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Peppers
Scientific name: *Capsicum* spp. (*C. annuum* / *C. frutescens*)
Order/Family: Solanales: Solanaceae
Local names: Pilipili (Swahili)
Common names: Sweet pepper, Bell pepper, Chilli, Hot pepper
Pests and Diseases: African bollworm Anthracnose Aphids Bacterial soft rot Bacterial spot Bacterial wilt Broad or yellow tea mite Cercospora leaf spot Collar rot Cutworms Damping-off diseases Fruit flies Fusarium wilt Leafmining flies (leafminers) Phytophthora blight Powdery mildew Root-knot nematodes Spider mites Thrips Viral diseases Whiteflies

General Information and Agronomic Aspects

Capsicum pepper is the most popular and most widely used condiment all over the world. Its fruits are consumed in fresh, dried or processed form as table vegetable or spice. Capsicum peppers are extensively pickled in

- Cucumber
- Eggplant
- Green gram
- Groundnut
- Maize
- Mango
- Millet
- Okra
- Onion
- Papaya
- Passion fruit
- Peas
- Peppers
- Pigeon pea
- Pineapple
- Potato
- Pumpkin
- Rice
- Sesame
- Sorghum
- Soybean
- Spider plant
- Spinach
- Sugarcane
- Sweet potato
- Tea

Geographical Distribution of Peppers in Africa

salt and vinegar. Colour and flavour extracts are used in both the food and feed industries, for example, ginger beer, hot sauces and poultry feed, as well as for some pharmaceutical products. Sweet, non-pungent capsicum peppers are widely used in the immature, green-mature or mature-mixed-colours stage as a vegetable, especially in the temperate zones. Capsicum extracts show promise against some crop pests.

Nutritive Value per 100 g of edible Portion

Raw Vegetable	Food Energy (Calories)	Protein (g)	Carbohydrates (g)	Ash (g)	Calcium (g)	Phosphorus (mg)	Iron (mg)	Potassium (mg)	Vitamin A (I.U)	T (
Pepper, (Hot), Mature, Red	65	2.3	15.8	1.2	16	49	1.4	564	21600	(
Pepper, (Hot), Immatur, Green	37	1.3	9.1	0.6	10	25	0.7	-	770	(

Teff
Tomato
Wheat
Yam
Zucchini/Courgette

Pepper, (Sweet), Immature, Green	22	1.2	4.8	0.4	9	22	0.7	213	420	(
Pepper, (Sweet), Mature, Red	31	1.4	7.1	0,5	13	30	0.6	-	4450	(

Pests/ diseases/ weeds

Medicinal plants

Fruit and vegetable processing

Natural pest control

Cultural practices

Climate, soil and water management

Climatic requirements and cultural practices for production of sweet peppers and chillies are the same. They also share a same complex of pests and diseases. Capsicum peppers tend to tolerate shade conditions up to 45% of prevailing solar radiation, although shade may delay flowering. Capsicum peppers grow best on well-drained loamy soils at pH 5.5-6.8. They grow at a wide range of altitudes, with rainfall between 600 and 1250 mm. Severe flooding or drought is injurious to most cultivars. Seeds germinate best at 25-30°C. Optimal temperatures for productivity are between 18 and 30°C. C. frutescens are more tolerant to high temperatures. Cooler night temperatures down to 15°C favour fruit setting, although flowering will be delayed as temperatures drop below 25°C. Flower buds will usually abort rather than develop to maturity if night temperatures reach 30°C. Pollen viability is significantly reduced at temperatures above 30°C and below 15°C.

Propagation and planting

Capsicum peppers are propagated by seed. Seeds should be harvested from mature fresh fruit after 2 weeks of ripening after harvest. Seeds remain viable for 2-3 years without special conservation methods if they are kept dry. They rapidly lose viability if they are not properly stored at high temperature or humidity. Seed dormancy may occur to a small extent, especially if seed is harvested from under-ripe fruits. Some 200-800 g of seed is required per ha, depending on plant density.
For information on hot-water treatment of seeds click here.
Seedbeds are usually covered with straw, leaves or protective tunnels. For better production, seedlings should be transferred to seedling pots (plastic pots, paper cups, banana leaf-rolls, etc.) when the cotyledons are fully expanded. Transplants are planted out in the field at the 8-10 true leaf stage, usually 30-40 days after sowing. Hardy transplants can be produced by restricting water and removing shade protection, starting 4-7 days before transplanting. Transplanting should be done during cloudy days or in the late afternoon, and should be followed immediately by irrigation. Direct sowing in the field is practised to a limited extent. Capsicum peppers are well adapted to sole cropping and intercropping systems. Capsicum peppers are often relay-cropped with tomatoes, shallots, onions, garlic, okra, *Brassica* spp. and pulses. They also grow well among newly established perennial crops.

Cultivars commonly grown in Kenya:

Sweet pepper (*C. annuum*):

- **California Wonder**
- **Yolo wonder**
- **Emerald Giant**
- **Ruby Giant**

Hot pepper (*C. frutescens*):

- **Anaheim**

- **Fresno**
- **Jalapeno**
- **Long Red Cayenne**
- **Rocket**
- **Short Bullet**

Husbandry

Capsicum peppers thrive best if supplied with a generous amount of organic matter. A reasonable recommendation is to supply 10-20 t/ha of organic matter. General nutrient requirements are 130 kg/ha of N, 80 kg/ha of P and 110 kg/ha of K. Nutrient availability is subject to soil type and environmental conditions, so local recommendations vary. Manual weeding is usual for weed control. It is most critical at the reproductive phase. Organic or plastic mulches are very effective for weed control, and reflective mulches help to minimize insect vectors of plant viruses. Staking can help minimise lodging. Capsicum peppers may be grown under rainfed or irrigated conditions. To avoid certain diseases, pests or allelopathic damage, capsicum peppers should not be planted after other solanaceous crops, sweet potato or jute.

Harvesting

Capsicum peppers are ready for harvest 3-6 weeks after flowering depending on the fruit maturity desired. Green fruits are mature when firm, if gently squeezed they make a characteristic popping sound. Harvesting is done by hand or with the aid of a small knife. Sweet capsicum peppers are often harvested at the green mature stage, although sometimes they are harvested red. Assorted fruit colours such as yellow, orange, chocolate and purple are also available in specialized markets. Hot capsicum peppers are harvested green or red depending on their utilisation. For the fresh market, fruits are harvested mature but firm, whereas capsicum peppers sold as dried pods may be left to partially dry on the plants before

harvesting. Yields under irrigated conditions tend to be higher than for rainfed production, but vary with other management practices. Unless sold for the fresh market, hot capsicum peppers can be sun-dried. Sun-drying usually takes place in a vacant field or roadside, on mats or a well-swept area. In the sun, capsicum peppers will dry adequately in 10-20 days, with frequent turning of fruits. Steaming of hot and capsicum pepper before being sun-dried tends to improve the appearance, making dried fruits look glossy.

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Information on Diseases

Damping-off and root rot (*Rhizoctonia solani* / *Pythium* spp. / *Fusarium* spp.

Seedlings fail to emerge (pre-emergence damping-off); small seedlings collapse (post-emergence damping-off); seedlings are stunted through root rot and / or collar rot. Nursery beds show irregular patches. The fungi causing seedling diseases are soil inhabitants. Pythium spp. are favoured by low temperatures while *R. solani* and *Fusarium* spp. thrive at higher temperatures.

What to do:

- **Growing certified disease-free seed**
- **Nursery beds be located on well drained sites not previously under vegetable production**
- **Proper watering regime**

Damping-off disease in chilli field

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More Information on Damping-off diseases

Powdery mildew (*Leveillula taurica*)

Yellowish blotches or spots appear on the upper leaf surface. The leaf surface is covered with a white to grey powdery fungal growth. The disease progresses from the older to younger leaves and shedding of the foliage is pronounced. Leaf defoliation leads to reduction in size and number of fruits. It also results in fruits being sun-burned. The disease is favoured by warm, humid and dry weather. The fungus causing powdery mildew also attacks eggplants and tomatoes. Overhead irrigation reduces disease severity.

Powdery mildew
Powdery mildew on leaves and fruit of chilli. Note fungal growth on pod.

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More Information on Powdery mildew

What to do:

- **Plant resistant cultivars, if available**
- **Apply sulphur based fungicides at the onset of disease symptoms**
- **Remove and destroy crop debris after harvest**

Viral diseases

About 17 viruses have been reported to attack peppers. Those considered economically important in Africa include alfalfa mosaic, chilli veinal mottle, cucumber mosaic, pepper veinal mottle, potato Y, tobacco etch, tobacco mosaic, tomato spotted wilt and chilli leaf curl.
Most of these viruses are transmitted by insects, infected seed

Virus diseases

and a few by mechanical means and infected seed: the first six above listed viruses are spread by aphids; tobacco mosaic is mechanically transmitted and infected seed; tomato spotted wilt by thrips; and chilli leaf curl by whiteflies.

Viral diseases are particularly difficult to firmly diagnose by symptoms because there is so much overlap in symptomatology. Furthermore, symptom expression can be altered by many factors among which are cultivar, age of host plant, environmental conditions, host plant nutrition, and viral strains, not to mention the occurrence of virus mixtures. General symptoms include mosaic patterns on leaves, yellowing , ring spots, leaf deformation or distortion, curling of leaves, and/or stunting of plants. They may also cause reduction of fruit size, distortion, and/or ring patterns.

What to do:

- **Plant resistant cultivars, if available**
- **Select planting dates to avoid high population of vectors**
- **Close plant spacing to compensate for diseased plants**
- **Use barrier crops to minimize virus spread**
- **Use oil sprays to reduce virus transmission by aphids**
- **Use reflective mulches to repel aphids and thrips. For more information on mulching click here.**
- **Use certified disease-free seed in case of tobacco mosaic virus.?**

Chilli plant affected by a virus disease

More Information on Viral diseases

Anthracnose (ripe rot) (*Colletotrichum capsici*)

Anthracnose caused by *Colletotrichum* spp. is a major problem of ripened fruits. The fungus produces dark, sunken spots up to 2.5 cm across on sweet pepper. The spots occur on green and ripe fruits and their surface may be covered in moist weather with salmon-pink mass of spores. The fungus is seed-borne.

What to do:

- **Use certified disease-free seeds**
- **Hot water treat own produced seeds. For more information on hot water treatment click here**
- **Practice field sanitation (removal of crop debris after harvest)**

Anthracnose
Anthracnose (*Colletotrichum capsici*) on sweet pepper (*Capsicum annuum*)

More Information on Anthracnose

Bacterial soft rot (*Erwinia carotovora* pv. *carotovora*)

Soft rot often begins in the peduncle and calyx tissues of harvested fruit. Infection can occur through wounds anywhere on the fruit. Fruit infected on the plant collapses and hangs on the plant like a water-filled bag. When the contents leak out, a dry shell of the fruit remains.

The bacteria are soil-borne. Soft rot is primarily a post-harvest problem although it can occur in the field being facilitated by injuries to the fruit by insects and water splash. The disease is serious during rainy periods because the bacteria are splashed from the soil onto the fruit, which are more susceptible due to their high moisture content.

What to do:

- **Rotation with beans or maize**
- **Control of insects that cause injury to fruits.**
- **Post-harvest decay can be reduced by harvesting fruits when dry, minimizing injury during handling, and store at cool temperatures.**
- **]If fruits must be washed, add free chlorine in the wash water to eliminate soft-rot bacteria. However, this treatment prevents infection during washing but does not prevent soft rot development in fruits that were already infected before washing.**

Bacterial spot (*Xanthomonas campestris* pv. *vesicatoria*)

Leaves, fruit and stems can be attacked by the disease. Leaf spots begin as circular, water-soaked that become necrotic with brown centres with yellowish borders. The spots are sunken on the upper leaf surface and slightly raised on the lower surface. On stems spots are elongated. Affected leaves turn yellow and drop. Affected fruits have raised brown spots that are wart-like in appearance. The disease has a wide distribution wherever peppers are grown. It spreads rapidly during warm, rainy conditions. High relative humidity with free moisture on leaves for long periods favour infection. Ideal temperatures for infection are above 20° C. The bacterium is seed-borne and survives in crop debris.

Bacterial spot
Bacterial spot of pepper (*Xanthomonas vesicatoria*)

What to do:

- **Use of resistant varieties, if available**

- **Use disease-free seed**
- **Crop rotation**
- **Copper sprays can reduce the rate of disease development**

Bacterial wilt (*Ralstonia solanacearum*)

The disease occurs in scattered plants or groups of plants in the field. Characteristic symptom is wilting of the entire plant with no leaf yellowing. Cross sections cut from roots and lower stems of diseased plants exude milky streams of bacteria from the vascular system when suspended in water. The bacteria have a wide host range and can survive in the soil for long periods. The disease is favoured by wet, warm conditions. Peppers are not as susceptible as eggplants, potatoes, tobacco or tomatoes. Rotation is not effective as the pathogen can survive for a long period - several years - in the soil and also attack a wide range of crops and solanaceous weeds.

Bacterial wilt
Bacterial wilt (*Ralstonia solanacearum*) on sweet pepper

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Bacteri... Bacteri... Bacteri...

More Information on Bacterial wilt

What to do:

- **Plant varieties that are tolerant / resistant, if available**
- **Do not grow crops in soil where bacterial wilt has occurred**
- **Remove wilted plants from the field to reduce spread of the disease from plant to plant**
- **Control root-knot nematodes since they could facilitate infection and spread of bacterial wilt**
- **Soil amendments (organic manures) can suppress bacterial wilt pathogen in the soil**
- **Rotation is of limited value since the disease has a wide host**

range, but still it is recommended to avoid continuous planting of solanaceous crops.

Cercospora leaf spot (Frogeye) (*Cercospora capsici*)

Spots on leaves are brown and circular with small to large light grey centres and dark brown margins. Spots on stems, petioles and peduncles are typically elliptical and also have light grey centres with dark borders. Infected leaves are shed. Extensive defoliation occurs under severe disease pressure. Fruits are not attacked. The fungus survives on seeds and in crop debris. The disease is favoured by prolonged periods of wetness.

Cercospora leaf spot
Cercospora leaf spot (here on soybean)

What to do:

- **Plant resistant cultivars, if available**
- **Use certified disease-free seeds**
- **Practice good field sanitation**

Collar rot (*Sclerotium rolfsii*)

It is a common and destructive disease of peppers widespread in the tropics. The fungus attacks the stem at ground level eventually girdling and killing it. White fungal growth usually is visible on the base of the stem and on the soil line around the base of the plant. On the white fungal mat, sclerotia (resting fungal spores) about the size of mustard seed that are tan to brown when mature are produced. High soil moisture and temperatures (30-35° C) favour disease development. Symptoms are more severe during dry conditions following a wet period. The fungus has an extremely broad host range and it is also a good saprophyte.

What to do:

- **The disease can be reduced by liming and deep ploughing**

Fusarium wilt (*Fusarium oxysporum* f.sp. *capsici*)

Disease symptoms include drooping and yellowing of lower leaves followed by wilting of the entire plant. Leaves on infected plants remain attached and the vascular system of the plant is discoloured, particularly in the lower stem and roots. The fungus lives indefinitely in the soil and is spread in irrigation water. It is very susceptible to changes in temperature and soil moisture. The optimum temperature for disease development is 24 to 27° C.

Soil moisture has the greatest influence. The wilt does not occur in dry soil, but it is serious in poorly drained fields.

What to do:

- **Plant resistant cultivars, if available**
- **Lime the soil**
- **Ensure the soil has a good drainage**
- **Apply soil antagonist Trichoderma spp., which is commercially available in Kenya**

Fusarium wilt
Chili plant infected with fusarium wilt (*Fusarium oxysporum* f.sp. *capsici*).

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Fusariu w... **Fusariu w...** **Fusariu w...**

More Information on Fusarium wilt

Phytophthora blight (*Phytophthora capsici*)

All parts of the pepper plant can be affected. Seedlings can be killed. Collar rot and wilt phase is most common and is characterised by a dark brown stem discolouration extending upward from the soil line accompanied by a sudden wilt of the entire plant. Upper stem lesions (spots) are also dark brown and occur primarily at branch points causing death of branches above the lesions. Leaf spots are round or irregularly shaped, dark green and water-soaked. They later dry and become light tan.

Fruit infection begins as water-soaked, dull green spots that expand rapidly to cover the entire fruit. Later the fruits become flaccid and wrinkled but do not detach from the affected plants. The host range of the fungus includes cucurbits, eggplants and tomatoes. The fungus can survive on and in seeds, in soil and in crop debris. The collar rot and wilt phase is most severe in over-irrigated or poorly drained fields. Aboveground infection is associated with extended periods of rainfall or overhead irrigation.

What to do:

- **Plant resistant cultivars, if available**
- **Use certified disease-free seeds**
- **Grow on elevated beds**
- **Practice good water management**
- **Practice crop rotation (avoid in the rotation crops such as cucurbits, eggplant and tomatoes)**
- **Remove and destroy crop debris after harvest**
- **Copper sprays can minimise disease losses**

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Information on Pests

Root-knot nematodes (*Meloidogyne* spp.)

Symptoms of infestation by root-knot nematodes are similar in all crops: wilting of plants and if infested plants are pulled from the soil the roots can be seen to be distorted, swollen and bearing knots (galls). The galls on pepper are much smaller than those on cucurbits or tomatoes. The infested roots eventually rot and affected plants die.

What to do:

- **Use of resistant varieties**
- **Crop rotation**
- **Mixed cropping / growing African marigold (Tagetes spp.)**
- **Maintaining high levels of organic matter in the soil (manure or compost). For more information on compost click here.**
- **Presently, some bioproducts are available for control of the root-knot nematodes (e.g. neem extracts). For more information on neem click here.**

Root-knot nematodes Root-knot nematode galls (here on tomato roots). Affected plants are normally stunted and eventually wilt and die. The most characteristic symptom is formation of root galls (knots) and these can be seen with the naked eye. Affected roots rot.

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More Information on Root-knot nematodes

Spider mites (*Tetranychus* spp.)

Spider mites suck the sap of the plants, causing mottling of the upper leaf surface. Infested leaves first show a white to yellowing speckling, and then eventually turn bronze and fall off as the infestation becomes heavy. Spider mites prefer the lower surface of the leaves, but in severe infestations occur on both leaves surfaces as well as on stems and fruits. High infestations cause defoliation.

What to do:

- **Field hygiene is important for the management of spider mites. Old crops or weeds infested with mites can cause infestation of any new crop.**
- **Natural enemies such as predatory mites are important for control of spider mites.**

Spider mites
Two-spotted spider mite (*Tetranychus urticae*). The adult female is 0.6 mm long. The male is smaller.

More Information on Spider mites

Aphids (*Aphis gossypii, Myzus persicae*)

Aphids (cotton aphid and green peach aphid) occur in colonies initially around tender plants parts (growing points, young stems and leaves, flower buds) and on the lower leaf surface. When numerous they can be found on all above ground parts of the plant. Aphids damage plants in three ways: by sucking their sap, excreting a sticky substance (honeydew) that coats the plants, or/and by transmitting viral diseases.

Green peach aphid

Feeding by aphids causes distortion (curling, wrinkling, or cupping) of young leaves, chlorotic spotting and mottling of older leaves, and may lead to stunting and wilting of plants. Growth of sooty mould on honeydew excreted by aphids reduces photosynthesis and affects fruit quality.

Aphids cause indirect damage as vectors of important viruses such as alfalfa mosaic, chilli veinal mottle, cucumber mosaic, pepper mottle, pepper severe mosaic, pepper veinal mottle, potato Y and tobacco etch virus.

