

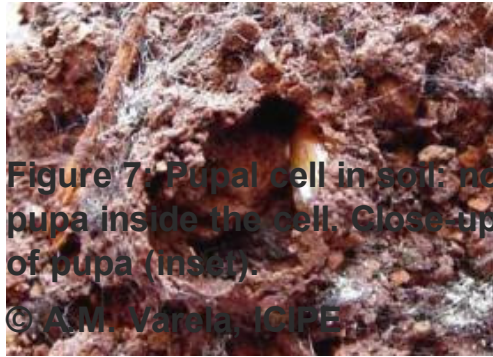


Figure 7: Pupal cell in soil: note pupa inside the cell. Close-up of pupa (Inset).

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days depending on temperature. Newly hatched caterpillars are about 1 mm long, light green in colour with black heads (Figure 4). Young larvae feed on the underside of leaves, causing characteristic 'windowing' (Figure 5). The fully-grown caterpillar is about 30 mm long, light green with conspicuous stripes along the sides of the body (Figure 6). The average larval period is about 11 days. The larvae pupate in the soil (Figure 7) and the adult moth emerges after about six days.

Cultural practices

Monitoring

To monitor the presence of armyworm, conduct visual inspection by going around all your fields. Armyworms feed at night and hide under debris during the day. Solitary forms are usually sparsely distributed and difficult to find. Consequently, armyworms are not usually noticed until severe damage occurs.

However, they can be monitored in late evening or early morning as they may still be actively feeding. Some caterpillars may be seen feeding on overcast days,

especially during a severe outbreak.

- **Hand-pick the caterpillars and feed these to chickens and ducks**

Regular monitoring is vital for timely action. Look in field margins, low areas where plants have lodged, beneath plant debris around the base of plants, on the ground, and underneath the plant leaves.

If conditions are known to be favourable to the pest, a close watch daily should be kept on grassland and young cereal crops. The earlier the infestation is noticed, the more effectively can control methods be carried out.

A recommendation for monitoring armyworms is to examine 100 plants at random by examining 20 plants from five locations.

Tentative nominal action thresholds for control measures have been determined for maize. To avoid yield losses of over 15%, action thresholds for early whorl maize should be taken as 200 second (L2), 80 third (L3), or 20 fourth (L4) instar caterpillars per 100 plants. Serious damage develops rapidly once caterpillars reach the L4 stage (CABI, 2000). As a general rule, control measures for the protection of pasture are not recommended unless caterpillar densities exceed 10/m² (CABI, 2000).

Control of armyworms is a large-scale venture and requires international collaboration. It usually involves early warning based on light traps or pheromone catches, or forecasts based on prevailing meteorological conditions. Accurate monitoring and prompt reporting of armyworm outbreaks is essential for forecasting and control.

A forecasting system for armyworms has been in operation in East Africa since 1969. National crop protection services have departments with special responsibility for control of migrant pests, including armyworm, such as the Plant Protection Services in Tanzania and the Crop Protection Branch in Kenya. In Tanzania, the National Armyworm Control Programme based at Tengeru-Arusha, runs a network of traps distributed throughout the country. Farmers are advised to inspect their fields for signs of infestation immediately the forecast warns of expected outbreak in the area. Recently, a community-based monitoring system has been implemented successfully in several high-risk districts, where armyworm forecasters have been elected and trained to monitor male moth numbers through the use of pheromone traps (Mushobozi et al., 2005).

In Kenya, radio dissemination is provided by Kenya Agricultural Information and Resource Centre.

The Desert Locust Control Organization for Eastern Africa (DLCO-EA) and the International Red Locust Control Organization for Central and Southern Africa (IRLCO-CSA) have regional responsibilities for armyworm.

Armyworm attacks are notifiable in the region. This means that if anyone spots armyworms, it should be reported immediately to the authorities (Ministry of Agriculture/ National Crop Protection Services), which will then send an eradication team, depending on the severity of the outbreak.

Listen to radio announcements to prepare yourself for armyworm outbreaks.

Field sanitation

Cut grass weeds from bordering fields. Remove weeds regularly to reduce breeding sites and shelter for armyworm. However, if fields do become infested leaving grass weeds until the caterpillar have pupated or been controlled may help to reduce damage to the crop, since caterpillars may feed on weeds. Remove all plant debris after harvesting.

Variety selection

Some maize varieties are more susceptible to attack than others, e.g. Katumani, a dryland variety grown widely in Eastern Kenya. These varieties are most at risk

where probabilities of armyworm infestation are high.

Tillage

Plough and harrow field thoroughly. Turning the soil exposes armyworm pupae to desiccation and natural enemies.

Habitat Management

Avoid burning and overgrazing of grasslands, which are the natural habitat and food store of the caterpillars. Burning often causes outbreaks because as soon as temperatures rise, eggs are laid in large quantities on the fresh new grass. No oviposition occurs at temperatures less than 20°C. Also if their natural habitat and food is unavailable they will attack other crops (HDRA).

An outbreak is more likely to occur if crops have been fertilised with high quantities of nitrogen as this causes green, sappy growth, which is very attractive to armyworm caterpillars.

Biological pest control

Natural enemies

Natural enemies should be encouraged by maintaining natural surroundings with plenty of breeding places for them, including trees and shrubs.

Many birds, toads, lizards, small mammals, insects and spiders prey on the African armyworm at different stages of its life cycle:

- **Lacewings, predatory wasps, parasitic wasps and flies, and spiders attack armyworm caterpillars.**
- **Night birds and bats feed on the African armyworm moths.**
- **Birds (storks and crows) may decimate small outbreaks but have little influence on larger ones.**

Viruses and fungi

Armyworms are also attacked by viruses and fungi. In some instances, viruses have been known to cause armyworm populations to crash within a few days. Armyworm caterpillars infected with a virus appear limp and hang from plants after they die.

A nuclear polyhedrosis virus, specific for the African armyworm (*SpexNPV*), sometimes act as a natural control during outbreak of caterpillars. First armyworm

outbreaks of the season may be virus-free, but this virus may eliminate later outbreaks, mortalities of over 98% being frequent. Widespread virus attack is often associated with overcast, cool, wet weather.

The main problem with NPV is that it generally spreads too slowly, and it arrives too late to prevent crop loss. However, NPV can be sprayed like other pesticides, and once sprayed the virus spreads and multiplies in the armyworm. To be effective NPV has to be sprayed on to very young caterpillars (during the first few days after hatching) so it is vital that information about outbreaks is gathered quickly. This requires early warning of outbreaks, through regular monitoring of moth numbers. A joint project to develop alternative, non-chemical technologies for the management of the African armyworm between the Tanzanian government and the UK's Natural Resources Institute (NRI) was initiated in Tanzania in 1999. The project has developed a system to mass-produce NPV cheaply and a community-based armyworm forecasting pack, which is now being promoted more widely, and decision tools. (Earth report 6, Mushobozi et al, 2005; New Agriculturist, 2006.).

Another virus (Cytoplasmic Virus) is also an important pathogen, killing pre-pupae and pupae. Fungi and bacteria are thought to be of minor importance (Odiyo and Stickler, 1977; Rose et al., 1996).

Also it is known that armyworms are attacked in nature by viruses e.g. *Spodoptera exempta* nuclear polyhedrosis virus (*SpexNPV*) and Cytoplasmic virus. Field trials proved that *SpexNPV* sprays at the rate of 1×10^{12} occlusion bodies per ha were effective in controlling armyworms. Sprays were applied at the third instar stage. Natural Resources Institute (UK) and Pest Control Services (Tanzania) has developed a system for mass production of *SpexNPV* as a biopesticide. The product is not yet commercially available.

