Crops/ fruits/ vegetables
Pests/ diseases/ weeds
African armyworm
African bollworm
African cassava mosaic virus (ACMV)
African maize

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Cabbage moth
Scientific name: *Crocidolomia pavonana (= C. binotalis)*
Order/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

stalkborer
Anthracnose
Aphids
Bacterial wilt
Bagrada bug
Banana weevil
Black rot
Cabbage looper
Cabbage moth
Cabbage webworm
Couch grass
Cowpea seed beetle
Cutworms
Damping-off diseases

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 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

Damage caused by caterpillars of the cabbage moth (*Crocidolomia binotalis*)

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nematodes
Snails (Giant East African Snail)
Spider mites
Spotted stemborer
Storage pests
Sweet potato weevil
Termites
Thrips
Tomato Yellow Leaf Curl Virus Disease (TYLCV)
Turnip Mosaic

the developing head. Even a single mature caterpillar per plant is capable of causing economic loss to cabbage at pre- and post-heading stages.

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.

Virus (TuMV)
Weeds
Whiteflies

Medicinal plants

Fruit and vegetable processing

Natural pest control

Cultural practices

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.

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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

© A. M. Varela, icipe

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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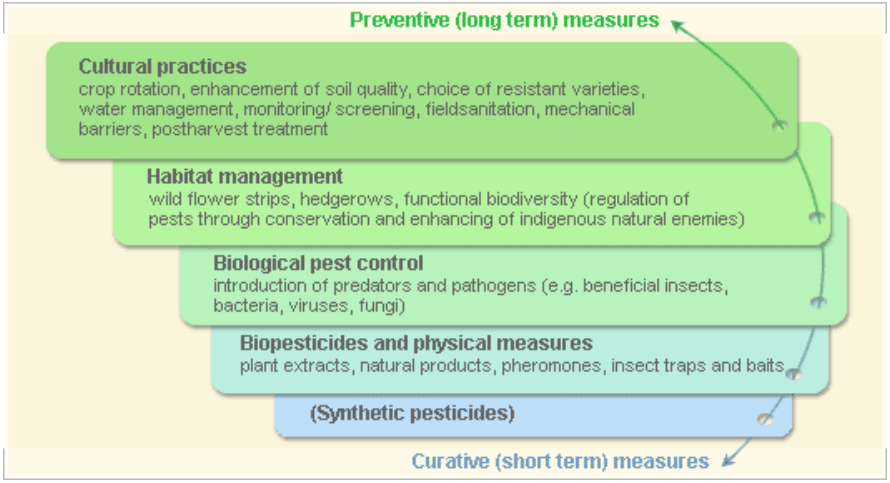
Pest and Disease Management

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



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Further below you find concrete preventive and curative methods against Cabbage moth.

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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.

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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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Information Source Links

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Crops/ fruits/ vegetables

Pests/ diseases/ weeds

African

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Snails (Giant East African Snail)
Scientific name: *Achatina fulica*
Order/Family: Pulmonata: Achatinidae
Local names: Swahili: Konokono; Kiluya: Likhorionio; Kikuyu: Dinoho; Kikamba: Inonga; Luo: Komunio

armyworm
African bollworm
African cassava mosaic virus (ACMV)
African maize stalkborer
Anthracnose
Aphids
Bacterial wilt
Bagrada bug
Banana weevil
Black rot
Cabbage looper
Cabbage

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

The Giant East African Snail is native to East Africa, especially Kenya and Tanzania. It has been introduced to many countries both deliberately as

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

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

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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

(leafminers)
Mango seed weevil
Mealybugs
Powdery mildew
Purple witchweed
Root-knot nematodes
Snails (Giant East African Snail)
Spider mites
Spotted stemborer
Storage pests
Sweet potato weevil

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.

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

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.

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!

- Termites
- Thrips
- Tomato Yellow Leaf Curl Virus Disease (TYLCV)
- Turnip Mosaic Virus (TuMV)
- Weeds
- Whiteflies

- Medicinal plants
- Fruit and vegetable processing
- Natural pest control
- Cultural

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 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,

Eggs of *Achatina fulica*

© Yuri Yashin, achatina.ru,

practices

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.

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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.

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

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

© Luis Ruiz Berti, www.wikipedia.org

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).