What to do:

- **Monitor regularly the crop.**
- **Aphids are naturally controlled by parasitic wasps; predators such as ladybird beetles, rove beetles, hoverflies, cecidomyiid flies, anthocorid bugs, spiders and lacewings; and by fungal diseases.**
  The parasitic wasps Aphidius spp are common in Kenya, and help to maintain aphids under control provided compatible pesticides are used for control of aphids or other pests.
- **Whenever necessary spray only affected plants (spot spraying).Use biopesticides that are not harmful to natural enemies (for instance neem, ashes, soapy water).**
- **Use biopesticides that are not harmful to natural enemies (for instance neem, ashes, soapy water). Neem products have a repellent effect and have been effective in reducing numbers of aphids on peppers. at 10 days intervals.**

Green peach aphid (*Myzus persicae*) on pepper leaf. Adult wingless females are oval-bodied, 1-2 mm in body length, of very variable colour.

© Magnus Gammelgaard
More Information on Aphids

Cutworms (*Agrotis* spp., *Spodoptera* spp.)

Cutworms are the caterpillars of various moths, belonging mostly to the genus *Agrotis*. Young caterpillars feed on leaves making small holes. After few days they drop to the soil where they live until pupation. Caterpillars remain in the soil during the daytime coming out at night to feed. They cut stems of young seedlings at the level of the soil, killing them and affecting establishment of the crop. Some *Spodoptera* species, in particular *S. littoralis* act sometimes as cutworms. Caterpillars, in particular under hot conditions, hide during the day in the soil around the base of the plants, and may cut them, especially seedlings, at the base of the stem. At night they climb into plants to feed.

Black cutworm
Black cutworm (*Agrotis ipsilon*). Early instars are about 7 to 12 mm long. Fully grown caterpillars are 3-5 cm long.

© Ooi P., Courtesy of Ecoport (www.ecoport.org)
More Information on Cutworms

What to do:

- **Eliminate weeds early, well before transplanting**
- **Plough and harrow the field to expose cutworms to natural enemies and desiccation**
- **Dig near damaged seedlings and destroy cutworms**
- **Conserve natural enemies. Parasitic wasps and ants are important in natural control of cutworms**

Fruit flies (*Ceratitis* spp. *Bactrocera* spp., *Dacus* spp.)

Fruit fly females lay eggs under the epidermis of the fruit. After

emerging from eggs maggots generally move to the core to feed, but they may also feed on the walls of the fruit. This causes secondary rot and premature fruit fall. An infested fruit usually has a small dimple where the female fly deposited an egg. As the maggot matures inside the fruit, the fruits turn red prematurely, becoming soft and rotten.
Soft spots can often be seen where the maggot has fed on the fruit. When infested fruit is picked, the cap usually separates from the fruit because the maggot has eaten the core. Fruit may drop from the plant. Maggots remain in peppers until fully grown (from 2 to 3 weeks). At this time the maggot leaves the pepper, drops to the soil to pupate. Yield losses can be considerable. One maggot can destroy an entire fruit.

Fruit fly
Fruit fly (*Daccus bivittatus*) on a chilli pod. Adults are 4-7mm long.

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More Information on Fruit flies

What to do:

- **Plough and harrow before planting. This exposes pupae in the soil to natural enemies and desiccation**
- **Monitor fruit flies to determine when they arrive in the crop. Check the crop regularly and use bait traps**
- **Collect and destroy damaged fruit**

Fruit borers (*Helicoverpa* spp., *Spodoptera* spp.)

Moths of fruitborers are active at dusk and at night, feeding on nectar and laying eggs on leaves. Caterpillars feed on leaves, flowers and fruits. Although severe leaf damage by feeding of African bollworm (*Helicoverpa* spp.) caterpillars may slow plant

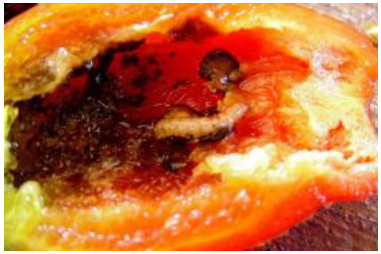
growth due to reduced leaf area, caterpillar feeding on leaves is usually of not economic importance. The bollworms are about 2-3.5cm long.

The main damage occurs on flowers and fruits. Attack on flower buds results in flower abortion. Caterpillars usually bore holes in fruits, causing extensive damage and promoting decay from secondary infection by diseases.

African armyworm (*Spodoptera* spp.) species are basically leaf-eaters and may cause defoliation when present in large numbers. They also feed on fruits, rendering them unmarketable.

What to do:

- **Plough the soil before planting. This exposes pupae to natural enemies and desiccation.**
- **Check the crop regularly. Early detection and destruction of eggs, or young caterpillars before they bore into the fruits is very important.**
- **Handpick and destroy damaged fruits, eggs and caterpillars. This helps when their numbers are low and in small fields.**
- **Conserve natural enemies. Parasitic wasps, ants, pirate bugs are very important for natural control of the African bollworm.**
- **Whenever necessary use biopesticides such as Bt, neem products or other plant extracts. This is particularly important from the onset of flowering. Target caterpillars before they enter the fruit. For more information on neem click here. For information on Bt click here.**



Fruit borer
Caterpillar damage in chilli fruit, they are about 2-3.5cm long

© A.M. Varela, icipe

Fruit bore...

Fruit bore...

More Information on African bollworm

Leafmining flies (Leafminers) *Liriomyza* spp.

Female flies make numerous small, whitish punctures on the foliage when feeding and depositing eggs. These punctures can serve as entry points for disease-causing organisms such as bacteria and fungi. The eggs hatch into tiny yellow maggots that feed on leaf tissues leaving a wandering track known as mines. Full-grown maggots come out of the mines to pupate in the soil beneath the plants or on the foliage. Maggots are the most destructive stage.
The mines may reduce photosynthetic activity, affecting development of flowers and fruits. In severe infestation, the leaves might be completely mined, dry and fall off prematurely, causing loss of vigour and turgidity of the plant. This may eventually result in wilting, in particular in warm weather, leading to yield loss, fruit sunscald, or in serious cases death of the plant, especially of young pants.

Leafminer
Mining of a chilli leaf by leafmining flies (*Liriomyza* spp.)

© A. A. Seif & B. Nyambo, icipe
More Information on Leafmining flies (leafminers)

What to do:

- **Control by natural enemies is important.**
- **Ploughing can help in exposing pupae to desiccation and natural enemies.**
- **Neem products are effective for controlling leafminers. For more information on neem click here.**

Thrips (*Frankliniella* spp., *Scirtothrips dorsalis, Thrips tabaci*)

Thrips usually feed on all above ground parts of plants, preferring the underside of young leaves, flowers and fruits. Often they are concealed under the calyx. Plant damage results from thrips puncturing leaves and sucking the exuding sap. At the initial stage of infestation leaves have a silvery sheen and show small, dark spots of faecal material on the underside. When the attack increase leaves curl upward, wrinkle and finally dry up. This may cause fruit sunscald.

Heavy feeding damage turns leaves, buds and fruits bronze in colour. It may cause wilting, retardation of leaf development and distortion of young shoots resulting in stunted plants. Attack on fruits causes deformation and scarring (manifested as brown lines) of the fruits making them unmarketable, especially fruits for the export market. Thrips attack at the seedling and early stages of the crop delays crop development. Thrips transmit the tomato spotted wilt virus in peppers. *S. dorsalis* transmit the leaf curl disease of chillies.

Thrips
Thrips damage on a chilli pod.

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Thrips **Thrips**

More Information on Thrips

What to do:

- **Natural enemies of thrips are important for natural control. Main natural enemies include anthocorid bugs (Orius spp.) predatory mites and spiders.**

Whiteflies (*Bemisia tabaci, Trialeurodes vaporariorum*)

Whiteflies damage plants in three ways. Whitefly immature stages (nymphs) and adults suck sap from leaves. Their feeding, in addition to removing plant nutrients, produces chlorotic spots on infested leaves. Nymphs excrete a clear sugary liquid known as honeydew, which often completely covers the leaves during heavy infestation. Honeydew supports the growth of a black sooty mould, and as a result the leaves may turn black, affecting photosynthesis.
Whiteflies are vector of important viral diseases such as chilli leaf curl, tiger disease, Serrano golden mosaic, and Texas pepper geminivirus.

Whiteflies
Whiteflies on chilli leaf. Adults are about 1mm long.

More Information on Whiteflies

What to do:

- **In areas where whitefly-transmitted viral diseases are a problem keep the seedlings protected under a fine meshed insect netting until they are ready for transplanting. Make sure the netting is always properly closed**
- **Conserve natural enemies. Parasitic wasps, predatory mites, ladybird beetles, and lacewings are important natural enemies of whiteflies**
- **Whenever necessary spray with neem products. Neem products inhibit growth and development of immature stages, repel whitefly adults and reduce egg laying**

Broad mite or yellow tea mite (*Polyphagotarsonemus latus*)

Broad mites are tiny (0.1-0.2 mm long) and cannot be seen with

the naked eye, and are even difficult to detect with a hand lens. An attack the broad mites can be detected by the symptoms of damage. They live on the underside of leaves, tender stems, fruits, flower peduncles and flowers. Their feeding produces discoloration, necrosis of tissues and deformation. Initial attack occurs on the stems of terminal shoots and the lower surface of young leaves.

Young leaves turn narrow, twisted or crumpled, fail to elongate and finally may wilt and dry, giving the plant a scorched appearance. Older leaves are generally cupped with corky brown areas between the main veins on the lower side of the leaves. The succulent part of the stem of young plants may become slightly swollen, roughened or russeted. The foliage becomes rigid. Attacked fruits become deformed with a cork-like surface or fail to develop. Severely infected fruits fall, and yield is significantly reduced. Symptoms remain for a long period of time after control.

Broad mite
Broad mite (*Polyphagotarsonemus latus*) damage on chillies

© A.M. Varela, icipe

What to do:

- **Broad mites are attacked by predacious mites. Phytoseiulus persimilisis not very much attracted to broad mites. Amblyseius spp are better predators of broad mites, in particular A. californicus is used for control of broad mites in different parts of the world.**
- **Broad mites can be effectively controlled with sulphur sprays. However, sulphur is toxic to predatory mites.**

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Information Source Links

- **Beije, C.M, Kanyagia, S.T., Muriuki, S.J.N., Otieno, E.A., Seif A.A., Whittle, A.M. (1984). Horticultural Crops Protection Handbook. National Horticultural Research Station.**
- **Black, L.L.,Green, S.K., Hartman, G.L., Poulos, J.M. (1991). Pepper Diseases: A Field Guide. Asian Vegetable Research and Development Center, Taipei. ISBN: 92-9058-048-8.**
- **CABI. (2005). Crop Protection Compendium, 2005 Edition. © CAB International Publishing. Wallingford, UK. www.cabi.org**
- **HCDA (1996). Chillies . Horticultural Crops Development Authority. Export Crop Bulletin: No 10, June 1996. Excerpted from the KEDS-Supported HCDA Export Crop Manual.**
- **Hill, D. S. (1983). Agricultural Insect pests of the tropics and their control. Second edition. Cambridge University Press. pp 76. ISBN: 0 521 24638 5.**
- **Sherf, A.F., Macnab, A.A.(1986). Vegetable Diseases and Their Control. 2nd. Edition. John Wiley & Sons Inc. USA. ISBN: 0-471-05860-2**
- **East African Seed Co. Ltd. Africa's Best Grower?s Guide www.easeed.com**

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Cowpea
Scientific name: *Vigna unguiculata*
Order/Family: Fabales: Fabaceae
Local names: Kunde (Swahili, Kipsigis), mathoroko (Kikuyu), likhuvi (Luhya),a lot-bo (Luo), nthooko (Kamba), egesare (Kisii), Kiyindiru (Luganda)
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General Information and Agronomic Aspects

Cowpeas are basically annual crops grown for their leaves and seed. The growth habit is climbing, spreading or erect and they belong to the bean family (*Leguminosae) (Papilionaceae)*. Cowpeas are native to Africa where they were domesticated over 4000 years ago. The crop exhibits much variation in growth habit, leaf shape, flower colour and seed size and colour.

Cowpeas are mainly important in the marginal rainfall areas because they are well adapted to dry climate and suitable for a variety of intercropping

- Onion
- Papaya
- Passion fruit
- Peas
- Peppers
- Pigeon pea
- Pineapple
- Potato
- Pumpkin
- Rice
- Sesame
- Sorghum
- Soybean
- Spider plant
- Spinach
- Sugarcane
- Sweet potato
- Tea
- Teff
- Tomato
- Wheat
- Yam
- Zucchini/Courgette

Pests/ diseases/ weeds

Geographical Distribution of Cowpea in Africa

systems. Cowpeas are cultivated for the seeds (shelled green or dried), the pods or leaves that are consumed as green vegetables or for pasture, hay, silage and green manure. Tender cowpea leaves and shoots contain 4% protein, 4% carbohydrates and are rich in calcium, phosphorus and vitamin B.

Dried seeds contain 22% protein and 61% carbohydrates. The leaves may be dried and stored for later use. Cowpeas that are sprayed with pesticides should not be eaten as leaves unless pre-harvest intervals are followed. In Africa, where cowpeas are the preferred food legume, they are consumed in three basic forms:

- **Cooked together with vegetables, spices and often palm oil, to produce a thick bean soup, which accompanies the staple food (cassava, yams, plantain)**
- **Decorticated and ground into a flour and mixed with chopped onions and spices and made into cakes that are either deep-fried (akara balls)**
- **Steamed (moin-moin)**

Climate conditions, soil and water management

Cowpeas are generally tolerant of drought and low light conditions, but are very susceptible to a variety of insects and diseases and do not do well in poorly drained and cool areas. Local land races of cowpeas grown by farmers in West Africa are well adapted so that they start to flower at the end of the rains at a particular locality. The optimum temperature to their growth and develop is 20 to 35°C. Cowpea can grow in a wide range of soils, well adapted to light sandy soils where most other crops produce poorly and they do well on acid soils. On heavy fertile soils they show a vigorous vegetative growth, but not necessarily a good grain yield. Most varieties need a minimum rainfall of 200 mm during a growing season.

Medicinal plants

Fruit and vegetable processing

Natural pest control

Cultural practices

Propagation and planting

Cowpeas are seed planted about 20 to 40 cm apart and are often grown as an intercrop with pearl millet, sorghum or maize at wide spacings (total plant population 10,000-20,000 plants per ha). When produced as a green vegetable, they are commonly grown as a monocrop in rows 30 to 40 cm apart with 8 to 12 cm between plants. Some very drought resistant types may grow for two seasons in the farm. Tillage normally follows the crop with which cowpeas are interplanted. When sown in rows, a seed-rate the seed-rate is 10-40 kg/ha.

Cowpea varieties and their characteristics:

Variety	Maturity Days	Remarks	Target areas of production	Recommended spacing(Kenya)
"Machachos 66" (M66)	85-95	Dual purpose variety. Erect, reddish colour and good for intercropping	Medium and higher altitudes 1200-1500m above sea level	60 cm between rows 20 cm between seeds
"Katumani 80" (K80)	75-85	Dual purpose variety, erect, improved, good for intercropping	Drier areas or areas below 1500m above sea level receiving less than 200 mm rain per season	60 cm between rows 20 cm between seeds
"KVU-419"	65-72	Has smaller seed than both "M66" and "K80". More of a grain type than a leaf type	Areas below 1200 m receiving less than 200 mm rain per season	50 cm between rows and 20 cm between seeds
"KVU HB 48E 10"	85-95	More vegetable type than grain type	Medium and higher altitudes 1200-1500 m	60 cm between rows 20 cm between seeds

			above sea level	
"Ngombe"		Semi spreading, good for green leaf production, sweet taste of grain		
Local varieties (land races)		Varying colours and spreading or semi spreading		

Husbandry

Most cowpea crops are rain-fed, a few are irrigated and others use residual moisture in the soil after harvest of a rice crop. Cowpeas are particularly well suited for rice-based cropping systems. Two to three weedings during the first 1.5 months after planting are recommended. Losses due to weeds can be 30-65%. Parasitic weeds, such as *Striga gesnerioides* (Purple withweed), generally associated with continuous cropping of cowpeas in Africa, may also cause severe damage.

One additional benefit of cultivating cowpeas is their ability to fix atmospheric nitrogen in root nodules through symbiosis with a *Rhizobium* bacteria that are common in most soils. An effective cowpea-*Rhizobium* symbiosis fixes more than 150 kg/ha of N and supplies 80-90% of the total N required. Inoculation may be advantageous, if the crop has not been grown for many years. In general, no fertilisers are applied. Cowpeas are commonly incorporated in crop rotations in semi-arid, humid and subhumid environments.

A cowpea crop of the leafy types grown before a maize or millet crop and incorporated green into the soil, can produce a good grain crop without any addition of more nitrogen. Intercropped cowpeas also share nitrogen with the other crops (for example maize, millet, sorghum and

cotton). For intercropping choose a cowpea variety carefully - the spreading types may over power other crops such as cotton by entangling their branches and interfering with fieldwork.

Cowpeas do not normally respond to nitrogen or phosphorus fertilisers, so none need adding. However where soils are highly eroded an application of 5 tons/ha of dry compost or manure is beneficial.

Weed during early stages of crop, later the cowpeas will cover the ground and suppress weeds including purple witchweeds. Two weedings are recommended, one two weeks after emergence and the second weeding just before flowering.

Harvesting

Leaves for eating must be young and tender. Three leaf pickings (starting 2 ½ -3 weeks after planting at weekly intervals have little effect on grain yields of five to six 90kg bags of seed per acre. Green pods are harvested by hand when they are still immature and tender (12-15 days after flowering). When grown as a grain, harvesting is complicated by the prolonged and uneven ripening of many cultivars. Time of harvesting is critical as mature pods easily shatter, so hand-picking can be advantageous. Sometimes plants are pulled when most of the pods are mature. For hay, the crop is cut when most of the pods are well developed.

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Information on Pests

The legume aphid (*Aphis craccivora*)

It is a widespread pest of cowpeas. Aphids suck sap on stems, terminal shoots and petioles of seedlings, and on pods and flowers of mature plants.

A heavy attack can cause death of young seedlings, stunting and delay in flowering on older plants. However, it is more important as vector of virus diseases (e.g. the cowpea mosaic virus) is more important.

What to do:

- **Use resistant varieties where available.**
- **Monitor build-up of aphids and natural enemies.**
- **Use neem seed or leaf extracts if necessary.**

Black legume aphid
Black legume aphid (*Aphis craccivora*) is a relatively small aphid. Immatures are slightly dusted with wax, adults without wax. They are about 1-2mm long.

© Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org


Black legu... **Aphids**

More Information on Aphids

African bollworm (*Helicoverpa armigera*)

The African bollworm caterpillars are 3 to 4 cm long. Several leaf-eating caterpillars feed on cowpeas. Several species of *Spodoptera* are sporadic cowpea pests. The hairy caterpillar *Amsacta moorei* causes extensive damage to seedlings and it has been considered the most important pests of cowpeas in Senegal. African bollworm (*Helicoverpa armigera*) can cause extensive damage on young pods. Natural enemies are important to keep pest populations at low level.

African bollworm
African bollworm (*Helicoverpa armigera*) on French beans. Fully grown caterpillars are 3-4 cm long.

© A.M. Varela, icipe
More Information on African bollworm

What to do:

- **Monitor regularly for caterpillar eggs and just emerging caterpillars.**
- **Hand pick eggs and young caterpillars. This helps when their numbers are low and in small fields.**
- **Use of bio-pesticides such as botanicals (e. g. neem extracts) and Bt. For more information on neem click here. For information on Bt click here**

Foliage beetles (*Ootheca*) spp.