For more information on [natural enemies click here.](#)

Biopesticides and physical methods

Biopesticides

Biopesticides (including botanicals/plant extracts and microbials) such as Neem, Pyrethrum and Bt should be applied if larvae are at or above threshold levels and preferably when caterpillars are approximately 12 to 20 mm long, namely before most damage has occurred. Once caterpillars are mature, that means they are 30 to 35 mm long, they will have done most of their feeding damage and it would no longer be economical to apply a biopesticide. In Namibia, the quoted threshold is 25 armyworms per trap. Traps are checked weekly (Namibian Crop Pests No. 28:

www.larsen-twins.dk/28african.)

Biopesticides should be applied in the evening since armyworms prefer to feed at night.

Precautions: It is important to follow all precautions and directions listed it on the label when using a commercial biopesticide (or a pesticide), ensure that the product is registered for armyworms on the specified crop. Pay particular attention to the required water volume to be used. Best control is achieved when using the highest water volumes. This applies to pesticide and bio-pesticide use for all pests/crops.

Neem

Trials carried out in Tanzania showed that both neem seed and leaf extracts could be used to kill armyworms. Eventhough neem extracts are as effective as SpexNPV and synthetic pesticides, their use is only practicable in small holdings.The high bulk of neem needed and high transport costs means it is not feasible to use it on a large scale.

How to prepare neem solution:

Fallen neem fruits are collected from underneath the trees. The flesh is removed from the seeds and any remaining shreds washed away. The seed is carefully dried in airy conditions (in sacks or baskets) to avoid formation of mould. When needed, the seeds are shelled, finely grated, and then soaked overnight in a cloth suspended in a barrel of water. Dosage: 50g of neem powder per litre of water. This solution is then sprayed on infested plants.

- **Grind 500 grams (g) of neem seed kernels in a mill or pound in a mortar.**
- **Mix crushed neem seed with 10 litres of water. It is necessary to use a lot of water because the active ingredients do not dissolve easily. Stir the mixture well.**
- **Leave to stand for at least 5 hours in a shady area.**
- **Spray the neem water directly onto using a sprayer or straw brush.**

About 20 to 30kg of neem seed (an average yield from 2 trees), prepared as neem water can treat one hectare of crop.

Neem water can be stored and will remain effective for 3 to 6 days if it is kept in the dark.

For more information on [neem click here](#)

Pyrethrum

Recipes for pyrethrum in pest control:

- **Pick the flowers on a warm day when they are fully open.**
- **Pile them up into small heaps in the sun to warm through.**
- **Then spread them out to dry on thick mats in a shady area.**
- **If they are to be stored, they need to be kept in an airtight container in the dark. Light reduces the effectiveness of the flowers.**

Pyrethrum powder:

Grind flowers to a dust. Use pure or mix with a carrier like talc or lime. Sprinkle over infested plants.

Pyrethrum liquid:

Mix 20g pyrethrum powder with 10 litres water. Soap can be added to make the substance more effective but it is not vital. Apply immediately as a spray.

For more information on [pyrethrum click here.](#)

Bt (*Bacillus thuringiensis*)

Commercial formulations of several Bt strains are available in East Africa. These include Dipel® , Thuricide® and Xentari® . Use an application rate indicated on the product label.

How to use Bt:

- **Spray thoroughly, covering all the plant surfaces.**
- **Apply when larvae are less than 5 mm long or when the eggs begin to hatch. Bt works best on young larvae.**
- **In the hot tropics, it is more effective to spray Bt in the late afternoon as there are longer and cooler hours ahead. This enables Bt to remain longer on the leaves' surfaces. Bt survives better in cooler temperature. Whereas, spraying in the morning provides a shorter and hotter environment.**
- **Do not mix the Bt concentrate with alkaline water (pH 8 or higher). Alkalinity reduces its effectiveness. To make the water acidic, add a few tablespoons of white vinegar in a gallon of water before adding Bt.**

For more information on [Bt click here.](#)

Physical methods

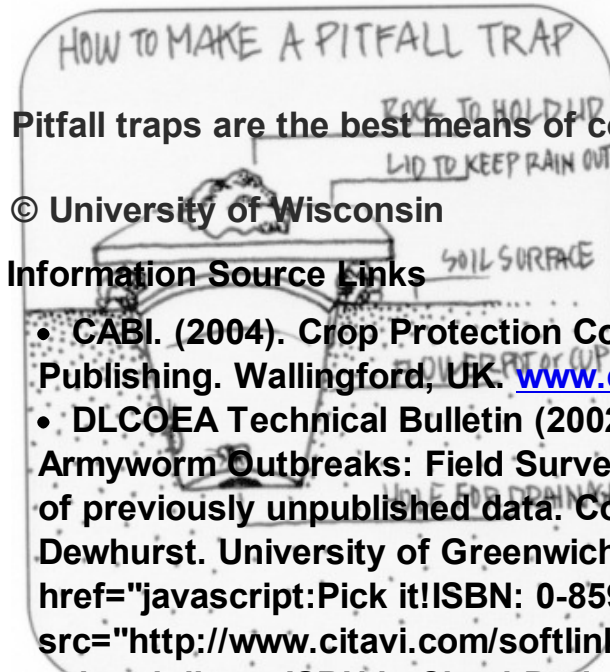
There are different physical methods mainly practicable in small holdings:

- **Plough a deep ditch. Keep it filled with water. This method is helpful, when caterpillars are found to be moving towards your field from the adjacent fields.**
- **Another method is to dig a deep ditch with vertical sides to trap the caterpillars and prevent them from crawling out. Dig a hole, a diameter of a fence post, in every 10 meters within the ditch. Caterpillars are lured to congregate in the holes. Collect and properly dispose the trapped caterpillars**
- **Make pitfall traps - see image below**
- **Use light traps. They can provide useful information about the population of moths and therefore of caterpillars. Light traps help to predict if there is going to be an outbreak. However, light traps attract many other insects, including other moths. Therefore, it is very important to be able to recognise moths of the African armyworm. Use of light traps is primarily a tool in monitoring. In addition, a wooden tripod with a kerosene lantern is a "light trap" locally improvised.**
- **A tripod made of wooden poles (bamboo) is constructed with a lantern (kerosene) hanging in the middle over a bowl of water. The lantern is a fire**

hazard so the tripod must be secure, and the lamp must be hung so that the wood does not catch fire.

- **Hand picking of caterpillars. This is only practicable in very small plots**

For more information [on traps click here](#)



Pitfall traps are the best means of collecting crawling insects.

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Banana weevil

Banana weevil



Scientific name: *Cosmopolites sordidus*

Family: Coleoptera: Curculionidae

Type: pest (insect/mite)

Common names: Banana weevil borer, banana root weevil, banana root borer, banana rhizome weevil, banana borer, plantain weevil, corm weevil, banana beetle

Host plants: Bananas Plantain and Ensete

General Information on Pest and Damage

Geographical distribution



The banana weevil (*C. sordidus*) is known from virtually all banana-growing countries of the world, including the New World, Afrotropics, Oriental and Australasian regions.

Geographical Distribution of Banana weevil in Africa (red marked)

Damage

Grubs feed making irregular tunnels in the corm and rootstock. Tunnels are roughly circular and can reach up to about 8 mm in diameter. The corm can be riddle with tunnels, which promotes fungal infection and decay reducing it to a black mass of rotten tissue. Injury to the corm can interfere with root initiation and sap flow in the plant, as a result the leaves turn yellow, wither and die prematurely. In particular young suckers show symptoms of wilting and die, but older plants are retarded in their growth. Heavily infested plants produce small bunches, and are easily blown over by the wind. Spent stems, cut or standing are attacked rapidly.

Damage is worst in neglected plants. In fertile soils and with good crop husbandry it is seldom serious. Banana weevil numbers are often low in newly planted fields. Population build-up is slow and weevil problems are most often encountered in ratoon crops. The banana weevil damage is more serious in low altitude areas that

in highland areas as a result of the influence of temperature. Weevils are usually not a problem beyond 1500 m above sea level (Karubaga and Kimaru, 1999; Gold and Messiaen, 2000).