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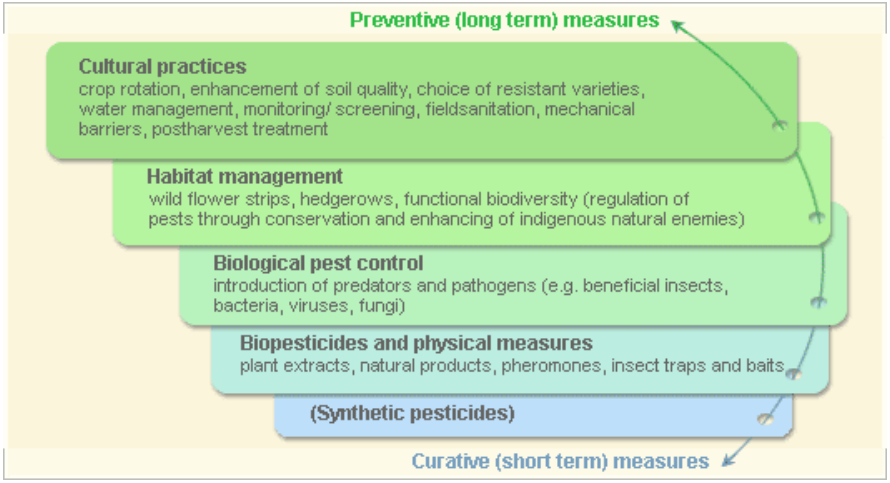
Pest and disease Management

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 Snails

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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'**

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Habitat Management

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.

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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**

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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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Crops/ fruits/ vegetables

Pests/ diseases/ weeds

African armyworm

African bollworm

African cassava mosaic virus (ACMV)

African

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Termites

Scientific name: *Ancistrotermes* spp., *Amitermes* spp., *Coptotermes* spp., *Macrotermes* spp., *Microtermes* spp., *Odontotermes* spp., *Pseudacanthotermes* spp.

Order/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
Biology and Ecology of Termites
Pest and Disease Management
Cultural practices
Biological pest control
Biopesticides and physical methods
Information Source Links

General Information on Pest and Damage

Geographical distribution

Geographical Distribution of Termites in Africa

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

diseases (red marked)
Diamondback moth (DBM)
Downy mildew
Early blight
Fruit flies
Fusarium wilt
Larger grain borer
Late blight
Leafmining flies (leafminers)
Mango seed weevil
Mealybugs
Powdery mildew
Purple witchweed

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.

- Root-knot nematodes
- Snails (Giant East African Snail)
- Spider mites
- Spotted stemborer
- Storage pests
- Sweet potato weevil
- Termites
- Thrips
- Tomato Yellow Leaf Curl Virus Disease (TYLCV)
- Turnip

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

- Mosaic Virus (TuMV)
- Weeds
- Whiteflies

Medicinal plants

Fruit and vegetable processing

Natural pest control

Cultural practices

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.

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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.

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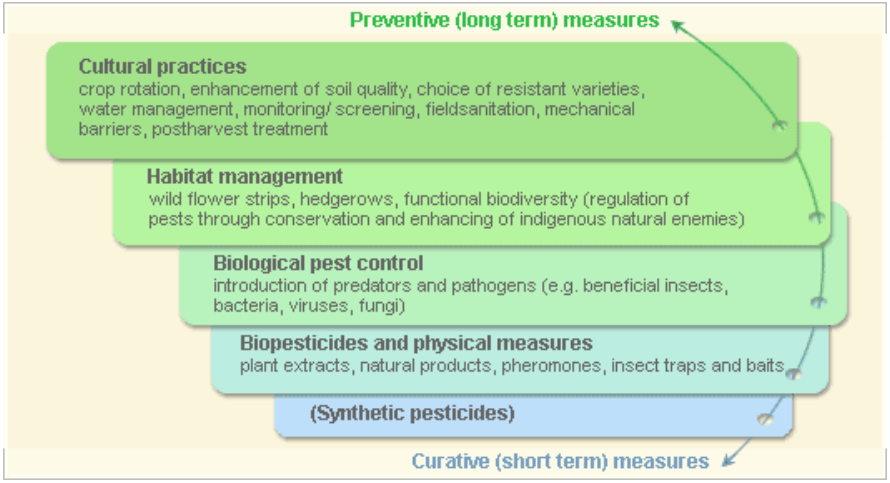
Pest and Disease Management

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



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

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

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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.**

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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.