A large number of beetles chew leaves and flowers of cowpea plants. The most important are the foliage beetles Ootheca mutabilis, and *O. bennigseni*, they are about 4-7mm long. They have been reported causing extensive damage in several countries in West and East Africa. High beetle population can cause complete defoliation of young plants. In addition, *O. mutabilis* is an efficient vector of the southern bean mosaic and

Foliage beetle

cowpea mottle viruses.

Foliage beetles chew small round holes in the leaves. They may be a serious problem when present in large numbers or when attacking young plants. Heavy attacks may cause defoliation. Attack on young plants may reduce plant vigour, plant size and yield. The problem is more acute in fields with continuous growing of beans. *Ootheca* beetles are also pests of French beans, and important pests of common beans in East Africa.

The larvae (grubs) of foliage beetles live in the soil feeding on roots. Their feeding may cause stunted growth and premature ageing of the plants. Grubs of weevils live in the soil feeding on roots or may bore into the stem of the bean plant causing swellings or galls, as is the case of the striped bean weevil. Plants attacked by grubs of this weevil show stunted growth and may die. The stem of the plant breaks easily during harvesting

What to do:

- **Adults can be picked manually and destroyed.**
- **Apply neem seed extracts. This has been shown to reduce beetle numbers and damage.**
- **Practice post harvest tillage to expose the grubs in the soil to the sun heat and to predators.**
- **Rotate cowpeas with non-host plants such as maize or sunflower to break the development cycle of the pest**

Foliage beetles damage on French beans

© A.M. Varela, icipe

Foliage be…

Foliage be…

Flower or blister beetles (*Mylabris* spp. and *Coryna* spp.)

These beetles can cause serious damage to cowpeas by feeding on flowers. The adults of the flower beetles, also known as blister beetles, feed on bean flowers (petals and / or pollen) reducing pod set.

The adults are medium to large sized beetles (2-5cm in length), usually black and yellow or black and red in colour. The immature stages (larvae) do not feed on plants. They live in he soil and eat grasshopper eggs.

What to do:

- **Handpick and destroy adult beetles to keep the numbers in check. However, care should be taken, since when disturbed, blister beetles can release a liquid that burn the skin. Whenever possible wear gloves to protect the hands**
- **Do not destroy the larvae, as they are beneficial (they feed on grasshopper eggs)**

Blister beetle
Blister beetle (*Mylabris oculata*). Adults are 2-5 cm in lenght.

Thrips (*Megalurothrips sjostedti* and *Frankliniella schultzei*)

Thrips are among the most widespread and important pests of cowpeas in Africa. The cowpea flower thrips or African bean flower thrips (*Megalurothrips sjostedti*) causes yield losses of up to 100%.

During the pre-flowering period, nymphs and adults of this thrips

may damage the terminal buds. However, the main damage is on the flower buds and flowers. Attacked flower buds become brown and eventually fall off, leaving behind dark red scares. Damaged flowers are distorted, malformed and show decolouration and may fall off. Attack on pods cause malformation of pods.

What to do:

- **Intercropping: There are several reports that thrips populations are reduced when cowpeas are intercropped with maize or sorghum. However, there are also conflicting reports (Ezueh, 1991) indicating increased pod borer and pod sucking bug populations in mixed cropping of cowpeas with sorghum (Nanpala et al, 2002).**
  In Kenya, populations of the African bean flower thrips (Megalurothips sjostedti) and Hydatothrips adolfifriderici on cowpea buds were almost halved by intercropping the cowpea with sorghum and maize (Parella and Lewis, 1997).
- **Use resistant varieties. The varieties "IT90K-277-2", "KVx404-8-1", "Moussa Local", "Sanzisabinli", "Sewe", "TVu1509", "TVx34236", and "IT91K-180" are reported to show resistance against the cowpea flower thrips in West Africa (IITA).**
- **Spraying with neem extracts. In Ghana a threshold of 5 thrips per flower is recommended as a guideline before spraying (GTZ/PPRSD). In Uganda the economic injury level has been established at 7 thrips per flower (IPM CRSP).**

Flower thrips
Flower thrips (*Megalurothrips sjostedti*). Real size (0.9 to 1.1 mm) about the size of a flea, are barely visible to the naked eye.

© Georg Goergen (Courtesy of EcoPort, www.ecoport.org)


Flower thr… **Thrips dam…**

More Information on Thrips

Bugs

There are several pod sucking bugs. The tip wilter (*Anoplocnemis curvipes*), the spiny brown bug (*Clavigralla tomentosicollis*, Riptortus bugs (*Riptortus dentipes*), *Mirperus jaculus*, the green stink bug (*Nezara viridula*) and *Aspavia* sp.

These attack cowpeas in Africa. The spiny brown bug *Clavigralla tomentosicollis* and *Riptortus dentipes* are the most important, causing serious damage. Nymphs and adults attack young, tender pods and causing shrivelling and rotting of pods and malformation of seeds, which lose viability.

Bugs are difficult to control since they usually feed on a wide range of crops and are very mobile.

What to do:

- **Control weeds to destroy roosting sites.**
- **Monitor crops regularly. A threshold of 2 bugs/metre row has been recommended as a guideline for bug control in Ghana (GTZ/PPRSD).**
- **Conserve natural enemies such as assassin bugs, spiders, praying mantises and ants. These are important natural enemies of bugs. They kill or deter bugs. Conserve and attract predatory natural enemies to your crop by planting flowering plants. For more information on natural enemies click here**
- **A number of plants (lantana, garlic, oleander, African marigold, blackjack, goat weed, wormseed, among others) are**

Spiny brown bugs
Spiny brown bugs (*Clavigralla* spp.) measure about 1cm in length.

© A.M. Varela, icipe


Spiny brow... **Riptort ...**

reported as effective repellent crops against various species of bugs (Elwell and Maas, 1995).

- **Alghali (1991) reported an integrated pest management strategy for cowpea production. In Nigeria, intercropping with sorghum reduced the numbers of Riptortus bugs in cowpea significantly.**
- **Bugs can be collected by hand regularly and killed, especially during flowering and pod formation.**
- **A commercial formulation of neem (Neemix®) gave effective control of stink bugs on cowpeas. This product was applied three times at the beginning at pod formation using 210.4 g azadirachtin per hectare (Abudulai et al., 2003).**
- **Pyrethrins are recommended for control of sucking bugs in organic production in USA (Layton, 2004).**

Legume pod borer (*Maruca vitrata*)

This is the most important pod borer pest, causing severe damage to cowpeas. Losses over 80% have been reported on indigenous varieties and even on high yielding varieties.

Moths usually lay eggs on flower buds, flowers, or on terminal shoots of young plants. Young caterpillars may feed on any part of the flowers or foliage. Several young caterpillars may be found together among flowers. Older caterpillars are highly mobile, feeding continuously on flowers and newly formed pods, causing severe damage to the crop. Upon reaching maturity the caterpillars drop from flowers or pods onto the soil and pupate

Legume pod borer
Legume pod borer (*Maruca vitrata*) reach a length of 18mm

© Ooi P. Courtesy of

beneath the plant under leaf debris. The caterpillar of the African bollworm bore into cowpea pods, but remain outside while eating whole seeds.

Caterpillars of the legume pod borer are dull to yellow-white and often reach a length of 1.8 cm. Each segment has dark spots that form a distinct series along the length of the body. The head is dark brown to black.

What to do:

- **In Ghana, spraying with neem extracts and use of the trap crop Crotalaria juncea has been recommended (GTZ/PPRSD). Neem products showed to be effective against the legume pod borer in Niger. Weekly applications of an aqueous neem seed extract proved to be more effective than neem oil at 12l/ha (Dreyer and Ostermann, 1995).**
- **Leaf and bark extracts of the forest trees Khaya anthotheca and K. grandifolia proved to have the same insecticidal and anti-feedant properties of neem on the legume pod borer in West Africa (IITA).**

Cowpea weevils (*Callosobruchus* spp.)

Adults are 2.0-3.5 mm long. They are also known as the cowpea seed beetles and are the principal storage pest of cowpea. These bruchids may infest up to 100% of the stored seeds within 3 to 6 months under ordinary storage conditions. A positive

relationship between pod damage by field pest (pod sucking bugs and pod borers) and bruchid infestation in storage was found in Uganda. Controlling pests infesting pods of cowpeas in the field significantly reduce bruchid carryover in storage (IPM CRSP).

What to do:

- **Use neem extracts**
- **Dry seeds for storage to a moisture level below 13%**

Cowpea weevils
Cowpea damaged by cowpea seed beetles and weevils (*Callosobruchus* spp.)

© A. M. Varela, icipe


Cowpe wee... **Cowpe see...**

More Information on Cowpea seed beetle

Root-knot nematodes (*Meloidogyne* spp.)

Relatively small galls or knots develop on roots of affected plants. Do not confuse root knot galls with naturally occurring bacterial nodules that are beneficial.

What to do:

- **Use resistant or tolerant varieties if available**
- **After harvest, uproot entire plants and destroy crop debris. Tops can be composted but any infested roots should be burnt since nematodes may survive the relatively low heat of compost heap.**
- **Flooding the soil for a few weeks will reduce nematode populations, as will bare fallow**
- **Use mixed cropping or grow African marigolds (Tagetes spp.). These have nematicidal properties that will help to reduce nematode populations.**
- **Rotate with nematode resistant or tolerant crops (e.g. cereals, onions or fodder grasses).**

Root-knot nematodes
Roots infected with Root-knot nematodes

© H.J. Jensen (Reproduced from CABI 2006)

More Information on Root-knot nematodes

The pod weevil (*Piezotrachelus varius*)

The pod weevil (*Piezotrachelus varius* or *Apion varium*), its a common pest of cowpeas in West Africa. Generally 13-26% of the pods are damaged. Losses of seeds up to 92% have been reported in Nigeria. The shiny black weevils bore holes in fresh green cowpea pods and lay eggs into the pods. The grubs feed on the seeds and pupate within the pods.

Pod weevil
The pod weevil Apion species on bean pod.

© Frank Peairs, Colorado State University

More Information on Storage pests

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Information on Diseases

Cowpea mosaic diseases

These viruses produce a mosaic pattern on cowpeas. They may be found singularly or in combination with others. They cause irregular light and dark green mosaic patterns in the leaves. Some virus cause thickened, malformed leaves. The mosaic patterns are best observed on the younger foliage. Plants may be stunted and fail to produce normal pods. If the disease attacks plants at the early growth stage, no pods should be expected.

Cowpea mosaic virus Cowpea mosaic virus (CpMV)

The most common virus disease on cowpeas is cowpea aphid-borne mosaic potyvirus. It is transmitted by aphids.

Mosaic diseases include:

- **Cowpea mosaic comovirus (CpMV)**
- **Blackeye cowpea mosaic potyvirus (BlCMV)**
- **Cowpea severe mosaic virus (CPSMV)**
- **Cowpea aphid-borne mosaic potyvirus (CAMV)**
- **Cowpea mottle carmovirus (CPMoV)**
- **Cowpea golden mosaic bigeminivirus.**

What to do:

- **Plant resistant varieties, where available.**
- **Use healthy, disease-free seeds rather than saving seed from a crop that could be infected.**
- **Practise crop rotation with non-legumes (e.g. cereals).**
- **Remove alternative hosts of virus diseases (legumes).**

Damping-off diseases (*Rhizoctonia* sp., *Phythium* sp., *Fusarium* sp.)

Seeds may rot before emergence from the soil and young seedlings may die. The condition is most common on early plantings or when soil contains a large amount of undecomposed plant residue.

Damping-off diseases are favoured by cool, wet soil conditions.

What to do:

- **Avoid planting in wet, cold soils.**

Damping-off
Damping-off disease (*Rhizoctonia solani*) - here on beans

© Jürgen Kranz, Courtesy of EcoPort, www.ecoport.org
More Information on Damping-off diseases

Bacterial blight (*Xanthomonas axonopodis* pv. *vignicola*)

This disease appears as tan to brown angular leaf spots with yellow margins on leaves, pods, and stems. It may cause severe defoliation during periods of high humidity. It is seed borne.

What to do:

- **Use certified disease-free seeds.**
- **Avoid working in the fields when it is wet.**
- **Practise good field sanitation.**

Bacterial blight
Bacterial blight (here on soybean leaf)

© Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org

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Anthracnose (*Colletotrichum lindemuthanium*)

This is a major cowpea disease, which can be very severe in areas where cowpeas are grown as the sole crop. Stems affected by anthracnose exhibit dark brown areas that later join up to cover the entire stem as well as branches, peduncles and petioles. The disease also attacks the pods.

Lesions on pods are sunken and brownish and under wet conditions they are covered with a pink fungal spore mass. Under severe infection, stems die. The disease attacks all legumes. Anthracnose is most prevalent during cool, humid

Anthracnose
Anthracnose (*Colletotrichum lindemuthanium*) on beans pod. Symptoms are similar

weather. It is transmitted through infected seeds and survives in crop debris.

What to do:

- **Plant resistant varieties, if available**
- **Use certified disease-free seeds.**
- **Practise good field sanitation**

on cowpea.

© Jim Sheppard (Courtesy of EcoPort, www.ecoport.org)



Anthra Anthra Anthra

More Information on Anthracnose

Powdery mildew (*Erysiphe polygoni*)

Symptoms consist of a light, greyish, powdery growth on the leaves, pods and occasionally the stems. This powdery growth is easily rubbed off. When the disease is severe, plants turn yellow and defoliate. Generally, powdery mildew does not damage early-planted cowpeas. It can, however, be quite destructive on a late-planted crop. A fairly dry soil and heavy application of nitrogen-based fertilizer tend to increase disease severity.

What to do:

- **Plant resistant varieties where available**
- **Practise good field sanitation**
- **Avoid close planting**
- **Control weeds**

Powdery mildew
Powdery mildew on peas

© A. M. Varela, icipe


Powde mi... Powde mi...

More Information on Powdery mildew

Leaf spots (*Cercospora* sp., *Aristastoma* sp., *Ascochyta* sp., *Colletotrichum* sp., *Stagnospora* sp.)

Various sized spots often yellowish in colour or with a yellow halo, others brown to purplish; these normally develop first on lower leaves. With *Cercospora* leafspot a dark, mouldy growth develops on the lower leaf surface corresponding to the spot. Leafspot diseases are most serious during periods of prolonged moist weather and on late plantings. Severe leaf spotting results in defoliation with subsequent yield reductions.

Cercosphora leafspot *Cercospora* leafspot on soybean

What to do:

- **Use certified disease-free seeds**
- **Practise crop rotation with non-legumes (e.g. cereals).**
- **Avoid cultivating fields when foliage is wet**

Brown blotch (*Colletotrichum truncatum*)

The fungus causes pre-emergence and post-emergence damping off when infected seeds are planted. The former rots the seed before emergence from the soil while post-emergence kills the seedlings after emergence. The disease also attacks the foliage, stems and pods. Sunken, oval spots may be seen on stems;

circular spots on leaves. Lesions are reddish-brown. Under prolonged wet weather heavy defoliation occurs. During late reproductive stages, infected tissues are covered with black fungal fruiting bodies, which produce minute black spines (setae) that can be seen with the unaided eye. It is transmitted through infected seeds and survives in crop debris.

What to do:

- **Use certified disease-free seeds.**
- **Use resistant varieties where available.**
- **Practise good field sanitation.**

Brown blotch
Brown blotch (*Colletotrichum truncatum*) (here on soybeans

Rust (*Uromyces vignae*)

Small, reddish-brown pustules (blisters) appear on both upper and lower leaf surfaces. Rust can develop rapidly, resulting in severe leaf damage and defoliation.

What to do:

- **Use sulfur based products or potassium carbonate. Do not spray sulphur when it is hot, as it can burn the foliage and flowers.**

Rust
Rust on cowpea (*Uromyces vignae*)

Cowpea wilt (*Fusarium oxysporum*

Cowpea wilt (*Fusarium oxysporum* f. sp. *tracheiphilum*)
Fusarium wilt usually causes the lower leaves on one side of the plant to turn yellow. Infected plants usually are stunted and wilted as the organism develops in the food and water conducting tissues. Brick red tissue can be observed in the stem when it is split lengthwise.

What to do:

- **Use resistant varieties, if available**
- **Control root-knot nematodes since nematodes increase plant susceptibility to Fusarium wilt**

Fusarium wilt
Fusarium wilt on peas



Fusariu w... **Fusariu w...** **Fusariu w...**

More Information on Fusarium wilt

Southern blight (*Sclerotium rolfsii*)

It attacks roots and stems of cowpeas. The first visible symptom of southern blight is a progressive, yellowing and wilting of the

foliage beginning on the lower leaves. The plant dies within a few days after the rust symptoms appear. A brownish vascular discolouration inside the stem may extend several inches above the soil line. During warm, moist conditions, the coarse, white mycelium of the fungus makes characteristic fan-shaped patterns of growth on the stem at the soil line. In this white-mat of the fungus, numerous smooth, round, light-tan to dark-brown mustard seed-like bodies called sclerotia are formed.

What to do:

- **Practise good field sanitation.**
- **Practise crop rotation with non-legumes.**
- **Plough the soil deep.**

Southern blight
Southern blight (*Sclerotium rolfsii*) on soybean

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Charcoal rot (*Macrophomina phaseolina*)

Charcoal Rot (fungus - *Macrophomina phaseolina*). Many plants are susceptible to this soil borne fungus and symptoms vary according to type. Infected stem tissue shows evidence of shredding with tiny black dots (sclerotia) between the remaining tissues. This gives those plant parts an ashy-grey appearance. This can be observed by splitting the stalk and noting the deteriorated soft pith tissue leaving the tougher vascular strands. Fungal structures (sclerotia) can be observed in the affected tissue which appears as though it has been dusted with black pepper

Charcoal rot
Charcoal rot of sorghum, showing the typical charcoal-grey within the

split base of the stem

© Joseph Krausz, Texas Agricultural Extension Service

Grain sorghum plants affected by the charcoal rot fungus fail to fill grain properly and may lodge in the latter part of the season.

Charcoal rot occurs most consistently when plants are experiencing moisture stress due to drought. The fungus is widely distributed and builds up in soil when susceptible host plants are present and conditions favour its development.

Avoiding moisture stress, proper management of crop residue, crop rotation, avoiding excessive plant populations, balancing nitrogen and potassium fertility levels, and growing drought-tolerant, lodging-resistant hybrids represent the best means of control.

What to do:

- **Rotate with unrelated crops (e.g. cereals) helps reduce the population of the fungus in the soil.**
- **Avoid moisture stress by increasing the moisture holding capacity of the soil and, if available, using irrigation when needed.**
- **Rotate with crops that are not seriously affected by this organism.**
- **Practices that hasten decomposition of crop residue may help decrease the population of the fungus in the soil.**

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Information on Weeds

Witchweed (*Striga hermonthica*)

The parasitic weed witchweed (*Striga gesnerioides*) is also a problem in cowpea.