Banana corm damaged by banana weevil. Note tunnelling by weevil grubs and rotting of corm.

© A. M. Varela, icipe

Host range

Banana weevil is an important pest of banana and plantain (*Musa* spp.), and ensete (*Ensete* spp.). Weevil problems appear to be most severe in plantains, highland cooking bananas and ensete. The weevil has contributed to the decline and disappearance of highland cooking banana in parts of East Africa. Weevil pest status in other groups of bananas is variable. In commercial Cavendish plantations, the banana weevil has been reported to be relatively unimportant (Gold and Messiaen, 2000).

Symptoms

Infestation by the banana weevil begins at the base of the outermost leaf-sheath and in injured tissues at the lower part of the pseudostem. Initially the young grubs make several longitudinal tunnels in the surface tissue until they are able to penetrate to adjacent inner leaf-sheaths; they then bore into the pseudostem base and rhizome/corm, but also into the base of suckers and into roots. Larval tunnels may run for the entire length of fallen pseudostems. Infested plants have dull yellow green and floppy foliage. Young infested suckers often wither and fail to develop. Plants are easily blown down by mild to strong winds.

Affected plant stages

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

Affected plant parts

Roots and stems.

Symptoms by affected plant part

Roots: internal feeding

Stems: internal feeding

Biology and Ecology of the Banana Weevil

The eggs are elongate-oval, about 2 to 3 mm long and white in colour. Eggs are laid singly in small cavities that are chewed out by the female in the base of the pseudostem just above ground level, in the upper part of the corm, in roots near the soil surface and at the end of cut stems (stumps). Due to their white colour they are rarely seen in the corm tissue. The duration of the egg stage is very variable (4 to 36 days) depending on temperature. Hatching takes place after 6 to 8 days under tropical conditions.

The larvae (grubs) are creamy white legless grubs, stout and distinctly curved and swollen in the middle of the body. The head is reddish-brown with strong mouthparts. Fully-grown grubs are about 12 mm long. Under tropical conditions, the larvae complete their



Grubs of banana weevils in tunnel in banana corm. The fully-grown larva is about 1 cm long.

development and pupate in 20 to 25 days.

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Pupa of banana weevil is white and about 12 mm long (picture much

Pupae are white and about 12 mm long. Pupation takes place in holes bored by the grubs; as it develops, the shape of the adult becomes visible. Adults emerge from the pupae 5 to 7 days after pupation.

**enlarged). As it develops,
the shape of the adult
becomes visible.**

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Banana weevil

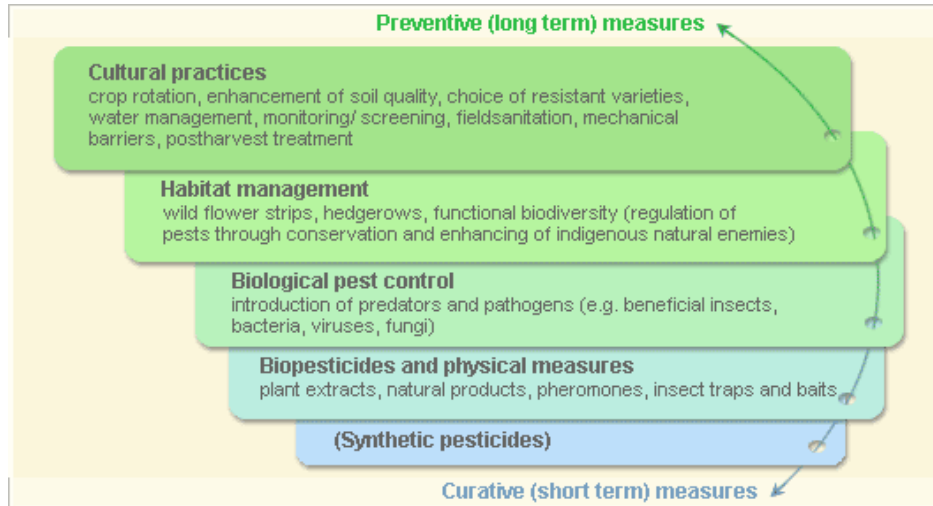
© A.M. Varela, icipe

Adults are 10 to 16 mm long weevils (snout beetles), hard-shelled, with a rather long curved snout. Newly emerged weevils are red brown, turning almost black after a few days. They are free living, they are most commonly found between leaf sheaths, in the soil at the base of the mat or associated with crop residues. They often remain within the plant before biting the external sheath and leaving the banana plant. They feed on dead banana plants, newly cut stems and other decaying plant material near the base of banana plants. Weevils may live for up to

two years, and can live without food for six months, but are very sensitive to desiccation and will die within 48 hours if kept in a dry substrate. They are active at night. The adults are sluggish rarely fly, but commonly walk over the soil surface and vegetation and feign death when disturbed. Adults are not strong flyers and only cover short distances.

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 synthetic pesticides.

Further below you find concrete preventive and curative methods against Banana weevil.

Cultural practices

Use clean planting material. Planting infected rhizomes/corm and suckers increases damage. This can be done by:

- **Selecting vigorous healthy planting material obtained from plants free of weevils. Examine planting material by taking one or two slices from it. If grubs, pupae or tunnels are present, the material should be destroyed.**
- **Paring (Trimming). If clean planting material is not available the planting material should be pared (trimmed) to reduce the number of eggs and grubs. However, badly damaged suckers should not be used for planting. Paring allows for superficial inspection of the rhizome surface and rejection of suckers containing weevil damage. However, significant internal damage may be present on suckers in which the rhizome displays little evidence of attack. Paring and removal of outer leaf sheaths also helps to remove most weevil eggs and nematodes.**
- **Hot water treatment. Recommendations suggest immersing clean trimmed**

suckers in a bath with hot water at 52 to 55°C for 15 to 27 minutes before planting. There have been reports of hot water treatment killing remaining eggs and a high percentage of grubs. For example, Gettman et al. (1992) reported over 99% mortality of weevil eggs and grubs when suckers of dessert bananas were placed in a water bath of 43°C for 3 hours. However, other sources indicate that hot baths are very effective in eliminating nematodes, but kill only a third of the weevil grubs. Thus, hot water treatment of planting material is likely to provide protection against weevil for several crop cycles only (Gold and Messiaen, 2000).

A simple method for farmers to control temperature has been developed in Kenya. It consists of a pith block (of about three cm) or a small piece of wood tied to an iron plate (3 x 3 cm and weighing about 10 g) covered with a thin film of candle wax. This device is allowed to sink in a half-empty oil drum with water, in which the banana material to be treated is placed. Wood is burnt underneath the drum, when the temperature rises to 55°C the wax melts releasing the pith or piece of wood, which then floats to the surface. At this moment the firewood is removed. (Prasad and Seshu Reddy, 1994).

Do not replant previously infested land while old corms remain on the ground, or

where insufficient time has passed for adult weevils to die after remnants of the previous crop has been removed.

Plant clean planting material as soon as possible in a new plantation. They should not be left overnight in heaps since they attract weevils and could be reinfested before planting.

Harvesting of all mature pseudostems at certain intervals, rather than continually, is suggested as a preventive measure of control. This discourages the continuous breeding of the weevil, as then there will be periods in which few young suckers are present (CABI).

Avoid moving infested plant material from plantation to plantation as this will spread banana weevils.