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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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Crops/ fruits/ vegetables

Pests/ diseases/ weeds

African

more Images

Purple witchweed
Scientific name: *Striga hermonthica*
Order/Family: Scrophulariales: Scrophulariaceae
Type: weeds
Local names: Swahili: Gugu chawi (viduha)

armyworm
African bollworm
African cassava mosaic virus (ACMV)
African maize stalkborer
Anthracnose
Aphids
Bacterial wilt
Bagrada bug
Banana weevil
Black rot
Cabbage looper
Cabbage

Host plants: Cowpea Maize Millet Pigeon pea Rice Sorghum Sugarcane Teff Upland rice

General Information on Pest and Damage

Geographical distribution

moth
Cabbage webworm
Couch grass
Cowpea seed beetle
Cutworms
Damping-off diseases
Diamondback moth (DBM)
Downy mildew
Early blight
Fruit flies
Fusarium wilt
Larger grain borer
Late blight
Leafmining flies

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.

(leafminers)
Mango seed weevil
Mealybugs
Powdery mildew
Purple witchweed
Root-knot nematodes
Snails (Giant East African Snail)
Spider mites
Spotted stemborer
Storage pests
Sweet potato weevil

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

Termites
Thrips
Tomato Yellow Leaf Curl Virus Disease (TYLCV)
Turnip Mosaic Virus (TuMV)
Weeds
Whiteflies

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.

Medicinal plants
Fruit and vegetable processing
Natural pest control
Cultural

practices **Whole plant: dwarfing; early senescence**

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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.**

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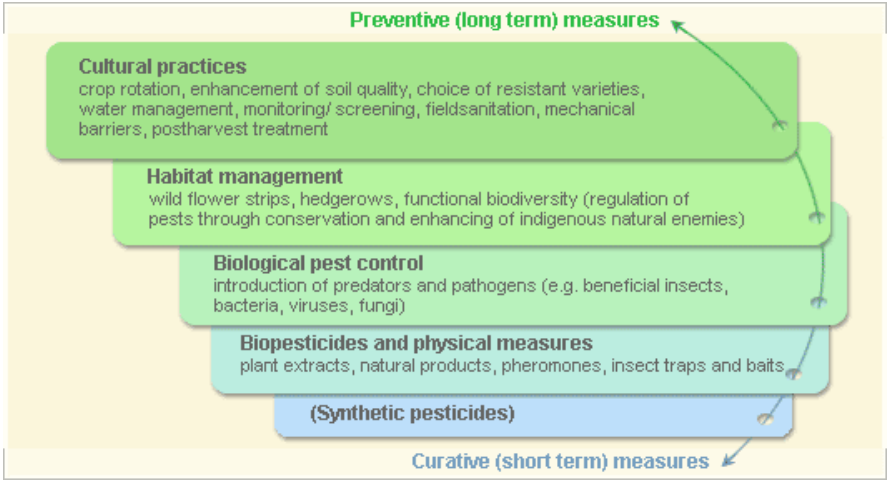
Pest and Disease Management

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



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

Further below you find concrete preventive and curative methods against Purple witchweed.

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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

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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.

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Crops/ fruits/ vegetables

Pests/ diseases/ weeds

- African armyworm
- African bollworm
- African cassava mosaic virus (ACMV)
- African

more Images

Storage pests

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

Introduction

Beetles: Weevils, Grain Borers, Bruchids, Khapra Beetles

Moths

Fungi

Storing Seeds and Grains - Principles of Preventive Storage Protection

Additives are useful to protect stored produce form pest attack

Information Source Links

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.

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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 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

- Root-knot nematodes
- Snails (Giant East African Snail)
- Spider mites
- Spotted stemborer
- Storage pests
- Sweet potato weevil
- Termites
- Thrips
- Tomato Yellow Leaf Curl Virus Disease (TYLCV)
- Turnip

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

round exit holes and the white eggs on the seed surface. Post-harvest losses are highly variable, but losses can be over 90%.

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)

- Mosaic Virus (TuMV)
- Weeds
- Whiteflies

Medicinal plants

Fruit and vegetable processing

Natural pest control

Cultural practices

bruchid (*Acanthoscelides obtectus*)

Bean bruchid (*Acanthoscelides obtectus* on soybean

© Clemson University - USDA Cooperative Extension Slide Series, (www.bugwood.org)

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 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

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

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

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*)

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

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

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 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.)

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.

Adult beetle of Maize weevil

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

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.

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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.

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.

