Information of www.infonet-biovision.org

African cassava mosaic virus (ACMV)

African cassava mosaic virus (ACMV)
Family: Geminiviridae: Begomovirus {GEM2 }
Type: disease (viral)
Host plants: Cassava Castor bean

General Information on Disease and Damage

Geographical distribution

Geographical Distribution of the African cassava mosaic virus in Africa (red marked)

Introduction

In East Africa, African cassava mosaic virus is the most important single factor limiting cassava production. Its wide distribution in the region is primarily due to the use infected planting material, the

widespread presence of the vector (Bemisia tabaci) and the use of traditional local varieties that are susceptible to the virus. During the 1990s, a pandemic of an unusually severe form of the disease expanded to cover a large part of East Africa, southern Sudan and eastern Democratic Republic of Congo. This has been associated with the occurrence of a novel and highly virulent cassava mosaic begomovirus. (Legg et al., 2005).

Damage

African cassava mosaic virus is the most important virus disease of cassava, but total losses are extremely difficult to estimate. Yield losses with individual cultivars have been reported from different countries to range from 20 to 95% (Seif, 1982). Losses depend on variety and crop growth stage at infection, but are usually substantial. In Côte d'Ivoire, total losses were estimated to be 0.5 million tonnes per year compared with actual production at the time of 0.8 million tonnes.

Host range

Cassava (*Manihot esculenta*) and castor bean (*Ricinus communis*) are the two major hosts of African cassava mosaic virus. Wild hosts are other plants of the family Euphorbiaceae (for example wild poinsettia, garden spurge).

African Cassava Mosaic Disease (ACMD). The leaves

of this local cultivar of cassava are expressing severe ACMD symptoms.

Symptoms

Symptoms of African cassava mosaic virus disease occur as characteristic leaf mosaic patterns that affect discrete areas and are determined at an early stage of leaf development. Leaf chlorosis may be pale yellow or nearly white with only a shade of green, or just noticeable paler than normal. The chlorotic areas are usually clearly defined and vary in size from that of a whole leaflet to small flecks or spots. Leaflets may show a uniform mosaic pattern or the mosaic pattern is localised to a few areas, which are often at the bases. Distortion, reduction in leaflet size and general stunting can be secondary effects that are associated with

symptom severity.

Symptoms vary from leaf to leaf, shoot to shoot and plant to plant, even of the same variety and virus strain in the same locality. Variation in symptoms may be due to differences in virus strain, plant age, and environmental factors such as soil fertility, soil moisture availability, radiation and particularly temperature.

Sometimes leaves between affected ones may seem normal and give the appearance of recovery. This behaviour is influenced by the ambient temperature and host-plant resistance. However, symptoms may reoccur on recovered plants when environmental conditions again favour symptom expression. The first few leaves produced by an infected cutting sometimes do not show symptoms and are subsequently followed by severely affected leaves, but there is a tendency for symptom severity to diminish as plants age, especially in resistant varieties. Symptoms tend to reappear on the axillary growth when the shoot tips are removed. De-topping stem tops is sometimes adopted to enhance expression in screening

clones for resistance.

Affected plant stages

Vegetative growing stage.

Affected plant parts

Leaves.

Symptoms on affected plant parts:

Leaves: Mosaic patterns; leaf deformation.

Biology and Ecology of African Cassava Mosaic Virus

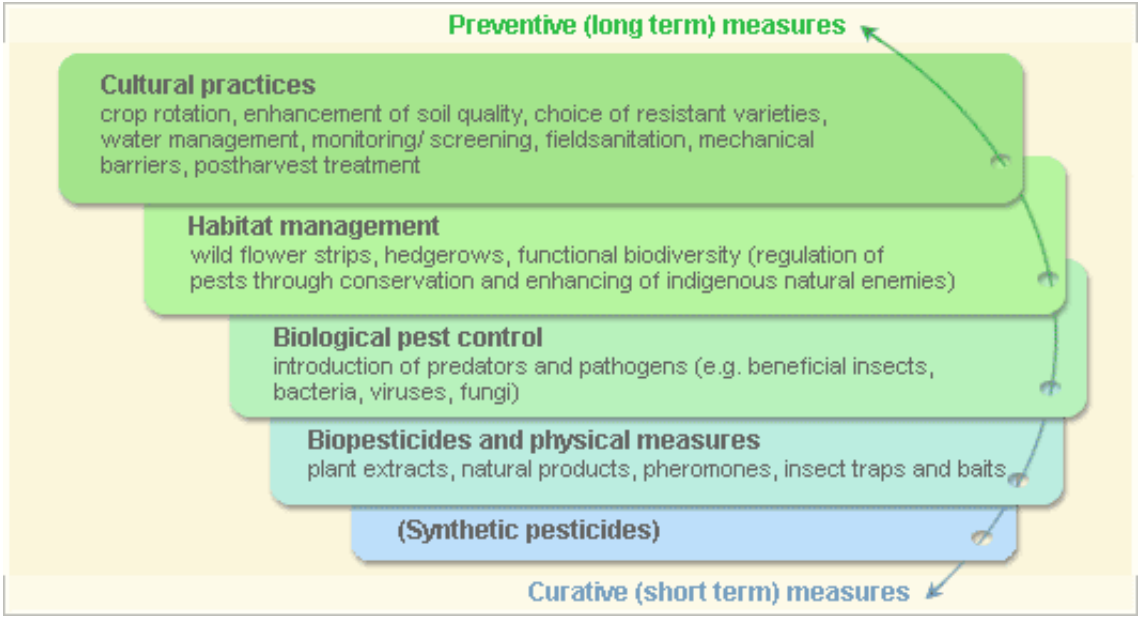
African cassava mosaic geminivirus (CMGV) is a vector-borne virus, transmitted by the whitefly *Bemisia tabaci* and disseminated in cuttings derived from infected plants.

Cassava is the major CMGV reservoir and possibly the main host of

whitefly vectors. Whiteflies are carried by the prevailing wind and can spread the virus over distances of several kilometers from cassava fields. Even a single whitefly can transmit the virus. Whiteflies prefer to feed on young leaves. Virus spread, cassava growth and whitefly populations are dependent on climatic factors. Also, seasons of fast spread coincide with periods of rapid cassava growth and population of whiteflies carrying the virus. Crop growth in turn, depends on radiation-associated factors in humid conditions or to rain-associated ones in drier environments. Cassava varieties also differ greatly in their susceptibility to the virus (Farguett and Thresh 1994).

Pest and disease Management

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



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

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

Further below you find concrete preventive and curative methods against African cassava mosaic virus.

Cultural practices

Sanitation

- **Remove all infected cassava or other host plants from within and around sites to be used for new plantings**
- **Use virus-free stem cuttings for all new plantings**
- **Remove diseased plants from within crop stands (roguing)**

For more information on sanitation see datasheet on anthracnose.

Roguing

Roguing is a well known means of virus disease control and it is only advocated when disease incidence is low (less than 5%). It has been often recommended to control the cassava mosaic virus.

- **Rogue once or twice soon after planting, when any infected cuttings develop shoots expressing obvious symptoms**
- **Roguing is more effective when practiced by farmers' groups and throughout whole localities.**
- **Frequent roguing is ineffective where there is a high spread of the virus to susceptible varieties**
- **Inspect cassava plantings at least once a week for the first 2-3 months of growth to find and remove immediately any occurring diseased plants**

Resistant/tolerant varieties

Use cassava varieties which are resistant and/or tolerant to mosaic virus. For example varieties derived from IITA, Nigeria, such as TMS

30337, TMS 30395, TMS 30572, TMS 60142, TMS 30001 and TMS 4(2)1425) have been widely distributed in Africa and are now grown by producers in many main cassava-producing countries in Africa.

If it is not possible to find cassava plants that are completely free from the disease, select cuttings from stem branches instead of the main stem. Stem cuttings from the branches are more likely to sprout into disease-free plants than stem cuttings from the main stems (James et al, 2000). Also, it has been found that growing of mixture of varieties in the same field aids in reduction of virus transmission (Legg et al, 2005).

Field size and shape

Virus incidence and whitefly numbers tend to be greatest in the outermost rows of plantings, especially the ones oriented across the prevailing wind.

- **Plant in large, compact blocks.**

- **Elongated plots should be oriented along the prevailing wind, rather than across, so that less plants will be exposed.**
- **Use the outermost rows to raise virus-free cuttings for distribution, or plant a resistant variety of cassava around the field margins.**

Crop disposition

The main spread of cassava mosaic virus is into and not within plantings. Thus, you can facilitate control by selecting suitably isolated sites where the risk of infection from outside sources is limited. There is little information available on the minimum isolation distance needed for an effective infection control.

The risk of infection is much higher where sources of infection are upwind and nearby than when the nearest sources are downwind and remote. Thus, spread can be decreased by planting sequentially in an upwind direction from the source.

Crop spacing

Studies in Uganda and in Ivory Coast showed that spread of cassava mosaic disease is influenced by host-plant population density and disease incidence was highest at the widest spacing between cassava stands and along footpaths or gaps in the stands. Thus, using uniform dense cassava stands rather than irregular widely spaced ones can help reducing disease incidence.

Planting date

You can facilitate the control of the cassava mosaic virus by avoiding exposition of vulnerable young plants to risk of infection in times when whiteflies are most abundant. Cassava grows readily from stem cuttings, enabling planting throughout much of the year, especially where there is enough rainfall.
In coastal districts of Kenya, spread of cassava mosaic virus occurs during the rains from May to July; it may be an advantage

planting later in the year if conditions are not so dry to influence crop growth.

Soil fertility and nutrient status

Cassava is able to grow in unfavourable environments. Plantings are often made in poor soils or after more nutrient-demanding crops. Studies in Uganda showed that poor soil may enhance damage caused by the virus: damage was most severe in the north, where soil conditions and rainfall are generally less favourable than in the south.
In Zanzibar, cassava grown on fertile land was less affected by the disease than on less fertile soils.

Intercropping

In many parts of Africa, cassava is usually grown with other crops including banana, sweet potato, cereals and legumes. Intercropping may improve overall land productivity and may decrease whitefly

vector populations, whitefly activity and virus spread. However, intercropping is more likely to complement rather than to replace other more effective control measures.

Plant many local varieties

Studies in Uganda showed that in areas where many varieties of cassava were grown, losses were much less than by planting only one variety. Also disease incidence in a susceptible variety was lower when mixed with resistant varieties than when it was grown alone.

(Thresh and Cooter, 2005)

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African maize stalkborer

African maize stalkborer
Scientific name: *Busseola fusca* (Fuller)
Family: Noctuidae
Type: pest (insect/mite)
Common names: African maize stalk/stem borer, maize stem/stalk borer, sorghum stalk/stem borer
Host plants: Maize Millet Sorghum

General Information on Pest and Damage

Geographical information: *Busseola fusca* is a common pest in many African countries throughout sub-Saharan Africa. In East Africa it occurs at altitudes of 1000 to over 2700 m while in Central Africa it is the predominant

Wszemborzer pests across all altitudes; in West Africa, it is only common on sorghum in the dry-hot zones.

Geographical Distribution of the African maize stalk borer in Africa (red marked)

Introduction

Busseola fusca **is indigenous to Africa. Its distribution and pest status varies with the region. In East and southern Africa it is a pest at higher altitudes (above 600 m), but in Central Africa it**

occurs from sea level to over 2000 m, while in West Africa it is primarily a pest of sorghum in the dry savannah zone.

Damage

Damage is caused by the caterpillars, which first feed on young leaves, but soon enter into the stems. During the early stage of crop growth, the caterpillars may kill the growing points of the plant, causing what is known as dead-heart (the youngest leaves can be easily pulled off).

At a later stage of growth, they make extensive tunnels inside the stem. This disrupts the flow of nutrients to the grain. Tunnelling weakens the stem so that it breaks and falls over. In older plants the

Stem damage on maize

first generation caterpillars bore in the main stem but later some of the second generation bore into the maize cobs. Caterpillars also tunnel into the peduncles of sorghum and millet inflorescences, and may seriously affect grain production.

Because they don't produce tillers, maize plants are less able to tolerate stem borer attack than sorghum and pearl millet plants and the effect on grain yields is therefore greater.

Colonisation of the plant by borers, severity of infestation and damage strongly depend on the cropping system and soil fertility, which affects the nutritional status of the plant. Stemborer damage is aggravated by the poor

stalk by African maize stalk borer

© Anne Bruntse, BioVision

nutritional status of the plant.

Studies on several stemborers in Africa showed that an increase in nitrogen is related to higher pest loads and tunnel damage. However, soil nutrient levels, such as nitrogen, greatly influenced the plant's tolerance to stemborer attack as well. This is due to an increase in plant vigour, which is reflected in lower yield losses (Setamu et al., 1995).

Damage caused by stemborers can average 20 to 40%, which means between 2 to 4 bags of maize are lost out of every 10 that could be harvested.

Stalkborer larvae (about 8 mm) feeding inside maize stem. Notice brown frass deposits.

Grains damaged by pests such as stemborers become susceptible to infection by mouldy fungi such as *Aspergillus* - see photo on the right side - which produce aflatoxin, a toxic by-product extremely poisonous to people and which can lead to liver cancer.

Maize cobs damaged by the African maize stalk borer (*Busseola*

***fusca*). Note caterpillar and secondary infection by moulds**

© Stemborer team, icipe

Host Range:

The main hosts of the African stalkborer are maize and sorghum. This stemborer is also a pest of pearl millet in Mali, Burkina and Eritrea. It also attacks few grass species, wild sorghum species mainly, but it is rarely found in natural habitats.

Symptoms:

Young plants show small holes and 'window-panes' in the leaf whorls where tissues have been eaten away. Small dark caterpillars may be seen in the funnel. In severe attacks the central leaves die,

forming the characteristic dry, withered 'dead-heart'.
Whole plant: dead heart; plant dead; dieback; internal feeding; frass visible. Older caterpillars tunnel in stems, and eat out long frass-filled galleries, which weaken stems and cause breakages.

Early warning signs in maize: Small holes in straight lines on the youngest leaves.

Affected Plant Stages

Flowering stage and vegetative growing stage.

Affected Plant Parts

Growing points, inflorescence, leaves, seeds, grain, ear/ head, stems.

Symptoms by affected plant part

Growing points: internal feeding; boring; external feeding; dead

heart; frass visible.
Inflorescence: abnormal colour; internal feeding; frass visible.
Leaves: external feeding; frass visible.
Seeds: frass visible; empty grains.
Stems: abnormal growth; internal feeding; dead-heart; visible frass.
Whole plant: dead heart; plant dead; dieback; internal feeding; frass visible.

Biology and Ecology of the African Maize Stalk Borer

Eggs of the African maize

Eggs are round, flattened and about one mm in diameter. They are usually laid in batches of 30 to 100 under leaf sheaths in a long column stretching up the stem, and may slightly compressed by pressure from the growing stem. They are white when first laid but darken as they age. Eggs hatch in

stalkborer (*Busseola fusca*). about 7 to 10 days.

© Stemborer team, icipe

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

© D. Cugala, Stemborer team, icipe

Caterpillars are light or dark violet to pinkish white in colour, often with a distinctive grey tinge. They lack conspicuous hairs and look smooth and shiny, but have rows of small black spots along the body. On hatching caterpillars are blackish. They crawl up the plant into the funnel where they feed on leaves for two to three days and then either move to other plants or enter inside the maize stem.

After the caterpillars bore into the maize stems, they feed and grow within the stems for 2 to 3 weeks. They grow to a length of about

40 mm. When fully grown, they cut a hole in the side of the stem before pupating within the tunnel inside the maize stem.

The total larval period is usually 35 days when conditions are favourable during the growing season, but during dry and/or cold weather caterpillars enter into a resting period (diapause) of six months or more in stems, stubble and other plant residues. With the beginning of the rains, the caterpillars pupate within the stems.

Pupae are shiny yellow-brown to dark brown and about 25 mm long. After 7 to14 days the adults emerge from the pupae and come out of the stem.

The adults have a wingspan of about 25 to 35 mm. Females are generally larger than males. The forewings are light to dark brown with darker markings and the hindwings are white

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

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© B. Le Ru, icipe

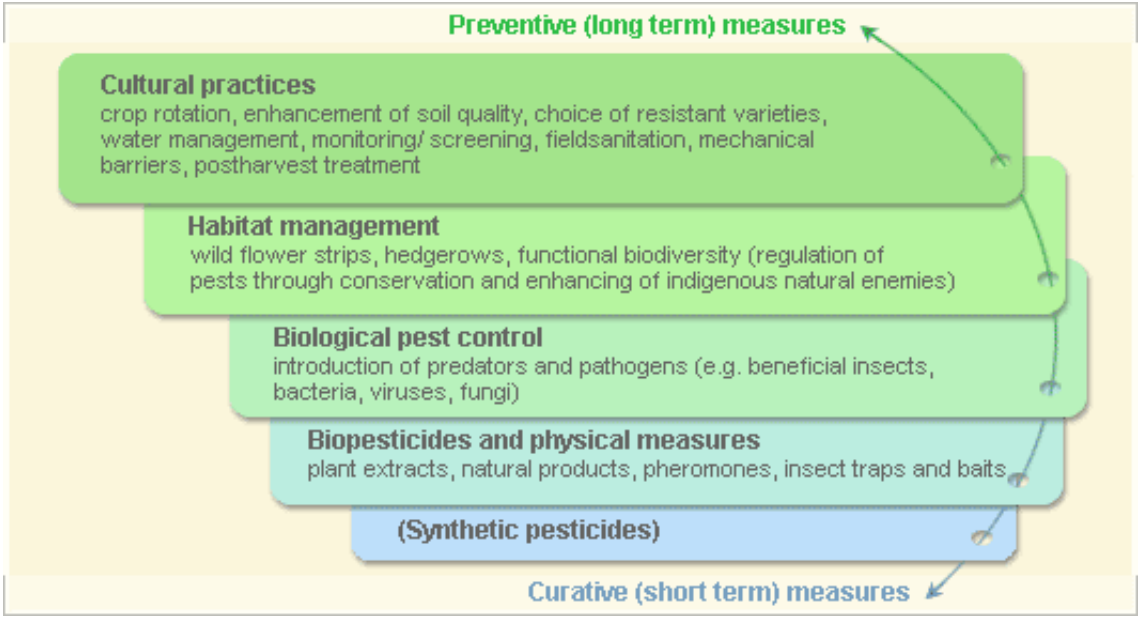
to greyish-brown. There is much seasonal and geographic variation with darker coloration developing in cold wet conditions.

Adult moths of stemborers are seldom seen in fields, as they are inactive during daytime. They become active after sunset and lay their eggs during the night.

They have several generations in a year, so their numbers increase towards the end of the season.

Pest and disease Management

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



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effect should be used in emergencies only. On infonet we do not promote synthethic pesticides.

Further below you find concrete preventive and curative methods against African maize stalkborer.

Cultural practices

Monitoring

Scouting and early control is essential for effective management of stemborers. Check the crop regularly. First signs of stalkborer attack are small holes or 'window panes' in straight lines across the newest leaves of maize or sorghum.

Field sanitation

Destroy crop residues. This is important to kill the pupae left in old stems and stubble and prevent carry-over populations, and so limit initial establishment of the pest on the following season's crops.

Plough and harrow. These practices help reduce borer populations by burying them deeply into the soil or by breaking the stems and exposing the caterpillars to natural enemies and to adverse weather conditions.

Slashing maize and sorghum stubble, complemented with cultivation by disking and ploughing can reduce larval populations by almost 100% (Kfir et al, 2002).
Burning crop residues is an effective way of killing stemborer caterpillars, but can create problems in farms where the organic content of soils is low and soil erosion is severe, since in many cases crop residues are the only organic matter added into soils. Alternative ways to destroy diapausing caterpillars without destroying the stems are needed in areas where stems of cereals are used as building and fencing materials, fuel, bedding for livestock, or as stakes. In this case, partial burning is recommended, while the leaves are dry but the stalks are not. Heat

generated from the burning leaves kills up to 95% of stemborer caterpillars within the stems, and at the same time cures the stalks, improving their quality as building materials and making them more resistant to termite attack.

Using crop residues for fodder and silage has also been recommended (CABI, 2000; Kfir et al, 2002).

Destruction of wild sorghum, which would act as alternative hosts, may help to reduce population upsurge.