Sanitation

Practice good crop hygiene:

- **Cut old stems after harvesting at ground level. Covering the cut rhizome with a layer of soil is said to prevent the weevil's entry and egg laying.**
- **Cut old stems as soon as the bunch is harvested and wind-damaged pseudostems (stumps) into small pieces and scatter them so that they quickly dry and thus do not attract the weevils. Alternatively, they can be cut into larger**

pieces and use for trapping weevils (see below)

- **Dig out and remove old corms, trash and other materials in which weevils may breed.**

Practice good crop husbandry to produce vigorous banana plants, which are more able to tolerate weevil damage:

- **Use mulch. Spread mulch away from banana stool leaving a clear ring of about 60 cm from the base of the stool to keep the roots from growing towards the surface, and to avoid moist conditions near the stool, which will attract banana weevils.**
- **Desucker and remove water suckers regularly**
- **Clean matts of dead leaves and plat debris**
- **Keep the plantation free of weeds at all times.**
- **Ensure proper fertilization. Application of manure is important in the early stages of growth of the banana plant.**

Biological pest control**Natural enemies**

Predatory ants such as the bigheaded ant (*Pheidole megacephala*) and *Tetramorium* spp. are important predators of the banana weevil. Although these

ants are generalists (feed on a wide variety of food materials such as nectar, sugar, honeydew, other insects substances with high fat content, etc.) high populations in banana stands make them very efficient predators. They will enter crop residues and living plants in search of weevil eggs, grubs and pupae. These ants have reportedly contributed to the successful control of banana weevil in plantain in Cuba. These ants can be encouraged to nest in pseudostem pieces that can then be used for further distribution. They are widespread and may also be important predators on the weevil in other localities. Studies in Tanzania and Uganda have shown that several species of ants are important natural enemies of the banana weevil in the region (Aberra, et al, 2007, A. M. Varela, icipe, personal communication).

Some fungi (e.g. *Beauveria bassiana* and *Metarhizium anisopliae*) have shown efficacy as control agents of this pest. Some of them caused weevil mortality of over 90%. In Cuba, the fungus *Beauveria bassiana* is reported to be effective against the banana weevil in combination with ants (CABI, 2000). However, there is little information on the performance under field conditions. Moreover, the distribution and application of these biocontrol agents are still restricted by lack of facilities and high costs.

Some nematodes, (*Steinernema* and *Heterorhabditis* spp.) attack both adults and

grubs in the field, but economic cost and their efficacy restricted only to high weevil population levels limit their use on a larger scale (Gold and Messiaen, 2000).

Biopesticides and physical methods

Neem (*Azadirachta indica*)

Applications of neem powder effectively controlled weevils and nematodes in on-farm trials and in farmer's fields in Kenya. Application of 60 to 100 g of neem seed powder or neem cake at planting and then at four months intervals significantly diminished pest damage and increased yields. Application of over 100 g or neem oil was phytotoxic (harmful to plants) and uneconomical.

Neem applications were economical in fertile soils with moderate pest infestation. Neem applications to banana plants grown in poor soil and under very high pest attack were uneconomical. A combination of application of cow dung and neem treatments resulted in yield increases of 50 to 75% (Musabyimana, 1999). Dipping suckers in a 20% neem seed solution at planting protects the young suckers from weevil attack by reducing egg laying through its repellent effect on adult weevils. Egg hatching rates may also be lowered in neem-treated plants (Gold and Messiaen, 2000).

For more information on [Neem click here.](#)

Trapping

Disc-on-stump traps and old pseudostems can be used for trapping weevils. Disc-on-stump traps consist of corm slices placed on top of harvested plants cut at the rhizome. Old pseudostems can be cut into lengths of 20 to 60 cm and split each length, and placed on the ground near the corm bases with the cut surface downwards. Adult weevils are attracted to the cut stems or corms for shelter, to feed and to lay eggs. When the eggs hatch the life cycle cannot continue as the cut pieces dry out and the grubs die from desiccation. The weevils can be collected by hand and destroyed. The efficiency of the traps depends on their numbers and frequency of trapping. Disk-on-stump traps collect 3 to 7 times as many weevils as pseudostem traps.

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Sweet potato weevil



Sweet potato weevil

Scientific name: *Cylas* spp

Family: Coleoptera: Brentidae (=Curculionidae)

Type: pest (insect/mite)

Host plants: Sweet potato (Minor host plants: Coffee, maize, cowpea, sesame)

General Information on Pest and Damage

Geographical distribution



Geographical Distribution of the Sweet potato weevils in Africa (red marked)

Introduction

The African sweet potato weevil (*Cylas puncticollis*) is one of the most important pests of sweet potato in tropical Africa, notably Uganda, Rwanda, Kenya and Cameroon. *Cylas brunneus* is known from West and Central Africa and some countries in East Africa (Rwanda, Burundi and Kenya). These two species are found together attacking sweet potatoes in East and West Africa (Hill, 1983). *Cylas formicarius* is a destructive pest of sweet potato throughout most of the tropical and subtropical regions and occurs in several African countries.

Damage

Adult weevils feed on leaves, the underground storage roots (tubers) and the vines of sweet potatoes. They prefer to feed on storage roots, but at the beginning of the growing season, when the plants have not yet produced storage roots, the adult weevils live on the stem and leaves. They lay eggs on vines and leaves, and the grubs will feed in the stem or the leaf and pupate inside the vines.

As the plant gets older and starts to form storage roots, the weevils search for exposed roots. Since they cannot dig, they reach the tubers through cracks in the soil. Weevils feed on the storage roots and lay eggs just below the surface of the root. Feeding and egg-laying punctures (numerous small holes) lower the quality of the root and can reduce the market price. If roots with egg punctures are stored they will serve as source of infestation for the clean roots stored beside them. Adult feeding on the foliage seldom is of importance.

The grubs are more damaging, feeding and boring and making tunnels into the stems and roots. Damage to the stems may cause serious mortality to seedlings. Allard et al. (1991) report on serious weevil attacks on sweet potato nurseries in Ethiopia. Feeding in the vines causes thickening and malformation and often cracking of the tissue. A damaged vine is discoloured, cracked, or wilted. Stem damage is believed to be the main reason for yield loss, although damage to the

vascular system caused by feeding, larval tunnelling and secondary rots reduces the size and number of roots.



Sweet potato weevil symptoms on tuber.

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Countries, Ghent
University, Belgium
(www.ipbo.ugent.be)**

An infested tuber is often riddled with cavities or tunnels; these wounds serve as entry point for infections, causing rotting of tubers. Attacked tubers start rotting from the top and develop an unpleasant smell and a bitter taste, making them unfit for human consumption. Even low level of infestation can reduce root quality and marketable yield because the plants produce a bitter toxin (a terpenoid) in response to feeding by weevils.

Weevil damage increases the longer the crop remains not harvested. In Kenya, where farmers practice piecemeal harvesting, losses are in the order of 10%. Pest damage usually continues during storage, therefore infested tubers cannot be stored for a long time. In conjunction with other beetle pests, *C. puncticollis* can completely destroy sweet potato plantations.

Damage by weevils can be recognised by the holes in the vines or the tunnels in

the tuber when you pull them up from the soil.

Host range

The main host of all species of sweet potato weevil is sweet potato, alternate hosts are morning glory, water spinach (*Ipomoea aquatica*) and other Ipomea weeds. *Cylas bruneus* has only been reported on sweet potatoes. *Cylas puncticollis* has also been reported on coffee, maize, cowpea, sesame, and *Cassia acutifolia* (*C. senna*)(CABI).

Symptoms

A symptom of infestation by sweet potato weevils is yellowing, cracking and wilting of the vines, but a heavy infestation is usually necessary before this is apparent. Damage by weevils can be recognised by the holes in the vines or the tunnels in the tuber when you pull them up from the soil. Attacked tubers become spongy, brownish to blackish in appearance.

Affected plant stages

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

Affected plant parts

Leaves, roots and stems.

Symptoms by affected plant part

Leaves: external feeding

Roots: rot; internal feeding; external feeding.

Stems: external discoloration; abnormal forms; internal feeding; external feeding.

Biology and Ecology of Sweet Potato Weevil

The egg is oval in shape and yellowish-white in colour. It is laid singly in small cavities on the sweet potato root or at the base of the vine. The cavity is then sealed with a plug of the mother's excrement (faecal material). The egg hatches in about 3 to 7 days depending on the environmental conditions.