Pupae of the potato tuber moth

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.

on potato tuber.
© J. Kroschel, CIP

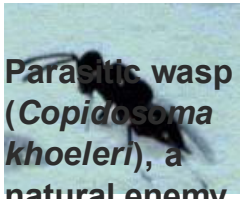
Major damage is caused by caterpillars burrowing in the tubers. Infestations start in the field; the pest is transferred with the harvested tubers to the potato store, where it can reproduce and infest other tubers. This may lead to total destruction of the stored crop.

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.



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

© J. Kroschel, CIP

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.

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).

Lantana leaves protect maize and cowpeas from storage pests

© Anne Bruntse, Biovision

- 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.
- 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 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.

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

© Clemson University-www.insectimages.org

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

Storage moth (*Ephestia cautella*).

© Ministry of agriculture, Japan (Courtesy of EcoPort)

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 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.

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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.

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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.

© J. Maundu, icipe

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. © J. Maundu, icipe

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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 sp.	**Leaves**	**Crushed and placed among 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	**Whole plants**	**Add dried plants in layers, or mix**

Marigold		**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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Information Source Links

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Crops/ fruits/ vegetables

Pests/ diseases/ weeds

- African armyworm
- African bollworm
- African cassava mosaic virus (ACMV)
- African maize stalkborer
- Anthracnose
- Aphids
- Bacterial wilt
- Bagrada bug

Weeds

Host plants: Amaranth Eggplant Potato Tomato

more Images

Introduction - What is a Weed?
Biology and Ecology of Weeds
Annual Weeds
Perennial Weeds

Weed Control
Pest and Disease Management
Information Source Links

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.

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Biology and Ecology of Weeds

wilt
Larger grain borer
Late blight
Leafmining flies (leafminers)
Mango seed weevil
Mealybugs
Powdery mildew
Purple witchweed
Root-knot nematodes
Snails (Giant East African Snail)
Spider mites
Spotted

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.

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

vegetable processing

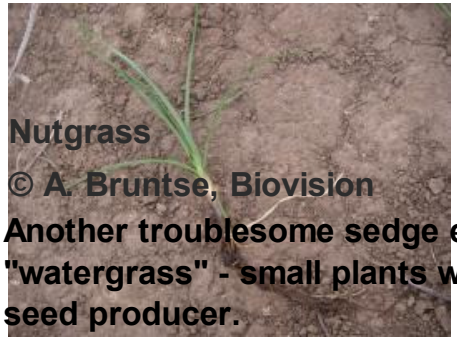
Natural pest control

Cultural practices

population.
Sedges are not real grasses and most livestock only eat them if there is nothing else available.

Sedge grass (*cyperus longus*) with underground stolons

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.



Nutgrass

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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)

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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

Blackjack.

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system, and provide medicine for animals and people.

Mexican marigold.

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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 Desmodium soil

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 legume (personal communication with farmer groups in the Rift

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, Biovision, courtesy of ReallPM, Thika, Kenya.

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 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

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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.
© A. Bruntse, Biovision

For more information on couch grass click here

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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.

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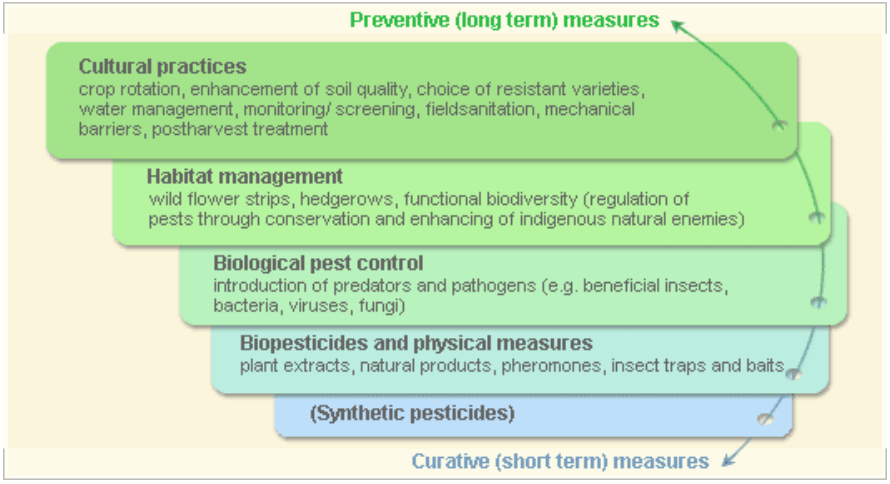
Pest and Disease Management

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



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

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

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

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Information Source Links

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Stemborers

Host plants: Millet Sugarcane

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