For these cultural measures to be effective, the cooperation of farmers in a region is required because moths emerging from untreated fields can infest adjacent crops.

Improvement of soil fertility

Maintaining soil fertility or applying practices that increase nitrogen

use efficiency in maize production are important for management of the African stalkborer. Thus, in studies in Cameroon, soil application of nitrogen improved the nutritional status of maize, which consequently enhanced its tolerance to the African maize stemborer attack (Chabi-Olaye et al; submitted). However, if nitrogen is applied at rates greater than required for maximum yield, plant biomass increases at expenses of yield.

Technologies to restore soil fertility include cereal-legume rotations, use of farmyard manure and green manure cover crops, among others. Legume cultivation and rotation are highly efficient in improving the supply of nitrogen in the soil.

Crop rotation

Maize-legume rotation sequences improve the supply of nitrogen in the soil and the nutritional status of maize, which compared to maize-maize sequences. This influences the maize susceptibility to

pests and diseases.

The use of short duration fallows with leguminous cover crops and grain legumes have been useful in reducing yield losses due to borers in the subsequent crop. Rotation with grain legumes (cowpea and soybean) or leguminous cover crop (pigeon pea and mucuna *Mucuna pririens*) improved the supply of nitrogen in the soil and enhanced the yield of subsequent maize crop in the humid forest of Cameroon.

An improved nutritional status of the plant led to an increase in attacks by the African stalkborer at the early stages of the plant growth, but also improved plant vigour, resulting finally in a net benefit for the plant and grain yield (Chabby-Olaye et al., 2005).

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.

Maize intercropped with non-host crops (e.g. cassava and grain legumes) have significantly lower stemborer damage and higher yield that monocrop maize. The effect is variable, if the crop to be protected is not planted after the companion crops. In studies in Cameroon, maize monocrops had 3 to 9 times more stems tunnelled and 1 to 3 times more cob damage than maize intercropped with non-host crops cowpea, cassava and soybean, which resulted in a higher yield in the intercropped maize.

In the mixed cropping system maize was planted 12 to 14 days after the non-host plants. Two plant arrangements were used:

1. One maize plant was followed by a non-host plant and 2. Strip planting in which two rows of maize were maize followed two rows of a non-host crop, with one row of non-host plants as borders.

Maize yield losses due to stemborers were about 2 to 3 times higher in monocrops than in intercrops. In addition land-

productivity was higher than with monocrop. The maize-cassava crop was the most effective in terms of land use and the most productive compared to pure maize stand with pesticide application. The net production of mixed cropping systems was economically superior to controlling stemborers with insecticide in monocropped maize (Chabi-Olaye et al, 2005; Chabi-Olaye et al, 2006).

Studies in Kenya suggest that intercropping maize and/or sorghum with cowpeas may reduce damage caused by the African stalkborer (Amoako-Atta and Omolo, 1983; Reddy and Masyanga, 1988). Trials in Eritrea showed that sorghum intercropped with haricot beans, cowpea, desmodium and Dolichos lablab had much lower deadheart damage compared to pure stand sorghum (icipe, 2005).

'Push-Pull Strategy'

Push-Pull is a simple cropping strategy, whereby farmers use

Napier grass and *Desmodium* legume (silverleaf and greenleaf *Desmodium*) as intercrops. For a more detailed description on push-pull click here

Farmer practices

Application of baits at first signs of stalkborer attack (small holes in straight lines across the newest leaves of maize or sorghum), one pinch per affected plant applied inside the funnel of maize plants. Examples of bait: Pymack (byproduct of pyrethrum production sold as cattle feed in Kenya) provides some control, maize flour or bran mixed with pyrethrum extract reportedly provides good control. Scouting and early control is essential for this method to have any effect.
Caution: Application of too much bait inside maize and sorghum funnels can kill the growing point - a pinch of bait per plant is enough.

Biological pest control

Natural enemies

Many natural enemies of the African stalk borer have been recorded in Africa. The most important are predatory ants, parasitic wasps and parasitic flies. Parasitic wasps may attack eggs (e.g. *Trichogramma* spp. and *Telenomus* spp.) or caterpillars ((e.g. *Bracon* spp and *Cotesia sesamiae*). Tachinid flies parasitise caterpillars. *Cotesia sesamiae* is the most common larval parasitoid (attack caterpillars) of this stemborer on maize in eastern Africa. For more information on natural enemies click here.

Biopesticides and physical methods

Neem

Simple neem products are reported to be effective for control of stemborers, including the African maize 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 be 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. Neem powder should be always applied as a mixture with inert materials (sawdust, rice hulls or dry fine clay), as the powder alone can be phytotoxic (harm the plants) owing to its oil content (Dreyer, 1986).

In studies in Tanzania, aqueous seed extracts combined with extracted ground neem seeds and sawdust, applied twice to the whorl of corn leaves was as effective in controlling the African stalkborer as endosulfan. The extract was prepared by soaking

120g of neem seeds and 120 g of sawdust in three litre of water for 12 hours. The mixture was filtered and the residue and the aqueous extract were then applied separately to the maize plants (Hellpap, C., 1995). For more information on neem click here.

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Contact links

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

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Bagrada bug

Bagrada bug
Scientific name: *Bagrada cruciferarum, Bagrada hilaris*
Family: Hemiptera: Pentatomidae
Type: pest (insect/mite)
Common names: Bagrada bug, harlequin bug, painted bug, stinkbug
Host plants: Cabbage/Kale, Brassicas Rape, Chinese cabbage, Turnips

General Information on Pest and Damage

Geographical distribution

The bagrada bug (*Bagrada hilaris* is found throughout East and Southern Africa, Egypt, Zaire and Senegal. (*Bagrada cruciferarum*) has been reported in East an Southern Africa. It is a major cabbage pest in Botswana, Malawi, Zambia and Zimbabwe.

Geographical Distribution of Bagrada bug in Africa (red marked)

Damage

Bagrada bugs damage plants by feeding on young leaves. Both adults and nymphs suck sap from leaves, which may wilt and later dry. Considerable damage is caused to young plants, which may die or have the growth points severely damaged. Significant damage may also be caused to older plants.

Damage caused by the bagrada bug on cabbage

© B. Loehr, icipe

Bagrada bugs are major pests of cultivated crucifers. Severe infestations on cabbage result in stunted plants, leaves turning

yellow with a rough texture, and death of the growing point. As a result, damaged plants do not produce heads or produce two or more small unmarketable heads instead of a large central head.

Symptoms

The bugs, especially in the early stages of development, gather in masses and suck the sap from plants. Feeding by the bugs causes small puncture marks visible as white patches starting on the edges of leaves. Eventually the leaves wilt and dry. Heavily attacked plants may have a scorched appearance.

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

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Host range

The bagrada bug is a common stinkbug on cabbage, kale, rape, Chinese cabbage, turnips and other crucifers such as radish. It also attacks potatoes, beetroot, papaya, maize, sorghum and pearl millet, legumes and cotton. It has also been recorded as an occasional pest on groundnuts, wheat, and rooibos tea. The bagrada bug has also been reported as a pest of capper (*Capparis spinosa*) (Colazza et al. 2004).

Biology and Ecology of the Bagrada Bug

The bagrada bug lays its eggs in clusters on leaves or on the soil underneath host

plants. Eggs are barrel shaped, initially white and turn orange with age. A single female can lay as many as 100 eggs within 2 to 3 weeks. The incubation period is 5 to 8 days.

Eggs of the bagrada bug (much enlarged)

Nymphs pass through five stages changing colour from bright orange to red with dark markings, gradually acquiring the colouration of the adult. Initially they do not have wings; wings are gradually developed as the nymphs grow. Wing pads are visible in the last instar

nymph.

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

Third instar nymph of the bagrada bug.

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Late instar nymph of the bagrada bug.

© F. Haas, icipe

The adult bug is typically shield-shaped, 5 to 7 mm long and 3 to 4 mm broad at its widest area. The upper surface has a mixture of black, white and orange markings, which gives the insect its common

names harlequin bug or painted bug.

The life cycle lasts 3 to 4 weeks and several generations may occur in a year.

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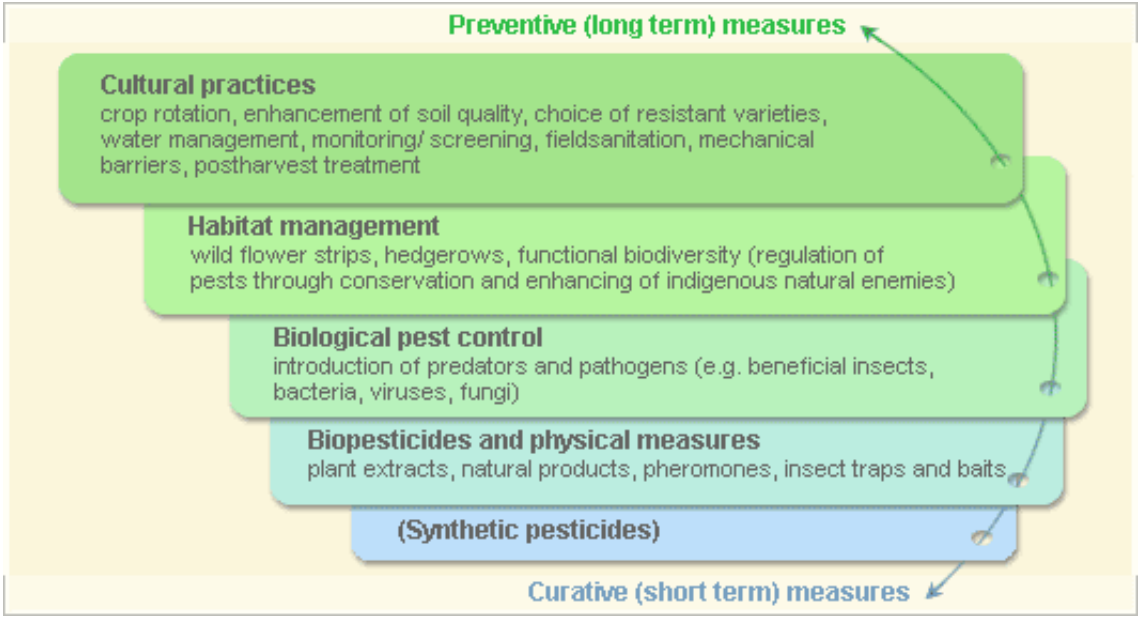
Pest and disease Management

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



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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 Bagrada bug.

Cultural practices

Monitoring

Regular monitoring of the crop is important to detect bagrada bugd before they cause damage to the crop.

Research in Namibia has shown that control measurements should start if the number of bugs/m² in the early growing stage exceeds one. If the crop is past the early growing stage, a higher threshold level of three bugs/m² can be maintained (Keizer and Zuurbier). However, note that these thresholds are given as examples. Economic thresholds depend on many factors (crop stage, crop age, and socio-economic and climatic conditions) and cannot be

adopted without taking into consideration local conditions.

Sanitation

Crop hygiene, in particular removal of old crops and destruction of weeds of the family Cruciferae prevents population build-up.

Hand picking

Handpicking and destruction of the bugs helps to reduce damage. This is particularly important in the early stages of the crop.

Cultivation

Eggs laid in the soil are readily killed by cultivation, so frequent light cultivation (once or twice a week) of the vegetable beds will help in controlling this pest (Keizer and Zuurbier; Horticultural Research Program, Botswana).

Irrigation

Watering and overhead irrigation disturb bugs discouraging them from feeding on the crop. However, note that use of sprinkler irrigation may lead to increase of diseases such as black rot and downy mildew.

Mixed cropping

Growing strong smelling plants such as garlic, onion or parsley near the crop are reported to reduce infestations (Dobson et al, 2002).

Biological pest control

Natural enemies

Eggs of Bagrada bugs are parasitised by tiny wasps. Bugs are parasitised by flies (e.g. *Alophora* sp.).

Biopesticides and physical methods

Plant extracts

A mixture of chilli, soap, garlic and paraffin has shown to be an effective control method in trials in Namibia (Keizer and Zuurbier).

Natural products

In Namibia there are reports that sprinkling the plants with crushed Bagrada bugs repels other bugs. This can be used effectively in combination with frequent soil cultivation (Keizer and Zuurbier).

Soap solution

Spraying plants with a soapy solution (bar soap) has been found effective against Bagrada bugs. It helps to wash off young bugs (Dobson et al, 2002; Elwell and Maas, 1995).

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Turnip Mosaic Virus (TuMV)

Turnip Mosaic Virus (TuMV)
Family: Potyviridae: Potyvirus
Type: disease (viral)

Common names: cabbage A virus mosaic / Cabbage black-ringspot virus
Host plants: Cabbage/Kale, Brassicas Crucifers (Black mustard, cauliflower, broccoli, radish) / Beets / Tobacco

General Information on Disease and Damage

Geographical distribution

Geographical

Distribution of the Turnip Mosaic Virus in Africa *(red marked)*

Damage

Infested plants are stunted, with leaves coarsely mottled and distorted. Black spots develop on leaves which prematurely drop. Early infection of cabbage by this virus in the seedbed or soon after transplanting, can reduce yield by 75%, whereas late-season infection has little or no effect on yield. It also reduces seed yield.

Host range

Turnip mosaic virus (TuMV) has a very wide host range infecting at least 318 species in 156 genera of 43 families. TuMV infects most cruciferous plants, but is most damaging in Chinese cabbage, turnip, mustard, and radish. It also attacks beets, spinach and

tobacco.

Symptoms

On cabbage: Mosaic, black speckling or stippling of cabbage heads at harvest or during storage can be caused by the TuMV or the cauliflower mosaic virus occurring singly or together. The latter causes lumpy or warty growths on the veins on the undersurface of leaves and vein clearing. In stored cabbage, black sunken spots develop on leaves throughout the head. The spots are considerably larger than those caused by cauliflower mosaic virus. Its mode of transmission is similar to TuMV (i.e. aphids and mechanically). However, cauliflower mosaic virus has a restricted host range. It is infectious only to members of the cabbage family (brassicas).

Affected plant stages

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

Affected plant parts

Leaves, seeds, stems and whole plant.

Symptoms by affected plant part

Leaves: lesions; abnormal colours; abnormal patterns; abnormal forms; yellowed or dead.
Seeds: empty grains; lesions.
Stems: external discoloration; abnormal growth; dieback.
Whole plant: plant dead; dieback; dwarfing; early senescence.

Biology and Ecology of the Turnip Mosaic Virus

Transmission

TuMV is transmitted by aphids notably green peach aphid (*Myzus pericae*) and cabbage aphid (*Brevicoryne brassicae*) and is readily transmitted mechanically. The virus is transmitted by aphids in a non-persistent manner (short virus transmission period of 10 to 30

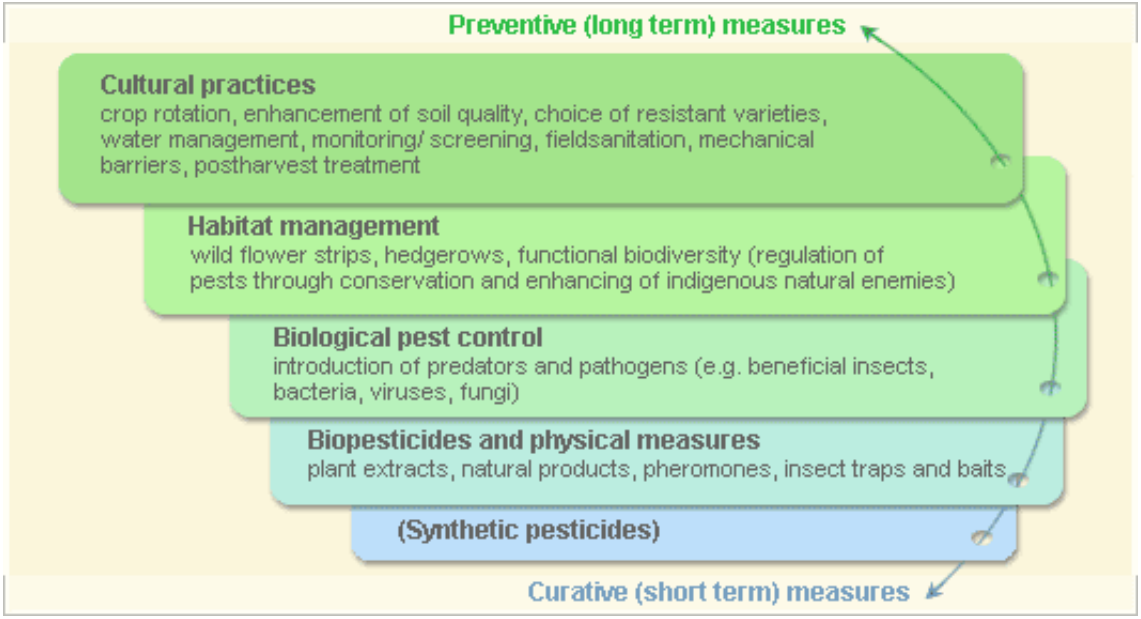
seconds) with no latent period (the time from start of an acquisition feeding until the vector can infect healthy plants with the virus). It can be acquired in less than one minute and can be inoculated in less than a minute. The transfer of viruses by aphids usually occurs over short distances (up to a few hundred metres), particularly down-wind and involves migrating alates (winged aphids). Weather conditions and temperature influence aphid activity and migration patterns which in turn affect dissemination of TuMV. Dry and warm conditions favour aphid reproduction and dissemination and hence early and increased spread of the virus. Cool, wet and windy conditions reduce the reproduction and movement of aphids and hence spread of the virus.
Once primary infections are established in fields, TuMV may spread relatively rapidly from plant to plant if aphids are not controlled. Seed transmission of the virus has not been observed.

Sources of Infection

Primary sources of TuMV infection are diseased host plants and weeds. Vectors can be introduced into field crops with infected transplants. Transplants can become infected during propagation in nursery beds. It is not seed transmitted.

Pest and Disease Management

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



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emergencies only. On infonet we do not promote synthethic pesticides.

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

Cultural practices

Control of Turnip Mosaic Virus is quite difficult due to the very wide host range of the virus, the ineffectiveness of insecticides in controlling the spread of non-persistently transmitted viruses, and the lack of immune crop cultivars.

Control options

Locate seedbeds away from weedy fields. Weeds and volunteer plants should be eliminated from seedbed areas and preferably from production fields. It may be helpful to discard plants from outside rows in seedbeds.

Hygiene

A very common method of transferring the virus from plant to plant is on contaminated hands and tools. When transplanting seedlings, wash your hands frequently and thoroughly with soap and water. Field equipment should be used in new fields first and then in older fields. Never attempt to transplant a healthy plant into the soil from which a diseased plant was removed. Roots from diseased plants will remain in the soil and provide the virus source for the new transplant. Field sanitation, particularly, weed control is very important since the virus can infect many weed species.

Resistant cultivars

In areas where Turnip Mosaic Virus is serious and endemic, growing of Danish cabbage varieties should be considered. These varieties have been reported to have some resistance to TuMV (Sherf and Macnab, 1986).

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Black rot

Black rot
Scientific name: *Xanthomonas campestris pv. campestris*
Family: Xanthomonadales: Xanthomonadaceae
Type: disease (bacterial)
Host plants: Cabbage/Kale, Brassicas Sweet potato mustard / radish

General Information on Disease and Damage

Geographical distribution

The pathogen that causes black rot is widely distributed in Africa, Asia, Australia and Oceania, Europe, North America, Central

America, the West Indies and South America. Black rot is endemic in Africa. It is the most important disease of brassicas in Kenya, Zimbabwe and Zambia (CABI, 2005).

Geographical Distribution of Black rot in Africa (red marked)

Introduction

Black rot affects cabbage and related crops (brassicas, mustard & radish) worldwide and is caused by the bacterium *Xanthomonas campestris* pv. *campestris*. Black rot is one of the most serious cabbage / kale diseases in warm climates. Diseased plants may rot

quickly before or after harvest because of secondary infection from bacterial soft-rot.

Soft-rot bacteria may invade heads of black-rot-infected plants, causing tissue to become slimy and foul-smelling. The black rot bacterium can over-season on infected cabbage seeds, in weeds belonging to the Brassica family (including: black mustard, field mustard, wild turnip, wild radish, shepherd's purse, and pepper weed); or in infected plant material in the soil. The bacterium can persist in plant residue for 1-2 years or as long as the plant debris remains intact.