What to do:

- **Practise crop rotation.**
- **Practise fallow**
- **Use resistant cultivars if available.**

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

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More Information on Purple witchweed

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Information Source Links

- **AIC, Nairobi, Kenya (2002). Field Crop Technical Handbook**

- **Abudulai, M., Shepard, B. M.,Salifu, A. B. (2003). Field evaluation of a neem (*Azadirachta indica* A. Juss)-based formulation Neemix® against *Nezara viridula* (L.) (Hemiptera: Pentatomidae) in cowpea. International Journal of Pest Management, Volume 49, Issue 2 April 2003 , pages 109 - 113. http://www.informaworld.com/smpp/content~content=a713867857~db=all**
- **Alghali AM, 1993. Intercropping as a component in insect pest management for grain cowpea, Vigna unguiculata Walp production in Nigeria. Insect Science and its Application, 14(1):49-54.**
- **Anthony Youdeowei (2002). Integrated Pest Management Practices for the Production of Cereals and Pulses. Integrated Pest Management Extension Guide 2. Ministry of Food and Agriculture (MOFA) Plant Protection and Regulatory Services Directorate (PPRSD), Ghana, with German Development Cooperation (GTZ). ISBN: 9988 0 1086 9.**
- **CAB International (2005). Crop Protection Compendium, 2005 Edition. Wallingford, UK. www.cabi.org**
- **Elwell, H., Maas, A. (1995). Natural Pest & Disease Control. Natural Farming network, Zimbabwe. The Plant Protection Improvement Programme and The Natural Farming Network.**
- **Ezueh, I. (1991). Prospects for cultural and biological control of cowpea pests. Insect Science and its Application. Vol 12 (5/6). Pp 585-592.**
- **GTZ/PPRSD (2000). Handbook of crop protection recommendations in Ghana: An IPM approach Vol: 1 Cereals and pulses. E. Blay, A. R. Cudjoe, and M. Braun (editors). May 2000. Plant Protection & Regulatory Services Directorate and Integrated Crop Protection Project (ICP) German Development Co-operation (GTZ/PPRSD).**
- **IITA. Integrated management of legume pests and diseases. http://www.iita.org/**
- **IPM CRSP. Eight Annual Report. Overview of the African Site in Uganda. http://www.oired.vt.edu/ipmcrsp/communications/annrepts/annrep01/ar01uganda.htm**
- **Jackai, L. E. N., Daoust, R. A. (1986). Insect pests of cowpeas. Annual Review of Entomology. Vol 31: 95-119.**
- **KARI Kenya: Legumes Recommended for intercropping at the Coast**
- **Layton B. (2004). Bug Wise.**

http://msucares.com/newsletters/pests/bugwise/2004/bw1804.pdf

- Lost Crops of Africa: Volume II: Vegetables (2006). Development, Security, and Cooperation (DSC). Online read-only: The National Academy Press: www.nap.edu/catalog/11763.html
- Nampala, P., Ogenga-Latigo, M.W. ,Kyamanywa, S. , Adipala , E. , Oyobo N. and Jackai,, L.E.N. (2002). Potential impact of intercropping on major cowpea field pests in Uganda. African Crop Science Journal, Vol. 10. No. 4, pp. 335-344.
- Ostermann, H., Dreyer, M. (1995). Vegetables and grain legumes. In "The Neem tree Azadirachta indica A. Juss. and other meliaceous plants sources of unique natural products for integrated pest management, industry and other purposes". (1995). Edited by H. Schmutterer in collaboration with K. R. S. Ascher, M. B. Isman, M. Jacobson, C. M. Ketkar, W. Kraus, H. Rembolt, and R.C. Saxena. VCH. pp. 392-403. ISBN: 3-527-30054-6
- Parella, M. P., Lewis, T. (1997). IPM in Field Crops. In Thrips as crop pests. (1997).. Edited by T. Lewis. CAB International. Institute of Arable Crops Research-Rothamsted, Harpenenden, Herts, UK. Pages 595-614. ISBN: 0-85199-178-5.
- Singh, S. R., van Emden, H. F. (1979). Insect pests of grain legumes. Annual Review of Entomology. Vol 24: 255-278.
- Singh, S.R., Rachie, K.O. (eds.)(1995). Fungal, Bacterial and Viral Diseases of Cowpeas in the USA- Patel, P.N. Chapter 14 in Cowpea Research, Production and Utilization. John Wiley & Son. http://www.hort.purdue.edu/newcrop/afcm/cowpea.html

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Groundnut
Scientific name: *Arachis hypogaea*
Order/Family: Fabales: Fabaceae
Local names: Njugu (Swahili)
Common names: Peanut, earth nuts, monkey nuts
Pests and Diseases: Aphids Aspergillus crown rot Bacterial wilt Damping-off diseases Groundnut blight Groundnut hopper Groundnut rosette disease Leaf spots Leafmining caterpillars Milipedes Root-knot nematodes Rust Snails (Giant East African Snail) Spider mites Storage moths and bruchid beetles Storage pests Termites Thrips White grubs

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General Information and Agronomic Aspects

Groundnuts originated in the area of South America from southern Bolivia to north-western Argentina. The Portuguese apparently took them from Brazil to West Africa and then to south-western India in the 16th century. Africa is now regarded as a secondary centre of diversity. Groundnuts are now grown in most tropical, subtropical and temperate countries between 40°N and 40°S latitude, especially in Africa, Asia, North and South America.

Groundnuts are a small erect or trailing herbaceous legume, about 15 to 60 cm high. The fruit is a pod with one to five seeds that develops

Millet
Okra
Onion
Papaya
Passion fruit
Peas
Peppers
Pigeon pea
Pineapple
Potato
Pumpkin
Rice
Sesame
Sorghum
Soybean
Spider plant
Spinach
Sugarcane
Sweet potato
Tea
Teff
Tomato
Wheat
Yam
Zucchini/Courgette

Geographical Distribution of Groundnut in Africa

underground within a needle-like structure called a peg. The seeds are rich in oil (38-50%), protein, calcium, potassium, phosphorus, magnesium and vitamins. Groundnuts have also considerable medicinal value. They are reported to be useful in the treatment of disease such as haemophilia, stomatitis, and diarrhoea.

Most of the world production of groundnuts is crushed for oil that is used mainly for cooking. The press cake from oil extraction is a feed rich in protein but is also used to produce groundnut flour, which is used in many human foods. The seeds or kernels are eaten raw, boiled or roasted, made into confectionery and snack foods, and are used in soups or made into sauces to use on meat and rice dishes. The vegetative residues from the crop are excellent forage.

In sub-Saharan Africa, groundnuts are a basic staple crop, cultivated mainly by small-scale farmers both as subsistence and as a cash crop. It is an important source of protein and other nutrients for poor rural communities. In Africa, groundnut yields are traditionally low, due to unreliable rains, little technology available to small-scale farmers, pest and disease occurrence, poor seed variety, and increased cultivation on marginal land (ICRISAT).

Climatic conditions, soil and water management

Groundnuts are grown in the warm tropics and subtropics below 1500 m above sea level, and in temperate humid regions with sufficiently long warm summers. Optimum mean daily temperature to grow is 30°C and growth ceases at 15°C. Cool temperatures delay flowering. Groundnuts cannot stand frost. Between 500 and 600 mm of water reasonably well distributed through the growing season allows a good production. Nevertheless, groundnuts are a drought-tolerant species and can withstand severe lack of water, but yield is generally reduced. If harvesting conditions are wet, aflatoxins (severe poison produced by some fungi such as *Aspergillus* spp.) may develop on the nuts. Aflatoxin contamination is a major hazard to human

Pests/ diseases/ weeds
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and animal health.
Because pods develop underground and must be recovered at harvest, crumbly, well-drained soils are preferred, but plants grow and develop adequately on heavier clay soils. For optimum growth, soil pH should be in the range 5.5 to 6.5, though Spanish types tolerate more acid conditions (pH 4.5) and some cultivars grow well in alkaline soils up to pH 8.5.

Propagation and planting

Ideally the seedbed should be deep and friable with an even particle size. Take care that the seedbed is weed-free. Cloddy and uneven seed beds can result in uneven emergence and heavy seed bed losses of plants. Recommended plant densities are near 200,000 to 250,000 plants/ha for the typically short-season Spanish cultivars. In most countries, cultivation is in rows with plant spacing ranging from 40 x 20 cm to 30 x 20 cm.

After ploughing and harrowing to a fairly good tilth, ridges, which are 80 cm apart with flattish tops, should be made so that two rows of nuts can be planted on each ridge. Seeds for planting should be well selected: they should be clean, well filled and without any blemishes. Seeds for planting should be kept in their pods and shelled a few days before planting. Planting depth is like maize about 5 to 8 cm. Seed rate is 40 to 50 kg/ha depending on the size of the seeds.
There are 2 types of groundnuts:

- Bunch type
- Runner type

Bunch varieties such as Red Valencia mature within 90 to 100 days, while runner types such as "Homa Bay" mature in 120 to 150 days (require a longer growing season).

Variety	Mean kernel yield Kg/ha
"Red valencia"	1500

~~"Severe 116" (white)~~	~~1250~~
"Texas peanut"	1360
"Bukene"	1530
"Manipintar"	2450
"Makulu red"	2720
"Altika"	900
"Homa Bay"	770
"Asirya Mwitunde"	1300

With good husbandry current farmers' yields of between 450-700 kg/ha could be doubled.

Intercropping

Groundnuts are grown as a sole crop and also intercropped with maize, soyabean and cassava. It is also a good intercrop for upland rice, sorghum, okra, sugarcane, and sunflower. To get a good yield however, proper planting distance should be observed along with the other recommended cultural practices. In some areas, they are grown under perennial tree crops such as coconut, oil palm or rubber. Groundnuts when used as intercrop for upland maize and planted along the contour reduces soil runoff. The plant also reduces population of African bollworm because it serves as a hiding place for beneficial insects. (OISAT)
There is an increase in the yield of groundnuts when intercropped with early maturing pigeon pea.

Husbandry

To achieve maximum economic yields, weeds must be eliminated. Groundnuts are very poor competitors with weeds during early stages of growth. Weeding should be done early while at the same time earthing up the ridges to encourage "pegging" i.e. young nuts penetration

through the soil. Once pegging has started, only hand weeding should be undertaken to avoid disturbing the young nuts or damaging the flowers. Clean weeding should be done up to 6 weeks after which hand weeding should take over.

The only peculiar nutrient requirement is for calcium (Ca) in the podding zone. Calcium is absorbed directly by the pods, if soil moisture is adequate. A shortage of Ca in that zone will result in empty pods (especially in Virginia cultivars). The crop's needs for nitrogen should be satisfied with symbiotic fixation by strains of *Rhizobium* of the cowpea group, so nitrogen fertilisers are not generally required. In some areas of acid soils, lime is applied to raise the pH and supply Ca. Moisture stress during flowering or pod filling reduces yield so that irrigation during those periods to minimise or eliminate the stress increases production and seed quality. Where yields are unsatisfactory (heavily eroded soils) an application of 200 kg/ha of rock phosphate is recommended.

Harvesting

Spanish cultivars are harvested 85-100 days after sowing and Virginia cultivars 110-130 days after sowing in the warm tropics.

Dig a few plants up to see if the nuts are ready. The nuts should be brown on the outside, firm and dry. Usually at maturity the inside of the pods is grey and some rattling occurs when pods are shaken. Severe disease of foliage sometimes results in harvesting before seeds are fully mature. Plants should be carefully dug out to avoid nuts breaking off and remaining in the ground. Dry for 2-3 days, then rip the pods from the bushes and place them on mats to dry for another 7-10 days to about 10% moisture.

Shelling should be done by hand. Broken, dirty or damaged nuts should be discarded as these will lower the quality and hence the selling price. Nuts to be used as seed the following year should not be shelled.

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Information on Pests

White grubs (*Schyzonycha* spp.)

Whitegrubs are the larvae of scarab "chafer" beetles. They are white, C-shaped with a brown head and three pair of legs. Many species of white grubs are associated with groundnut damage in parts of sub-Saharan Africa. The most important are *Schyzonycha* species.

White grubs attack plants at all stages of growth. They eat roots and damage pods of groundnuts. White grubs feed mainly on the taproots and/or peripheral roots leading to stunting or death. They inflict cuts in the crown region of taproots; these lesions are often invaded by rot-causing fungi. White grubs also cut out pods from the base of groundnut pegs and destroy larger, soft pods. Plants are often attacked in a row. White grubs seem to prefer soils with sandy or loamy sand textures and are seldom observed in clay soils.

Whitegrubs
Chafer grub (*Schyzonycha* spp.)

What to do:

- **Allow enough time between manure application and planting of groundnut. The excessive use of organic manure in groundnut farms has been observed to increase the incidence of white grubs, especially when manure is applied during the cropping season.**

- **Deep ploughing or hand hoe tillage exposes soil pests to desiccation and to predators, thus helping to reduce their numbers and damage.**

Termites

Termites
Termites (*Coptotermes formosanus*)

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Termites are serious groundnut pests throughout the southern African region and West Africa. Species of *Microtermes* and *Odontotermes* are the most damaging, while *Macrotermes* cause occasional damage. The small-sized *Microtermes* spp., in particular, attack and invade growing groundnut plants through the roots and stem near ground level, hollowing them out and causing the plants to wilt and die with a consequent reduction in crop stand.
Roots damaged by other soil pests, such as white grubs, are also prone to attack by termites. Some termite species (*Macrotermes* spp., *Hodotermes mossambicus*) cut off stem bases, and may cause 25-100% of plant losses. As the crop ripens the outer layers of the pods are scarified (removal of soft corky tissue between the veins of the pod) by termites allowing contamination of the seed with soil fungi, such as *Aspergillus flavus*, which produce lethal "aflatoxins".

Scarification of pods is by far the most common type of termite damage at plant maturity, a factor often aggravated by late harvest. Scarification as high as 30% has been reported. Infested plants are not obviously diseased and are frequently harvested with and contaminate the rest of the crop. Species such as *Microtermes* spp. also penetrate the pod to feed off the soft inner

lining, filling the pod with soil. This form of attack leads to additional loss through premature germination of kernels. Stacks of plants left drying in the fields are also frequently attacked by species such as *Odontotermes* spp. with farmers losing between 30-40% of their crop at this stage.
Termite damage is generally most serious towards the end of the growing season just prior to harvesting, and it is particularly serious during periods of drought (ARC/LRN. 2007).

What to do:

- **Remove residues of previous cereal crops (sorghum, millet and maize). Plant residues left in the field serve as food for termites, which may infest the new crop. Termite infestation of 100% has been observed in groundnut crops with high plant residues.**
- **Planting should be carried out early enough to avoid drought periods. Moisture deficiency may stress a crop and lead to attack by termites due to low vigour.**
- **Harvest promptly. Research has shown that termite damage increases with delay in harvest. Furthermore, most groundnut-producing areas in sub-Saharan Africa experience drought and high temperatures during the later part of the growing season, conditions that favour termite infestation as well as fungus (A. flavus) infection of pods leading to aflatoxin formation in seeds.**
- **The complete destruction of mounds and removal of queen termites are effective control measures against mound-**

building species (Macrotermes spp.). Partial destruction of mounds is unlikely to solve the problem, since replacement reproduction may develop from the remaining termites.

- **It has been reported that close spacing in groundnut helps to deter termite infestation, although the reason for this was not given. However, high density sowing, followed by thinning of surviving plants where necessary to reduce competition, offsets anticipated losses due to termites.**

Millipedes (*Peridontopyge* spp.)

Millipedes are among the economically important soil pest of groundnuts. They are brown to blackish in colour and curl when disturbed. They attack groundnut seedlings, between planting and approximately 20 days after planting, feeding on the emerging cotyledons and moving to the root system at the collar region. The cortex is often damaged serving as an entry point for secondary infection by microorganisms. The development of plants surviving the attack is often retarded.

Millipedes also attack maturing groundnut during pod formation, i.e. when the pods are still soft. Immature pods from severed pegs are often perforated and thus suffer secondary infection or invasion by rot-causing organisms such as *Aspergillus flavus*. Millipedes may also damage flowers. Birds are main predators of millipedes.

Millipedes
Millipedes (*Peridontopyge* spp.) are brown to blackish in colour and curl-up when disturbed.

What to do:

- **Practice good sanitation.**
- **Prepare land properly.**
- **Select sites away from forest (breeding sites for millipedes)**
- **Cover exposed pods**
- **Close cracks in the soil.**
- **Use varieties with pods well buried.**

Aphids (*Aphis craccivora*)

It is a serious pest as a vector of virus diseases, such as the rosette virus disease, a major constraint to groundnut production, particularly in the dry season. The groundnut aphid is black or dark brown in colour, variable in size (1.5 to 2.0 mm long) with two black cornicles (horns at the rear of the body), and a black tail.

What to do:

- **Early planting and dense close spacing are effective cultural practices.**
  Early planting allows plants to start flowering before aphids appear.
  Dense planting provides a barrier to aphids penetrating in from field edges, discourage population build-up of aphids and reduce incidence of "rosette" disease.
- **Monitor and observe build-up of aphids and of natural enemies.**
- **Conserve natural enemies. Ladybird beetles are reported as important natural enemies in groundnuts.**

Groundnut aphid
Groundnut aphid colony on cowpea. Apterae are 1.4-2.2 mm long. Alatae (winged form) 1.4-2.1 mm.

More Information on Aphids

- **Use neem seed or leaf extracts if necessary.**
- **Do not cultivate groundnut or other legumes continuously on the same ground.**
- **Use tolerant / resistent varieties. The groundnut variety "Nyanda" is reported to be tolerant to aphids.**

Groundnut hopper (*Hilda patruelis*)

It is about 5mm in length, brown or green in colour with white marks and strips on the wings. The nymphs resemble the adults but without fully developed wings. These insects live in clusters or colonies, and are attended by ants that eat the honeydew excreted by the hoppers. These sucking insects attack the plants at the base of the stem, usually below ground level. The toxic saliva injected while feeding causes the plant to wither, turn yellow and die. The extent of damage can be important when the insect occurs in large numbers. The first sign of infestation is the presence of black ants.

What to do:

- **Use tolerant / resistant varieties. The groundnut variety "Nyanda" is reported to be tolerant to aphids and to the groundnut hopper (IAN, 2003).**

Thrips (*Megalurothrips sjostedti* and *Frankliniella schultzei*)

Several species of thrips attack groundnuts. They have been reported as important pests of groundnuts in Uganda. The flower thrips (*Frankliniella schultzei* and *Megalurothrips sjostedti*) infest mainly buds and flowers. Attacked flowers are

discoloured and scarred; terminal leaf buds are blackened and distorted after unfolding. Other species of thrips (e.g. *Scirtothrips dorsalis* and *Caliothrips indicus*) infest foliage.

Thrips feeding causes yellowish-green patches on the upper leaf surface and brown necrotic areas and silvery sheen on the lower surface of the leaf; leaves become thickened and some curling occurs. In severe infestations, young leaves are severely deformed, plants are stunted and leaves are blighted.

What to do:

- **Conserve natural enemies. Thrips are attacked by predatory thrips, lacewings and predatory bugs.**
- **Whenever necessary spray the crop with botanicals. Some plant extracts (e.g. garlic, rotenone, neem, pyrethrum, etc.). A mixture of garlic and pepper has been recommended for organic growers in USA.**
- **Plough and harrow before transplanting. This can be useful in reducing thrips attacks by killing pupae in the soil.**

Thrips
Thrips damage on groundnut

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More Information on Thrips

The groundnut leafminer (*Aproaerema modicella*)

It is a common pest of groundnuts in South and South-East Asia and a major pest in India, and it has recently invaded Africa. It was first found in Uganda in 1998 and is now recorded in Mozambique, Malawi, Democratic Republic of Congo and South Africa. In all African countries where this leafminer has been

found, the pest has reached epidemic densities and severe yield losses have been observed on groundnut (The New Vision. 2004; Kenis and Cugala, 2006). The adult is a mottled moth, with a full wing span of up to 18mm. The moth lays eggs on the underside of the groundnut leaf and petioles. Yellowish green caterpillars hatch, tunnel into the leaves and feed between the upper and lower epidermis of the leaf. Mined leaves become distorted within a few days. Caterpillars are grey-green with a shiny black head. There are five larval instars. The first instar has an average length of 0.56 mm. At pupation, they rarely exceed 8 mm in length.

Three or four mines per groundnut leaflet can cause so much distortion that a leaf exposes as little as 30% of the potential photosynthetic area to the sun. Later, when the caterpillar become too large to occupy the mine, they emerge to the leaf surface and either fold over a single leaf and hold it down with silk, or web together two or more leaflets. They live and feed in the shelter they have constructed. Pupation takes place inside the webbed leaflets. Damaged leaves become brownish, rolled and desiccated, which results in early defoliation and affects the growth and yield of the plants.