The larva is a legless grub, white in colour. The fully-grown grub is about 8 mm long. The head is comparatively large, and brown or pale-yellow. The body is slightly curved. The grub is found feeding on the vine near the base of the plant and goes down to the roots to feed. Larvae develop for 11 to



Sweet potato weevil larvae on sweet potato. The full-grown larva about 8 mm long.

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33 days before pupating.

The fully-grown grub turns into a pupa in an enlarged area of the feeding tunnel. The pupa is whitish and about 6 mm long. Initially it is white, but with time it becomes greyish in colour with darker eyes and legs. The pupa is similar to the adult in appearance, although the wings, the head and the long snout are bent downwards. Adults emerge after 7 to 28 days depending on the environmental conditions.

The adult insect is a weevil. Weevils are beetles with a long pointed snout. The body of the sweet potato weevil is slender resembling ants. The length of the adult is between 6 to 8 mm. They vary in colour in size according to the species. *Cylas puncticollis* is larger and entirely black. *Cylas brunneus* is brown with blue or bluish-green elytra (hard wings) and reddish legs, and is smaller than *C. puncticollis*. *Cylas formicarius* is as small as *C. brunneus* but has a bluish-black abdomen and a red thorax.



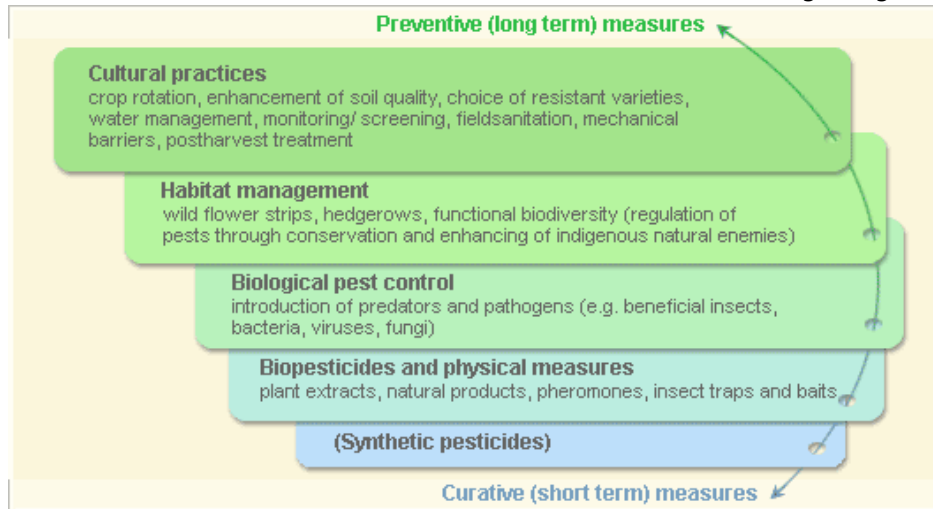
The weevils complete their lifecycle in the storage roots (tubers). They flight infrequently and generally only for short distances (500 to 1000 m). The development of the weevil from egg to adult takes 32 days in average.

Sweet potato weevil. Adult female, body length 6 to 8 mm.

© Land Care Ltd. New Zealand. 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 Sweet potato weevils.

Cultural practices

Monitoring

At the beginning of the growing season, when the plants have not yet produced any storage roots, the adult weevils are commonly found on the foliage, but they quickly drop to the ground if disturbed. During the day they often hide under leaves or in soil cracks. Most of the larvae are found in the upper 15 cm of the tubers and basal 10 cm of the vine. Select storage roots that appear soft, smell, or have external scarring or small, darkened holes. Cut these open and look for tunnelling and larvae. Pheromone traps are useful in monitoring weevil populations, but this technology is expensive and not widely available. Efforts are going on to develop pheromones traps for monitoring and control in East Africa (refer to section on traps below).

Among various control measures attempted, modification of cultural practices has the greatest potential in combating the sweet potato weevil at low cost.

Crop rotation

Avoid planting sweet potatoes in the same area for two to three successive seasons. It has been suggested that, if possible, sweet potatoes should be grown in a field only once every five years. Rice and sorghum are often used in rotation with sweet potatoes. This rotation will help break up the cycle of the weevil and will help to control sweet potato weevil, particularly if integrated with other

management approaches, such as the ones described below.

Intercropping

Experimental studies in Taiwan showed that intercropping with chickpea, coriander, pumpkin, radish, fennel, black gram and yard long bean reduced weevil infestations considerably. However, intercropping with black gram, fennel, pumpkin, and yardlong bean also reduced sweet potato yields. The best results were obtained with coriander. Similarly, reduced weevil damage was observed when sweet potato was intercropped with proso millet and sesame, but sweet potato yield was also considerable reduced. Sweet potato has been found to inhibit germination of proso millet (Peterson et al., 1999).

Planting time

Plant early or plant early maturing varieties. This will allow harvesting before the end of the growing season, minimising in that way the risk of drought and consequently the damaging effect of weevils, which enter the soil through cracks.

Use of clean cuttings

Carry-over of the weevils from an infested crop to the new planting could be reduced by carefully selecting fresh cuttings for planting a new crop. Use clean

(insect-free) vines as planting material. Prefer planting material from vine tips. Weevils tend to lay eggs in the older woodier parts of the vine, so if the tender tips are used for planting they are less likely to be infested by weevils. Studies in Taiwan showed that cuttings (25 to 30 cm long) taken from fresh terminal growth, even from an infested crop, were rarely infested with weevils, whereas older portions of the stem were (AVRDC).

Keep distance to infected fields

Planting away from weevil-infested fields, and or use barrier crops such as cassava, maize, bananas or sorghum planted around the perimeters in stripes of at least 3 to 5 m in width between fields to restrict movement of weevils between fields (CIP, VITAA).

Avoid soil cracking

Avoid or minimise cracks in the soil. Soil cracks are the major route of weevil access to roots. This can be done by:

- **Planting cuttings deep in the soil and using of deep-rooted cultivars reduce weevil damage. The growth of roots, especially in cultivars that set roots near the soil surface can produce cracks and increase exposure of roots to the weevil.**
- **Ridging: it prevents the soil from cracking by hilling the area around the plant.**

Re-hill mounds about 30 days after planting to close soil cracks. Close ridges after piecemeal harvests to cover exposed tubers. This should be implemented before the adult weevil reaches the roots.

- **Mulching: mulches conserve soil moisture and minimise soil cracking. The physical cover made by mulching materials further reduces access of roots to the weevil even if the soil cracks. The soil surface should be covered soon after planting and the cover should be maintained until harvest.**
- **Routine irrigation: it is important to provide sufficient water to prevent soil cracking. This is a practical method for farmers with a reliable water supply.**

Sanitation

Remove and destroy (through burying, burning or feeding to livestock) any crop residues left in the field after harvest. Infested roots must be complete buried (over 15 cm deep); avoid cracks, which allow emerging weevils to reach the soil surface. If vines are left in the field to improve soil fertility, care should be taken to ensure they are dead and not able to sprout. Care should be taken to remove and destroy any infested roots when doing piecemeal harvest.

Field sanitation is important because weevils survive in roots and stems and infest succeeding or neighbouring sweet potato plantings. However, to effectively

reduce weevil infestation it should be practised in a large area or community. Clean cultivation is particularly important where rotation is not possible, for example in areas where sweet potato is a staple food and is planted year-round.

Flooding of fields

Flooding of infested fields for at least 48 hours after completing harvest drowns weevils induces rotting of the leftover plant materials and thereby reduces weevil densities from one planting to the next. This is an option in areas where rotation is not possible.

Flooding of fields between two consecutive sweet potato crops may reduce the immediate source of weevils from the field.