Damage

In Kenya, black rot is endemic and the cause of much damage (Onsando, 1988, 1992). The disease is considered of intermediate economic importance in Mozambique (Plumb-Dhindsa and Mondjane, 1984). Black rot is widespread in Zimbabwe where it is considered the most important disease of brassicas (Mguni, 1987,

1995).

Host range

Black rot is a pathogen of most cultivated cruciferous plants and weeds. Cauliflower and cabbage are the most readily affected hosts in the crucifers, although kale is almost equally susceptible. Broccoliand Brussels sprouts have intermediate resistance and radish is quite resistant, but not to all strains. Kohlrabi, Chinese cabbage, rutabaga, turnip, collard, rape, jointed charlock (*Raphanus raphanistrum*) and mustard are also susceptible hosts.

Symptoms on cabbage

The plant can be infected at any time during its life cycle. On young seedlings a yellowing appears along the margin of the cotyledons, which later shrivels and drops off. On the margins of mature leaves, similar yellowing appears. Initially, a small V-shaped area develops, but as the diseased area enlarges, the veins become

distinctly black. In contrast to *Fusarium* yellows the veins are brownish in colour. The affected stem, when cut crosswise, shows a characteristic black ring. In later stages the entire head may turn black and soft due to secondary infection by soft rot bacteria (*Erwinia carotovora* var.*carotovora*).

Bacterial black rot. Note

blackening of water-conducting tissues of the stem

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

© A.A. Seif, icipe

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

Affected plant stages

Seedling stage, vegetative growing stage and heading stage (cabbages).

Affected plant parts

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

Symptoms by affected plant part

Leaves: 'V' shaped lesions
Seeds: discolorations; lesions.
Stems: Internal discoloration (black in colour) .
Vegetative organs: internal discoloration (black in colour); dry rot.
Whole plant: plant death

Biology and Ecology of Black Rot

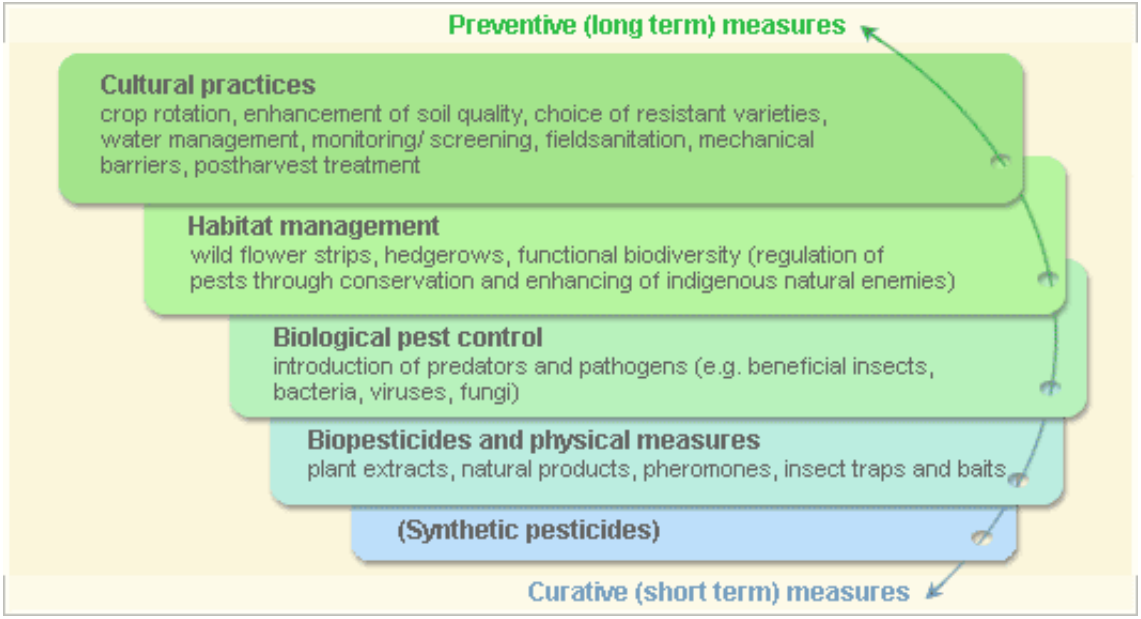
Source of infection and spread

The bacteria survive in infected seed, in debris from diseased plants left in the field and in infested soil. Seed-borne bacteria can be disseminated long distances. Many cruciferous weeds can harbour the black-rot bacteria. In a new field, black rot is usually introduced via infected seed or diseased transplants.

Further spread is facilitated by water-splash, running water, and handling infected plants. The bacteria enter the plant mainly through water pores at the edges of leaves. They can also enter through the root system and wounds made by chewing insects. They then move through the water vessels to the stem and the head. Black rot is favoured by warm (26-30°C) wet conditions.

Pest and disease management

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



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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 Black rot.

Cultural practices

Control options

- **Use certified disease-free seed.**
- **Establish crops in seedbeds in black rot-free soils that have not grown crops from the family Crucifers for at least 3 years.**
- **Seedlings should not be crowded in the nursery.**
- **Transplants should not be dipped in water before transplanting.**
- **Mulching of the field crop, where practicable, is highly recommended.**
- **Black rot is usually most severe in wet, poorly-drained soils**
- **Avoid overhead irrigation.**
- **Field operations during wet weather should be discouraged.**

- **Keep the field free of weeds, particularly of the crucifer family.**
- **Growing cabbage on raised beds helps eliminate conditions that induce black rot.**
- **When possible, remove, burn, or plough down all crop debris immediately after harvest to reduce the amount of bacteria in the soil**
- **A crop rotation based on at least a 2-year break in cruciferous crops is advocated.**
- **Use of resistant/tolerant varieties, where commercially available, provides the most effective control of the disease.**

Hot water seed treatment

For information on hot water seed treatment click here.

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Cabbage webworm

Cabbage webworm
Scientific name: *Hellula undalis*
Family: Lepidoptera: Pyralida
Type: pest (insect/mite)
Common names: cabbage centre worm, cabbage borer
Host plants: Cabbage/Kale, Brassicas

General Information on Pest and Damage

Geographical distribution

The cabbage webworm *(Hellula undalis)* is an important pest of brassicas in many parts of

Geographical Distribution of the Cabbage webworm in Africa (red marked)

the world. In Africa, it occurs in Eastern and Southern Africa region. In Malawi and Mozambique, it is considered a major pest.

Damage

Young caterpillars mine the leaves while older caterpillars feed on the

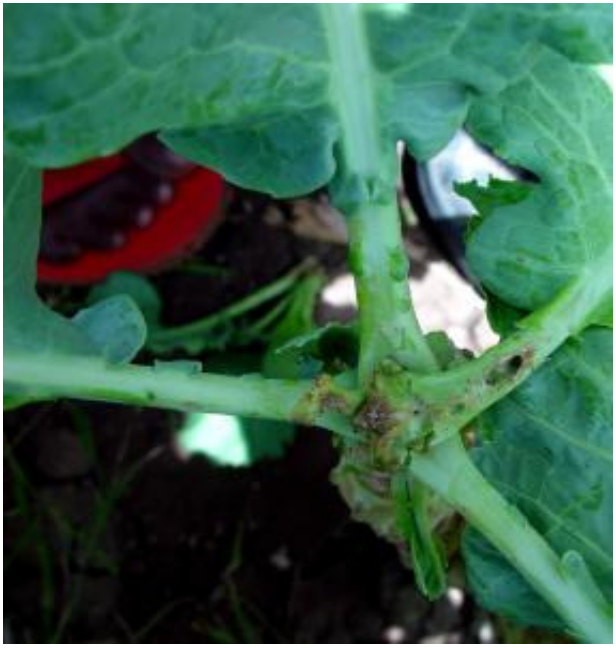
underside of rolled leaves within spun webs. Mature caterpillars (last instars) feed on leaves as well as stems and growing points. They are often hidden behind a web of silk and masses of frass (insect faeces). These are usually the first signs noticed.

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

Caterpillars feeding on young plants frequently causes death of the plants,

especially when the larvae feed on the growing point. In older cabbage plants, new shoots are produced and the attacked plants produce several small heads of little commercial value. Caterpillar feeding after heading may cause head stunting. In addition, insect feeding and the presence of caterpillars and/or their excrement reduce the market value of the produce. On kale, young caterpillars mine in the leaves and older caterpillars bore into the stem of the plants. Frass accumulated at the entrance of the tunnel along the stems is an indication of damage.

Damage by the cabbage webworm as stemborer on a kale plant



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

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Host range

Principal host plants are cabbage, Kale and all other brassica crops (cauliflower, kohlrabi, broccoli etc). Cauliflowers appear to be the preferred food plant of the cabbage webworm. It is also found feeding on radish.

Symptoms

Young caterpillars mine leaves, bore stems and feed externally on the leaves; they then often penetrate the heart of the plant destroying the terminal bud, and prevent heading. While feeding they spin a silken tube. Plants wilt, and frass is exuded from the affected plant parts.

Affected plant stages

Flowering stage and vegetative growing stage.

Affected plant parts

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

Symptoms by affected plant part

Growing points: external feeding.
Inflorescence: wilt.
Leaves: external feeding; internal feeding; webbing.
Stems: internal feeding.
Whole plant: dead heart; wilt.

Biology and Ecology of the Cabbage Webworm

The eggs are small, oval and slightly flattened upon the plant surface. They are creamy white when freshly laid, become pinkish the next day and then turn brownish-red with the dark head of the caterpillar visible at one end just before hatching. The eggs are laid singly, or in groups or chains of 2 or 3 on the surface of leaves or on younger parts of the plant. At temperatures between 25 and 29°C, a single female moth lays as many as 150 eggs, which hatch in 4 to 5 days. In Hawaii, eggs hatch in 2 to 3 days at mean

temperatures

Caterpillars are creamy white with light pinkish brown stripes along the body and have a black head. Mature caterpillars have faint stripes. They measure 15 mm when fully grown. Duration of larval development varies between 6 to 18 days, depending on temperature and on the host crops. Thus, on cabbage larval development is completed in 16 to 19 days, but on cauliflower it may require

Cabbage webworm caterpillar (*Hellula undalis*) and damage on a kale leaf.

only 11 to 13 days.

The pupae are shining pale brown with a dark dorsal stripe. Pupation occurs in leaf tissue, in tunnels made by the feeding larvae inside the stem. Adults emerge in 7 to 8 days

Adult moths are greyish-brown in colour, small and rather delicate with a wingspan of approximately 1 cm. Each front wing has a black spot and zigzagging pale brown lines.

The adult moth is capable of flying long distances and occasionally migrates to

Moth of the cabbage webworm *(Hellula*

areas well outside its normal breeding range. Adult lifespan is about 4 to 8 days.

undalis)

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Cabbage webworm (*Hellula undalis*)

feeding on a cabbage head

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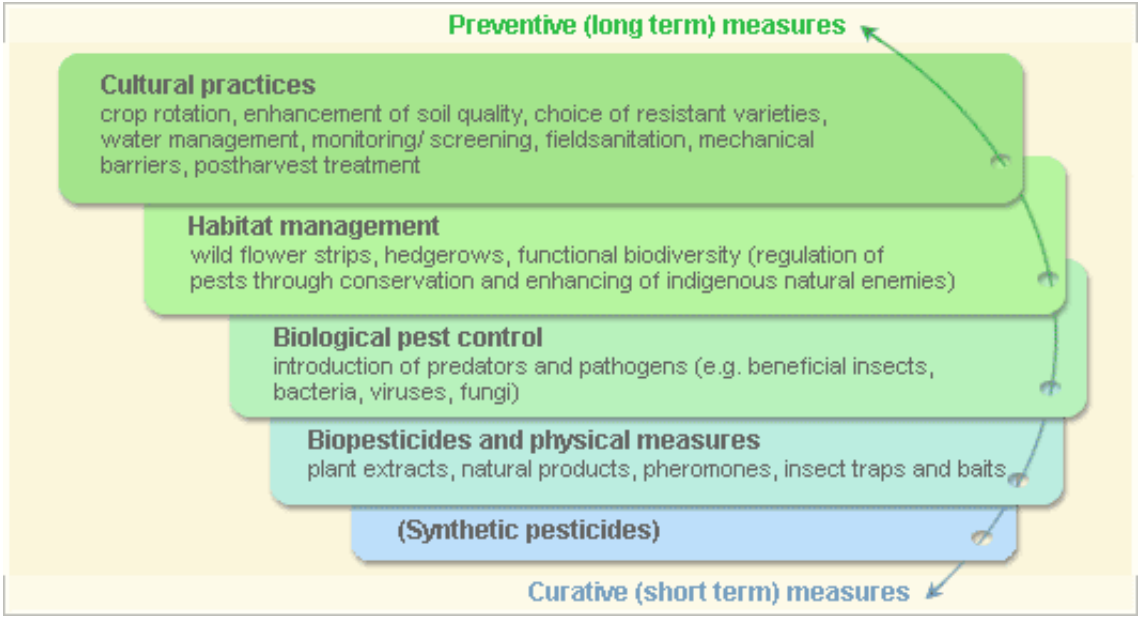
Caterpillar of the cabbage webworm *(Hellula undalis)* feeding in the stem of a kale plant.

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 Cabbage webworm.

Cultural practices

Monitoring

Regular monitoring of young plants in the nursery and after transplant is important. Inspect crops for the presence of caterpillars and damage symptoms.

Use clean planting materials: transplant only healthy, vigorous

insect-free seedlings.

Field sanitation

Uprooting and burning of cabbage and kale stalks and crop rotation are important to reduce field populations.

Biological pest control

Natural enemies

Natural enemies of the cabbage webworm include parasitic wasps (such as braconid, ichneumonid and chalcidoid wasps).

Conservation of these natural enemies is important. Care should be taken when deciding on options to manage this or other cabbage pests. The cabbage webworm frequently occurs in the same areas where aphids and diamondback moths are major pests. This may complicate the control of cabbage webworm, since pesticides used

to control aphids, and other pests, may kill natural enemies of the cabbage webworm resulting in outbreaks of this pest.

For more information on natural enemies click here.

Biopesticides and physical methods

Bt (Bacillus thuringiensis)

***Bacillus thuringiensis* var. *aizawai* and *Bt* var. *kurstakiare* very effective in controlling infestations of the cabbage webworm. *Bt* var. *kurstakiis* widely used at a weekly interval and a rate of 0.5/ha. This type of strategy provides effective control of the cabbage webworm. However, continuous use of Bt can induce development of resistance.**

It is important to start control measures early when caterpillars are still young and have not yet penetrated plant tissue.

Bt is a naturally occurring soil bacterium that causes disease on

insect pests. It is accepted as an alternative in organic farming and is considered ideal for pest management because it is host specific and is non-toxic on natural enemies and on humans.

Bt is commercially available in most agricultural suppliers. It is sold in various formulations (spray, dust, and granule) and strains (*Bt tenebrionis, Bt kurstaki, Bt israelensis, Bt aizawai, Bt san diego*).

Products: Bt products in Kenya are sold under the following commercial names: Dipel, Javelin, Thuricide and Xentari. They kill the cabbage webworm and do not harm beneficial insects.

Application: Bt insecticides should be applied when the first L1-larvae are appearing. Sprays may need to be applied at intervals of 5 to 7 days when populations are high. Because Bt insecticides are UV-degraded treat crops in the late afternoon.

For more information on Bt click here.

Spinosad

Spinosad, a broad-spectrum insecticide derived from fermentation of the naturally occurring soil bacterium Saccharpolyspora spinosa, controls many caterpillars, leafmining flies, and thrips. It is useful for the management of caterpillar pests in brassicas, including the diamondback moth, the cabbage looper and the cabbage webworm. Spinosad has low activity against most beneficial insects.

Farmer experiences - homemade biopesticides

Farmers in some countries produce their own homemade biopesticides by collecting diseased diamondback moth larvae (fat and white or yellowish or with fluffy mould on them), crushing them and mixing them with water in a blender. Large tissue clumps are

filtered out and the liquid is sprayed onto the crop (Dobson et al, 2002).

Neem

Botanicals, especially neem-based insecticides give good control of the cabbage webworm. Weekly applications of simple neem products afforded good control in Togo (Ostermann and Dreyer, 1995). It is important to start control measures early when caterpillars are still young and before they have penetrated plant tissue.

For more information on Neem click here.

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Downy mildew

Downy mildew
Scientific name: *Albugo* spp., *Bremia* spp., *Peronospora* spp., *Pseudoperonospora* spp.,
Family: Peronosporales: Peronosporaceae
Type: disease (fungal)
Host plants: Cabbage/Kale, Brassicas Cucumber Millet Onion Peas Pumpkin Soybean Spinach Zucchini/Courgette Grapes, hops

General Information on Disease and Damage

Geographical distribution

Geographical Distribution of Downy mildew in Africa (red marked)

Damage

Damage caused by downy mildews is usually associated with the sporulation of the fungus. Sporulation of

Peronospora destructor **can cause up to 55% reduction in the dry weight of onion leaves (Yarwood, 1941). The corresponding figures for *Pseudoperonospora humuli* on hops and *Peronospora farinose* on spinach were 17 and 48%, respectively. Losses from downy mildews can be considerable. It is estimated that in 1962 downy mildew of tobacco (*Perenospora tabacina*) reduced yields in Europe by at least 100,000 metric tons (Peyrot, 1962).**

Downy mildew on cabbage

© A.M. Varela, icipe

Symptoms

Plants can be infected at any time during their growing period. Symptoms of downy mildew infection include small, pale yellow spots with indefinite borders on the upper leaf surface. Purplish discoloration of the upper leaf surface is seen on some hosts. A downy growth (sporangiophores) may be seen directly under the spots on the underside of the leaf or on fruits or stems early in the morning or when foliage is wet. Young leaves and cotyledons may drop off when yellow. Thus, the disease can cause severe damage to seedlings in the seedbed. Older leaves usually remain attached, and affected areas enlarge, turning brown and papery. When the disease is severe, whole leaves die.

Affected plant stages

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

Affected plant parts

Leaves and whole plant.

Symptoms on affected plant part

Leaves: lesions; fungal growth.
Stems: fungal growth.
Flowers: fungal growth; flower abortion; flower drop.
Fruiting stage: fungal growth.

Biology and Ecology of Downy Mildew

Several different fungi cause downy mildew disease on vegetables, fruits, ornamentals, forages, field crops and blue mold of tobacco. These include *Albugo* spp. (on crucifers), *Bremia* spp. (on lettuce), *Peronospora* spp. (mildew on tobacco, spinach, soybeans, alfalfa, onion, many ornamentals), *Plasmopara* spp. (on grape and sunflower), *Pseudoperonospora* (on cucurbits), *Peronosclerospora* (on sorghum and corn), *Sclerospora* (on grasses, millet), and *Sclerophthora* (on maize, rice, wheat).

Downy mildew fungi are fairly host specific. The downy mildew fungus that infects one type of plant (e.g., rose) is not the same downy mildew fungus that infects another (e.g., grape). However, if you see downy mildew on one plant, then environmental conditions (i.e., cool, wet weather) are favourable for development of downy mildews on a wide range of plants.

Downy mildew of grape, spinach, and tobacco cause serious economic losses. It spreads rapidly through fields and is dependent on a wet, humid environment with cool or warm, but not hot, temperatures. A film of water is needed on plant tissue for spore germination and infection.