Groundnut leafminer Leafmining caterpillar on groundnut (*Aproaerema modicella*) are grey-green with a shiny black head. There are five larval instars. The first instar has an average length of 0.56 mm; caterpillars are ca 6 mm long at the time of pupation, and rarely exceed 8 mm in length.

What to do:

- **Use tolerant/resistant varieties. In Uganda, it has been reported that the variety "Egola-1" had shown signs of relative resistance.**

- **Plant during the first short rains when normally the miner population is low.**
- **Avoid drought stress by irrigating or sowing so as to avoid periods when drought is likely. Plants that are drought stressed are much more susceptible to leafminer attack than irrigated plants.**

Storage pests: moths and beetles

Stored groundnuts are attacked by moths (*Ephestia cautella, Plodia interpunctella*, *Cadra cautella*), and beetles (*Caryedon serratus, Tribolium castaneum, Trogoderma granarium*).

The larvae of moths and the grubs and adult beetles bore into and damage seeds. Moths cause extensive webbing. The bruchid beetle *Caryedon serratus* is the major pest of groundnut in shell in West Africa. A good post harvest pest management programme based on good storage practices is very important. vel was very effective (INPhO Compendium)

What to do:

- **As most post-harvest groundnut pests except bruchids are unable to penetrate intact pods, leaving the crop in the shell for as long as possible during storage is an effective method of limiting damage.**
- **Research into low cost technology to protect stored groundnut showed that Samadaka (Swartzia madagascariensis), 2 kg of powder fruits to treat 100 kg**

Dried currant moth
Dried currant moth (*Cadra cautella*) - The larvae range from 1.5 mm to 1.5 cm (15 mm) in length and are light brown in colour with dark brown spots on the skin (cuticle).

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More Information on Storage

groundnuts, was very effective against bruchids and moths for the groundnuts stored in granaries.

- **Addition of sand as an abrasive material at the farm level was very effective (INPhO Compendium)**

pests

Root-knot nematodes

They are widespread but their seriousness in yield reduction is unknown. They cause plant stunting, gall or knot formation on roots, and in severe cases wilting of affected plants

What to do:

- **Rotate with cereals**

Root-knot nematode
Root-knot nematode galls on tomato roots. Root-knot nematodes (*Meloidogyne incognita* / *M. javanica*) affected plants are normally stunted and eventually wilt and die. The most characteristic symptom is formation of root galls (knots) and these can be seen with the naked eye. Affected roots rot.

© Bridge J., IIP. Courtesy of

Ecoport (www.ecoport.org)
More Information on Root-knot nematodes

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Information on Diseases

Leaf spots (*Cercospora* spp.)

Symptoms of early leaf spot (*Mycosphaerella arachidis*, *Cercospora arachidicola*) consist of sub-circular dark brown spots produced on the upper leaflet surface. The spots are of lighter shade of brown on the lower side of the leaflets. Yellow halo is seen around the brown spots. Oval to elongate spots are also seen on stems, petioles, and pegs. Late leaf spot can be distinguished from those of early leaf spot.

Late leaf spots (*M. berkeleyi*, *Cercosporidium personatum*) are darker with no or light yellow halo. The late leaf spots on the lower leaflet surface are rough in appearance. They exhibit circular rings of fungus fruiting structures on the lower leaflet surface with the aid of a hand lens. Severe disease attack leads to shedding of leaflets resulting in premature ageing of the crop. Oval to elongate spots similar to early leaf spot are also formed on stems and pegs. Late leaf spot attack is usually seen along with rust disease.

Early leaf spot
Early leaf spot (*Mycosphaerella arachidis*)

© Jürgen Kranz (Courtesy of EcoPort, www.ecoport.org)\n

What to do:

- **Plant tolerant / resistant varieties, if available**
- **Collect and destroy the infected crop debris**
- **Follow cereal-cereal- groundnut crop rotation.**

Rust (*Puccinia arachidis*)

Puccinia arachidis
Pustules (spots or blisters) can form on all aerial plant parts except flowers. Orange coloured pustules first appear on the lower surface of leaflets. Later, pustules may appear on the upper surface of the leaflets. The pustules on the stem are elongate and elevated. The pustules when mature rupture to release masses of reddish-brown spores, which blown by wind, spread the disease from plant to plant and far away to other groundnut fields.

Rust
Rust (*Puccinia arachidis*)

© Gerlach W. Courtesy of EcoPort, www.ecoport.org

What to do:

- **Plant resistant varieties if available**
- **Remove volunteer groundnut plants from the field to check build-up of rust infection**
- **Adopt cereal-cereal-groundnut crop rotation**
- **Adjust the sowing time to avoid the most conducive environmental conditions for rust development i.e., high humidity, cloudy weather.**

Aspergillus crown rot (*Aspergillus niger*)

Aspergillus crown rot
Aspergillus crown rot (*Aspergillus niger*)

Aspergillus niger
The fungus causes both seed and seedling rot and drastically reduces plant stand. In moist soil, seeds may be attacked and killed due to rotting. Seeds removed from soil show black sooty cover. The infected areas of seedlings are covered with black fungal spores. Mature plants are also attacked. Symptoms include wilt of branches permanently, and or wilting of entire plant. The dead and dried branches are easily detached from the collar region. Infected pods reveal patches of black sooty spores. Related species (*Aspergillus flavus*) causes deterioration of seeds.
It also produces the toxin (aflatoxin) in infected seeds that can cause death or other symptoms of toxicity when eaten by animals or humans.
***A. flavus* as a mould contaminant and toxin producer is much less serious during growth of the crop than during subsequent storage of kernels. Minimising moisture stress during growth can reduce invasion and toxin production by *A. flavus*.**

What to do:

- **Rapid drying to moisture content of about 10% is the only means of preventing infection by A. flavus.**
- **Minimise damage to the nuts during harvesting because the fungus can easily enter a broken shell.**
- **Remove diseased crop debris from the field to reduce source of infection.**

Groundnut blight (*Sclerotium rolfsii*)

Groundnut blight
Groundnut blight (*Sclerotium rolfsii*)

Sclerotium rolfsii
The fungus attacks all parts of the plant, but stem infection is the most common and destructive. Yellowing and wilting of branches near the base of the plant is the first symptom. White fungus growth develops at or near the soil around the affected stem. Severely infected pods are completely covered with a white fungal growth, and eventually decay. In some cases the seeds from the diseased pods show a characteristic bluish-grey discoloration known as 'blue damage'. The incidence of blight is greatest in wet weather.

What to do:

- **Plough deeply**
- **Practise sanitation**
- **Control moisture**
- **Rotate with cereals, onion and garlic**

Bacterial wilt *Ralstonia solanacearum*

It can cause serious losses, if a crop is infected early. Infected plants show water stress symptoms and may wilt suddenly without yellowing of the foliage, particularly, when temperatures are high.

What to do:

- **Rotate with cereals**

Bacterial wilt on pepper
Bacterial wilt (*Ralstonia solanacearum*) on pepper

More Information on Bacterial wilt

Groundnut rosette disease

It consists of three types namely groundnut chlorotic rosette, groundnut green rosette and groundnut mosaic.

The disease is caused by a complex of different strains of groundnut rosette umbravirus. Symptoms vary depending on strain(s) present. They include yellowing, mottling and mosaic symptoms on leaves and stunting and distortion of the shoots. Older leaves are dark green, reduced in size, and show downward rolling of leaflet margins. If the plants are infected when they are young, they may not produce nuts.

The virus is transmitted by aphids (*Aphis craccivora* and *A. gossypii*), which feed on the undersides of the leaves.

Groundnut rosette disease Symptoms in a field-infected groundnut plant in Malawi.

What to do:

- **Sow early in the rains and plant close (high density planting).**

- **Plant tolerant / resistant varieties, e.g. "Asirya Mwitunde" .**
- **Remove virus-infected plants after harvest, and volunteer plants that are primary source of infection.**

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Information Source Links

- **AIC (2002). Field Crops Technical Handbook. Nairobi Kenya.**
- **ARC/LRN. (2007). Termites in crops. www.arc.agric.za**
- **Blay, E., Cudjoe, A. R., Braun, M. (eds). (2000). Handbook of crop protection recommendations in Ghana: An IPM approach Vol:1 Cereals and pulses. May 2000. Plant Protection & Regulatory Services Directorate and Integrated Crop Protection Project (ICP) German Development Co-operation (GTZ/PPRSD).**
- **Bohlen, E. (1973). Crop pests in Tanzania and their control. Federal Agency for Economic Cooperation (bfe). Verlag Paul Parey. ISBN: 3-489-64826-9.**
- **Brunt, A.A., Crabtree, K., Dallwitz, M.J., Gibbs, A.J., Watson, L. and Zurcher, E.J. (eds.) (1996 onwards). `Plant Viruses Online: Descriptions and Lists from the VIDE Database. Version: 20th August 1996.**
- **CAB International (2005). Crop Protection Compendium, 2005 edition. Wallingford, UK www.cabi.org**
- **Groundnut (*Arachis hypogaea*), women and development: Impact on nutrition and women's role in Western Africa. http://forest.mtu.edu**
- **ICRISAT, http://www.icrisat.org**
- **INPhO Compendium. Chapter 21. Groundnut. 4.3. Pest control. http://www.fao.org**
- **IPM CRSP. Seventh Annual Report. Overview of the African Site in Uganda. http://www.oired.vt.edu**
- **International Arachis Newsletter (IAN). No. 23, 2003.**
- **J.D. Acland (1980). East African Crops. FAO/Longman. ISBN: 0 582 60301 3**

- **Kenis, M., Cugala, D. (2006). Prospects for the biological control of the groundnut leaf miner, Aproaerema modicella, in Africa. CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources, 1, No. 31, 9 pp. Insect Sci. Applic. Vol. 21, No. 3 pp. 257-265. http://www.pestscience.com**
- **National Research Centre for Groundnut (ICAR) (http://www.icar.org.in/). P.C. Nautiyal. Major pests species of stored groundnuts. Chapter XXI - Groundnut. http://www.fao.org**
- **OISAT: Organisation for Non-Chemical Pest Management in the Tropics. www.oisat.org**
- **Participatory evaluation of the distribution, status and management of the groundnut leafminers in the Teso and Lango farming systems. Final technical report. NARO/DFIFD COARD Project. October 2004. By George Epieru Naro Saari).**
- **Paulraj, M.P. & S. Ignacimuthu (2006). Integrated control of groundnut leafminer. Entomology Research Institute Loyola College, Chennai. www.thehindu.com**
- **The New Vision (2004). Uganda's leadings website. http://www.newvision.co.ug**
- **Umeh, V. C. , Walyyar, F. , Traoré, S., Chaibou, I. M., Omar, B., Detognon J. (2001). Farmers' opinions and influence of cultural practices on soil pest damage to groundnut in West Africa. Mini Reviewhttp://www.bioline.org.br**
- **Umeh, V. C., Youm, O., Waliyar, F. (2001). Soil Pests of Groundnut in sub-Saharan Africa - A Review. Insect Sci. Applic. Vol. 21, No. 1, pp. 23-32. Bioline International, 1989 - 2007, Site last up-dated on 14-May-2007. www.bioline.org.br**
- **Youdeowei, A. (2002). Integrated Pest Management Practices for the Production of Cereals and Pulses. Integrated Pest Management Extension Guide 2. Ministry of Food and Agriculture (MOFA) Plant Protection and Regulatory Services Directorate (PPRSD), Ghana, and German Development Cooperation (GTZ). ISBN: 9988 0 1086 9.**

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Green gram
Scientific name: *Vigna radiata*
Order/Family: Fabales: Fabaceae
Local names: Pojo (Swahili)
Common names: Mung bean
Pests and Diseases: African bollworm Anthracnose Aphids Bacterial blight Bean flies Bugs Cowpea seed beetle Damping-off diseases Foliage beetles Powdery mildew Rust Storage pests Thrips Whiteflies Yellow mosaic virus

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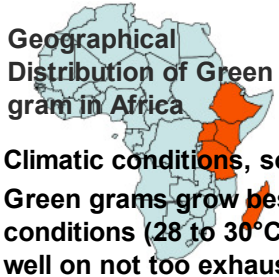
General Information and Agronomic Aspects

Grams are annual legume crops grown for their seed. Grams could be green, black or yellow in colour. The green grams are the most commonly grown in Kenya. Grams are native crops of India. Often called green gram or golden, it is cultivated in several countries of Asia, Africa, and the Americas. The dried beans are prepared by cooking or milling. They are eaten whole or split. The seeds or the flour may enter a variety of dishes like soups, porridge, snacks, bread, noodles and even ice cream. Green gram also produces great sprouts, which can be sold in health food



Geographical Distribution of Green gram in Africa

shops or eaten at home. Crop residues of *V. radiata* are a useful fodder. Green gram is sometimes specifically grown for hay, green manure or as a cover crop.

Climatic conditions, soil and water management

Green grams grow best at an altitude of 0-1600 m above sea level and under warm climatic conditions (28 to 30°C). They are well adapted to red sandy loam soils, but also do reasonably well on not too exhausted sandy soils. Green grams are not tolerant of wet, poorly drained soils. They are drought tolerant and will give reasonable yields with as little as 650 mm of yearly rainfall. Heavy rainfall results in increased vegetative growth with reduced pod setting and development.

Propagation and Planting

Avoid planting green gram for more than one season because toxic residues and disease organisms from the previous green gram crop may affect the following crop adversely.
Land should be prepared to a medium tilth before planting and early enough so that planting can start immediately after the rain starts. When using oxen plough for planting, place the seed at the side of the furrow.
Propagation is by seed. There is no seed dormancy. Seeds may sprout in the pod under very humid conditions. In areas with higher rainfall, it is recommended to grow green grams on raised beds. Prepare the beds, raised about 20 cm and spaced 1 m from the centre of one bed to the centre of the next. Sow seeds on raised beds in two rows per bed, spaced 45 cm apart. Green grams will respond to fertiliser or manure application but will normally give satisfactory results if grown on relatively good soil.

Green gram is grown mainly on smallholdings, often as mixed crops or intercrops. Associated crops are usually of longer duration than green gram (sugar-cane, cotton, sorghum). To make use of a short cropping period, short-duration green gram is often relay-cropped.

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Varieties

Green grams usually mature in 60 to 90 days. The early maturing varieties can often produce before drought destroys many bean species. Two varieties can be distinguished in Kenya:

Variety	Maturity Days	Potential yield Bags/ha	Remarks
"KUR 22"	"80-90"	"11-14"	• Golden seed colour • Tolerant to aphids • Resistant to yellow mosaic • In the driest areas will perform poorly due to its lateness
KVR 26	60-65	14-17	• Green seed colour • Best performer in dry areas due to its earliness

Husbandry

With the newer cultivars ripening in 60 to 75 days, maximum yields are obtained at plant densities of 300 to 400,000 plants per ha. The later-maturing traditional cultivars generally need wider spacing. Usually no fertilisers are applied to green gram. Over the centuries, green gram's adaptation to stable performance in marginal environments has resulted in a low yield potential, which limits responsiveness to better environments and improved cultural practices. However, if planted in heavily eroded soil gram will benefit from any kind of manure or compost.

Grams planted at the end of the long rains are normally intercropped into other major crop. In Meru, Kenya, green gram is a preferred intercrop for millet, each said to protect the other against diseases and pests. If grams are intercropped with maize, the maize spacing is the same as in pure stand, but the grams are interplanted mid-way between the maize rows.

Early weeding is recommended. First weeding should be done just after emergence and second weeding just before flowering.

Harvesting

Harvesting is generally by two to five hand-pickings at weekly intervals and is the most expensive single operation in growing green gram. Short-duration cultivars, which ripen more uniformly, may be processed as whole plants on small rice threshers. Cultivars differ markedly in harvesting efficiency, depending on position (above or within canopy) and size of pods. Harvesting before the maturity of crop, usually result in lower yields, higher proportion of immature seeds, poor grain quality and more chances of infestation during storage. Delay in harvesting results in shattering of pods and other losses caused by pests. In Kenya, harvesting when 95% of pods have turned black is recommended. The whole plant can then be uprooted and dried for about 2 days, then threshed and winnowed. Harvesting during adverse weather condition i.e. rains and overcast weather should be avoided. Such weather is conducice to fungal infection. The harvested bundles should be kept in one direction in order to ascertain efficient threshing. They should be stacked in a dry, clean place in cubical way to facilitate circulation of the air around.

Storage

Grams must be dry before storage. Like most pulses moisture content at storage should not be above 13%. Grams are very susceptible to bruchid (bean weevil) attack and are best stored immediately after sun drying either in airtight drums tins or gunny bags and be kept in a clean, ventilated place. Mixing seed with ash is effective against bruchids, also treatment with sunflower oil or mixing with neem leaves is said to be effective against storage pests. Proper drying of grains is very important to prevent the growth of fungi and contamination with aflatoxins. Infected grains should be separated from sound grains to avoid aflatoxin contamination.

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Information on Diseases

Bacterial blight (bean blight) (*X. axonopodis* pv. *phaseoli*)

Leaf spots first appear as small, water-soaked or light-green areas on leaflets. They later become dry and brown. The spots may join to affect much of leaf surface eventually killing the leaflet. Similar water-soaked spots develop on pods. The spot margin is a shade of red. Severely diseased pods shrivel. In humid weather, a yellowish crust of the blight bacteria covers the spot surface.

Bacterial blight
Bacterial blight (*X. axonopodis* pv. *phaseoli*) on beans. Symptoms are similar on green grams.

What to do:

- **Cultural practices are important in controlling bean blights. Eliminate weeds, volunteer beans and other potential hosts of bean blight, as this will reduce disease incidence.**
- **Good weed control will also improve aeration around the crop so that the plants dry faster, this will reduce the chances for bacterial spread and infection.**
- **The bacteria are readily spread by water, and walking or working in the field while plants are wet will splash the bacteria and create wounds. Therefore avoid field operations when it is wet.**
- **A rotation of at least 2 years between bean crops will give time for the bacteria population to decline in the debris.**
- **Deep ploughing will also encourage the breakdown of infected**

plant debris.

- **The incidence of bean blight can also be reduced if beans are grown with maize rather than in a monoculture.**

Powdery mildew (*Erysiphe polygoni*)

White powdery patches appear on leaves and other green parts, which later become dull coloured. These patches gradually increase in size and become circular covering the lower surface. When the infection is severe, both the surfaces of the leaves are completely covered by whitish powdery growth. Severely affected parts get shrivelled and distorted. In severe infections, foliage becomes yellow causing premature defoliation. The disease also creates forced maturity of the infected plants which results in heavy yield losses. The fungal agent (pathogen) has a wide host range and survives on various hosts in off-season. It is spread by wind and water splash.

Powdery mildew
Powdery mildew on peas

© A.M. Varela
More Information on Powdery mildew

What to do:

- **Plant resistant varieties, if available**
- **Plant early**
- **Remove weeds**
- **Practice a good field sanitation**

Rust (*Uromyces phaseoli*)

The disease appears as circular reddish brown pustules (blisters)

which appear more commonly on the underside of the leaves, less abundant on pods and sparingly on stems. When leaves are severely infected, both the surfaces are fully covered by rust pustules. Shrivelling of pods is followed by defoliation resulting in yield losses. Long distance spread of rust is by wind. Plant to plant spread is by farm tools, and moving bodies within the crop.

What to do:

- **Plant resistant varieties, if available**
- **Avoid continuous cropping with legumes**
- **Practice crop rotation with non-legumes such as cereals**

Rust
Rust on lower surface of French beans. Symptoms are similar on green grams.