Early harvesting

Harvest the crop as soon as it has developed roots of acceptable size.

Control of alternative hosts

Alternative hosts of the sweet potato weevil (e.g. morning glory, water spinach, wild Ipomoea etc) can shelter weevils between planting seasons and serve as a source of weevil infestation when a new crop of sweet potato is planted.

Therefore, removal of these host plants growing in the vicinity of sweet potato

plantings is recommended as a control measure. However, indiscriminate elimination of these plants is not recommended since they may also be lead to undesirable ecological effects. To minimise this, all Ipomoea could be eliminated for one cropping season and allowed to grow in the subsequent seasons, once the area is free of the weevils.

Biological pest control

Natural enemies

Predatory ants, earwigs, spiders and ground beetles are important predators of the sweet potato weevil. Among those ants seem to be most important. In Cuba, two species of predatory ants, *Pheidole megacephala* and *Tetramorium guineense*, which are common inhabitants of banana plantations, are used for control of sweet potato weevils. These ants are encouraged in reservoir areas, such as patches of forest, where they are naturally abundant. Ants nests are moved by a simple method using rolled banana leaves as 'temporary nests' to transport the ants from their natural reservoir to sweet potato fields, or banana stems, baited with honey, are placed in the reservoir areas and, when covered in ants, transported to the sweet potato fields. The ants then prey upon sweet potato weevils and other insects. Setting up colonies in the field 30 days after planting with 60 to 110 nests/ha can keep weevil infestation at low levels (3 to 5%) (FFTC;

Sheehy Skeffington, 2006).

Disease-causing microorganisms, especially the fungus *Beauveria bassiana*, have been observed to cause high mortality of sweet potato weevils in the field under conditions of high humidity and high insect density. This fungus is commercially available in some countries. It can be used for treating the planting material and the soil to reduce soil infestation.

Traps

Pheromone traps are widely used for monitoring the sweet potato weevils. However, these traps are expensive and not widely available. In 1995, a collaborative project of the National Agricultural Research Institutes, Natural Resources Institute (NRI), and the International Potato Center (CIP) began developing pheromones for monitoring and controlling the African sweet potato weevils in East Africa. Pheromone compounds that proved effective in catching male weevils under field conditions in Uganda were identified, and several traps were tested. A five-litre plastic jerry can with rectangular openings of 11×5 and 6×5 cm filled with 0.5 l soapy water (1 g Omo/1 l water), with 0.1 mg lures to be replaced every 8 weeks is presently the most effective and robust trapping system. Experiments on the use of these traps for mass trapping of males for weevil control are going on (CIP; Smit et al., 1997).

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Couch grass



Couch grass

Scientific name: *Cynodon dactylon*

Family: Cyperales, Poaceae

Type: weeds

Common names: Bermuda grass, Bahama grass, Common star

grass, Dhub grass, Devil grass
Host plants: Maize

General Information on Pest and Damage

Geographical distribution



Couch grass (*C. dactylon*) is thought to have originated in Africa but now occurs worldwide in both tropical and subtropical regions.

**Geographical
Distribution of
Couch grass in**

Africa (red marked)

Introduction

The couch grass (*C. dactylon*) is treated by Holm et al. (1977) as the second most important weed in the world (after *Cyperus rotundus*), a status that is justified by its occurrence in virtually every tropical and subtropical country and in virtually every crop in those countries.

The weed is an alternate host of some plant diseases such as brown spot, leaf spot, early blight, stripe disease of rice, barley yellow dwarf, lucerne dwarf and of nematodes. Couch grass is used as a cover crop to control erosion and for soil stabilization, feed for livestock, lawn beautification and herbal medicine.

Description:

The stem creeps at full-length along the ground. The leaves are small, linear and blue-green with rough margins. The undersides are smooth but hairy on the upper surfaces. The flowering stalks bear many slender and purplish spikelets. The fruit is reddish-brown or orange-red. The seeds are flattened, oval and straw-coloured. The weed can be spread through seeds, runners, rooting nodes or underground rootstocks. It is mat forming. A single plant can produce up to 720 seeds. It can endure both extensive flooding and drought.

Host Range:

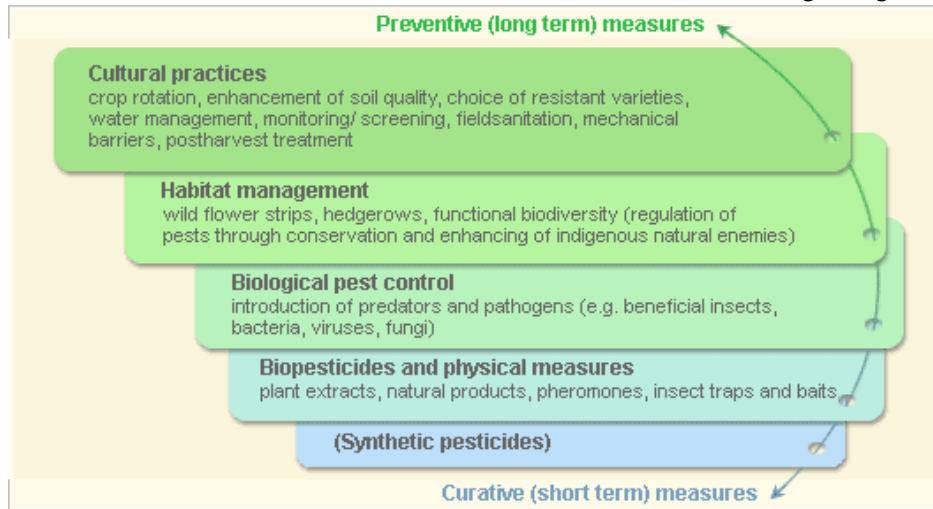
The crops in which couch grass is most commonly a major problem are those of the subtropics that are planted in wide rows, for example, cotton, sugarcane, tobacco, citrus, olive, deciduous fruit, forestry and ornamental species and many vegetables, but also some closer-planted but less competitive crops such as rice, lucerne, lucerne and grass pastures, onion and jute.

Biology and Ecology

***C. dactylon* tolerates a wide range of temperatures, especially very high temperatures in near-desert conditions. Freezing point ranges from -2 to -3°C. Growth is favoured by medium-to-heavy, moist, well-drained soils but *C. dactylon* will also grow on acid and quite highly alkaline soils and the rhizome system can survive flood conditions and drought.**

Pest and Disease Management

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



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Further below you find concrete preventive and curative methods against Couch grass.

Notes for REVISION

mh, 26.6.09 most open points have not been addressed since the last version received on 23 may 08. pls describe 'spikelets' for inclusion into glossary or exchange word.

Cultural practices

Control Methods

- **Proper selection of seeds (ensure whatever crop you plant its seeds are not contaminated with couch grass seeds)**
- **Thorough land preparation**
- **Regular plant monitoring**

Legumes or other cover crops are sometimes used for smothering *C. dactylon* since the weed does not tolerate deep shade. Vigorous crops and higher crop density may be important in reducing weed competition.

Traditional techniques of controlling *C. dactylon* rely very little on manual methods, as it easily survives shallow hoeing and positively thrives on mowing. However, the benefits of deep cultivation have been confirmed in Botswana and Zimbabwe where double ploughing, either after crop harvest or before the onset of the next season's rains, provided a high degree of control and was beneficial to

crop yields.

The main non-chemical approaches to control couch grass are deep tillage and shading/smothering crops.