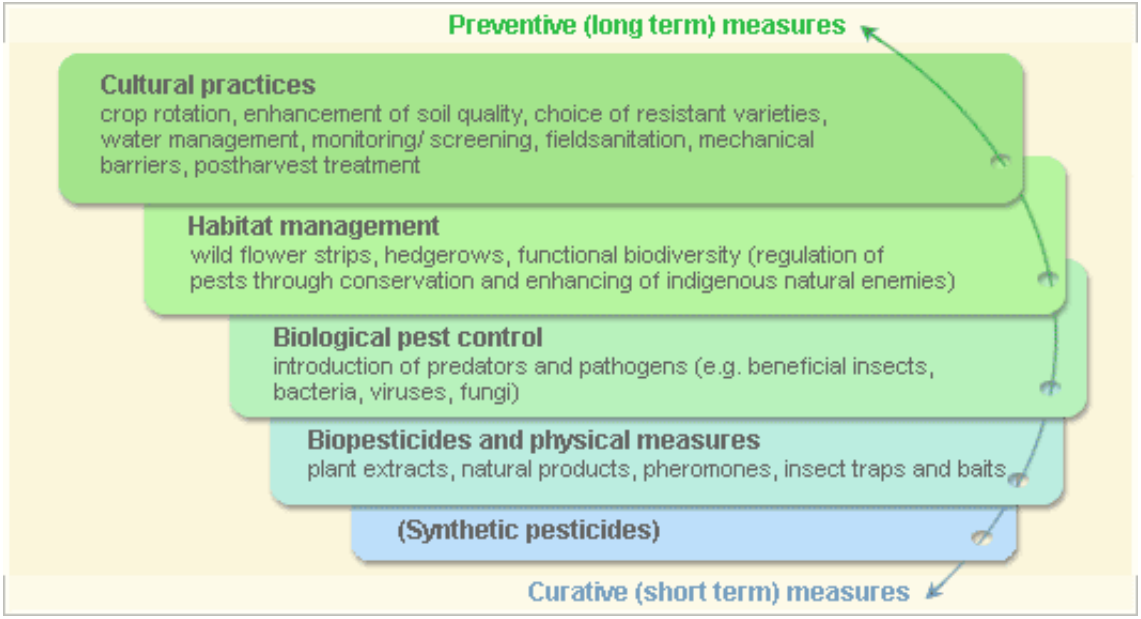
Conditions that favour development include:

- **Cool, moist weather conditions**
- **Host weeds found in between the crops**
- **Crop residues in the field**

- **Poor plant aeration**
- **Overcrowding (planting in high densities)**

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 Downy mildew.

Cultural practices

Prevention

1. Use resistant varieties where available
2. Use only certified diseased-free seeds for sowing. Transplant only healthy seedlings.
3. Ensure proper land preparation to make sure that your soil is well drained.
4. Provide adequate plant spacing to reduce the density of the canopy and minimize humidity.
5. Pruning of new growth also helps proper plant's aeration.
6. Remove infected plants and prune infected shoots.
7. Properly dispose of collected diseased-parts either by burning or

burying them.
8. Avoid overhead watering. It lengthens the duration of leaf wetness and favours further development of the disease.
9. Plough-under all the plant debris after harvest.
10. Practice crop rotation.

Control options

Control should be emphasised in nurseries since downy mildew is particularly damaging in the seedbed.

1. Seedbeds should have well-drained soils and be sited away from hedges and windbreaks. The site should not have been under susceptible crops for at least the previous 2 years.
2. Seedlings should not be excessively watered.
3. Weeds should be eradicated in and near seedbeds and out in the production fields.
4. Crop residues should be removed from the field after harvest.
5. Avoid sprinkler irrigation.

6. Thin plants to reduce plant density and increase air movement.
7. Time irrigations so that they do not elongate leaf wetness.
8. Alter planting dates to avoid periods of high disease pressure.

Biopesticides and physical methods

Copper

There are many copper compounds that are used as fungicides. The most common are derived from either copper hydroxide or copper oxychloride. These products are readily available in most third world countries and very reasonably priced. Copper products are still accepted in organic farming provided that the number of applications is strictly followed and a proper soil amendment is observed to prevent copper accumulation in the soil. For information on Copper click here.

Garlic bulb extract

For information on garlic bulb extract click here.

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Cabbage looper

Cabbage looper
Scientific name: *Trichoplusia ni*
Family: Lepidoptera: Noctuidae
Type: pest (insect/mite)
Common names: semi-looper, cabbage semilooper
Host plants: Cabbage/Kale, Brassicas Tomato

General Information on Pest and Damage

Geographical distribution

Geographical Distribution of the Cabbage looper in Africa (red marked)

Introduction

The cabbage looper is widely distributed in the tropics and subtropics. It is a serious pest of cruciferous crops, but it also attacks other important crops such as tomato, lettuce, potatoes, sweet potatoes, cotton, cucurbits, etc. The cabbage looper is

somewhat erratic in ocurrence, typically very abundant one year, and then scarce for two to three years.

Damage caused by cabbage looper on kales

© A. M. Varela

Damage

Caterpillars feed primarily on leaves and cause irregular holes.

Young caterpillars eat small holes, but older caterpillars feed on the tissue between the veins skelotinising the leaves (leaving only the midribs and veins) or giving them a ragged appearance. Plants can be severely defoliated and stunted, prodcing no heads or becoming unfit for consumption. They may also bore into the heads of lettuce and cabbage, contaminating them with frass. The presence of caterpillars and contamination of marketable plant parts will frass reduce the market value of the produce. Thus, large amounts of dark green pellets excreted by te feeding looper may stain cauliflower heads. The presence of cabbage looper caterpillars in broccoli heads renders them unmarketable.

Host range

The cabbage looper has a wide host range that includes crucifers, beans, cotton and various vegetable crops. It is listed as feeding on over 160 species of plants in 36 families, but cultivated crucifers are preferred.

Affected plant stages

Vegetative growing stage.

Affected plant parts

Leaves and whole plant.

Symptoms by affected plant part

Leaves: external feeding; internal feeding; webbing; frass visible; shredding.
Whole plant: plant dead; dieback; dwarfing; internal feeding; external feeding; frass visible.

Biology and Ecology of the Cabbage Looper

The eggs are round or slightly dome-shaped with ridges, and about the size of a pinhead. They are pearly or silvery white and darken

when they age. Eggs are laid singly usually on the undersides of leaves. A female moth can lay from 300 to 1600 eggs. Caterpillars hatch in 2 to 6 days after the eggs were laid.

The caterpillars go through five instars during development. very young caterpillars are white and almost clear with a black head capsule. Older caterpillars are green with a thin white line on each side just above the spiracles and two other white lines on the dorsum. Caterpillars have three pairs of legs near the head and three sets of prolegs (false legs) near its

Young cabbage looper feeding on a

rear. They move in a "looping" manner, arching the middle portion of the body as they move forward. Fully-grown caterpillars reach 3 to 4 cm in length.

kale leaf. Mature caterpillar reach 3 to 4 cm in length.

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Pupa. Caterpillars pupate in white loose cocoons attached to the underside of leaves, or in a folded webbed leaf or between two webbed leaves. The pupae are light green when young and gradually turn dark brown when mature. The moths are light green when young and

gradually turn dark brown when mature. The moths emerge from the pupae 10 to 16 days after pupation.

Pupa of the cabbage looper. During its last larval stage the caterpillar spins a cocoon.

© A. M. Varela, icipe

The adult is a mottle, greyish-brown moth, about 2.5 cm long and with a wingspan of 4 cm. The front wings have two small silvery spots, one small and round, the other U-shaped (resembling an '8'), near the middle part of the wing. The hindwings are pale

Moth of the cabbage looper. Real size: ca

brown. Cabbage looper moths are strong fliers and are primarily nocturnal. During the day the moths can be found resting in foliage or in crop debris.

2.5 cm in length, wingspan is ca. 4 cm

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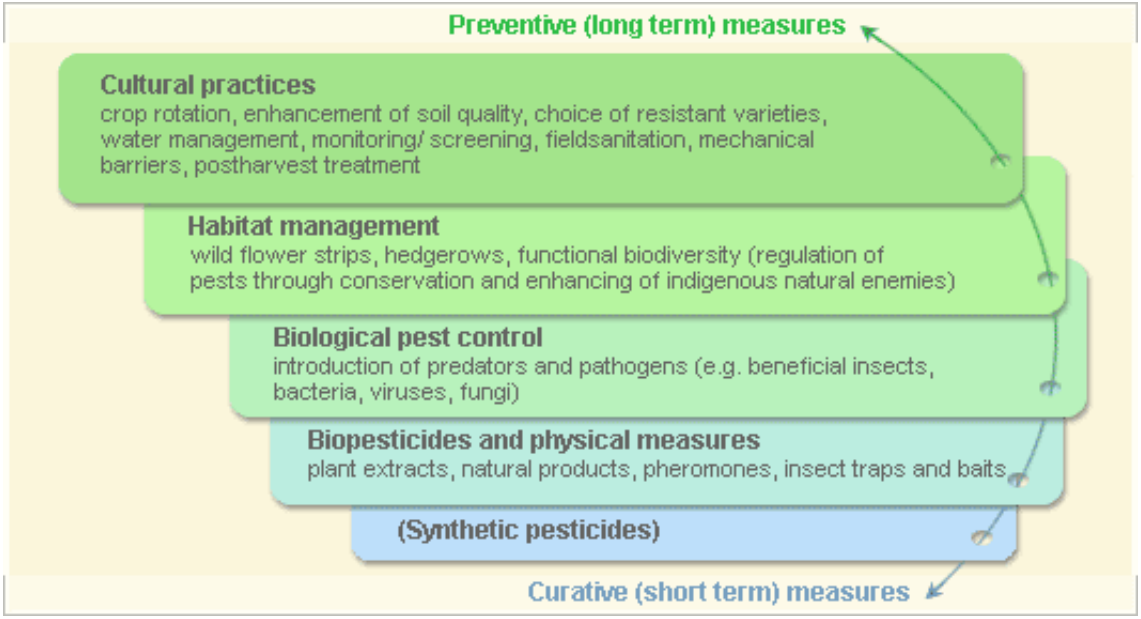
Development from egg to adult takes about 4 to 6 weeks.

Pest and Disease Management

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



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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 Cabbage looper.

Cultural practices

Monitoring

Inspect plant regularly for the presence of caterpillars, leaf damage and the presence of frass. Caterpillars can be detected by scouting the crop, while adults can be monitored by using light- or pheromone-baited traps.

Monitor the presence of natural enemies. They play an important role in controlling the cabbage looper. Check plants twice a week once seedling emergence begins. When populations appear to be increasing, check more often.

Treatment thresholds vary depending on the crop and location. Normally, spraying should not occur when there is less than one caterpillar per five plants (CABI, 2000). A control measure is not necessary unless you find more than nine small to medium-sized caterpillars per plant.

Management options

1. Plant resistant varieties, if available. Some resistant varieties are Mammoth Red Rock, Chieftan Savoy, and Savoy Perfection Drumhead. Ask for assistance from local agriculturist office to obtain cabbage looper resistant cultivars that are available in the local markets.
2. Remove and destroy all the plant debris after harvest. The pupae might still be present in the plants. Plough and harrow the field after harvest.
3. Clear the surrounding area of weeds, which may serve as

alternative hosts for the pests.

Biological pest control

Natural enemies

Natural enemies usually keep the pest populations at low levels and control measures are not often needed. Therefore, their conservation is very important. Avoid using broad-spectrum pesticides for the control of this or other pests. Cabbage looper infestations often increase after use of broad-spectrum pesticides due to elimination of natural enemies.

A wide range of natural enemies attacks the cabbage looper: predators, egg and larval parasitoids (parasitic wasps) and pathogens (Bt and viruses).

Egg predators and parasitoids are important since they kill eggs preventing any subsequent damage by caterpillars.

The nuclear polyhedrosis virus is particularly important in controlling this pest. The virus occurs naturally in the soil or on plants in most crop areas. Virus-infected insects can be reintroduced into the field by collecting diseased insects, mixing them in a blender, filtering out large tissue masses and then spraying the virus particles back onto the field.

Biopesticides and physical methods

Bt (*Bacillus thuringiensis*)

Bt products give good control of the cabbage looper, and do not harm natural enemies. For optimum control, treatments should be applied when caterpillars are small. Frequent crop monitoring is helpful to know the optimal time to apply Bt and other insecticides. For more information on Bt click here

Neem

Neem-based pesticides are reported to control the cabbage looper by interfering with the growth of young caterpillars. Fairly good control of this pest has been obtained with a 2% ethanolic extract of neem seeds (Ostermann and Dreyer, 2000). For more information on neem click here.

Physical control methods

1. Handpick the caterpillars and egg masses.
2. Use fine nylon nets as row covers to protect seedlings from egg-laying moths.

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Cabbage moth

Cabbage moth
Scientific name: *Crocidolomia pavonana (= C. binotalis)*
Family: Lepidoptera: Pyralidae
Type: pest (insect/mite)
Common names: Cabbage moth, cabbage head caterpillar, Larger Cabbage Webworm
Host plants: Cabbage/Kale, Brassicas Cabbage/ Kale, Cauliflower, Chinese cabbage, Broccoli, Kohlrabi, Radish and Mustard

General Information on Pest and Damage

Geographical distribution

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

Introduction

The cabbage moth is common during dry cool seasons in many

tropical and subtropical regions. It is an important pest in Kenya and Uganda.

Damage

Young caterpillars chew off top leaf surfaces. Older caterpillars feed under a web of silk on young leaves, petioles and growing points of the plant, often damaging it entirely, by eating most of the soft tissue leaving only the ticker veins (skeletonisation). In addition to the feeding damage, host plants are often completely soiled with excrement. On cabbage the caterpillars of the cabbage moth

Damage caused by caterpillars

skeletonise the outer leaves and bore into the developing head filling it with frass and excrements. Damage in the cupping stage results in either aborted or multiple heads. They cause borehole damage with frass and excrements in the developing head. Even a single mature caterpillar per plant is capable of causing economic loss to cabbage at pre- and post-heading stages.

of the cabbage moth (*Crocidolomia binotalis*)

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Caterpillars nibble on the growing tip of seedlings/transplants of cawliflower causing 'blindness'. They also cause skeletonisation of outer leaves after planting and discoloration of curd. Caterpillars damage pods and eat the seeds.

On mustard caterpillars cause extensive skeletonisation of leaves and webbing of leaves and inflorescences. They also bore holes in pods eating the seeds.

On kohlrabi caterpillars cause extensive skeletonisation of leaves.

Host range

The cabbage moth is primarily a pest of brassicas and is occasionally an important pest of cabbage. Economically important hosts are cabbage, cauliflower, Chinese cabbage, broccoli, kohlrabi, radish and mustard. Wild plants like thyme, steaved tree *(Crataeva religiosa)*, an ornamental crop *(Clerodendron fragranspeniflorum)* and spider flower *(Cleome gynandra)* are found to harbour this pest. Cabbage moth has also been recorded feeding on cotton and pigeon pea.

Affected plant stages

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

Affected plant parts

Fruits/pods, growing points, inflorescence and leaves.

Symptoms by affected plant part

Fruits/pods: internal feeding; external feeding.
Growing points: external feeding.
Inflorescence: internal feeding; external feeding; webbing.
Leaves: external feeding; abnormal forms; internal feeding; webbing.

Biology and Ecology of the Cabbage Moth

Eggs have a brown furry appearance, and are laid in batches on the lower surfaces of leaves usually close to the midrib or the veins, and arranged like roof

tiles in an overlapping manner. The colour of egg mass is green on the first day turning to reddish-brown after two or three days (at the time of hatching). A large egg mass measures about 5 mm in diameter. Each female lays 75 to 300 eggs. Smooth leaf surfaces are preferred for egg laying. Eggs hatch 4 to 7 days later.

Eggs of cabbage moth are laid in clusters and held together by a gelatinous glue.

© Ooi P. Courtesy of EcoPort (www.ecoport.org)

Caterpillars are dark green

with a light brown head and dark and yellowish white light stripes along the body. These stripes are less visible when larvae are close to pupation. They measure 1.6 to 2 cm in length when fully grown. They go through five instars to pupate. Young caterpillars are often found in groups feeding near the egg mass. Older caterpillars disperse moving from plant to plant. Caterpillars actively feed for 10 to 18 days, descending into the soil to pupate.

Caterpillars of the cabbage moth (*Crocidolomia binotalis*) feeding on cabbage

The pupa is yellowish green when formed and turns dark brown

later. Pupation takes place in a loose silken cocoon 2 to 6 cm below soil surface. Pupae are about 1 cm long. Moths emerge from pupae 10 to 15 days after pupation.

Adult moths are light brown with a wingspan of about 2 cm. Adults emerge during the night. They are weak fliers. Moths live for about 8 days.

The cabbage moth (*Crocidolomia*

***binotalis*)**

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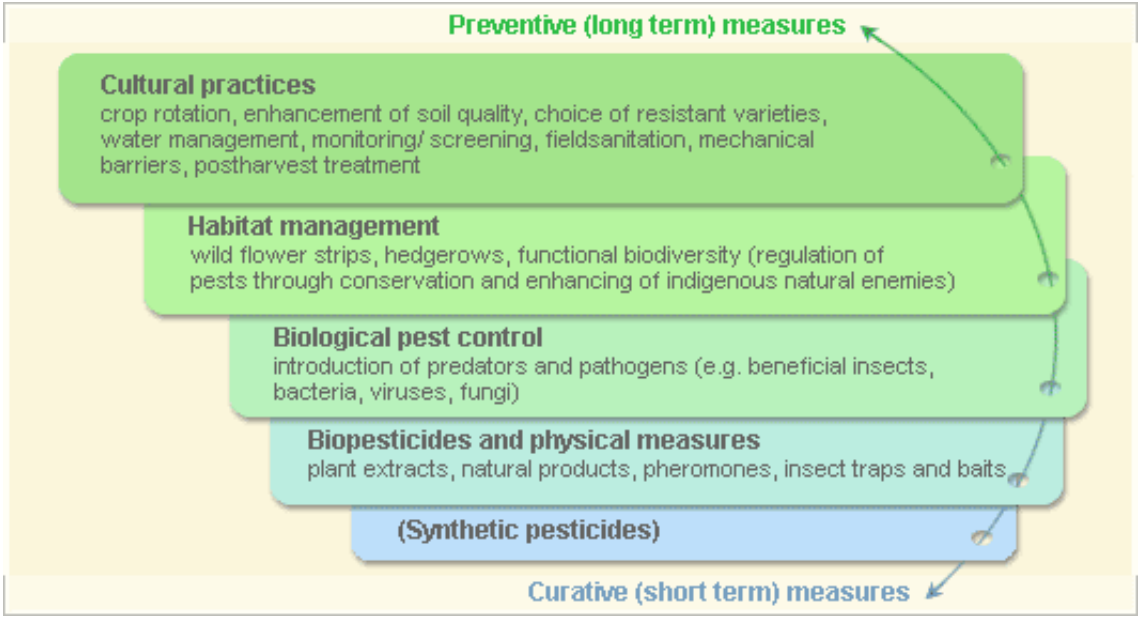
Pest and Disease Management

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



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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 Cabbage moth.

Cultural practices

Monitoring

Monitoring is very important in the first stages of the crop. Fortunately, monitoring is quick, easy and effective in the initial stages of the crop, this is for approximately the first 70 days from cabbage planting (or 40 days from transplant). The cabbage moth *Crocidolomia* can be detected by looking for the window-like leaf damage caused by the young caterpillars. Check the crop twice weekly in order to detect the caterpillars before they move towards the growing centre of the plant. After this time, when the cabbage plant is larger and structurally complex, it becomes too difficult to detect the caterpillars and sampling becomes much less effective.

Trap cropping

Trap cropping cabbage with Indian mustard in a planting pattern of 15 rows of cabbage followed by mustard rows has been shown to reduce attack on cabbage. Plant Indian mustard (*Brassica juncea*) as a trap crop between several rows of common cabbage to attract most cabbage moths and some diamondback moth (DBM) adults. Mustard attracts almost the entire population of cabbage moths and 80% of diamondback moths. Intercropping cabbage with tomato, which acts as a repellent, can also reduce attack on cabbage. The cabbage crop is planted 30 days after tomato. Remove the trap crops when these are heavily infested with the pests or else these pests will transfer to the main crop

Other important cultural practices include field sanitation, crop rotation and intercropping. Please refer to the page on diamondback moth (click to follow link) to find more information on

cultural practices that can also be applied for the cabbage moth.

Biopesticides and physical methods

Bt (Bacillus thuringiensis)

Spraying with Bt reduces damage by the cabbage moth. It is very important to spray when caterpillars are small and before they bore into the cabbage heads. Spot spraying (spraying only affected plants) has been considered effective when the percentage of plants infested with these caterpillars is below 15%. If it is higher it becomes more efficient to spray the entire field.
For information on Bt click here.

Neem

Neem extracts give good control of the cabbage moth. (Cabi, 2000; Osterman and Dreyer, 1995) For information on Neem click here.