Anthracnose (*Colletotrichum lindemuthanium*)

It attacks all above ground parts of the plant. It does most serious damage on pods. Affected pods have brownish sunken spots, which under humid conditions are covered with a pink spore mass. Infected seeds become discoloured (brownish black).

What to do:

- **Plant certified disease-free seeds**
- **Plant resistant varieties, where available**
- **Practice crop rotation with non-legumes such as cereals**

Anthracnose
Anthracnose (*Colletotrichum lindemuthanium*) on beans pod. Symptoms are similar on green grams.

© Jim Sheppard (Courtesy of EcoPort, www.ecoport.org)
More Information on Anthracnose

Damping-off diseases (*Pythium* spp., *Fusarium* spp., *Rhizoctonia solani*)

They are caused by a complex of fungi. They cause rotting of seeds before emergence and seedlings after emergence from the soil. Affected fields appear patchy. They are favoured by wet, cool weather.

What to do:

- **Use certified disease-free seeds**
- **Practice proper irrigation**
- **Treat seeds with hot-water, if necessary. For more information on hot-water seed treatment click here.**

Damping-off disease
Damping-off on beans (Rhizoctonia solani)

© Jürgen Kranz, Courtesy of EcoPort, www.ecoport.org
More Information on Damping-off diseases

Yellow mosaic virus

Initially mild scattered yellow spots appear on young leaves. The spots gradually increase in size and ultimately some leaves turn completely yellow. Infected leaves also show necrotic symptoms.

More Information on Yellow mosaic virus

Diseased plants are stunted, mature late and produce very few flowers and pods. Pods of infected plants are reduced in size and turn yellow in colour. The virus is transmitted by whiteflies (*Bemisia tabaci*).

What to do:

- **Use certified disease-free seeds**
- **Plant tolerant/resistant varieties**
- **Weed properly**
- **Control whiteflies**

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Information on Pests

Bean flies (*Ophiomyia phaseoli* and related species)

Bean fly
Bean fly maggot (*Ophiomyia phaseoli*) in a french

Bean flies are tiny (about 2mm long) flies, shiny black-bluish in colour. They can cause serious stand reductions at the seedling stage. Bean flies lay eggs in punctures of leaves near the petiole. The small white maggots feed inside the main stem just above the soil line. Pupation occurs inside the stem. The life cycle may be completed rapidly, often in less than 2 weeks.

Seedlings attacked by beanflies may wilt or die. Leaves of older plants may be yellow and stunted. Stems are thicker than normal and cracked lengthwise just above the soil. Maggot feeding facilitates the entry of

disease-causing microorganisms leading to secondary infections. In cases of heavy infestation, many plants die. Bean flies are important only during the seedling stage (up to 4 weeks after germination).

What to do:

- **Plant early in the season. Bean fly numbers tend to be low during the early stages of the growing season and increase with time.**
- **Plant after green manure crop**
- **Avoid planting near cowpea, beans and other leguminous crops, that may be the source of bean flies. Practice crop rotation with non-legumes such cereals.**
- **Mulch with rice straw. The mulch covers the seed leaves (cotyledons) making them inaccessible for egg laying.**
- **Ridging the plants 2-3 weeks after germination helps to cover the adventitious roots produced by plants damaged by beanflies (these roots grow directly from stems and/or leaves). The soil support prevents lodging and improves the survival of the damaged plants.**
- **If necessary, spray neem extracts. Frequent foliar applications of neem extract give satisfactory control of bean flies.**
- **Remove and destroy crop residues and all plant parts with symptoms of damage by bean flies.**

bean stem

© A.M. Varela, icipe

Bean fly

Bean fly

Aphids

Aphids, mainly the legume aphid (*Aphis craccivora*) (also called groundnut aphids) are relative small aphids. Immatures are slightly dusted with wax, adults without wax. Apterae are 1.4 to

2.2 mm long. Alatae (winged form) 1.4 to 2.1 mm. They feed on young plants, leaflets, stem and pods of green gram. Attacked young leaves become twisted. Excretion of honeydew leads to growth of sooty mold. Aphids are also vectors of virus diseases.

What to do:

- **Plant early**
- **Cultivate clean**
- **Avoid excess use of nitrogen**
- **Conserve natural enemies**

Black legume aphid
The black legume aphid (*A. craccivora*) is a relatively small aphid. Immatures are slightly dusted with wax. Adult size 1.4-2.2 mm long.

More Information on Aphids

Foliage beetles (*Ootheca* spp.)

Foliage beetles have been reported as pests of green grams in West Africa. They are a threat, when present in large numbers since they can defoliate young plants. They are 4-7mm long.

What to do:

- **Practice post harvest tillage to expose the grubs in the soil to the sun heat and to predators.**
- **Rotate beans with non-host plants such as maize or sunflower to break the development cycle of the pest.**
- **Delay sowing, where practicable, to allow the crop to escape from high populations.**
- **Apply neem; it has been shown to reduce flea beetle numbers and damage.**

Foliage beetle
Foliage beetle feeding on pumpkin leaf, the adult is 4-7mm long

© A.M. Varela, icipe


Foliage be... **Foliage be...**

Pod-borers (African bollworm, Legume pod-borer, lima pod borer)

Pod borers such as the African bollworm (*Helicoverpa armiguera*), the legume pod borer (*Maruca vitrata*), and the lima bean pod borer (*Etiella zinckenella*) can cause serious economic damage. Young caterpillars of the African bollworm feed on leaves by scraping tissue for short time, and then bore into the

pods and feed on the seeds with their heads thrust inside and most part of the body outside. The entry hole is large and circular. They also cause significant damage to flower buds and flowers.

Caterpillars of the legume pod borer (*Maruca vitrata*) are dull to yellow-white and often reach a length of 18 mm. Each segment has dark spots that form a distinct series along the length of the body. The head is dark brown to black. Caterpillars web together leaves, buds and pods and feed inside the web. Flowers attacked may be discoloured and have damaged or missing reproductive parts. Damage by this caterpillar also results in flower bud shedding and reduced pod production. Damaged pods have small, darkened entry holes on the surface.

Young caterpillars of the lima bean pod borer are green, later turning red. They feed inside the pod reaching a length of 14 mm. They are generally found in maturing and dried pods. Faeces in the form of granules are found inside the damaging pods. Once the caterpillars have entered the pods they are difficult to control and by then they have caused damage

What to do:

- **Monitor the crops frequently as there is only a brief period from hatching to entering buds or pods**
- **Hand pick and destroy eggs and caterpillars. This helps when their numbers are low and in small fields.**
- **Biopesticides such as Bt or neem products usually give good**

Legume pod borer
Legume pod borer (*Maruca vitrata*) reach a length of 18 mm



Legum pod… **African bo…** **African bo…**

More Information on African bollworm

control of pod borers, provided they are applied to the young caterpillars before they enter into the pods. For more information on neem click here. For information on Bt click here

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Pod sucking bugs

Pod sucking bugs such as giant coreid bugs (*Anoplocnemis curvipes*), spiny brown bugs (*Clavigralla* spp.), green stink bugs (*Nezara viridula, Acrosternum acutum*), and Riptortus bugs (*Riptortus* spp) are the most important pests of green gram at the podding stage.

They suck sap from pods and seeds and cause various levels of damage depending on the stage of growth of seeds at the time of attack. Feeding may cause necrosis, pod malformation, premature drying, shrivelling of seeds, loss of germination ability, and formation of empty pods. Bugs are difficult to control since they usually feed on a wide range of crops and are very mobile.

Spiny brown bugs
Spiny brown bugs (*Clavigralla* spp.) measure about 1cm in length.

© A.M. Varela, icipe


Spiny brow...


Tip wilter


Green stin...


Riptort ...

What to do:

- **Bugs can be collected by hand regularly and killed, especially during flowering and pod formation.**
- **Conserve natural enemies such as assassin bugs, spiders, praying mantises and ants. These are important natural enemies of bugs. They kill or deter bugs. Conserve and attract predatory natural enemies to your crop by planting flowering plants. For more information on natural enemies click here**

Flower thrips (*Megalurothrips sjostedti*)

It may feed on petioles and leaves, but prefer flowers. Attacked petioles and leaves have tiny holes surrounded by discoloured areas. Affected flowers are brown, dried, or completely distorted. The flowers drop prematurely. Thrips also feed on pollen leading to decrease in pollination and seed set. Pod production is low and pods are deformed.

What to do:

- **Plough and harrow before planting. It can reduce subsequent thrips attacks by killing pupae in the soil.**
- **Conserve natural enemies. Natural enemies, particularly, predators are important in natural control of thrips. Main natural enemies include predatory bugs (Orius spp. and Anthocoris spp.) and predatory thrips.**
- **Spray with biopesticides (e.g. Spinosad), if infestation is severe.**

Thrips
Thrips (*Megalurothrips sjostedti* (black) and *Frankliniella occidentalis* (yellow). Real size (0.9 to 1.1 mm)

© GTZ-IPM Horticulture, Kenya


Thrips Thrips

More Information on Thrips

The cowpea weevil (*Callosobruchus maculatus*)

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, green gram and lentils). They attack both pods in the field and seeds in storage. They attack nearly mature and dried pods. Infested stored seeds can be recognised by the round exit holes and the white eggs on the seed surface. Post-harvest losses are highly variable, but losses can be over 90%.

It is a serious storage insect, which can destroy whole seed-lots.

What to do:

- **Dry grains to moisture level below 13%**
- **Store grains in dry, well ventilated areas**

Cowpea seed weevil
The cowpea weevil *Callosobruchus maculatus* on cowpea (*Vigna unguiculata*) seeds. Adults are 2 to 3.5 mm long

© Peter Credland. Reproduced from the Crop Protection Compendium, 2006 Edition.


Cowpe see... **Pupa of th...**

More Information on Cowpea seed beetle

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- **AIC (2002). Field Crops Technical Handbook.**
- **Adamu, R. S., Dike, M. C., Akpa, A. D. (2001). Insect fauna associated with greengram (*Vigna radiata* (L.) Wilc.) in the Northern Guinea Savanna of Nigeria. Journal of Sustainable Agriculture and the Environment, (Vol. 3) (No. 2) 331-336.**
- **CAB International (2005). Crop Protection Compendium, 2005 edition. Wallingford, UK www.cabi.org**
- **From ECHO's seedbank. Green Gram or Mung Bean (*Vigna radiata*). By Bob Hargrave, ECHO Staff. http://food-security.info**
- **Insect Pest Management in Moong. Integrated Pest Management. http://www.jnkvv.nic.in/**
- **JNKVV, Madhya Pradesh, India: Diseases of green grams. http://www.jnkvv.nic.in/**
- **Kenya Agricultural Research Institute. KARI. Improved Green Gram Production. http://www.kari.org**
- **Lost Crops of Africa: Volume II: Vegetables (2006) Development, Security, and Cooperation (DSC). Online read-only: The National Academy Press: www.nap.edu**
- **Post harvest profile of green gram. Government of India, Ministry of Agriculture (Department of Agriculture and Cooperation) Directorate of Marketing and inspection. Branch Head Office. Nagpur - 440001. MRPC-76. http://agmarknet.nic.in/**
- **Publications and Fact Sheets on Mungbean. AVRDC Extension Materials. http://www.avrdc.org**

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Contact links

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Email: meruherbs@meruherbs.com
Website: www.meruherbs.com
Products: Organic produced chamomile, hibiscus, and fruits (bananas & mango).

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Maize
Scientific name: *Zea mays*
Order/Family: Cyperales: Poaceae (Graminae)
Local names: Mahindi (Kenya, Tanzania); mbembe (Kenya)
Pests and Diseases: African armyworm African bollworm African maize stalkborer Angumois grain moth Aphids Common rust Common smut Couch grass Cutworms Ear rots Grasshoppers Grey leaf spot Head smut Larger grain borer Maize ladybird beetle Maize leafhoppers Maize plant hopper

Brassicas
Carrot
Cashew
Cassava
Citrus plants
Cocoa
Coconut
Coffee
Cotton
Cowpea
Cucumber
Eggplant
Green gram
Groundnut
Maize
Mango
Millet
Okra
Onion
Papaya
Passion fruit
Peas
Peppers
Pigeon pea
Pineapple
Potato

Maize streak virus Northern leaf blight Purple witchweed Satintail
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General Information and Agronomic Aspects

Geographical Distribution of Maize in Africa

Maize is the most important cereal crop in sub-Saharan Africa. It is a staple food for an estimated 50% of the population. It is an important source of carbohydrate, protein, iron, vitamin B, and minerals. Africans consume maize in a wide variety of ways (porridges, pastes and beer). Green maize, fresh on the cob, is eaten baked, roasted or boiled. Every part of the maize plant has economic value: the grain, leaves, stalk, tassel, and cob can all be used to produce a large variety of food and non-food products. In sub-Saharan Africa maize is mostly grown by small-scale farmers, generally for subsistence as part of mixed agricultural systems. The systems often lack inputs such as fertilizer, improved seed, irrigation, and labour. According to FAO data, Africa produced 7% of the 598 million tonnes produced worldwide in 138 million hectares in 2000 (IITA).

Maize is also an important livestock feed both as silage and as crop residue, grain and is also used industrially for starch and oil extraction.

- Pumpkin
- Rice
- Sesame
- Sorghum
- Soybean
- Spider plant
- Spinach
- Sugarcane
- Sweet potato
- Tea
- Teff
- Tomato
- Wheat
- Yam
- Zucchini/Courgette

- Pests/ diseases/ weeds
- Medicinal plants
- Fruit and vegetable processing
- Natural pest control

Climate conditions, soil and water management

Maize is a versatile crop, growing across a range of agroecological zones. With its large number of varieties differing in period to maturity, maize has a wide range of tolerance to temperature conditions. It is essentially a crop of warm regions where moisture is adequate. The crop requires an average daily temperature of at least 20°C for adequate growth and development. Optimum temperature for good yields is around 30°C. The time of flowering is influenced by photoperiod and temperature. Maize is considered to be a quantitative short-day plant (short days can induce premature flowering). It is grown mainly from 50°N to 40°S and from sea level up to about 3000 m altitude at the equator. At higher latitudes, up to 58°N, it can be grown for silage.

Maize is especially sensitive to moisture stress around the time of tasselling and cob formation. It also needs optimum moisture conditions at the time of planting. In the tropics it does best with 600-900 mm of rain during the growing season. Maize can be grown on many soiltypes, but performs best on well-drained, well-aerated, deep soils containing adequate organic matter and well supplied with available nutrients. The high yield of maize is a heavy drain on soil nutrients. Maize is often used as a pioneer crop, because of the high physical and chemical demands it makes of the soil. Maize can be grown on soils with a pH from 5-8, but 5.5-7 is optimal. It belongs to the group of crops that is considered to be sensitive to salinity. Since a young crop leaves much of the ground uncovered, soil erosion and water losses can be severe and attention should be paid to adequate soil and water conservation measures.

- **Local seed. Low to medium yields, usually well sheathed and so more resistant to weevil attack in storage, possibly more palatable to local tastes. Example: Kikuyu maize. Exotic varieties of maize can be collected to add genetic diversity when selectively breeding new domestic strains.**
- **Hybrids. High yielding but also requiring large amounts of fertiliser. Seed from hybrids**

Cultural practices

cannot be saved for planting so new hybrid seed is required each year.

- **Composite (e.g. "Katumani", "Coast Composite"). These are stabilised varieties and new seed is not required each year. If proper selection procedures are followed, farmers can use their seeds selected from their harvest.**

Maize growing zones in Kenya and recommended varieties

Ecozone and main areas where found	Recommended varieties	Maturity (Months)	Yield potential (Bags/acre)	Resistance
Highland zones with high rainfall: Altitude: 1500-2100 m above sea level Areas: Trans Nzoia, Uasin Gishu, Nakuru, Kericho, Nandi, Bungoma, Laikipia, Kisii, Narok, and Tea zones of Central and Eastern Province	"H 627" "H626" "H 625" "H 614 D" ---------- "H 6213" "H 6210"	6-8 6-8 6-8 6-8 ---------- 6-8	42 38 34 32 ---------- 52 50	---------- ------- Rust, grey leaf
West Pokot, Nyeri, Lower Nyandarua and upper Kiambu	"KH600-14E" "KH600-15A"	5-6	34-38	spot, stem and leaf blight As above No

				resistance reported
Highland zones, high rainfall Altitude: 1000-1700 m above sea level Areas: Baringo, Siaya, Kisumu, Busia, Bungoma, Kakamega, Nakuru, South Nyanza, Taita Taveta	"H 632" "H 622"	6-8 6-8	24 22	
Coffee zone medium long growing Season Altitude: 1000-1800 m above sea level Areas: Coffee zones of Central and Eastern Provinces, Kisii, Narok, Nakuru, Siaya, Kisumu, Busia, Kakamega, Bungoma, West Pokot, Keiyo, Marakwet	"H 513" "pH B 3253" "H512" "H511" "CG 4141" "CG 5222" "H 516"	4-5 4-5 4-5 4-5 4-5 4-5 3-4	20 20 18 16 18 18 28	Ear rot, rust, GLS, stem and leaf blight
Dryland Areas: Marginal areas with low rainfall (400-800 mm) Altitude: 1000-1800 m above sea level Areas: Kitui, Machachos, West Pokot, Makueni, Kajiado, Isiolo, Lower Meru and Embu, Siaya, Kisumu Altitude: 800-1200 m above sea level: Drier areas, same as for Katumani composite	"Katumani Composite" "DH 01" "DH02" "Makueni"	3-4 3-4 3-4 3-4	12 14 14 11	

Lowland Zones: Hot humid **Altitude: 1-1200 m above sea level**	**"pH4"** **"Pwani Hybrid 1"** **"Coast Composite"**	**3-4** **3-4** **4-5**	**18** **16** **14**	

AIC 2002 and The Organic Farmer Feb 2007

Propagation and planting

Maize is nearly always planted through direct seeding. Maize should preferably be sown early in the season, as soon as soil conditions and temperature are favourable. Delayed planting always leads to reduced yields. In Kenya there is a drop of expected yields of 1-2% every day planting is delayed (AIC 2002). Hand planting requires 5-10 man-days/ha. Seed is dropped in the plough furrow or in holes made with a planting stick. Planting may be done on hills or in rows, on flat land or on ridges. On heavy soils ridging is advisable, to improve drainage.
For pure stand of maize in Kenya the Ministry of Agriculture recommends spacing between rows of 75 cm and between seeds 30 cm for all areas with adequate rainfall, resulting in a total plant population of 44,000. In the coffee zones this can be increased to 75cm x 25 giving total plant population of 53,000 plants/ha. In dry or marginal areas the recommendation is to increase spacing to 90 cm between rows and 30 cm between seeds - total population 37,000 plants /ha. Approximate seed rate is 25kg/ha.The depth of planting is commonly 3-6 cm, depending on soil conditions and temperature. Deep sowing is recommended on light, dry soils. Animal manure or fertilizers are applied at the time of planting.

Weed control
Adequate weed control is very important. Maize is very sensitive to weed competition during the

first 4-6 weeks after emergence. It should be planted as soon as possible after the preparation of the seedbed. Inter-row cultivation to control weeds and to break up a crusted soil surface may be done until the plants reach a height of about one m. In Kenya two weedings are necessary for most maize varieties, though a third weeding may be necessary for varieties that need 6 to 8 months. Weeding by hand requires a minimum of 25 man-days/ha.

Water management
Irrigation is used in areas of low rainfall and is particularly valuable at the time of tasselling and fertilization.