For more information on [weeds click here](#)

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Damping-off diseases

Damping-off diseases

**Scientific name: *Pythium* spp., *Rhizoctonia solani*
(*Thanatephorus cucumeris*).**



Family: *Pythium* spp: Pythiales: Pythiaceae *Rhizoctonia* spp:

Ceratobasidiales: Ceratobasidiaceae

Type: disease (fungal)

Common names: Wilt, Damping-off, Seedling blight, Root rot, Rhizoctonia damping-off, Rhizoctonia

Host plants: Amaranth Cabbage/Kale, Brassicas Carrot Citrus plants Coffee Cotton Cowpea Cucumber Green gram

Groundnut Okra Peppers Rice Sorghum Tomato Wheat

General Information on Disease and Damage

Geographical distribution



**Geographical
Distribution of
Damping-off
Diseases in Africa
(red marked)**

Damage

Damping-off is caused by a fungus, it usually occurs in small patches at various places in the seedbeds or field. The disease spots often increase from day to day until the seedlings harden. Seedlings are extremely susceptible for about two weeks after emergence. As the stem hardens and increases in size, the injury no longer occurs. Some seedlings are not killed at once, but the roots are severely damaged and the stem is girdled at the ground level. Such plants remain stunted and often do not survive transplanting.



The injury from damping-off fungi is of two

types:**Okra seedlings affected by damping-off**

- **Pre-emergence damping off consists of a © A.A. Seif & A.M. Varela, icipe decay of the germinating seed or death of the seedling before it can push through the soil. This injury is a common cause of poor stands, which are often attributed to inferior quality of the seed or the untreated seeds. *Pythium* spp. and *Phytophthora* spp. cause seed decay.**
- **Post-emergence damping-off which occurs after the seedlings have emerged from the soil but while still small and tender. The roots may be killed, and affected plants show water soaking and shrivelling of the stems at the ground level; they soon fall over and die. Post-emergence damping-off is mostly caused by *Rhizoctonia* spp.**

Host range

The fungal disease caused by *Rhizoctonia solani* has a very wide host range, infecting plant species belonging to 32 families, and 20 weed species from 11 families.

Symptoms

In crucifers, this fungus causes damping-off and wirestem of seedlings in the seedbed; bottom rot and head rot in the field; and storage and root rot of horseradish, radish, rutabaga and turnip.

Damping-off:

Seeds can decay in cold wet soils and stems can become light brown and water-soaked near the soil line. Such seedlings wilt, topple and die. Wet soils and temperatures at or above 24°C favour disease development.

Wirestem in cabbage:

This is the most common and destructive phase of the disease. The stem above and below the soil line shrivels and darkens, and outer tissues come off leaving a dark wiry and woody inner stem. Such plants do not fall over, but they have an unhealthy stunted appearance. Some may die, but most survive and do poorly when transplanted to the field. When moisture is adequate, plants may produce a small poor-quality head.

Bottom rot in cabbage:

The disease occurs in mid-season as a carry-over from wirestem seedlings and from new infections that occur when outer leaves come in contact with moist infested soil. Lower leaves wilt, decay and turn black, but do not drop off. Some

plants may recover and produce heads, but usually bottom rot develops into head rot.

Head rot in cabbage:

A firm to slimy dark decay at the base of outer leaves and in cabbage heads develops during the period between head formation and maturity. The fungus grows up to main stem, passing between the leaf petioles. Foliage leaves die and drop off, thus exposing the stem beneath the head. Over the whole head surface, brown fungus mycelia and tiny brown resting fungal bodies (sclerotia) may develop and be visible over the head surface. Secondary rot bacteria usually invade the diseased tissue and turn the head into a slimy foul-smelling mass.

Root rot:

It is usually dark brown, sunken and spongy. Infected tissues easily separate from advancing edges of the rot. A white to brown surface mould and irregular brown sclerotia distinguish this rot form other root rots. It mainly affects horseradish, radish, rutabaga and turnip.

Affected plant stages

Heading stage (in cabbage), post-harvest (in cabbage), pre-emergence, seedling stage and vegetative growing stage.

Affected plant parts

Leaves, roots, seeds, stems and whole plant.

Symptoms by affected plant part

Leaves: lesions; abnormal colours; abnormal forms; wilting; fungal growth.

Roots: lesions.

Seeds: rot; discolorations.

Stems: external discoloration; canker; abnormal growth; mycelium visible.

Whole plant: plant death; dieback; damping-off.

Biology and Ecology of Damping-off Diseases

Many fungi are associated with damping-off diseases and seedling blights. The species most often encountered belong to *Pythium* spp. and *Rhizoctonia* spp. For the two an excess of moisture is recognized as the most important condition for damping-off and seedling blights.

Infection by *Pythium* spp. and *Rhizoctonia* spp. is favoured by:

- **heavy soils**
- **low pH**
- **heavy seeding resulting in dense planting**

- **careless handling**
- **excessive soil moisture**
- **low light and presence of weeds**

Exudates derived from host plants stimulate growth of these fungi.

Other fungi also implicated in causing damping-off and seedling blights include *Aphanomyces* spp., *Alternaria* spp., *Botrytis cinerea*, *Colletotrichum* spp., *Fusarium* spp., *Helminthosporium* spp., *Phytophthora* spp., *Sclerotinia* spp., and *Thielaviopsis* spp.

One feature that many of the fungi concerned have in common is their ability to survive for relatively long periods in soils. There are several forms in which they do so:

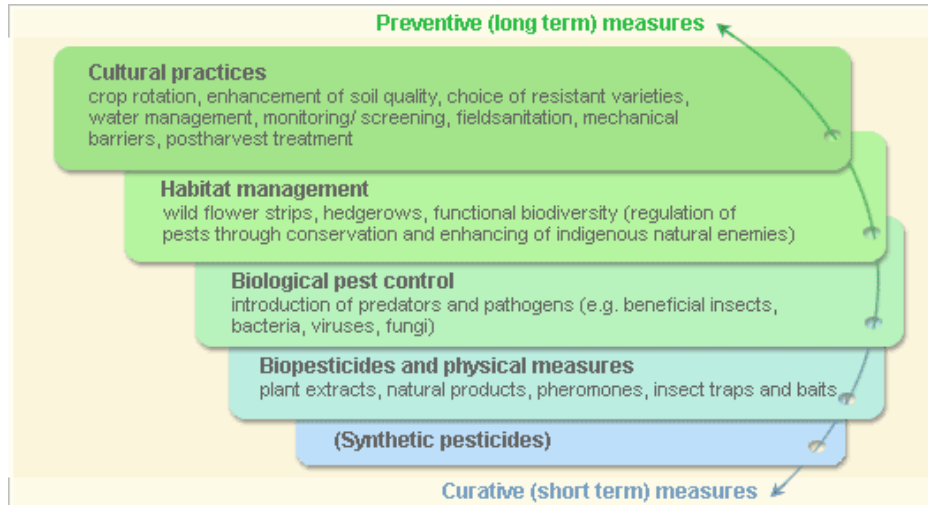
- (1) as mycelium in the soil (e.g. *Rhizoctonia* spp.)**
- (2) as resting spores (e.g. oospores of *Pythium* spp. and *Phytophthora* spp., chlamydospores of *Fusarium* spp.) and**
- (3) as sclerotia (tiny brown resting fungal bodies) (e.g. *Sclerotinia* spp., *Rhizoctonia* spp. and *Botrytis cinerea*).**

Spread of damping-off fungi depends primarily on the mechanical transfer of mycelia, sclerotia or resting spores in infested soilparticles (on flats, tools,

baskets or end of the watering hose) or infected plant tissue.

Pest and Disease Management

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



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only. On infonet we do not promote synthetic pesticides.

Further below you find concrete preventive and curative methods against Damping-off Diseases.

Cultural practices

General disease prevention

- **Good seedbed management**
- **Avoid fields with a history of the disease.**
- **Practise crop rotation.**
- **Deeply plough fields**
- **Use certified disease-free seeds. If using own seed, hot water treatment can be used. For more information on [hot water treatment click here](#).**
- **Solarisation of seedbeds should be done where feasible. For more information on [solarisation click here](#).**
- **Thin the seedlings in seedbeds to permit good air circulation.**
- **Avoid excessive watering and fertilisation, particularly with nitrate.**
- **Plant on raised beds to reduce moisture content in the root zone and provide the appropriate drainage in the field to prevent waterlogged conditions.**
- **Schedule planting times to avoid temperature and moisture conditions that are conducive to the pathogen. It also will reduce disease severity.**
- **As free water is important for distribution and development of the diseases,**

efforts to reduce soil moisture will help to reduce disease severity.