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Snails (Giant East African Snail)

Snails (Giant East African Snail)
Scientific name: *Achatina fulica*
Family: Pulmonata: Achatinidae
Local names: Swahili: Konokono; Kiluya: Likhorionio; Kikuyu: Dinoho; Kikamba: Inonga; Luo: Komunio
Type: pest (insect/mite)
Common names: East African Land Snail; Giant East African Snail; Giant African Land Snail
Host plants: Bananas Beans Cabbage/Kale,

Brassicas Cassava Cocoa Coffee Groundnut Papaya Peas Lettuce, Sunflowers, Breadfruit, Brinjal, Cauliflower, Marigold, Rubber and most varieties of cucurbits

Geographical distribution of Snails in Africa

Geographical Distribution of the African armyworm in

The Giant East African Snail is native to East Africa, especially Kenya and Tanzania. It has been introduced to many countries both deliberately as pets and accidentally and have become serious pests. In Africa, it is now widespread in southern Ethiopia, southern Somalia, northern Mozambique, Madagascar, Mauritius, Seychelles, Morocco, and in Ghana and Ivory Coast in West Africa. However, the species is presently also widely

Africa (red marked)

established in Asia, the Pacific and Indian Ocean islands, and in the West Indies.

General information on pest and damage

Introduction

The Giant East African Snail, scientific name *Achatina fulica*, is a species of large, air-breathing land snail, a terrestrial pulmonate gastropod mollusc in the family Achatinidae. It is a macrophytophagous herbivore; it eats a wide range of plant material, fruit and vegetables. It will sometimes eat sand, very small stones, bones from carcasses and even concrete as calcium sources for its shell. In rare instances, the snails will consume each other.

In captivity as a pet, this species can be fed on grain products such as bread, digestive biscuits and chicken feed. Fruits and vegetables must be

washed diligently as the snail is very sensitive to any lingering pesticides. In captivity, snails need cuttlebone to aid the growth and strength for their shells. As with all molluscs, they enjoy the yeast in beer, which serves as a growth stimulus.

It is considered to be one of the most damaging land snails in the world. Compared to other snails, this pest is really big about 20 cm long overall with the shell making up half its length. It is also showy, with a light-brown shell striped with brown and cream bands.

The Giant East African Snail (*Achatina fulica*). Adults of the species may exceed 20 cm in shell length but generally average about 5 to 10cm

© Ahoerstemeier, www.wikipedia.org

Two qualities make this tropical snail especially dangerous. First, it can survive cold conditions and even snow by aestivating. This

means that the snail will become slow and sluggish, essentially hibernating until warm weather returns. Second, the snail is a whiz at reproduction. For one thing, each snail contains both female and male reproductive organs! After a single mating session, each snail can produce a batch of 100 to 400 eggs. And it can keep this up several more times without having to mate again. In a typical year, every mated adult lays about 1,200 eggs. It can live as long as 9 years, and that is plenty of time to cause trouble in the local environment.

Damage

Giant East African Snail is a major agricultural pest, feeding on a variety of crops and causing significant economic losses. In the US state of Florida it has been estimated that Giant East

Eggs of *Achatina fulica*

© Yuri Yashin, achatina.ru, Bugwood.org

African Snail would have caused an annual loss of $US 11 million in 1969 if its population had not been controlled. In India it attained serious pest status, particularly in 1946/47, when it appeared in epidemic proportions in Orissa and caused severe damage to vegetable crops and rice paddies. Plants most likely damaged by the snail are garden flowers and ornamentals, vegetables, (especially Cruciferae, Cucurbitaceae and Leguminosae) and immature specimens of breadfruit, cassava and teakwood. Giant East Aftrican Snail may also increase the spread of plant diseases (for example, black pod disease caused by *Phytophthora palmivora*), which it spreads in its faeces.

Giant East African Snail is a vector for several pathogens and parasites, including the roundworm responsible for eosinophilic

meningo-encephalitis in humans and the bacterium *Aeromonas hyfrophila* (also found in shellfish in New Zealand). The parasites carried by the snail are usually passed to humans through the consumption of raw or improperly cooked snails.Giant East African Snail is also a general nuisance when found near human habitations and can be hazardous to drivers, causing cars to skid. Their decaying bodies also release a bad stench and the calcium carbonate in their shells neutralises acid soils, altering soil properties and the types of plants that can grow in the soil.

Host range

Giant East African Snail has a remarkably broad range of host plants on which it feeds. Young snails with shell heights of 5 mm to 3 cm are most predacious on living vegetation, with very small and older individuals preferring detritus and decaying vegetation. The major requirement of hatchlings is calcium until their shell reaches

the 5 mm size. Young Giant East African Snail appear to prefer soft textured banana (*Musa*), bean (*Beta vulgaris*) and marigold (*Tagetes patula*). As the snail matures its dietary preferences broaden to include a larger variety of plants, including brinjal (*Solanum melongena*), cabbage and cauliflower (*Brassica oleracea* v. *capitata* and *botrytis*), lady's finger (*Abelmoschus esculentus*), sponge gourd (*Luffa cylindrica*), pumpkin (*Cucurbita pepo*), papaya (*Carica papaya*), cucumber (*Cucumis sativus*) and peas (*Pisum sativum*).

Symptoms
External feeding on foliage and fruits

Affected plant stages
Seedling stage, vegetative stage and fruiting stage

Affected plant parts
Leaves and fruits

Symptoms by affected plant parts
External feeding on foliage and fruits

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

These illustrations show 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.

Biology and Ecology of the Giant East African Snail

Life cycle

Giant East African Snail has a narrow, conical shell, which is twice as long as it is wide and contains 7 to 9 whorls when fully grown. The shell is generally reddish-brown in colour with weak yellowish vertical markings but colouration varies with environmental conditions and diet. A light coffee colour is common. Adults of the species may exceed 20 cm in shell length but generally average about 5 to 10cm. The average weight of the snail is approximately 32 grams.

Shell of the Giant African Snail (*Achatina fulica)*

© Luis Ruiz Berti, www.wikipedia.org

Adult size is reached in about six months, after which growth slows but does not ever cease. Life expectancy is commonly five or six years in captivity, but the snails may live for up to ten

years. They are active at night and spend the day buried underground.

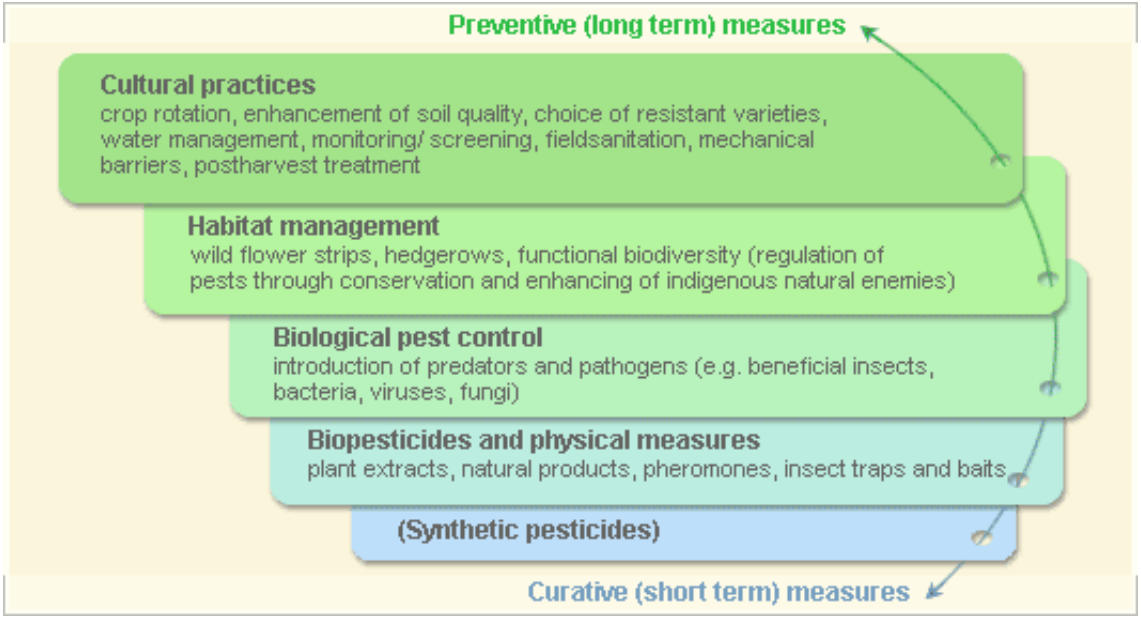
It is capable of aestivating for up to three years in times of extreme drought, sealing itself into its shell by secretion of a calcerous compound that dries on contact with the air. This is impermeable; the snail will not lose any water during this period.

Giant East African Snail is an obligate-outcrossing hermaphrodite, which means that one externally fertilised snail can establish a population A. fulica produces large eggs that are 4.5 to 5.5 mm in diameter and only hatch at temperatures above 15°C. Snails begin laying eggs at six months of age and fecundity lasts approximately 400 days. Snails lay up to 100 eggs in their first year, and up to 500 in their

second year; fecundity declines after the second year, but snails may live up to five years with a total egg clutch of up to 1000. Dependent on the temperature, the babies will hatch in anything from 5 to 21 days. Snails mature at around 5 to 15 months, depending on the temperature (with cold winter temperatures inducing hibernation and delaying sexual maturity).

Pest and disease Management

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



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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 Snails

Cultural practices

- **Practise good field sanitation**
- **Monitor regularly for the pest in the nursery and in the field.**
- **In East Africa, sprinkling their habitats and / or around crop base with table salt in dry seasons, has proven effective in their control**
- **Brewers' waste in water containers is effective trap. They are attracted by the yeast and they get drowned when going for the 'brew'**

Habitat Management

Areas of natural habitat

Areas of natural habitat

All of the countries in which the Giant East African Snail *(Achatina fulica)* is established have tropical climates with warm, mild year-round temperatures and high humidity. The species occurs in agricultural areas, coastal areas and wetlands, disturbed areas, natural and planted forests, riparian zones, scrublands and shrublands, and urban areas. These snails thrive in forest edge, modified forest, and plantation habitats. Wherever it occurs, the snail keeps to the hot lowlands and the warm temperate lower slopes of the mountains. It needs temperatures well above freezing year-round, and high humidity at least during part of the year, the drier months being spent in dormant aestivation. It is killed by sunshine. *A. fulica* remains active at a temperature range of 9°C to 29°C, and survives temperatures of 2°C by hibernation and 30°C by aestivation.

Biological pest control

The introduction of Giant East African Snail has often lead to the purposeful introduction of predatory snails and predatory flatworms as biological control agents. These agents usually have a devastating effect on the environment. For example, a particularly important cause of the demise of the endemic snails in forested habitats in Tahiti and Hawaii has been the deliberate introduction of the predatory snail (*Euglandina rosea*) and predatory flatworms, such as *Platydemus manokwari* to control Giant East African Snail.

Natural enemies:
Predators:

- ***Euglandina rosea*, attacking adults**
- ***Eupelmus australiensis*, attacking adults**
- ***Gecarcoidea natalis*, attacking adults**
- ***Gonaxis quadrilateralis*, attacking adults**
- ***Lamprophorus*, attacking adults**
- ***Platydemus manokwari*, attacking adults**

- ***Solenopsis geminata*, attacking adults**

Biopesticides and physical methods

Biopesticides

There are no commercially available biomolluscicides albeit there is a lot of work ongoing in attempt to finding plant derived molluscicides. Plants found to possess molluscicidal effects include Garlic *(Allium sativum)*, Neem *(Azadirachta indica)*, Cedar *(Cedrus deodare)* and Ginger *(Zingiber officinale)* among others. In some countries less potent molluscicides are allowed for use in conservation agriculture and organic farming. These include the following:

- **Metal salt-based molluscicides as snail baits and snail pellets. These are derived from iron phosphate, copper sulfate and**

aluminium sulfate. They are not toxic to humans and animals *(In organic culture, consult your certification body before use*)

- **Sluggo Plus® is a blend of iron phosphate and Spinosad. The latter is derived from naturally occurring soil dwelling bacteria. This product is not commercially available in East Africa *(In organic culture, consult your certification body before use*)**

Physical methods

- **International quarantine and surveillance activities**
- **Hand collection (in some countries they constitute a food source and even exported as a food delicacy to Europe. Also in some European countries snails are kept as pets)**
- **Food baits (e.g. over-ripe papaya fruit pieces). However, these baits should be daily removed from orchards and destroyed.**

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Termites

Termites
Scientific name: *Ancistrotermes* spp., *Amitermes* spp., *Coptotermes* spp., *Macrotermes* spp., *Microtermes* spp., *Odontotermes* spp., *Pseudacanthotermes* spp.
Family: Isoptera: Hodotermitidae, Rhinotermitidae, Termitidae
Type: pest (insect/mite)
Local names: white ants, mchwa (Swahili); Harvester termite (*Hodotermes mossambicus*); Bark-eating termites (*Macrotermes* spp.,

***Odontotermes* spp.).**
Host plants: Cassava Citrus plants Coconut Coffee Groundnut Maize Mango Pigeon pea Rice Sorghum Sugarcane Sweet potato Tea

General Information on Pest and Damage

Geographical distribution

Termites are probably present in most, if not all, African countries.

Geographical Distribution of

Termites in Africa (red marked)

Damage

Termites primarily feed on wood, but some species collect green grasses and seeds and store these in their granaries inside their nest as food reserves. They are sporadic pests, and locally are important on a wide range of crops.

Some termites eat into the taproots of young (e.g. cotton and groundnut) immediately below the soil surface, destroying the central root portions, and fill the resulting cavities with soil. Damaged plants wilt and may die within a few days particularly under drought conditions. Some termites also attack the roots of maize and sorghum, and the damaged plants topple. Termites may also travel up through the roots into the trunk and branches. They eventually disrupt the movement of nutrients and water through the vascular system resulting in death of the plant.

Bark-eating termites attack a wide range of crops and occasionally are locally important pests. They cover the tree trunks or plant stems with tunnels built of soil, plant fragments and saliva and gnaw away the bark underneath these tunnels. Some damage is done underground to the roots and underground stem of the plant. The collected plant material is taken back to the nests for construction of fungus gardens.

Tunnelling damage may kill seedlings or ring-bark trees when large cavities are eaten out of the trees. However, they do not cause damage when feeding on the dead bark of established trees. Sometimes root damage may be serious. Some termites gain access through the dead ends of pruned branch stumps, from which they may invade the living tissues.

Soil-covered tunnels built by termites on a mango tree.

© A. M. Varela, icipe

The sugarcane termite *(Pseudacanthotermes militaris)* causes poor germination of sugarcane setts, mature cane is encrusted with earthen tunnels and stalks are often felled when nearing maturity. This termite is a major pest of sugarcane in East Africa. Other species of termites can also cause considerable damage to

sugarcane; under severe attack no shoots can be formed and large gaps are left in the field.

Harvester termite carrying a piece of plant material to the nest.

Harvester termites cut and gather pieces of grass and wood, leaf and herbaceous twigs and carry them to the mounds. They have small earth mounds (about 10 cm) scattered through areas with short grasses. They are major pests of grasslands, and occasional pests of cotton, wheat and groundnuts.

Several species of drywood and subterranean termites are storage pests and can become a problem in farmers' granaries or in village stores. Most of the damage occurs in wooden storage structures, but some subterranean

termites also feed directly on the stored grain. Direct grain losses due to termite feeding are generally low, but contamination with moulds, as a consequence of their attack, is frequent.

Host range

Hosts include: Cotton, maize, wheat, sugarcane, upland rice, potatoes, sweet potatoes, groundnuts, soybean, coffee, cassava, tea, cocoa, rubber, oil palm, coconut, some vegetables, some fruit trees like; mango, papaya, citrus, etc.

Symptoms

The first signs of termite attacking roots on seedlings or older plants is wilting. Eventually some plants die or fall over. Pulling out the affected plants and examining the roots and lower stem for live termites and tunnelling will confirm the presence of termites. Plant roots and stems may be completely hollowed out and soil-filled.

Often plants in the field are covered with soil runways or soil sheeting, under which termites may be found. It is important to examine plants in the early morning or late evening, as termites may have moved deeper into the soil during the day when temperatures are high.

Termite attack on trees and bushes often begins in an area of dead wood produced by pruning or other damage. Small cracks or tunnels made by other insects such as wood-boring beetles may allow winged termites (reproductive stage) to enter. Termites may also travel up through the roots into the trunk and branches. They eventually disrupt the movement of nutrients and water through the vascular system, this results in death of the plant.

Galleries in the wooden parts of the construction reveal the presence of drywood termites in granaries is revealed by galleries. As termites avoid the surfaces of attacked wood, their presence may only be detected after substantial damage has occurred.

Subterranean termites construct visible galleries that are used as runways.

Affected plant stages

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

Affected plant parts

Leaves, roots, stems and whole plant.

Termite damage on mango tree bark.

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Biology and Ecology of Termites

Termites are social insects, living in large colonies consisting of many workers, soldiers and reproductive

forms. They live sometimes in elaborate nests, some build nests on moist dead tree stumps, while others build subterranean nests, which in many cases have mounds that may reach 2 m in height. They forage away from the nest protected through underground tunnels or under soil-covered tunnels.

Entrance to termites nest.

© A. M. Varela, icipe

Termites feed on dead plant material, such as wood, leaf litter, roots, dead herbs and grasses, dung, and humus. Some termites are able to digest cellulose (wood) with the assistance of symbiotic (mutually beneficial) bacteria present in the gut of the termites. Other termites use the cellulose to cultivate fungi that are then eaten.

Eggs hatch into tiny larvae, which are incapable of feeding on their own and are raised by specialised workers of the colony. Larvae are capable to develop into any caste (workers, soldiers or reproductive forms), depending on time of year, diet etc.

A termite mound in a mixed cropped farm in Kenya.

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Workers are whitish, wingless and usually blind. They have pale yellow round heads. They comprise the bulk of the population. Workers feed all the dependent castes. They also dig tunnels, locate food and water and build and repair the nest.

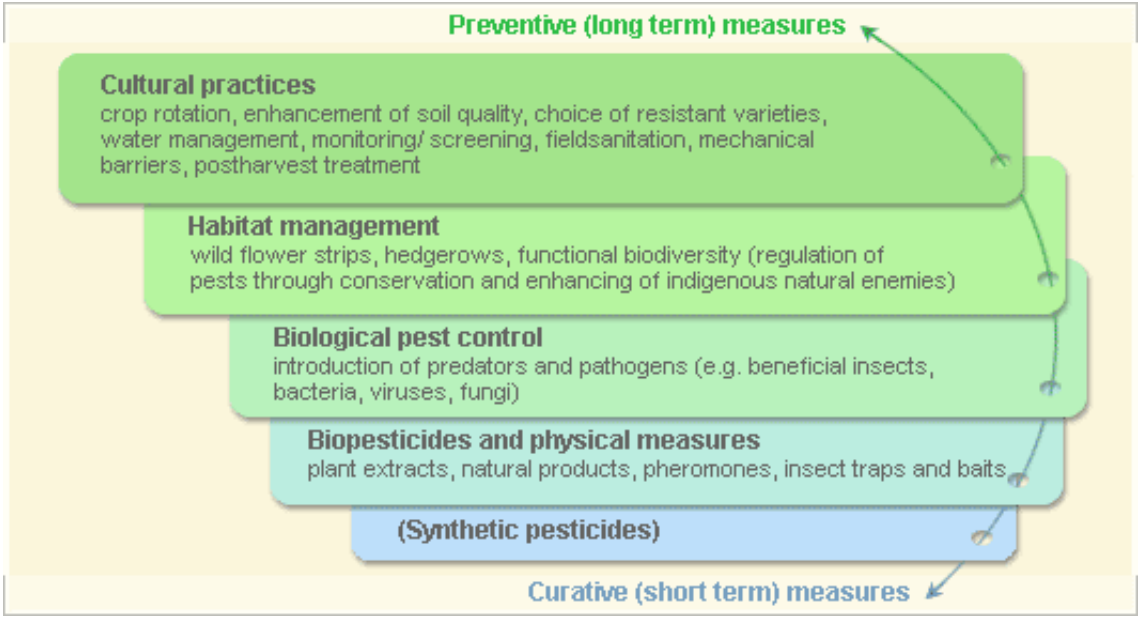
The soldiers are whitish, wingless and blind; they are larger than the workers and have large, brownish heads and strong jaws. With their specialised defensive weaponry, the role of the soldiers

soldiers is to protect the colony against numerous predators such as ants and centipedes.