Fertilization
Maize usually responds well to fertilisers, provided other growth factors are adequate. The quantity of manure applied by smallholders is usually very limited. Improved varieties can only reach their high yield potential when supplied with sufficient nutrients. A maize crop of two t/ha grains and five t/ha stover removes about 60 kg N, 10 kg P_2O_5 and 70 kg K_2O from the soil. Nitrogen uptake is slow during the first month after planting, but increases to a maximum during ear formation and tasselling. Maize has a high demand for nitrogen, which is often the limiting nutrient. High nitrogen levels should be applied in three doses, the first at planting, the second when the crop is about 50 cm tall, and the third at silking.

Many soils provide substantial amounts of the phosphorus (P_2O_5) and potassium (K_2O) but this is not adequate enough, especially at the seedling stage. Apply P_2O_5 near the seed for early seedling vigour. K_2O is taken up in large quantities but plants' requirement can usually be estimated by soil analysis. K_2O deficiency results in leaves with burnt edges and yellow or light green colour and empty cob ends, while P_2O_5 deficiency results in purple tinged leaves and hollow grains. Nitrogen deficiency shows as yellow or light green stunted plants.
Phosphate is not taken up easily by maize and, moreover, some tropical soils are deficient in available phosphate. It is advisable to apply organic manures to improve soil structure and supply nutrients, all before ploughing.

Nitrogen (N) can be applied in organic farming via green manure (legumes fixing N directly from the atmosphere), farmyard manure (FYM) or compost. Phosphorus can be supplied through FYM, compost, and in the form of Rock Phosphate (available in East Africa as Mijingu Rock Phosphate). Rock Phosphate should be applied in the rows or planting holes at planting to promote root formation., Potassium can be supplied through FYM, compost and ashes. However, fertiliser recommendations based on soil analysis provide the very best chance of getting the right amount of fertiliser without over or under fertilising. Ask for assistance from a local agriculturist office.

In rainfed maize growing areas, plant seeds along with the first rain. This will allow roots to absorb the natural nitrates formed with bacterial action in the soil. Roots are susceptible to poor drainage, which cause stunted and yellowing of leaves. Stagnant water results to loss in N through leaching and denitrification (FADINAP, 2000).
For more information on organic plant nutrition click here.

Intercropping
In Africa maize does well when intercropped with beans or other legumes. The intercropped legumes should be sown at the time of first weeding in order not to crowd out the young maize plants. As maize is a heavy feeder and takes considerable nutrients out of the soil, maize can only be grown continuously on the richest soils or when heavily fertilized. Recommended legumes for intercropping in Kenya are beans, pigeon peas, cowpeas, groundnuts and soybeans. Other crops that have been tried with varying success include potatoes, cassava and pumpkin.

Intercropping maize with beans and other legumes regulates pests (leafhopper, leaf beetles, stalk borer, and fall armyworm) and increases the land utility. Intercropping Canavalia (*Canavalia* spp.) with maize improves soil productivity. Sow Canavalia seeds four weeks after sowing maize. Place one seed/hole in a row between maize rows with 50 cm between holes.

Allow Canavalia to grow after harvesting maize until it is time to plant the next crop. Then plough the plant materials into the soil (CIAT, 2000).

Intercropping maize with beans and squash enhances parasitism of caterpillars. This practice increases food sources for beneficial insects whereby increasing abundance of natural enemies. The intercropping system of maize-beans-squash is a low input and high yield strategy in the tropics. Maize yield is increased by as much as 50% over monoculture yield. Although the yields for beans and squash are reduced, the overall yield for the three combined crops is greater than when grown separately in monocultures (Agroecology Research Group, 1996).

Push-pull
Desmodium (*Desmodium uncinatum*) and molasses grass (*Melinis minutifolia*) when planted in between maize rows keep the stem borer moths away. These plants produce chemicals that repel stem borer moths. In addition Desmodium supresses the parasitic witchweed *Striga hermonthica*. Napier grass (*Pennisetum purpureum*) and Sudan grass (*Sorghum vulgare sudanese*) are good trap crops for stem borers. Napier grass has its own defence mechanism against crop borers by producing a gum-like-substance inside its stem, this prevents larva from feeding and causing damage to the plant. Both grasses attract stemborer predators such as ants, earwigs, and spiders. Sudan grass also increases the efficiency of natural enemies, in particular parasitic wasps, when planted as border crops (Herren; Pickett, 2000; ICIPE, 2006). For more information on push-pull click here

Alternative uses of maize in mixed cropping

- **Shading of vegetable crops by planting single rows between vegetables in areas of high intensity of sunshine can increase yields of intercropped vegetables.**
- **Use as support for runner beans for export or local consumption.**

Harvesting

Maize can be harvested by hand or by special maize combine harvesters. The stage of maturity can be recognized by yellowing of the leaves, yellow dry papery husks, and hard grains with a glossy surface. Maize is often left in the field until the moisture content of the grain has fallen to 15-20%, though this can lead to attack by grain borers in the covered cobs. In hand harvesting the cobs should be broken off with as little attached stalk as possible. They may be harvested with the husks still attached. These may be turned back and the cobs tied together and hung up to dry.

Yield

The world average yield in 2000 was 4255 kg per hectare. Average yield in the USA was 8600 kg per hectare, while in sub-Saharan Africa it was 1316 kg per hectare. Average yields in Kenya 2001-2005 ranged from 15-19 bags/ha (1350-1750 kg/ha) (Economic Review of Agriculture 2006).

Handling after harvest

The major problems in most maize-producing areas are reducing the moisture content of the grain to below 13%, protection from insects and rodents, and proper storage after harvest. High moisture content with high temperatures can cause considerable damage such as development of aflatoxin producing fungi, making the product unsuitable for human consumption.
Maize for home consumption is either sun-dried on the cob for several days by hanging up tied husks, or put in a well-ventilated store or crib. Easy test for moisture content: take a few grains and try to crush them with your teeth - below 13% moisture the grains are extremely hard and almost impossible to crush this way. Shelling (the removal of grains from the cob) is usually carried out by hand, though several hand and pedal-powered mechanical shellers are now available. The average recovery is about 75%. The shelled grain is dried again for a few days and then stored in bags, tins or baskets.
The optimum moisture content for storage is 12-13%, but often it is not below 18%. In Indonesia

seed for the next crop is generally selected from the last harvest. The selected cobs are stored at home in the husk above the fireplace to prevent losses by insects. Crop residues are removed from the field and then used as fodder, fuel, etc.

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Information on Pests

General information

Infestation and damage by pests have been ranked as the third most important constraint upon maize production in semi-arid eastern Kenya after moisture stress and poor soil fertility (Songa et al., 2002).

Stemborers and striga weed account for losses in maize in the eastern and southern Africa region of 15-40% and 20-100% respectively. When they occur together, farmers can lose their entire crop (ICIPE, 2006). Earworms and armyworms are other major pests.

The principal pests of stored maize are Angoumois grain moth (*Sitotroga cerealella*), the Larger grain borer (*Prostephanus truncatus*), maize weevils and rodents.

Examples of Maize Pests and Organic Control Methods

Cutworms (*Agrotis* spp. and other species)

Cutworms cut maize seedlings at or a little below ground level, make small holes along the initial leaves, or remove sections from the leaf margins.

What to do:

- **Eliminate weeds early, at least 2 weeks before transplanting.**
- **Plough and harrow the field prior to transplanting. This exposes cutworms to natural enemies and desiccation and helps destroy plant residue that could harbour cutworms.**
- **Make barriers to protect the transplanted seedlings. Barriers can be made by wrapping paper, aluminium foil, thin cardboard or similar materials around the base of transplant stems. Toilet rolls are handy as cutworm collars since they are readily available and will biodegrade into the soil .**
- **Dig near damaged seedlings and destroy cutworms.**
- **Conserve natural enemies. Parasitic wasps and ants are important in natural control of cutworms.**

Cutworms
Cutworm (*Agrotis* spp.

More Information on Cutworms

The maize aphid or corn leaf aphid (*Rhopalosiphum maidis*)

It is dark green to bluish-green in colour with black cornicles. Particularly during dry/periods the colonies appear on the inflorescences and young leaves. Feeding by this aphid causes yellow mottling, but this damage is seldom of economic importance. Their role as vector of the sugarcane virus, maize dwarf mosaic virus and maize leaf-fleck virus makes a pest of considerable importance. This aphid usually attack maize plants

Maize aphid

at the end of the mid-whorl stage. Aphid colonies may completely cover emerging tassels, and the surrounding leaves, preventing pollen release. In severe outbreaks the ear shoot is also infested, and seed set may be affected.

What to do:

- **Conserve natural enemies. Aphids have a wide range of natural enemies, which normally keep them under control.**

The maize aphid *Rhopalosiphum maidis*. Colony on leaf of maize

© www.inra.fr


Maize aphi...


Aphids


Maize aphi...

More Information on Aphids

Termites (*Microtermes* spp., *Macrotermes* spp., *Allodontermes* spp., and *Odontotermes* spp)

Often referred to as "white ants", they occasionally cause partial or total defoliation of maize seedlings, but are mainly damaging to older maize plants. Severely damaged plants may lodge and be completely destroyed by termites. The longer a field has been cultivated, the greater will be the yield losses caused by termites. Their feeding inside the stems causes the plant to wither and sometimes die. Termites begin to attack the roots and stems about three months after planting, and eventually cover them with tunnels built of soil. As plants mature the amount of damage increases rapidly. Infestation is particularly serious in dry season. It has been established that termites can damage up to 25% of maize crops in Malawi (WISARD Project Information,

Termites
Termites (*Coptotermes formosanus*)

© Scott Bauer, USDA Agricultural Research Service, Bugwood.org

2001).

More Information on Termites

What to do:

- **Promote conditions for healthy plant growing to prevent termite damage.**
- **Plough field to destroy the termites' nest, runways, and tunnels and to expose them to predators, such as ants, birds, chicken, etc.**
- **Practice crop rotation to reduce the build-up of termites.**
- **Remove plant residues and other debris especially moist and decaying woods.**
- **Harvest at the right time, as termites often attack maize left in the field after maturity. 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.**

Grasshoppers and locusts

Several species of grasshoppers and locust feed on maize. The edible grasshopper *Homorocoryphus nitidulus vicinus* (*Ruspolia differens*), a long horned grasshopper has been reported to occasionally attack maize in Tanzania (Bohlen, 1973). This grasshopper attacks maize in the silking stage, arresting pollination. Other grasshoppers and locust attack maize from the mid-whorl stage to maturity, and may consume every part of the plants. Attacks vary in severity from location to location.

Grasshopper *Ruspolia nitidula* in Uganda

What to do:

© Kurt Kulac

- **Conserve natural enemies. Avoid destroying larvae of blister beetles, since they feed on eggs of grasshoppers. Other natural enemies include ants, parasitic flies, assassin bugs, predatory wasps, birds, lizards, snakes, frogs, and fungi. Robber flies are a major predator of grasshoppers.**
- **Domesticated poultry (e.g. chickens, turkeys, guinea fowl, geese, and ducks) and wild birds are good for keeping grasshopper populations in check. However, birds may damage the plants too. To avoid this enclose the birds in wire fencing along the perimeter so that they can prey on visiting grasshoppers while staying out of the crop.**
- **Ensure the ground is covered with crops, grass or mulch. This is reported to reduce grasshopper numbers since they prefer laying eggs on bare soil.**
- **Catch grasshoppers by hand or with a butterfly net. Catching them in the early morning is easier, as they are less active in the mornings.**
- **Digg or cultivate the land before planting to expose the eggs to predators and to to the weather.**
- **Whenever necessary spray biopesticides. Neem extracts act as antifeedant (grasshoppers stop feeding when exposed to neem products) and affect development of grasshoppers. For more information on neem for control of grasshoppers link to section of grasshoppers in cassava datasheet. IITA (the International Institute of Tropical Agriculture) researchers and partners have developed an environmentalfriendly biopesticide "Green Muscle" based on a naturally occurring**

fungus strain indigenous to Africa (Metarhizium anisopliae). This fungus is deadly to locusts and grasshoppers but reportedly does not damage other insects, plants, animals, or people. Typically 70 to 100 percent mortality rates were obtained after 8 to 28 days of application. (www.iita.org)

The larger grain borer (*Prostephanus truncatus*) and the grain weevils (*Sitophylus* spp.)

They attack stored maize grains. Both the adults and the larvae (grubs) of these beetles feed in the grains. Adults come from infested cobs in the field or from an infested maize store and lay eggs in the grains. They attack maize both in the field and after harvest. Attacked maize grains lose all their contents and are not fit to eat. These pests become a serious problem in short time if not control measures are applied. The larger grain borer also attacks dried cassava roots and even the wooden structures of the stores.

What to do:

- **Conserve natural enemies. An imported predatory beetle Teretrius (formerly Teretriosoma) nigrensis has been released in several African countries in an attempt to control the larger grain borer.**

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


Larger **Maize**

gra... weev...

More Information on Larger grain borer

The Angoumois grain moth (*Sitotroga cerealella*)

Angumois grain moth
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 larvae of the Angoumois grain moth penetrate and feed inside maize grain. This insect may also infest the crop in the field prior to harvest. The moths are small (nearly 1 cm long) yellowish or straw-coloured, a have a fringe along the posterior margins of the wings. They can be observed flying around infested stores.
Female moths lay eggs at night. Eggs are laid singly or 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 whitish. The larvae prepare a round exit hole for the moth, leaving the outer seed wall only partially cut as a flap over the hole, resembling a trap door. The adult pushes its way out through this "window" leaving the trap door hinged to the grain. Infested grains can be recognised by the presence of these small windows. The adult lifespan may be up to 15 days, and one female can lay over 100 eggs.

What to do:

- **Practice store hygiene. All residual pockets of infestation should be cleaned out at the end of the storage season. This**

is important to minimise re-infestation of the new crop.

- **Store old and new lots separately**
- **Do not leave maize in the field after drying, this increases the chances of infestation**
- **Whenever possible separate stores from fields. The grain moths are good flyers and adults from infested stores often infest growing maize in the field.**
- **Keep the temperature and humidity as low as possible. There are indications that storing grain in a dry place can reduce infestation.**
- **Prevent pest entry by sealing the store (windows, doors, ventilation facilities) with insect-proof gauze. Hermetic storage at low humidity gives good levels of control. In Malawi, plastering stores with mud to reduce water uptake was found to be effective (Golob and Muwalo, 1984, in CABI, 2000).**
- **Periodically inspect and remove any infestated maize.**

Spider mites

They can damage maize from the seedling stage to maturity. The presence of small, faint yellow blotches on the lower leaves is an indication of spider mite injury. As the colonies of mites increase in size they cause the lower leaves to become dry. The mites then migrate to the upper leaves. In Africa several species of spider mites have been reported on maize (mainly *Tetranychus* spp. and *Olygonichus* spp.). In Kenya, they are occasionally found on maize, but usually they are not of economic importance.

Spider mites
Two-spotted spider mite (*Tetranychus urticae*). The adult female is 0.6 mm long.

What to do:

- **Provide good growing conditions for the crop.**
- **Conserve natural enemies. Predatory mites and anthocorid bugs usually control spider mites.**

The male is smaller.

© Image supplied by Warwick HRI, University of Warwick

More Information on Spider mites

White grubs

White grubs are the larvae of scarab "chafer" beetles. They are white, C-shaped with a brown head and three pair of legs. Some species of whitegrubs (e.g. *Phyllophaga* spp, *Heteronychus* spp.) feed on roots of maize plants. Root damage is manifested by wilting seedlings, poor stands, and patches of tilted or lodged plants showing uneven growth. Injured plants can easily be pulled out of the ground.

Feeding of adults on maize leaves is usually not of economic importance. However, adults of the black maize beetles (*Heteronychus* spp.) are reported as major pests of cereals in many parts of Africa. They eat the stems of young shoots just below the ground. One adult beetle may destroy several seedlings in a row.

Whitegrub
Chafer grub on French bean plant

© A.M. Varela, icipe

What to do:

- **Remove old plants and weeds before planting**

- **Plough and harrow the field to expose eggs and grubs to predators (e.g. ants and birds) and to desiccation by the sun. Once exposed, they can also be picked by hand. This is feasible in small plots.**
- **Provide conditions for growing healthy plants. They can tolerate grub feeding without serious damage.**
- **Ensure proper drainage. Grubs love moist soil, especially with decaying organic matter. Female beetles prefer to lay eggs on moist-decaying organic matter.**
- **Avoid planting maize immediately after old pasture in areas where grubs are frequently seen.**
- **Practice crop rotation. In particular, in fields where whitegrubs are common**
- **Use trap crops and / or repellent plants. Good trap crops are African marigold, sunflower, and castor. Repellents plants are chives, garlic, tansy, and catnip. The crops trap and repel adult beetles from attacking the main crop grown (Golden Harvest Organics, 2003).**

Stemborers: African maize stalkborer (*Busseola fusca*)

Stemborers are the most important insect pests of maize in sub-Saharan Africa. Yield losses vary between 10-70%. Several species have been reported. The importance of a species varies between regions, within a country or even the same eco-region of neighbouring countries. At least four species attack maize in eastern and southern Africa, with yield losses reported to vary from 20 to 40%, depending on agroecological conditions, crop cultivars, agronomic practices and intensity of infestation.

African maize stalkborer
African maize stalkborer

The most important are the African maize stalkborer (*Busseola fusca*) and the spotted stemborer (*Chilo partellus*) (see also below).

The pink stalkborer (*Sesamia calamistis*) and the sugarcane stalkborer (*Eldana saccharina*) are of minor importance in maize.

Early warning signs: Young plants have pinholes in straight lines across the newest leaves. This is the time to treat - before the caterpillars move on into the stem.

What to do:

- **Conserve natural enemies. Parasitic wasps and and predatory ants are important in natural control of stemborers.**
- **Destroy crop residues to kill pupae left in old stems and stubble and prevent carry-over populations. This helps in limiting initial establishment of stemborers on the following season's crops.**
- **Intercrop maize with crops that are non-hosts for stemborers (e.g. cassava and grain legumes).**
- **Intercrop maize with a repellent plant such as desmodium and plant an attractive trap plant, such as Napier grass, as a border crop around this intercrop to protect maize from stemborers. This technology is known as "push-pull". For more information on push-pull click here**
- **Use neem products. Simple neem products are reported to be effective for control of stemborers. Place a small amount of**

(*Busseola fusca*) damage on maize. Caterpillars are relatively featureless and noctuid, growing to a length of up to 4 cm. They lack conspicuous hairs or markings and look smooth and shiny. Colour is variable but usually creamy-white

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



African ma... African ma... Sugarc ...

More Information on African maize stalkborer

neem powder (ground neem seeds) mixed with dry clay or sawdust at a rate of 1:1 in the funnel of the plant. One kg powder should be sufficient to treat 1500 to 2000 plants. Rainwater dissolves the active substances in neem powder as it gathers in the funnel and washes out the powder. Where rainfall is irregular a liquid neem seed extract can be sprayed into the funnel.

Stemborers: Spotted stemborer (*Chilo partellus*)

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The most important are the African maize stalkborer (*Busseola fusca*) (see above) and the spotted stemborer (*Chilo partellus*). The pink stalkborer (*Sesamia calamistis*) and the sugarcane stalkborer (*Eldana saccharina*) are of minor importance in maize.

Early warning signs: Young plants have pinholes in straight lines across the newest leaves. This is the time to treat - before the caterpillars move on into the stem.