- **Products of the soil fungus *Trichoderma* spp. are reported to suppress damping-off fungi**

Additional measures for:

- **Tomatoes: The seedbed should not be sited on a field previously planted with eggplant, pepper, potatoes, tomatoes or other related crops. Do not site the seedbed next or near to tomato production fields. The seedbed should preferably be up-wind to tomato fields.**
- **Brassicas: Seedbeds and production fields should not have had crucifers for at least 3 years. All seedlings with wirestem symptoms should be discarded. During cultivation, take care to avoid throwing soil into plant heads.**
- **Okra: Avoid fields previously planted with cotton or other related crops.**

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Mango seed weevil

Images

Mango seed weevil adult, after emerging of a mango. It is 8 mm long.



Monique Hunziker, Biovision

Mango seed weevil close-up, after emerging of a mango. It is 8 mm long.



Monique Hunziker, Biovision

Damage by mango seed weevil larvae. First instar larvae of the mango seed weevil are elongate, cylindrical, legless and extremely slender; they are 1.3 to 1.4 mm long. The body is white and the head is black. Final instar larvae are white and legless, they have a curved form, and are 1.6 - 1.8 cm long.



Peter A. Follet. Reproduced from the Crop Protection Compendium, 2005 Edition. © CAB International, Wallingford, UK, 2005.

Egg of mango seed weevil on mango fruit. The very small egg laying scars are barely discernible at harvest. When freshly laid the eggs are creamy-white. They are extremely small (0.8 mm long).



**The State of Queensland,
Australia, Department of
Primary Industries and
Fisheries, 2007. Reproduced
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ipcu@dpi.qld.gov.au.**

**Adults of the mango seed weevil
(*Sternochetus mangiferae*) have a
compact body, they are about 7 to 9
mm long.**



**Georg Goergen/IITA Insect Museum,
Cotonou, Benin. Reproduced from the
Crop Protection Compendium, 2005
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African cassava mosaic virus (ACMV)

Images



African Cassava Mosaic Disease (ACMD). The leaves of this local cultivar of cassava are expressing severe ACMD symptoms.

**International Society for Plant Pathology,
www.isppweb.org**

**African mosaic virus on cassava - transmitted
by whiteflies (*Bemisia tabaci*)**



ETHZ

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African maize stalkborer

Images

Caterpillars of the African maize stalkborer (*Busseola fusca*).



D. Cugala, Stemborer team, icipe

Caterpillar of the African maize stalkborer and damage to maize cob.



David C. Nowell Courtesy of Ecoport (www.ecoport.org).

**Moth of the African maize stalkborer
(*Busseola fusca*).**



Stemborer team, icipe

Stemborer damage to a maize plant.



Stemborer team, icipe

Stemborer damage to maize cob.



Stemborer team, icipe

African maize stalkborer eggs.



**Agricultural Research
Council of South Africa.
Courtesy of Ecoport
(www.ecoport.org).**

**Eggs of the African maize stalkborer
(*Busseola fusca*).**



Stemborer team, icipe

Female moth of African maize stalkborer (*Busseola fusca*) . Wingspan is about 2.5 to 3.5 with females and larger males.



B. Le Ru, icipe

**Male moth of African maize stalkborer
(*Busseola fusca*) .**



B. Le Ru, icipe

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Bagrada bug

Images

The adult bagrada bug (*Bagrada hilaris*) is typically shield-shaped, 5-



7mm long and 3-4mm wide. The upper surface has a mixture of black, white and orange markings.

F. Haas, icipe

Late instar nymph of the bagrada bug.



F. Haas, icipe

Third instar nymph of the bagrada bug.



F. Haas, icipe

Newly emerged nymphs (first instar) of the bagrada bug.



F. Haas, icipe

Eggs of the bagrada bug (much enlarged)



F. Haas, icipe

Initial symptoms of damage by bagrada bugs . Note small white punctures on the edges of leaves.



A. M. Varela, icipe

Kale plant severely damaged by bagrada bugs



B. Loehr, icipe

**Kale plant severely damaged by
bagrada bugs**



B. Loehr, icipe

Kale plants killed by attack by bagrada bugs



B. Loehr, icipe

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Turnip Mosaic Virus (TuMV)

Images

**Severe Turnip Mosaic Virus symptoms
(mosaic and distortion) on cabbage**



leaves (*Brassica oleracea*)

Image supplied by Warwick HRI,
University of Warwick.

Turnip Mosaic Virus



David B. Langston, University of Georgia, Bugwood.org

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Black rot

Images

Bacterial black rot on cabbage



G. Gichini, icipe

Bacterial black rot on cabbage



A.M. Varela, icipe

Black rot on cabbage. Characteristic yellowish V-shaped areas at the leaf margin, sites of infection by black rot, *Xanthomonas campestris* pv. *campestris*.



**Laing M.D. Courtesy of EcoPort
(www.ecoport.org)**

**Black rot on cabbage. Black rot leaf
internal symptom. Note blackening of
veins**



A.A. Seif, icipe

Bacterial black rot. Note blackening of water-conducting tissues of the stem



A. M. Varela, icipe



A. M. Varela, icipe

Bacterial black rot on kales

Bacterial black rot on cabbage



A.A. Seif, icipe

Bacterial soft rot. Note slimy rot (whitish) of the centre of the cabbage head



A. M. Varela, icipe

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Information of www.infonet-biovision.org

Cabbage webworm

Images



Cabbage webworm caterpillar (*Hellula undalis*), about 1.5cm long, and damage on kale leaf.

A.M. Varela, icipe

First instar caterpillars of the cabbage webworm feeding in a leaf of kale.



A. M. Varela, icipe

Caterpillar of the cabbage webworm (*Hellula undalis*) feeding in the stem of a kale plant. Caterpillars attain a length of 1.5 cm when fully grown.



A.M. Varela, icipe

Cabbage webworm (*Hellula undalis*) feeding on a cabbage head. The caterpillars have dark brown or black heads. The body is creamy white with light pinkish-brown longitudinal stripes, attaining a length of 1.2-1.5 cm when fully grown.



A.M. Varela, icipe

Moth of the cabbage webworm - Adults are greyish-brown with pale dusky hindwings. Wings ca 1.2cm long in males, 1.4 cm in females.



A.M. Varela, icipe

Cabbage webworm adults are greyish-brown with pale dusky hindwings; each forewing has a prominent black spot and zigzagging, light brown lines, central band between lines sometimes filled with darker brown scales. Wings ca 1.2 cm long in males, 1.4 cm in females.



David Agassiz. Reproduced from the Crop Protection Compendium, 2005 Edition. © CAB International, Wallingford, UK, 2005.

Damage by the cabbage webworm as stemborer on a kale plant



A. M. Varela, icipe

Damage to the growing tip of a kale plant caused by the cabbage webworm



A. M. Varela, icipe

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Downy mildew

Images



Downy mildew on cabbage

A.M. Varela, icipe

Downy mildew (*Peronospora parasitica*) on *Brassica oleracea*



**Clemson University - USDA Cooperative
Extension Slide Series
(www.insectimages.org)**

**Downy mildew (*Pseudoperonospora cubensis*) on
cucumber. Severe defoliation of cucumber caused
by infection from downy mildew. Fruits are not
infected, but those that form are small and do not
ripen properly.**



**Denis Persley and Tony
Cooke, Department of
Primary Industries and
Fisheries, Queensland,
Australia. Courtesy of
EcoPort (www.ecoport.org)**

Information of www.infonet-biovision.org