The reproductive termites are winged and are known as alates. Numerous winged males and females, generally dark in colour and with well-developed eyes, are produced for swarming. Swarming is often at dusk after the onset of heavy rains. After flying, they shed off their wings, mate, and burrow into holes in the soiol and cracks in wood to found a new colony. The queen termite typically develops an enormously distended abdomen. At her peak, a queen will be laying an egg every 3 seconds or 30 000 a day in some species; and she will lay tens of millions of eggs during her life.

Pest and Disease Management

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



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emergencies only. On infonet we do not promote synthethic pesticides.

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

Cultural practices

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

- **Promote conditions for healthy plant growing to prevent termite damage. Termites more often attack sickly or water stressed plants than healthy plants.**
- **Avoid unnecessary injury to the plants as this may facilitate entry of termites.**
- **Plough field to destroy termites' nest, runways, and tunnels and to expose them to predators, such as ants, birds, chicken, etc.**

- **Practise crop rotation to reduce the build-up of termites. Planting the same crop every cropping season makes it susceptible to a termite attack.**
- **Grow crops in mixed cropping systems to lessen termite damage. Know and make a list of the annual crops that are attacked by termites.**
- **Remove plant residues and other debris especially moist and decaying woods. However, take into account that termites may attack plants if there is no other food available, for instance if there are no other sources of organic matter such as soil humus and mulch; therefore ensure there is plenty of soil humus; avoid bare, dry disturbed, organic-deficient, residue-free soil.**
- **Inspect plants, especially the pruned fruit trees, for termite attack. Do this either early in the morning or late in the afternoon.**
- **Remove affected plants or part plants, and kill the termites; they are normally found inside the hollowed parts.**
- **Harvest at the right time, as termites often attack maize, sorghum and millet left in the field after maturity. The attacked**

stalks may fall down and the termites may attack the cobs and panicles.

- **Where there is risk of termite infestation, avoid leaving the crop in the field after harvest on stooks, stacks or windrows.**

Biological pest control

Natural enemies

Termites are attacked by a wide range of natural enemies including man. In Africa masses of reproductive forms are caught in simple traps and eaten raw or roasted in oil. Natural predators include ants, dragonflies, ground beetles, some spiders, bats, many kinds of birds, frogs, and some large mammals (aardvarks, pangolins and monkeys). Despite the large number of predators, most termites are able to maintain high populations by means of mass production of reproductive forms.

Biological control measures against termites are generally difficult because of their social nature and secure enclosed environments

that protect them against most natural enemies. Preparation based on insect-attacking nematodes and the fungi *Beauveria bassiana* and two species of *Metarhizium* are effective when applied into the mounds. Fungi spores can act as repellents.

Biopesticides and physical methods

Neem

Neem products reportedly have a repellent effect on termites. *Odontotermes* spp. and *Microtermes obesi* were repelled from scarifying groundnuts pods lying in heaps on the ground, by a layer of neem cake between the surface of the soil and the pods (Gold et al, 1989). Neem oil and neem leaves reduced the weight loss of wood pieces exposed to termites (Sharma et al, 1990). Neem seed extracts have been used against Microtermes termites on trees and Odontotermes termites on field crops with good results (Schmutterer, H. 2002).

Ash

Heaping wood ash around the base of tree trunks or mixing it into seedling bedding soil is reported to reduce termite attack. Wood ash should be replaced regularly.

Physical measures

- **Burn plant residues on top of termites' mound to suffocate them. However, this does not give long lasting results, as it does not penetrate deep enough to kill the queen.**
- **Locate their soil runways/tunnels and destroy the worker termites either by hand tilling or by flooding. This is not a long lasting solution since the termites would eventually re-infest the plants.**
- **Destroy termite mounds manually. However, this method is labour intensive since the building material of the mounds is very hard, and some mounds are large. To be effective the queen has to found and destroyed; the queen maybe hidden deep inside and**

is not easily found. After killing the queen, pour boiling water or burn dried grass straws (any plant debris) to kill the rest.

Protection of traditional granaries

- **Clear the building site for the granary from all organic material that might attract termites, such as wood and straw. Dig out roots of chopped trees and shrubs that have been left in the ground close to the storage structure. Keep the ground around the building free from any plant growth.**
- **Avoid construction sites that are infested with termites or are close to such areas.**
- **Use termite resistant timbers (e.g. teak) as poles for granaries. If termite resistant wood is not available, protect the poles by charring the outer layer of wood or by coating the poles with engine oil.**
- **Pour used engine oil, wood ash or pounded neem leaves or seeds into the pole holes in order to repel termites.**

- **Use concrete or stone platforms resting on poles made out of same materials as basement for grain stores.**
- **In areas where termites occur regularly, avoid placing granaries directly on the ground and using mixtures of clay with straw, because termites are encouraged to tunnel thought he walls. Use pure mud walls instead.**
- **Underground pits are easily invaded by termites; to avoid this line with clay or soil from termite mounds, which is then fired to harden.**
- **Apply a layer of ash to the base of the granary, or plant materials with insecticidal or repellent properties to the grain.**

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Information of www.infonet-biovision.org

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Purple witchweed

Purple witchweed
Scientific name: *Striga hermonthica*
Family: Scrophulariales: Scrophulariaceae
Type: weeds
Local names: Swahili: Gugu chawi (viduha)
Host plants: Cowpea Maize Millet Pigeon pea Rice Sorghum Sugarcane Teff Upland rice

General Information on Pest and Damage

Geographical distribution

Geographical Distribution of Purple witchweed in Africa *(red marked)*

Introduction

The purple witchweed *Striga hermonthica* threatens the lifes of over 100 million people in Africa and infest about 40% of arable land

in the savanna region, causing an estimated annual loss of $ 7 to 13 billion (www.icipe.org). It is almost certainly responsible for more crop loss in Africa than any other individual weed species. Over 5 million ha of crops - mainly sorghum, millets and maize - are affected in six countries of West Africa alone, possibly 10 million ha in Africa as a whole. One plant of *S. hermonthica* per host plant is estimated to cause approximately 5% loss of yield (Parker and Riches, 1993) and high infestations can cause total crop failure. Overall yield losses are estimated at 21% of all sorghum in northern Ghana, 10% of all cereals in Nigeria, 8% in Gambia and 6% in Benin. Other countries seriously affected include Cameroon, Cote d'Ivoire, Burkina Faso, Niger, Mali, Senegal, Togo, Sudan, Ethiopia, Kenya, Uganda and Tanzania.

The damaging effect of *S. hermonthica* on the host plant derives not only from the direct loss of water, minerals, nitrogen and carbohydrate, but from a disturbance of the host photosynthetic efficiency and a profound change in the root/shoot balance of the

host, leading to stimulation of the root system and stunting of the shoot. Young *Striga* seedlings are completely parasitic on the host while they are below the soil level and, at this stage, cause maximum damage to the host.

As *S. hermonthica* occurs mainly under conditions of low fertility. It is also associated with farming systems in Africa in which farmers have few resources and very few options in terms of control measures.

Symptoms

***S. hermonthica* causes characteristic yellowish blotches in the foliage about 1 cm long by 0.5 cm wide. In later stages whole leaves may wilt, become chlorotic and die. Stems are shortened, though leaf number may not be reduced. Inflorescence development is delayed or prevented. Root systems, at least in early stages, may be stimulated, and haustoria 1-2 mm across appear like nodules.**

Host range

The natural host range of *S. hermonthica* is normally limited to *Gramineae* (*Poaceae*), but weak attachment to groundnut, cowpea, lablab and soyabean was obtained in pots and there have been unconfirmed reports of infestation of groundnut and sesamum fields in West Africa. Apart from the wild hosts listed above, *S. hermonthica* is occasionally observed on crowfoot grass (*Dactyloctenium aegyptium*), *Panicum walense*, goose grass (*Eleusine indica*), ricegrass paspalum (*Paspalum scrobiculatum*), *Pennisetum violaceum* and on *Cynodon, Cymbopogon, Ophiuros* and *Brachiaria* spp. Individual biotypes may have a narrower host range than the species. In particular, there are forms which attack sorghum but not pearl millet and vice versa.

Affected plant stages

Flowering stage, fruiting stage, pre-emergence, seedling stage and

vegetative growing stage.

Affected plant parts

Leaves, stems and whole plant.

Symptoms by affected plant part

Leaves: abnormal patterns; yellowed or dead.
Stems: abnormal growth.
Whole plant: dwarfing; early senescence

Biology and Ecology of Purple Witchweed

The biology and ecology of *S. hermonthica* are described in detail by Parker and Riches (1993). It is an obligate hemi-parasite, with green foliage capable of photosynthesis and can at least partially support its own growth once established. Its minute seeds (about 0.2 x 0.3 mm) have inadequate reserves to establish without a host. Seeds are produced in enormous numbers and they are generally

dispersed by wind, water, livestock and man.

Relatively high temperatures, 30-35°C, are optimal for germination and for growth. Dry conditions of soil and air are most favourable, and *S. hermonthica* rarely occurs in irrigated cereals, though wet conditions can be tolerated for short periods. Neither soil type nor pH is critical for its growth, *S. hermonthica* occurs on almost all soil types from sandy acidic to alkaline clay soils, as in Sudan.

Habitat

***S. hermonthica*, as most other Striga species, is associated with low-fertility soils, especially those low in nitrogen. Unlike *Striga asiatica* it occurs not only on light, sandy soils but also on heavy clays and even on vertisols. It is also favoured by low soil moisture, and rarely occurs on irrigated soils, but can tolerate abundant moisture for short periods. It is a plant of African savanna, almost invariably associated with cereal cropping and relatively uncommon**

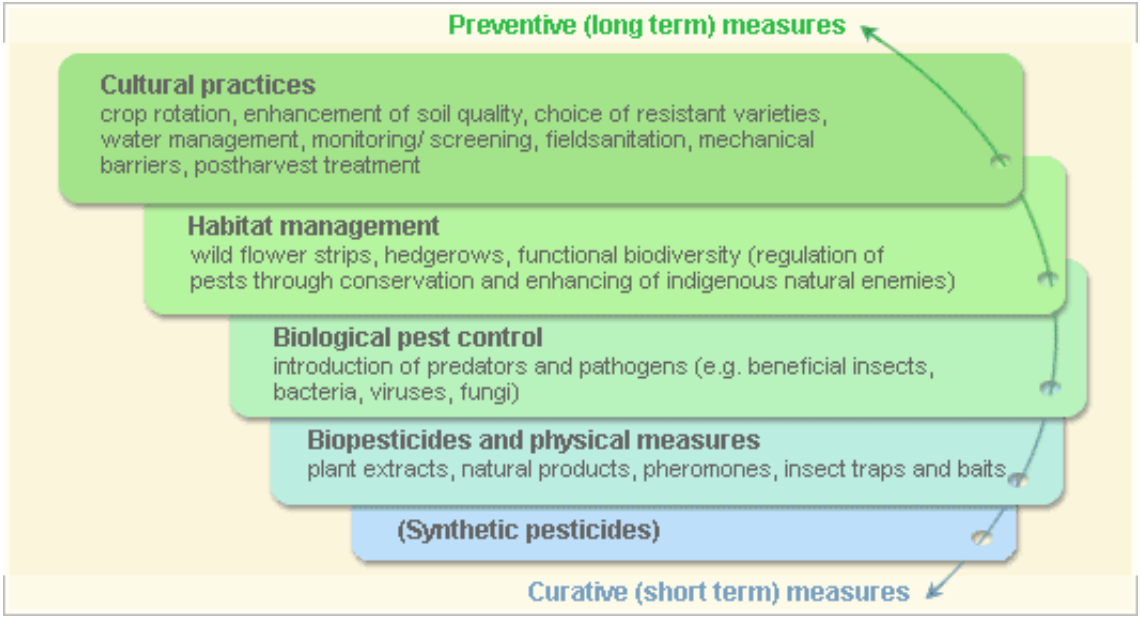
in natural vegetation.

Morphology

S. hermonthica **is a herbaceous annual plant 30-100 cm high, the most robust forms occurring in Sudan and Ethiopia. Larger plants may be much branched. The root system is weak with little or no ability to absorb materials from the soil, but branches develop from lower nodes of the plant, ramifying and developing attachments on contact with other host roots.**

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 Purple witchweed.

Cultural practices

Detection and inspection methods

Infestation of a cereal crop by *S. hermonthica* may be apparent before emergence from the soil, by the chlorotic blotches on the crop foliage. Uprooting may confirm the presence of the haustoria and young parasite seedlings on the root.

Resistant/ tolerant varieties

No completely immune cereal varieties have yet been developed, but many sorghum varieties show high levels of resistance, at least under local conditions. Selection and breeding programmes in India

and Africa have led to the development and release of many lines with at least reduced susceptibility, and these may be valuable as components of an integrated control approach. However, traditional varieties in *Striga*-infested areas often show relatively high tolerance, and these may yield well in spite of heavy infestation. Identified resistant cultivars of sorghum include 'N-13' from India, 'Framida' from South Africa, 'Serena', 'SAR 29' from Tanzania. Among millets the following cultivars are considered resistant in Tanzania: 'Buruma', 'Shibe', 'Okoa' and 'Serere 17'.

In maize there are no effectively resistant varieties, though some show partial resistance, such as 'Katumani' in Kenya, and some more tolerant lines have been developed by the International Institute for Tropical Agriculture. Work is now in progress to transfer high-level resistance into maize from wild relatives including *Zea diploperennis*.

Little progress has been possible with the out-crossing pearl millet, but there are promising results from work in progress to select and develop rice varieties with resistance to *Striga* species.

Characteristics/weaknesses in *S. hermonthica* which may be exploited in cultural control measures include the following:

- **Dependence on a susceptible host for establishment: Crop rotation avoiding a susceptible cereal will prevent new seeding and allow decline of the soil seed bank. In some areas, there may be alternative cereals which are not attacked (e.g. sorghum in a millet-growing area, or *vice versa*). Among the non-cereal crops, many are known to exude germination stimulant, though they cannot be parasitized. These trap crops, such as cotton, groundnut, cowpea, sunflower and soyabean, are especially beneficial in causing suicidal germination and accelerating a decline in the soil seed bank. But they need to be sown at a time when *Striga* germination is likely to be high, usually early in the rainy season, before the onset of any secondary dormancy. Some of the catch crops are susceptible cereals which may be grown at the beginning of the season or in short rains prior to the main season, to stimulate germination of the *Striga*. However, they need to be destroyed before the weed can mature and set seed.**

- **Preference for low nitrogen: Additional nitrogen fertilizer usually reduces *Striga* incidence, though not always, especially when applied as a single dose. However, improved soil fertility is a vital key to long-term control, whether by organic, inorganic or green manuring, rotation with legumes, or agroforestry techniques involving mulching.**
- **Preference for dry conditions: Irrigation is rarely an option, but moisture conservation techniques may be beneficial. Any means of raising humidity will reduce *Striga* transpiration and its ability to draw nutrition from the host. Hence leafy crop varieties, dense, uniform planting and intercropping with legumes, all tend to suppress the weed.**

None of the methods described above will, alone, provide complete control, and without complete control there is the certainty that surviving plants will mature and replenish the soil seed bank. It is therefore essential that manual and mechanical methods are used to destroy surviving *Striga* plants. Hand-pulling is the most

common traditional technique, though a late hoeing or ridging may also be effective.

ICIPE developed a habitat management strategy for effective control of *Striga* in cereal-based farming systems. It involves planting desmodium legume (*Desmodium uncinatum*) intercrop in maize fields. Roots of desmodium secrete chemicals (isoflavones) that stimulate *Striga* seed germination and also inhibit attachment of Striga to maize roots thereby causing suicidal germination of *Striga* seed and reducing its seed bank in the soil. The legume also maintains soil stability and improves soil fertility through nitrogen fixation. In addition it serves as a highly nutritious animal feed. This habitat management strategy is part of an integrated appraoch called "push and pull" for control of both maize stemborers and *Striga* (www.icipe.ch). For more information on push-pull click here

For more information on weeds click here

Biological pest control

Biological Control

The reduction in seed production from gall-forming *Smicronyx* spp. is often substantial, but there has been no successful development of a biological control programme based on these weevils. Attempts to introduce *Smicronyx albovariegatus* (and the moth *Eulocastra argentisparsa*) from India into Ethiopia apparently failed. Meanwhile, conclusions from a mathematical modelling project have suggested that *Simicronyx* spp. would in any case be unlikely to have a significant impact on Striga population dynamics.

Other potentially useful organisms for *Striga* management include the following: a) the butterfly *Precis* (=*Junonia*) species whose larvae feed on leaves, buds and capsules of many Striga species and b) a range of fungal diseases including *Fusarium equiseti* that causes girdling of the stem, abortion of seed capsules or wilting and death of young *Striga* plants.

Integrated control

As virtually none of the treatments described above is likely to achieve complete control, integration of one or more is essential for any substantial reduction of the problem. Furthermore, such integrated treatments will almost certainly need to be repeated over a number of years for long-term control. Parker and Riches (1993) propose a range of programmes depending on the initial density of the problem, involving various combinations of rotation, varietal selection, soil fertility enhancement and intercropping with legumes, supplemented in all cases by hand-pulling.

Information Source Links

- **Crop Protection Compendium, 2005 Edition. © CAB International, Wallingford, UK, 2005 www.cabi.org**
- **ICIPE Biennial Scientific Report (2004-2005). Habitat management strategies for control of stemborers and *striga* weed in cereal-based farming systems. pp. 40-58. www.icipe.ch**
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Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Storage pests

Storage pests

Host plants: Beans Cassava Cowpea Green gram Groundnut Maize Millet Peas Potato Rice Sorghum Soybean Wheat

Introduction

One of the main causes of food insufficiency in East Africa is the high prevalence of storage pests. Grains, dry legume seeds and tubers are excellent food not only to humans but also to lots of other creatures. Food stores are excellent breeding sites for all those pests. A farmer has to take adequate measures about food storage to conserve his/her crops to be able to feed the family even during longer droughts.

The main storage pests, apart from rodents, are beetles and moths. Some pests such as grain borers, weevils and Angoumois grain moths are able to feed on whole, healthy grains, they are considered primary pests. Secondary pests such as flour beetles

can attack only broken grain, moist and thus soft grain, grain damaged by primary pests or processed products such as flour.

Contamination by fungi also causes direct losses and poses a threat to human and animal health by producing poisons known as mycotoxins, which contaminate food and feed.

Beetles: Weevils, Grain Borers, Bruchids, Khapra Beetles

The main beetle pests of storage are bruchids (e.g. cowpea seed beetles and bean bruchid), grain borers (e.g. the larger and the lesser grain borers), weevils (e.g. grain weevils), flour beetles, Khapra beetles and dried fruit beetles.
The larvae and some adult beetles feed in the seeds and grain, leaving them full of small holes. Sometimes a fine dust is found around the holes, being the excrements of these beetles. Beetle damage renders grains and seeds unsuitable for human and, in case of heavy attack, even for animal consumption.

Cowpea bruchids (*Callosobruchus* spp.)

Cowpea seed beetle (*Callosobruchus maculatus*). Adult female on cowpea (Vigna unguiculata) seeds.

© Peter Credland. Reproduced from the Crop

Cowpea bruchids (*Callosobruchus* spp.) are the most common and widespread insect pests in storage. Adults are 2 to 3.5 mm long. They are major pests of pulses (cowpeas, pigeon peas, soybean, geen gram and lentils). They attack both pods in the field and seeds in storage. They attack nearly mature and dried pods. Infested stored seeds can be recognised by the round exit holes and the white eggs on the seed surface. Post-harvest losses are highly variable, but losses can be over 90%.

Protection Compendium, 2006 Edition. © CAB International, Wallingford

What to do:

Pods should be harvested as soon as they mature and the seeds sundried before stored in clean beetle-proof containers. A coating of edible oils or of inert clay can prevent further development of bruchids in the stored seeds. Some farmers in East Africa use wood ash in grain stored for food or seed for planting, or chillies or smoke from cooking fire to preserve seeds for planting. Other farmers store unthreshed pods as a strategy to minimise grain damage by bruchids (Minja et al. 1999).

For more information on cowpea pests click here For more information on cowpea seed beetle click here

(click on image to enlarge)

The bean bruchid (*Acanthoscelides obtectus*)

Bean bruchid (*Acanthoscelides obtectus* on soybean

© Clemson University -

This beetle, also known as the dry bean weevil, is about 3 to 5 mm long, oval in shape, grey and reddish brown with yellowish and dark patches of hairs on the wing cases. The wing cases are short and do not cover completely the abdomen. This beetle is a major pest of beans. Attack by this beetle often starts in the field. Female beetles lay eggs on the ripening pods on the crop or among stored beans. The larvae bore

USDA Cooperative Extension Slide Series, (www.bugwood.org)

the way into the seed and feed inside. The presence of mature larvae or pupae can be recognised by the small circular windows on the bean seeds.

The life cycle is completed inside the seed and the adult beetle emerges by pushing the window, which falls off leaving a neat round hole about 2 mm in diameter.

What to do:
Intercropping maize with cowpeas, and not harvesting crops late significantly reduced infestation by the bean bruchid (*Acanthoscelides obtectus*) and cowpea bruchids in Kenya (Olubayo and Port, 1997).

The larger grain borer (*Prostephanus truncatus*)

Larger grain borer (*Prostephanus truncatus*). The adult beatle is 3 to 4.5 mm long.

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.

What to do:
Use botanicals or plant parts to protect stored cassava. There are reports in Kenya, that the larger grain borer can be effectively repelled by storing cassava or grains with a fairly large amount of dried lantana or eucalyptus leaves (Personal

communication, field officer of Meru herbs). Neem is also reported to be effective.

For more information refer to datasheet on [the larger grain borer (click here)]

The lesser grain borer (*Rhizopertha dominica*)

Lesser grain borer (*Rhyzopertha dominica*). Adults are 2 to 3 mm in length and reddish-brown in colour (shown on wheat grains).

This is a tiny beetle (2-3 mm long) with a slim and cylindrical shape and red-brown to black in colour. 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. Eggs are laid loose among the cereal grains. The larvae are mobile. Both larvae and adult bore through the stored produce usually causing characteristic round tunnels (up to 1 mm diameter).

In later stages of infestation this beetles may also hollow out the grains. Pupation usually takes place within the eaten grain. The lesser

United States, (www.bugwood.org)

grain borer is primarily a pest of cereal grains, other seeds, cereal products and dried cassava. It will be controlled by any method that controls the larger grain borer.

For more information refer also to datasheet on the larger grain borer (click here)

Grain weevils (*Sitophilus* spp.)

Adult beetle of Maize weevil (*Sitophilus zeamais*). Adults can be found wandering over the surface of grain.

The adults are small (2.5 to 4.0 mm long), brown weevils with a long, narrow snout. Female lays eggs inside the grain. The larva (grub) lives and feeds inside the grain hollowing it out. The adult attacks whole or damaged grains causing irregularly shaped holes. Grain weevils attack grains either in the field before harvest or in the store.

Wallingford.

Rice weevil (*Sitophilus oryzae*)

The rice weevil (*Sitophilus oryzae*) is a major pest of rice, maize and other cereals in store.

Flour beetles (*Tribolium castaneum*, *T. confusum*)

The adults are elongated beetles, 3 to 4 mm long, red brown to dark brown in colour. The wing cases are marked with finely punctured lines. Larvae and adults are secondary pests and attack cereals and cereals products, groundnuts, nuts, spices, coffee, cocoa, dried fruits and occasionally pulses. Infestation leads to persistent unpleasant odours of the products.

Khapra beetle (*Trogoderma granarium*)

The adults are oval beetles, 2 to 3 mm long, dark brown in colour often with blurry reddish markings. The larvae are very hairy. They are common in hot dry areas. Damage is done only by larvae feeding on cereal grains and products, groundnuts, oilseed cakes,

nuts, pulses, etc.

Dried fruit beetles(*Carpophilus* spp.)

They are slightly flattened ovate to oblong beetles, 2 to 5 mm in length. The wing cases are short, leaving part of the abdomen exposed. They are light brown to black in colour, but several species have yellow or red markings on the wing cases. They are secondary pests; presence of these beetles is an indicator of damp, mouldy conditions. Adults and larvae cause damage on poorly dried cereal grains, cocoa, copra, oilseeds, dried fruit, vegetables, herbs and mouldy produce.

Moths

The potato tuber moth (*Phthorimaea operculella*)

This moth is the most serious pest of potatoes in the region. It occurs

in Africa wherever potatoes are grown, and it also attacks tobacco, eggplants and tomatoes.

Pupae of the potato tuber moth on potato tuber.

© J. Kroschel, CIP

Caterpillars of the potato tuber moth are up to 12mm long and feed as leafminers, causing silver blotches on leaves, and bore into the petiole or a young shoot or main leaf vein and later into the tuber. This causes wilting of plants. When eggs are laid on tubers, caterpillars begin feeding on the tubers immediately upon hatching making long irregular black tunnels, which are filled with excreta (faeces), where disease-causing microorganisms grow.

Major damage is caused by

caterpillars burrowing in the tubers. Infestations start in the field; the pest is transferred with the harvested tubers to the potato store, where it can reproduce and infest other tubers. This may lead to total destruction of the stored crop.

Potato tubers damaged by the potato tuber moth.

© J. Kroschel, CIP

Natural enemies are important for natural control of the potato tuber moth. However, in many cases control by local natural enemies is not satisfactory. Therefore, several parasitic wasps, native from South America the area of origin of the pest, have

been introduced to several countries in Africa. These wasps have provided effective control of the pests in several countries in Southern and Eastern Africa.

Cultural methods (e.g. ridging, use of healthy seed tubers, etc.) and biopesticides (e.g. Bt, neem, lantana, etc) as described below are also important for managing this pest.

Parasitic wasp (*Copidosoma khoeleri*), a natural enemy of potato tuber moth.

© J. Kroschel, CIP

What to do:

- **Farmer experience: Meru MoA Field officer Mr Mwai had tested mixing dried lantana leaves with stored maize and beans - his samples had stayed for over a year without getting attacked by storage pests. (2007).**
- **Use healthy, clean seed, since infested seed tubers are the main cause of re-**

infestation in the field.

- **Avoid planting in rough soil. Plant as deeply as possible (10 cm deep) and ridge at least three times during the growing season. Experiments in Sudan showed that increasing the sowing depth from 2.5 cm practiced by farmers to 7.6 cm, significantly reduced damage by the cutworms and the potato tuber moth and resulted in an increase of 3.7 t/ha in marketable yield (Siddig, 1987).**
- **Compact hilling is very important to prevent moths reaching the tubers to lay eggs. For caterpillars it would also be difficult to reach the tubers, and emerging moths from infested tubers will be killed, since they are not able to penetrate so deep into the soil.**
- **Provide enough water to prevent soil cracks.**

Lantana leaves protect maize and cowpeas from storage pests

© Anne Bruntse, Biovision

- **Mulch the plants with rice straw and/or with leaves. Mulching with neem leaves during the last 4 weeks before harvest significantly reduced insect damage in Sudan (Ali, 1993).**
- **Intercrop potatoes with hot pepper, onions or peas.**
- **Harvest the crop immediately as it matures, as tubers left in fields for longer periods are highly infested.**
- **At harvesting, ensure that the tubers are not exposed to moths before they are properly protected in the store. All harvested tubers have to be bagged and removed before late afternoon every day.**
- **Destroy all infested potatoes immediately and remove all plant residues from the field. Caterpillars pupate in the tubers and dry stems left in the field.**
- **Destroy all volunteer potato plants before planting new potato crops.**
- **Use alternative pesticides to protect potatoes in store. Neem can be applied to reduce damage by the potato tuber moth. For instance, in India a four moths protection was achieved when**

harvested potatoes and the covering material was sprayed with 5 and 10% enriched neem seed extract (Saxena, 1995). In Sudan spraying neem seed and leaf extracts (1 kg/40 l water) and then placing tubers in jute sacks reduced post harvest losses by the potato tuber moth compared with traditional methods such as leaving the tuber unprotected or covering them with banana leaves only (Siddig, 1987). Salem (1991) showed that a neem seed extract was effective for control of the potato tuber moth on potatoes in a store in Egypt. Storage loss after 6 months in potatoes treated with 100ppm neem oil was 25% (compared to 10% with the insecticide carbaryl). Adults from larvae treated with neem oil were deformed. Work in Yemen confirmed the beneficial effect of neem; neem oil and sunflower oil halted the development of caterpillars of the potato tuber moth in storage. However, caution is needed since the oil seemed to interfere with potato respiration, leaving the potatoes very soft with dark tissue (Kroschel, 1995).

- **A Bt (*Bacillus thuringiensis*) preparation in powder form mixed**

with fine sand (1:25) dusted was very effective in controlling this pest in the store in Yemen and Kenya (Kroschel, 1995) Tuber infestation was also reduced by bedding the potatoes in the leaves of the Peruvian pepper tree (*Schinus molle*), also known as mpilipili in Swahili, and Eucalyptus sp. (Kroschel, 1995).

- **Where this pest is present potatoes should be stored in layers with branches of lantana (KIOF), which repels tuber moth but does not actually kill it. Also application of plenty of wood ash or diatomite earth may prevent rapid build up of tuber moth**

For more information about the potato tuber moth click here

Grain moths

Angoumois grain moth (*Sitotroga cerealella*)

The moths of the Angoumois grain moth are small (about 1 cm long with a wing span

Angumois grain moth on maize. The moth is small, pale brown, 5-7 mm long with wings folded, wingspan 1-1.6 cm

of 10 to 18 mm), yellowish or straw-coloured, and have a fringe along the posterior margins of the wings. They can be observed flying around infested stores. Female moths lay ovoid and pinkish eggs at night in clumps on the outside of cereal grains, in cracks, grooves or holes made by other insects. Eggs are initially white turning red near hatching. The larvae are caterpillars of dirty white colour and about 8 mm long when fully grown. Caterpillars penetrate into and feed inside whole grains. They prepare a round exit hole for the moth, leaving the outer seed wall only partially cut as a flap over the hole, resembling a trap door.
The adult pushes its way out through this "window" leaving the trap door hinged to

the grain. Infested grains can be recognised by the presence of these small windows. The adult lifespan may be up to 15 days, and one female can lay over 100 eggs.
They are pests of whole cereal grains like paddy, sorghum, maize and wheat. Damage is similar to that caused by weevils. This moth may also infest the crop in the field prior to harvest, and damage can reach serious levels, before the grains are stored.

Storage moths or tropical warehouse moth (*Ephestia cautella, Corcyra cephalonica, Plodia interpunctella*)
The main storage moths are the tropical warehouse moth (*Ephestia cautella*), the rice moth (*Corcyra cephalonica*), and the Indian meal moth (*Plodia interpunctella*). These storage moths are small (15 to 20 mm wingspan), greyish brown in colour

Storage moth (*Ephestia cautella*).

© Ministry of agriculture, Japan (Courtesy of EcoPort)

with an indistinct pattern. The moth of the Indian meal moth is distinctive with the outer half of the forewings a coppery-red separate from the creamy inner half by dark grey bands. Female moths lay eggs through holes in the bags. Larvae are elongated whitish caterpillars about 2 cm long. They feed on the seed germ, moving about freely in the stored foodstuff. They cause extensive damage in cereal flowers and other milled products, but also in whole grains, mainly feeding on the germ. They also attack nuts, groundnuts, dry fruit, cocoa, copra and other foodstuff. The dense white cocoons of the pupae are often seen attached to the bag surfaces. Infestations are characterised by aggregations of kernels, frass, cocoon and dirt caused by webbing, which contaminates the foodstuff reducing its quality.

Fungi

Storage fungi include species of Aspergillus and Penicilium.
Storage fungi require a relative humidity of at least 65%, which is equivalent to equilibrium moisture content of 13% in cereal grain.
Storage fungi grow at temperatures of between 10°C to 40°C.
Infection with certain species of fungi may already occur in the field, reducing considerably the storage life of grains.
Infection with storage fungi can cause:

- **Loss of nutrients**
- **Discolouration of the grain**
- **Reduction of germination capacity**
- **Caking of grains**
- **Increase in the temperature of the stored goods up to spontaneous combustion**
- **Mouldy smell and taste**
- **Production of mycotoxins; these are toxic substances produced by various fungi under certain conditions, which remain in the stored product as residues. They are highly poisonous to**

both human and animals. The best-known mycotoxins are aflatoxin, ochratoxin, patulin and citrin. Aflatoxins, which are produced by *Aspergilum flavus* are regarded as very dangerous substance causing liver cancer

Damage caused by fungi is often neglected until it has reached an advanced stage. However, it is very important to prevent growth of fungi, since it is the only way of avoiding mycotoxins. Mycotoxins are very stable and cannot be destroyed by boiling, pressing and processing. This means that infected produce has to be destroyed. Mycotoxins can be found in the stored product as soon as 24 hours after infection with fungus.

To prevent contamination by fungi, the produce must be properly dried, and any source of moisture in the store should be avoided.

Storing Seeds and Grains - Principles of Preventive Storage

Protection

1. Choice of variety and selection of healthy seeds

Select the most suitable seeds for planting. Indigenous seed has been developed for hundreds of generations and are well adapted to the area where it is grown, whereas some modern varieties are higher yielding but may be more susceptible to pests. There is a widespread perception that modern, high-yielding varieties of maize may be more susceptible to storage pests. These varieties often have open cob husks, allowing insects and birds to easily attack maize in the field, whereas some of the traditional varieties have closed husks, thus effectively protecting the crop from insect attack. The same have been observed with some sorghum varieties. Therefore, the increased yield offered by some varieties should be weighed against the susceptibility to storage pests, the expected period of storage and the price to be expected for grain of a particular damage level. Efforts are going on to develop high yielding varieties with resistance to storage pests

Select the best seeds for next years planting avoiding damaged and sick looking seeds.

2. Choosing harvest time

If planting and harvesting is planned so that harvest falls in the dry season there are no special problems with drying the crop. Care should be taken when cultivating new high yielding and early ripening varieties, since the harvest may fall in the wetter part of the year, and this may create new problems of storage.

Some storage pests (e.g. bean beetles, cowpea bruchids, the larger grain borer and some moths) infest beans and grains in the field only when the crop is almost dry. Timely harvest can therefore ensure that these pests are not carried into the store along with the beans or grain. Thus, timely harvesting (avoiding late harvesting) significantly reduced infestation by the bean bruchid and cowpea

bruchids in Kenya (Olubayo and Port, 1997). As a rule, do not leave crops in the field when they are ready for harvest, this increases the chances of infestation by some storage pests

3. Drying

Drying is an important procedure in storage protection. It prevents seed form germinating and prevents attack of fungi. Some fungi can cause cracking of seed thereby making the seeds more susceptible to pest attack. All seed must be dried to not more than 12-13 % moisture in order to be stored safely. To make sure the seed is properly dried put one seed or kernel in the mouth and chew. If it cannot easily be cracked it is dry enough - if it crushes between the teeth it is not dry enough. This is known as the tooth test. See also salt test in 'The Organic Farmer Magazine' Nr. 30. November 2007.

Heat used for drying the produce will also kill larvae and chase

away adults of insect storage pests. Care should be taken to avoid overheating since excessive heat can damage seed or grains. Care should be taken not to exceed the following temperatures: beans: 35 °C, seeds: 43 °C, cereals: 60 °C.

The following methods of drying are possible:

- **Seed can be spread out in the sun on a hard clean surface to dry for several days in dry weather, until a seed cannot be bitten into when putting it in the mouth. The thickness of the layers of cobs, panicles, pods or grains must not exceed 5cm, and the seed must be turned regularly in order to ensure good and even aeration. In the evening, the produce must be put in a pile and covered.**
- **Simple driers. Several designs of solar driers are available.**

4. Sorting and cleaning the produce

Check whether the produce is infested by taken samples. Pay

particular attention to cracks and gaps where insects may hide. If the produce is infested, ensure it is stored separately (quarantine) and treated in order to prevent the pests infesting clean produce. In case of heavy infestation discard the produce. In case the produce is slightly attacked, heating to no more than 50°C can kill moths and weevils; use a thermometer, as heating to any higher temperature will destroy the germination capacity the seeds (See also heat treatment for seeds click here).

Removal of infested grains or cobs and pests can also be done by hand, sieving, winnowing or moving the grain (shaking, restacking). When using methods that merely separate the pests from the stored product, ensure that the pests removed from the produce are killed to avoid reinfestation.

5. Store location

Site stores away from any potential source of infestation. The grain

and tuber moths are good flyers and adults from infested stores often infest growing crops in the field. Separations of stores from fields may help to reduce attack.

6. Characteristic of store

A good seed store must be airy, shady, cool and dry. Temperature variations should be as small as possible, because these encourage condensation of water, which promotes fungus development.

Crops in the store should be protected against dampness rising from the ground, and the site should be safe from flooding in the rainy season. The roof should have no leaks. Keep the temperature and humidity as low as possible (perform controlled ventilation). There are indications that storing grain in a dry place may help reduce infestation of grain moths.

Prevent pest entry by sealing the store (windows, doors, ventilation facilities) with insect-proof gauze. In Malawi, plastering stores with mud to reduce water uptake was found to be effective (Golob and Muwalo, 1984, in CABI, 2000).

Hermetic, airtight storage at low humidity gives good protection against storage pests. However, to avoid mould growth care should be taken to ensure that the produce is dry. This is particularly applicable for long-term storage in warm dry areas. It is advisable however, not to store seed grain for more than a few months. In conditions where the relative humidity is high, airtight storage is not recommended due to the risk of mould growth.
Hermetic storage is useful for storing small amount of seeds or grains (e.g. to be used for replanting); they can be stored in a strong airtight container with a close fitting lid (glass, ceramic, strong plastic can be useful). Ceramic pots that do not have lids must be covered very carefully or topped up with dry soot, ashes or fine dry soil.

7. Storage Hygiene

Always keep the store and its surroundings clean; it has been said: "the most important, economic and effective tool for storage hygiene is the broom". Before newly harvested crops are stored, the store should be carefully prepared well ahead of time. Old stored products should be removed and the room completely cleaned up. The whole building should be well aired and if possible fumigated or disinfected (see store fumigation and disinfection below). The walls and roof and floor should be both watertight and rat proof, and small holes and cracks, which are potential breeding places for storage insects, should be sealed.

8. Inspecting the store

Periodic inspection (weekly to fortnightly) and removal of any infested produce is essential. Check for droppings and footprints of birds and rodents. Look for flying moths at dusk. Brush stacks

of bags with a trick or broom to disturb and discover resting moths. Lift bags in order to detect moth cocoons along the line where bags touch each other.

When looking for beetles, pay particular attention to cracks, bag seams and ears where they often hide. Empty individual bags in a thin layer onto a sheet and examine the contents for beetles and larvae. This should be done in the shade so that the insects do not flee immediately.

Insects can be also be sieved out using a box sieve with a mesh of 1 to 2 mm. Identify the insect found in order to perform the correct treatment. These measures should prevent the breeding of carry-over insects from former crops. The surroundings should also be cleared to discourage easy re-infestation by insects and rodents.

Infection with fungi can be detected by the mouldy smell, which is noticeable even before any visual changes to the product can be seen. Pay attention to water marks on bags, which can be still noticed after the bags have dried.

9. Store fumigation

Farmers in the Philippines as well as in Benin lit fires in which powdered chilli pepper is burnt underneath grain stores once a month to keep away storage pests. One disadvantage is that the smoke is very sharp and uncomfortable for eyes and respiratory system also for humans.

10. Store disinfection

After the store has been cleaned completely and all old deposits of dust (possibly containing insect eggs) has been removed, is good practice to dust the whole store with Diatomite earth, lime or ashes as a further prevention of problems. Where larger grain borer has attacked the wood in the construction, the wood should be treated with any of the approved wood preservatives or thoroughly sprayed with kerosene, oil mixture to get rid of any surviving grain borers.

Modernised granary

Raised modernised granary with a high iron sheet roof with old oil smeared on the lower side of the support poles to prevent termite attack.

Traditional granary

Raised traditional granary with several layers of thick grass and old oil smeared on the lower part of support poles to prevent termite attack.

Additives are useful to protect stored produce form pest attack

Introduction

The use of mineral substances such as fine sand, clay dust, lime and wood ash cause invisible injuries to the stored food pest

leading to dehydration. They also fill the spaces between the grains, making difficult for the pest movement and respiration. When using mineral substances the amounts required are around 50 to 100 g per kg of stored product, except for sand, of which larger amounts are required.

The addition of ashes, fine sand, lime, diatomite earth, and mineral or vegetable oils is particularly useful for protecting small farm seed storage, or for storing small amounts for replanting. However, this is not always practical for large quantities of seed in terms of labour required. For larger amounts of grains and seeds it is often more practical to simply mix the seed with any strong smelling plant material available to repel insects. Some plants such as pyrethrum and derris can actually kill storage insects.

Wood ash

Wood ash either alone or mixed with powdered chilli pepper is an

efficient method of pest control. However, ashes may have an effect on the taste of the treated product. The success of this method depends on the amount of ashes being added. Ashes at 2 to4 % by weight of grain is said to give 4 to 6 months protection if the moisture content of the grain is below 11%. Ashes from casuarinas, derris, mango and tamarind are particularly suitable. Any other ash mixed with powdered pyrethrum, Mexican marigold or syringa seeds will increase the protection against insects. Ashes do not control the larger grain borer.

Lime

Mixing seeds with 0.3% lime have given good results in weevil control.

Sand

In districts where fine sand is easily available it can be used for protection of stored products. It is best used with bigger seeds, the

intention being that all the spaces between the larger seeds should be filled by sand, which can easily be removed again by sieving. The more sand used the better, but at least equal amounts of sand and seed should be used.

Diatomite

Diatomite or diatomaceous earth (DE) is mined in Kenya and can be obtained at a very reasonable price. It consists of tiny fossil diatoms whose skeletons, made mostly of silica, form the diatomite deposits. Diatomite is a very effective and non-poisonous insect killer. As a dust it can absorb a lot of water, and it kills insects by drying them out. It has been used in South Africa for many years by organic farmers in various kinds of insect control.

Farmers using ½ kg DE/ bag of grain do not experience any problems with weevils. The sales office at African Diatomite Industries in Gilgil, Kenya claim that as little as 3 kg/ton of seed is

enough to protect the grain/beans. See also article in 'The Organic Farmer Magazine' No 30, November 2007.

Bt or *Bacillus thuringiensis*

Bt in powder form mixed with fine sand is effective against potato tuber moth. May be tried against grain moths as well. For more information see on potato datasheet

Vegetables Oils

Oils of coconut, castor bean, cottonseed, groundnut, maize, mustard, safflower, neem and soybean affect egg laying, and egg and larval development of stored pests. The addition of vegetable oil is particularly useful in protecting legumes against pulse beetles (bruchids). Losses in pulses can be prevented with the addition of 5 ml oil per kg of grain/seed. To be effective the seed must be coated properly with oil. Sunflower oil is not very effective. The effect of oil treatment decreases with time, so seeds stored this

way should be treated again at any new sign of infestation. Small seeds may loose some of their germination capacity after oil treatment. If neem seed oil or any other non-food oil is used the bitter taste can be removed by immersing the seed in hot water for a few minutes before food preparation.

Admixture of plant parts

Traditionally many different types of parts plants are used against store products pests.
Examples of plant materials that help protecting the stored grain/seed:

Plant names	Plant parts	Treatment
Aloe	Whole plant	Parts dried, ground and dust mixed with the grain

Chilli peppers	Ripe, dried pods with ashes, dung or fine clay	Whole pods mixed with grain or dusted as powder on beans
Pyrethrum	Flower heads	Pick on hot days. Dry in the shade. Crush to powder and mix with grain/seed.
Sunnhemp (Crotolaria)	Seeds	Mix seed between gaps in stored larger size grains.
Datura (thorn apple)	Leaves and stems (careful - seed are very poisonous)	Dry and mix with produce
Derris	All parts	Stored produce dusted or sprayed
Eucalyptus	Leaves	Layered or mixed with stored produce
Lantana	Leaves	Crushed and placed among

sp.		**seeds**
Syringa (*Melia Azedarach*)	**Leaves, ripe seeds**	**Dried, powdered, mixed with stored grain using 2% if powder from seed, 4% if powder from leaves**
Mexican Marigold	**Whole plants**	**Add dried plants in layers, or mix in powdered plant or place 3-5 cm layer of crushed plants in base of grain bins**
Spearmint	**Whole plant**	**4% leaf powder will give good protection for more than 4 months**
Neem	**Leaves, crushed seeds and their extracts and oils**	**-**

The dosages of plant substances required are generally around 50g per kg of stored product (Gwinner et al., 1990).

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Weeds

Weeds
Host plants: Amaranth Eggplant Potato Tomato

Introduction - What is a Weed?

According to CABI's (2005) definition, a weed is a plant which grows where it is not wanted. In conventional agriculture all the plants germinating in the field, which are not specifically planted by the farmer, are often called weeds. This definition of weeds have led to "weeds" being rigorously weeded out or killed by herbicides as an integral part of what is currently known as conventional farming.

Another definition is that a weed is a plant, the use of which has not yet been discovered. This definition fits in better with the natural law of Biodiversity, nature striving to create balances in vegetation/soil and fauna (creatures living off plants). Farmers in Kenya are often observed to be leaving edible weeds in the fields

when weeding, not enough to threaten the main crop but just enough to have early maturing vegetables to eat until the main crop is ready.

In an integrated approach to weeds as part of biodiversity a connection can also be made to growing companion crops which will cover the ground and do the job weeds do in a natural system, namely keep the soil covered protecting it from erosion.

Notorious (troublesome) weeds are generally divided into two major categories:

- **Annual weeds (e.g. purple witchweed/Striga)**
- **Perennial weeds (e.g. couch grass and sedges)**

Management practices depend on which type is predominant in the field.

Biology and Ecology of Weeds

Annual weeds

These are all the weeds germinating from seed along with every crop and going through a full lifecycle from germination to flowering to setting and dropping seeds in one season. All healthy topsoils have myriads of different types of weed seed, and every time the soil is disturbed a new lot germinates, in order for the ground to keep itself covered. If we leave these weeds to grow unchecked, the crop we are trying to cultivate will not do well as there is too much competition.

Witchweed (*Striga hermonthica*) flowering on a sorghum crop.

© Chris Parker/CAB International. Crop Protection Compendium, 2005 Edition. Wallingford, UK

For more information on purple witchweed (striga) click here

Perennial weeds

These are weeds with a root system that survives the dry seasons and stay alive for two or more seasons. If not controlled, perennials can completely crowd out crops in some cases by sending a dense network of underground roots and stolons in all directions. They are very difficult to control as the roots go deep and a very small piece of root or stem can regrow after weeding and create new networks.

Perennials such as couch grass and sedges have a function though: they help the soil restore aeration and natural life in the patch of ground where they grow. They also protect the soil from soil erosion, being carried away by water or wind and the grasses provide fodder for livestock. . If these perennial weeds cover unproductive corners of the farm or steep hillsides they are not harmful, so far they do not invade the crop area.

Sedges (*Cyperaceae*) have smooth leaves and triangular flower stems. The clustered seed heads differ according to species (there

are more than 50 species in East Africa)(Terry 1976). They have underground bulbs, stolons or tubers which can remain dormant for long periods of time. They are often only minor problems in shambas with a mixed weed population.
Sedges are not real grasses and most livestock only eat them if there is nothing else available.

Sedge grass (*cyperus longus*) with underground

The most common species of *Cyperus* includes *Cyperus longus* with underground stolons like couch grass and no visible "nuts". This is particularly troublesome in rice fields and other waterlogged locations. *C.rotundus* , more common in hot areas, has underground nuts and thin connecting stolons.

stolons
© A. Bruntse, Biovision

Nutgrass

© A. Bruntse, Biovision

Another troublesome sedge especially for non-tillage farmers is "watergrass" - small plants with a tiny underground "nut" and a prolific seed producer.
Sedges (including nutsedges and watergrass) release chemicals that reduce the growth of other plants near them, which is why

most crops grow very poorly in the presence of sedges.

Among the many weeds we see everyday some do not seem to have any function that we know of. But this does not mean they are useless. However, *oxalis* in spite of its tiny size has been found to reduce the yield of maize up to 24% (Terry 1984).

If you look carefully, most of these perennial weeds are most serious where the soil is compacted, waterlogged or has generally become infertile, or on mechanized farms where annual weeds have been killed by herbicides.

Oxalis **growing and some uprooted - note the small underground bulbs from which the stems break very easily.**

Couch grass (*Cynodon dactylon*) is a perennial grass, with underground rhizomes and on the ground runners.

© Charles T. Bryson, USDA ARS, www.insectimages.org

For more information on couch grass click here

Weeds and soil fertility

In studying the relationship between weeds and soil fertility a clear connection appears. Of all the seeds stored in the topsoil, those suited to the soil status will be the ones germinating. Certain weeds will germinate on very poor and damaged soil and very different ones will grow on a soil in good fertility.

Weeds, as any other plants, take up nutrients from soil and air and return them to the soil when they die. On a poor soil the weeds growing will be those that are able to extract or fix nutrients the more demanding plants are not able to take up under the same conditions. The poor fertility plants/weeds will therefore enrich the soil and slowly improve it, if left to do their job. High fertility weeds left to do the same on fertile soils will improve the soil even faster as they take up/fix higher amount of nutrients.

It is known that too many weeds reduce yields, but not much research has been carried out on retaining some weeds for soil protection but keeping them down to a manageable level, so as not

to interfere with the main crop.

On slopes there are many recommendations for strip cropping in order not to loose valuable top soil. The grass strips than become soil conservation measures. However, very good results have been achieved by The Conservation Agriculture research team on replacing weeds as ground cover with legumes, both as far as yields and reduced workload for the farmers is concerned. (IIRR 2005)

Annual Weeds

1. Edible weeds

Many weeds are useful, some are edible and very nutritious (e.g. amaranth, nightshade, mustard, etc.) and in traditional gardens some of these are often left to grow and harvest for the family meals. Improved varieties with bigger leaves have been developed commercially and these are planted as traditional vegetables for market and home use, and show a much better nutritional content than the normal commercial vegetables. Mustard plants also

contain compounds that will combat such soil diseases as bacterial wilt and nematodes (See also biofumigation).

Amaranth.

© A. Bruntse, Biovision

For more information on amaranth click here

2. Medicinal weeds

Other weeds such as blackjack, Mexican marigold and many others (normally the smelly ones) have plant protection properties and yet others (such as the Wairimu Waweru of Kinangop) have medicinal properties which can be very valuable in a self sufficient farming system, and provide medicine for animals and people.

Blackjack.

Mexican marigold.

Usually the old people in the area will know which weeds have medicinal properties, what they can be used for and how to prepare medicine from them. Ask the elders about the weeds; they will be delighted to teach and perhaps they can even help develop a little business selling such medicine. It is also good to keep records of

knowledge about medicinal weeds/herbs as such knowledge is fast disappearing, and could become very useful in the future.

If you have any useful tips to share with other farmers through this website please send us a note about it and we shall contact you and quote you by name on this site.

3. Nitrogen fixing weeds

Healthy

Still other weeds such as various clover varieties, desmodium and other legumes fix nitrogen from the air and help improve soil fertility. Weeds such as tithonia (wild sunflower), also helps improve soil fertility when the leaves are incorporated into the soil as green manure.

Many farmers are always complaining about the Kenya white clover , which is a powerful growing

Desmodium soil cover in Passion plantation reduces weeding costs and benefits soil and crop. When the legumes become too vigorous, they can be cut and used as animal feed or mulch for other crops.

© A. Bruntse,

legume (personal communication with farmer groups in the Rift Valley of Kenya) . It falls in between an annual and a perennial plant, as it produces seed in the first season, but plants do not die and continue into the next season if moisture levels permit. It is a creeper which when left undisturbed develops large patches of dense clover. Farmers say it gives cattle bloat. This can be true if animals are allowed to graze while the leaves are wet (same as for any other high protein legume), but if you wait till the leaves are dry and mix the clover leaves with grass, it is very good protein rich feed for all livestock. Clover can also be cut and dried as hay along with grasses.

Clover overpowers other weeds including couch grass, many other grasses and sedges and as such can be used to control them. In Europe

Biovision, courtesy of ReallPM, Thika, Kenya.

clover is used in grass mixes for pasture feed production for grazing, hay making and silage making, and it has been measured that a good mixture of clover grass can fix over 300 kg/ha of nitrogen in one season (6 months). In Kenya, clover is a versatile plant, which can survive the shade underneath maize plants, provide ground cover on walking paths and non utilized patches of crop land - there is always that corner where nothing else grows. It can greatly help in preventing soil erosion by protecting the soil from the sun and the rain.

So farmers, should not kill the clover and other nitrogen fixing legumes, but experiment with them and let them help improve the fertility of the soil. When patches are getting too big, dig up some of the plants and transfer to areas that have no legumes. Taller plants are not affected by clover growing underneath, but small plants with superficial root systems need to be given space for their own initial root development.

For more information on purple witchweed/striga click here

Perennial Weeds

Couch grass and sedges (*Cyperaceae*) are especially troublesome. Sedges have underground storage roots such as nuts or stolons; the plants are also known as nut-sedges or watergrass. These weeds even produce chemicals that hinder the growth of other plants, which is why crops usually do poorly in the presence of sedges.

Strawberry field with sedges.

For more information on couch grass click here

Weed Control

Control of annual weeds

Many methods and gadgets have been devised to combat annual weeds at an early stage to get optimum yield of our food crops:

1. Digging or pulling the weeds and removing them from the field (in small gardens). This removes from the field all the nutrients collected by the weeds.

2. Shallow cultivation at an early stage and leaving the weeds to dry on top of the soil either by hand or by animal or tractor mounted

equipment. Tools include row cultivators, small grain seed spring harrows and hard brushes for row treatment. These 2 first methods as well as no 5 and 6 are developed in the cool temperate climates and generally aim to keep the soil in between crop plants bare. Under the African sun, bare soil is also unprotected soil. Unprotected soil is prone to erosion, crusting after heavy rains and general soil degradation. There will also be a flush of germination of weeds after every rainfall as nature strives to repair the damage, and repeated energy consuming weeding operations will need to be carried out.

3. Slashing weeds at ground level when 10-15 cm tall and definitely before flowering, then leaving them on the ground as mulch, reduces the weeding work substantially. It is much lighter work to slash than to dig with a hoe (jembe) and intervals between slashing can be longer than between traditional weeding/digging. This method can also be using either hand slashing or animal/tractor drawn equipment such as mowers or the knife rollers developed by

Conservation agriculture studies in East Africa.

4. Planting of ground cover plants especially legumes to crowd out further "weed" germination. This not only provides ground cover but also enriches the soil, and will eliminate further weeding operations. The legumes will often continue growing after the main crop is harvested, providing soil protection until the next crop is planted. They can also become useful for feeding livestock or for incorporating into the soil as green manure.

5. Burning. Mechanised farming can choose between a variety of equipment for weed control by burning, both back pack types and tractor mounted equipment. This method will not improve soil fertility, but instead burn off badly needed humus in the top layer of the soil.

Herbicide spraying is not allowed in organic farming. This method uses various plant poisons to kill the weeds, all of which are

harmful to natural systems and some of which can stay in the soil for a very long time and become part of the food we eat. There have been many examples in East Africa especially from Flower companies renting land from small farmers, returning that land poisoned to an extent that attempts at selling export food crops from this land has been rejected from the export markets due to too high levels of herbicide contamination. Do we really want to eat such food ourselves?

Control of perennial weeds

Management of sedges:

- **Ground covering legume plants and mulches can play a very important role in both improving the soil fertility and combat perennial weeds. Clover and other leafy and strongly growing legumes planted in sedge infested land will both overpower the**

sedges and enrich the soil. In the case of watergrass or nutsedges, harrowing only makes the problem worse, as the root nuts will be separated from the stems and given the opportunity to send out many new shoots.

- **Solarisation. Covering a sedge infested piece of land with black polythene after wetting it, and leaving for some days with hot sunshine, will completely eliminate any of the sedge species. However plastic is expensive, so if it cannot be afforded try the first option: ground cover with legumes. For more information on solarisation click here**
- **Mulching. *C. rotundus* has been successfully controlled with heavy mulching. Initially the weeds grow prolifically, but after a wet period they are easy to remove by careful hand pulling making sure the "nut" does not stay in the soil. This does not work on hard unmulched soils.For more information on mulching click here**
- **Hand digging. Very careful hand digging with a knife ensuring all the little underground bulbs are removed can give a small**

reduction in *oxalis* populations (annual or perennial), but is very time consuming and bound to leave a few bulbs here and there which will waste no time in germinating.

Weed control in row crops

Best weed control there is, is to keep the soil covered with useful plants during the growing seasons and with mulch or tree cover as far as possible during dry seasons. Once the green manure crops cover the soil in between the maize or cassava, there is no more need for weeding. Remember weeds/plants are nature's tool to create biodiversity and a healthy soil. Help nature create the biodiversity and the heavy weeding work (fighting nature) becomes much lighter.

Weeds or green manure left in the field after a crop should be left to grow during the dry season if they can. If not they will at least protect the soil which can then be prepared for planting just before

the rains are expected. On slopy land which has not been terraced, cultivate in strips across the slope only. Any soil washing off will then be caught by the next strip of weeds.
Mechanical tractor pulled row cultivators are also available for those who can afford them. Alternatively hand weeding is needed.

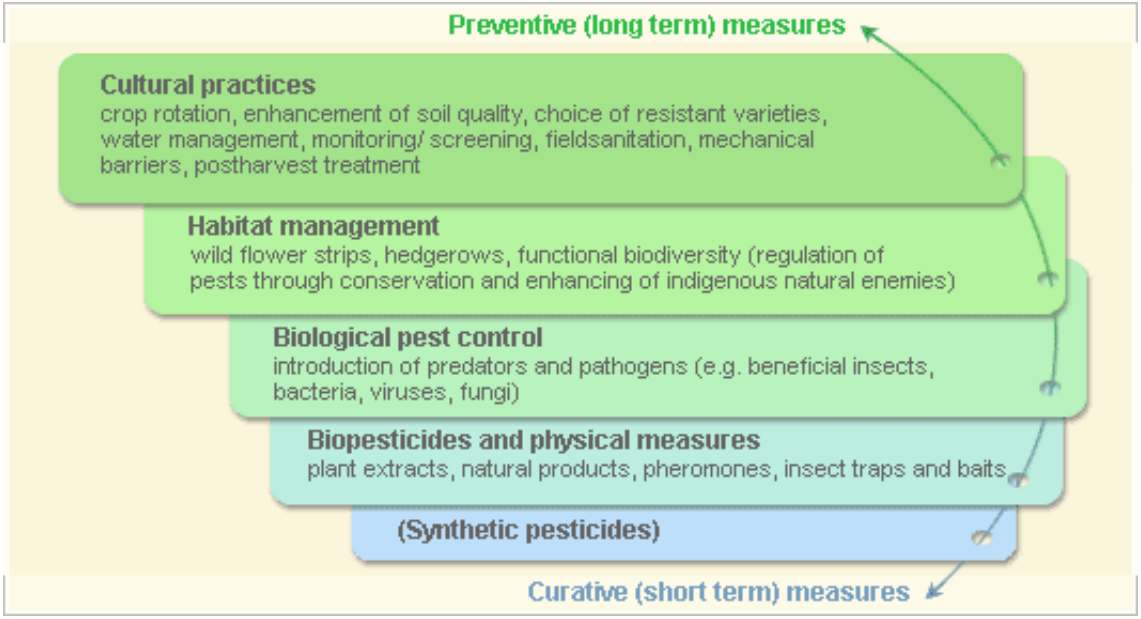
Weed control in small grain crops

Small grains such as wheat, barley, etc are normally planted in dense populations as their rate of ground cover per plant is fairly poor. This poses problems for weeding. In Europe and other places there is equipment specially constructed for mechanical weed control in grain fields, but such equipment is not yet available in East Africa. Therefore, small fields of organic wheat should be sown in rows far enough apart to be able to weed at least once with a hoe. Measure the width of your hoes and make sure they can fit in between the rows of grain when seeding.

If legumes are available for intercropping they should be sown directly after the first weeding. Blue vetch is a good legume to intercrop with small grains. Also peas in an oat field will both improve the forage yield and nutritional value of the combined crop, while keeping other weeds under control.

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 Weeds.

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Tomato mirid bug

Tomato mirid bug
Host plants: Tomato

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Viral diseases

Viral diseases

Host plants: Peppers Potato

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Yellow mosaic virus

Yellow mosaic virus
Host plants: Green gram

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Stemborers

Stemborers
Host plants: Millet Sugarcane

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Sour skin

Sour skin
Host plants: Onion

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