Spotted stemborer Caterpillar of the spotted stemborer (*Chilo partellus*) is about 2.5cm long

© Stemborer team, icipe



Spotte st... **Spotte st...** **Spotte st...**

What to do:

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- **Destroy crop residues to kill pupae left in old stems and stubble and prevent carry-over populations. This helps in limiting initial establishment of stemborers on the following season's crops.**
- **Intercrop maize with crops that are non-hosts for stemborers (e.g. cassava and grain legumes)**
- **Intercrop maize with a repellent plant such as desmodium and plant an attractive trap plant, such as Napier grass, as a border crop around this intercrop to protect maize from stemborers. This technology is known as "push-pull". For more information on push-pull click here**
- **Use neem products. Simple neem products are reported to be effective for control of stemborers. Place a small amount of neem powder (ground neem seeds) mixed with dry clay or sawdust at a rate of 1:1 in the funnel of the plant. One kg powder should be sufficient to treat 1500 to 2000 plants. Rainwater dissolves the active substances in neem powder as it gathers in the funnel and washes out the powder. Where rainfall is irregular a liquid neem seed extract can be sprayed into the funnel.**

More Information on Spotted stemborer

African bollworm (*Helicoverpa armigera*)

Caterpillars of the African bollworm also known as the corn

worm or earworm attack mainly the developing cobs, although they may occasionally feed in the leaf whorl or on tender tassels. Eggs are laid on the silks. Caterpillars invade the cobs and feed on developing grain. Development of secondary infections is common. Local outbreaks of this pest are sometimes severe.

What to do:

- **Conserve natural enemies. Parasitic wasps, ants and predatory bugs are important in natural control of the African bollworm.**
- **Monitor the crop regularly**
- **Use bio-pesticides. Plant extracts (e.g. neem, garlic, chilli,) and Bt are reportedly effective against the African bollworms. However, timing of application is very important. Spraying when caterpillars are inside the cob would be ineffective. For more information on neem click here. For information on Bt click here**
- **Handpick and destroy pod borers. This helps when their numbers are low and in small fields.**

African bollworm
African bollworm (*Helicoverpa armigera*) on maize. Larvae and pupae on corn cob.

© Dr. Jan Breithaupt (Courtesy of EcoPort, www.ecoport.org)
More Information on African bollworm

The African armyworm (*Spodoptera exempta*)

The African armyworm is a very damaging pest, capable of destroying entire crops in a matter of weeks. Although they are regarded as occasional pests, in an outbreak large number of caterpillars will appear destroying the whole plant to ground level.

What to do:

- **Monitor regularly field margins, low areas where plants have lodged, beneath plant debris around the base of plants, on the ground, and underneath the plant leaves. Check daily young crops if conditions are known to be favourable to the pest.**
- **Spray Bt or botanicals such as neem and pyrethrum extracts. Spray when caterpillars are small. Once caterpillars are mature (about 3 to 3.5 cm long) they may have cause serious damage and it may no longer be economical to treat the crop. For more information on (neem click here, for pyrethrum click here and for Bt click here)**
- **Conserve and encourage natural enemies. For more information on natural enemies click here**
- **Practise field sanitation. For more information on field sanitation click here**

African armyworm
African armyworm (*Spodotera exempta*). Mature caterpillars measure up to 4 cm.

© University of Arkansas
More Information on African armyworm

The maize ladybird beetle (*Epilachna similes*)

The adult is oval in shape, about 6 mm in length and reddish brown in colour with black spots on the wing covers. The body is covered with short, light coloured hairs. The larvae are 7-9 mm in length, soft and covered with dark coloured spines. They pupate on leaves. Both larvae and adults of the maize ladybird beetle feed on leaves, scrapping them, usually on the underside, leaving the upper epidermis intact. This beetle will cause much damage only when present in large numbers. It also attacks cereals such

Maize ladybird beetle
Damage by plant-feeding l

as wheat and sorghum.
The maize ladybird beetle rarely causes serious defoliation and therefore control is usually not necessary.

What to do:

- **In case of severe attack spray neem products. Weekly applications of simple neem products have given control of Epilachna beetles in other crops such as cucurbits**

(*Epilachna similes*) on maize leaf. Note close-up of beetle (inset).

© A. M. Varela

The maize leafhoppers (*Cicadulina* spp.)

The adults are about 3 mm long, slender and cream to pale yellow green in colour. These leafhoppers have two small black spots between the eyes and brown marks behind the eyes extending along the body. They have brown lines along the wings. They usually hop away when disturbed. The direct damage cause by maize leafhoppers by sucking plants is insignificant, but the indirect damage is high because they transmit the maize streak virus, a major disease of maize. *Cicadulina mbila* is the most important vector.

Control of the maize leafhoppers is difficult since they are very active, remain infectious for a long time and are very quick in transmitting the virus. Measures that help to reduce leafhopper attack and virus infection include:

What to do:

Maize leafhopper
Streaked foliage damage caused by maize leafhopper (*Cicadulina mbila*)

© Agricultural Research Council of South Africa (Courtesy of EcoPort)

- **Plant maize well away from grassland or previously irrigated cereals; in particular, avoid planting downwind of such areas. The numbers of leafhoppers generally increase in irrigated cereals and grasslands, or in wild grasses during rainy seasons. Leafhoppers disperse away from these areas when dry.**
- **Plant early, and if possible planting in an area should be carried out at the same time. Staggered planting of crops will favour multiplication of leafhoppers and increase the risk of virus transmission to later plantings.**
- **Keep the fields free from weeds, in particular grasses.**
- **Leave a barrier of 10 m of bare ground between maize fields and previously infested crops. This is reported to reduce virus incidence, by restraining movement of leafhoppers.**
- **Remove residues of cereal crops since they serve as infection sources.**
- **Use resistant varieties where available.**

The maize plant hopper also known as corn lantern fly (*Peregrinus maidis*)

It is 4-5 m long and greyish in colour. The transparent wings are about twice as long as the body and show marked dark-brown veins. It is commonly found in groups in the funnel of the plants, the whorl, leaf sheath or underside of leaves. This insect produces large quantities of honeydew. As a result, sooty mould is often evident near the sites of aggregation. Nymphs and adults are in close association with ants, which feed on the honeydew produced by this plant hopper.
This plant hopper transmits the maize mosaic nucleorhabdovirus (MMV),

Maize plant hopper

maize stripe tenuivirus (MSpV), and maize line virus that can become a limiting factor in maize production.

What to do:

- **Practice crop rotation (alternate maize with cotton, root crops, and other non-graminae crops) to break the lifecycle of plant hoppers.**
- **Plough under or burn stubbles and plant debris right after harvest to kill remaining eggs, nymphs and adults.**
- **Avoid excessive N-fertiliser applications (N makes plant susceptible and attractive to maize plant hoppers).**
- **Keep planting distance wide enough for sunlight to penetrate (shady areas favour the maize plant leafhopper.**
- **Conserve natural enemies. Important plant hopper natural enemies are parasitic wasps (parasitise eggs and nymphs), mirid bug (prey on eggs), dragonflies and damselflies (prey on moving adults), spiders and earwigs (prey on nymphs and adults). Intercropping with legumes is recommended as harbourage of natural enemies, as soil conditioners, and for added income.**

Maize plant hopper (*Peregrinus maidis*)

© Jannette Mitchel, ARC Pretoria. Courtesy of www.ecoport.org

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Information on Diseases

Maize streak virus

The virus causes a white to yellowish streaking on the leaves.
The streaks are very narrow, more or less broken and run parallel

along the leaves.
The virus is transmitted by leafhoppers (*Cicadulina mbila* and *C. bipunctella zeae*). Maize streak virus is a serious constraint to maize production in sub-Saharan Africa. The reduction in yields depends on the time of infection. Plants infected at early stage usually do not produce any cobs. Yield losses in East Africa vary between 33 and 55% under natural infection conditions. In Nigeria, 75-100% of maize plants can be infected at the end of the growing season. However, resistant varieties in these areas appear to withstand these epidemics (Anon., 1983). Sugarcane, sorghum, millet, wheat, barley, oats, rye and wild grasses can also be severely affected.

Maize leaf streak virus

What to do:

- **Use of tolerant / resistant varieties / hybrids, if available**
- **Plant early in the season**
- **Eradicate grass weeds**
- **Control vectors**

Northern leaf blight (*Exserohilum turcicum (Helminthosporium turcicum / Dreschslera turcica / Trichometasphaeria turcica*))

Small oval (egg-shaped) spots first appear as water-soaked areas. They are dark and greyish-green in colour, turning greenish tan. With age they get bigger and become cigar-shaped. After rains or heavy dews, spores develop abundantly on both surfaces of the spots, particularly at the centres, giving a dark-green, velvety look

to the spots. The spots may join and form large areas, which may kill entire leaves. Heavily infected leaves appear dry as if affected by drought. The disease is favoured by heavy and frequent rains, high relative humidity (above 90%) and relatively low temperatures (20-25°C). Warm dry conditions check disease development.

What to do:

- **Use of tolerant / resistant varieties / hybrids, if available**
- **Practise good field sanitation. Remove or plough in crop residues after harvest.**
- **Practise crop rotation**

Northern leaf blight
Early development of light brown, elliptical lesions of Northern corn leaf blight (*Setosphaeria turcica*) on maize leaves.

© David C. Nowell, www.ecoport.org

Southern leaf blight (*Bipolaris maydis (Helminthosporium maydis / Cochliobolus heterostrophus)*)

Symptoms first appear as small yellow dots that become elongated between veins. They later become brownish to creamy white in colour with reddish to purplish brown borders. Light brown leaf spots with a brown margin, at first elliptical, becoming rectangular, up to 25 mm long and 2?6 mm wide. The spots are at first restricted by the leaf veins, but later they may merge. Leaves dry out and die prematurely.

Silks, portions of the husks and cobs may turn black. A black mould may develop on cobs. Disease development is promoted by prolonged wetness on foliage, extended dew, RH (97-100%) and relatively warm temperatures (24-35° C).

Southern leaf blight of maize
Southern leaf blight (*Cochliobolus heterostrophuson*) on maize

© LandCare Ltd., New

Zealand. Courtesy of www.ecoport.org

Spread is by airborne spores; and the fungus is also seedborne. Survival in soil occurs for up to 12 months.

What to do:

- **Use disease-free seed or treated seed (steam-air mixture at 53.9 - 55°C for 17 minutes or by treatment with fungicides)**
- **Practice field sanitation, destroy crop residues and volunteer plants**
- **Practice crop rotation**
- **Use tolerant/resistant varieties/hybrids, if available**

Grey leaf spot (*Cercospora zeae-maydis*

Grey leaf spot
Grey leaf spot on maize

© A.A. Seif, icipe

Symptoms are similar to Southern leaf blight but the spots are much narrower. They are initially light brownish in colour, and with age they bleach to ashen grey surrounded by narrow light-brownish border. When wet, spore mass is formed on the spots with a light shade. This disease is favoured by prolonged periods of high relative humidity. It can cause yield losses of 30 to over 50%.

What to do:

- **Use resistant varieties / hybrids, if available**
- **Practise field sanitation. It helps in reducing the inoculum (infection) source**

Common rust (*Puccinia sorghi*)

It is recognized by the appearance of circular to elongate pustules scattered over both surfaces of the leaf. Pustules are powdery and cinnamon-brown in colour. They contain masses of spores (uredospores). Pustules can appear on any above-ground part of the plant, but they are most abundant on the leaves. With time the pustules split exposing the spores, which are spread by wind and initiate new infection. As maize matures, colour of spores in pustules change from reddish to black due to formation of teliospores (resting spores). The disease is spread by air transport.

Common rust
Necrotic rust lesions of common rust on sweet corn caused by *Puccinia sorghi*

What to do:

- **Use of resistant varieties / hybrids, if available.**
- **Deep plough crop residue.**
- **Destroy the weed Oxalis sp. (an alternate host).**

Southern rust (*Puccinia polysora*)

Symptoms resemble those of common rust, particularly in the uredial stage (urediospores). The cinnamon-brown pustules tend to be smaller and more circular in outline than those of common rust. Pustules of telial stage (teliospores) are chocolate brown to black and circular to elongate. They are distinguished from common rust by retention of the epidermis of the leaf over the pustule for a long time. No alternate host has been reported for Southern rust.

What to do:

- **Use resistant varieties / hybrids, if available.**

Common maize smut (*Ustilago maydis*)

Characteristic symptom of common smut is formation of galls or tumuors on above-ground parts of maize plant. Galls frequently are from one to several centimetres in diameter. The galls are at first covered by a shining, whitish-green membrane. As the gall enlarges, the membrane ruptures, exposing a powdery black mass of spores.

What to do:

- **Use resistant varieties / hybrids, if available.**
- **Practice crop rotation.**
- **Practice field sanitation. In smallholdings remove and destroy smut galls before smut spores are produced. This may help reduce prevalence of the disease in following years.**

Common maize smut
Blister-like galls of common maize smut (*Ustilago maydis*), up to 15 mm diam., on a corncob before they have ruptured to release spores.

Head smut (*Sphacelotheca reiliana*)

The first symptoms become evident when tassels and cobs (ears) appear. These parts may be completely or partly converted into smut galls. Smut galls are initially covered by a delicate membrane

that breaks open and exposes a mass of reddish-brown to black spores and strands of vascular tissue. The strands or fibers in the galls distinguish this disease from common smut. Head smut is seed-borne.

What to do:

- **Use resistant varieties / hybrids, if available**
- **Practise crop rotation**
- **Eliminate volunteer host plants.**

Head smut on maize Partial infection by head smut fungus (*Sphacelotheca reiliana*) of the tassel of maize

© David C. Nowell. Courtesy of www.ecoport.org

Ear rots (*Gibberella zeae / G. fujikuroi*)

Characteristic symptoms include pink to brick-red colour on ears, husks and kernels. The fungi often gain entrance to the ears through channels made by earworms and borers. Bird damage to the ears also facilitates disease infection.

Symptoms
Roots: dry rot.
Seedlings: blight and subsequent death of the seedling.
Leaves: leaves become a dull green colour when rots and stalks are infected early.
Stalks: lesions are a dark brown to black colour in which black perithecia may be produced

near the lower nodes. The pith is shredded and is pink to red in colouration.
Ears: the fungus infects the ear via the silk channel and causes a red rot of the kernels form the tip of the ear. This may spread over the whole ear.

What to do:

- **Use resistant varieties / hybrids, if available**
- **Manage pests attacking the ears.**

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Information on Weeds

Purple witchweed (*Striga* spp.)

The parasitic weeds *Striga* spp. known as witchweeds, are important pests of maize, particularly in drier areas. The weeds grow on the roots of maize affecting development of maize plants. The young weeds tap the roots of maize plant and draw water and nutrients. A single weed plant produces many thousands of tiny seeds that survive in the soil for long periods. A heavy infestation can cause complete yield loss.

Striga weeds infest 40% of the arable land in the savannah region, causing annual crop losses of 7 to 13 billion dollars. Around the Lake Victoria basin infestation by *Striga hermonthica* causes 30 to 100% loss in maize yield. Striga infestation is associated with increased cropping intensity and declining soil

Striga (*Striga hermonthica*) weeds in maize field.

© David C. Nowell, EcoPort
More Information on Purple witchweed

fertility. Whichweed infestation has resulted in the abandonment of much arable land by farmers in Africa. The problem is more serious in areas with low soil fertility and rainfall.
None of these methods described will, alone, provide complete control and without complete control there is the certainty that surviving plants will mature and replenish the soil seed bank. Therefore, integration of one or more methods 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.

What to do:

- **Weed regularly. This is the conventional method for striga control, but is time-consuming and labour-intensive.**
- **Rotate maize with trap crops. Some plants, such as such as sunflower, pulses and cotton, stimulate the germination of striga seeds, but also inhibit post-germination growth of the weed. Thus, although the seeds germinate, striga cannot develop successfully in these roots.**
- **Intercrop maize with Desmodium or other legumes. Desmodium have been shown to be more effective in reducing striga when interplanted with maize in the field than other legumes such as cowpea, soybean and sun hemp. Desmodium progressively reduces the number of striga seeds in the soil. For more information on push-pull click here**
- **Use resistant/tolerant varieties. Some maize varieties show partial resistance, such as "Katumani" in Kenya.**

Couch grass or Bermuda grass (*Cynodon dactylon*)

It is a spreading perennial grass with vigorous mat-forming stolons. It reproduces and spreads mostly by means of rhizomes but also propagates by seed. This grass is considered as one of the most important weeds in the world. It is present in virtually every tropical and subtropical country and in virtually every crop in those countries. Couch grass and other species of Cynodon are common in East Africa, and some species are occasionally troublesome as a weed of arable land and perennial crops. Couch grass is reported in Ghana as a problem in crops such as eggplant, okra, onion, peppers and tomato.

What to do:

- **Where couch grass is a problem, control it before planting maize, as it will not be possible to grow a profitable maize crop in a couch dominated field.**
- **Harrow with a tooth harrow during the dry season in order to uproot the rhizomes and letting them dry completely on top of the soil. If possible, collect and burn dry rhizomes. Burning them will increase the success of couch control.**
  The same tooth harrow can be used to sweep the dry rhizomes together in bands on the field which can then be burned on site or collected and used for fuel elsewhere (farmer experience).
- **Practice crop control. Introduce shade producing cover crops, within a crop rotational system.**

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

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


Couch gras…


Couch gras…


Couch gras…

More Information on Couch grass

Satintail (*Imperata cylindrica*)

In south-western Nigeria, satintail is a major weed reducing maize yields. The rhizomes of this weed often reduce the efficacy of farmers' weed control practice (slashing followed by 2-4 times of additional weeding) and contribute to high yield losses. In field trials grain yield was 62% less than in fields where rhizomes had been removed from soil before sowing maize.

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Information Source Links

- **AIC, Kenya (2002). Field Crops Technical Handbook.**
- **Agroecology Research Group. Corn-bean-squash intercrop in Mexico. www.agroecology.org**
- **Asean IPM Knowledge Network Management. Management of corn plant hoppers in the Philippines.**
- **Borgemeister, C., Holst, N., Hodges, R. J. (2003). Biological control and other pest management options fo larger grain borer *Prostephanus truncatus*. In Biological Control in IPM Systems in Africa. Neuenschwander, P., Borgemeister, C and Langewald. J. (Editors). CABI Publishing in association with the ACP-EU Technical Centre for Agricultural and Rural Cooperation (CTA) and the Swiss Agency for Development and Cooperation (SDC). pp. 311-328. ISBN: 0-85199-639-6.**
- **Brunt, A.A., Crabtree, K., Dallwitz, M.J., Gibbs, A.J., Watson, L. and Zurcher, E.J. (eds.) (1996 onwards). `Plant Viruses Online: Descriptions and Lists from the VIDE Database. Version: 20th August 1996.' URL http://biology.anu.edu.au/Groups/MES/vide/**
- **CAB International (2005). Crop Protection Compendium, 2005 Edition. Wallingford, UK www.cabi.org**
- **FADINAP. Integrated plant nutrition systems. www.fadinap.org**
- **Herren, H., Pickett, J. (2000). Kenya: Vuta-sukuma (Push-pull) pest management in**

smallholder systems. ICIPE annual reports.

- **ICIPE (2003). Development of biocontrol-based management of *Helicoverpa armigera* in eastern and southern Africa. 2000-2003 ICIPE Scientific Report. International Center for Insect Physiology and Entomology, Nairobi, Kenya. www.push-pull.net**
- **ICIPE. Implementation of habitat management strategies for the control of the stemborers and striga in maize-based farming systems in Eastern Africa and mechanisms of striga suppression by Desmodium sp. www.push-pull.net**
- **IITA. www.iita.org**
- **Kranz, J., Schumutterer, H., Koch, W. (1977). Diseases, pests and weeds in tropical crops. Verlag Paul Parey. ISBN: 3-489-68626-8.**
- **Le Pelley, R. H. (1959). Agricultural insects of East Africa. East African High Commission. Nairobi, Kenya.**
- **Ministry of Agriculture 2006: Economic Review of Agriculture**
- **OISAT: Organisation for Non-Chemical Pest Management in the Tropics www.oisat.org**
- **Ortega, A. O. (1987). Insect pests of maize. A guide for field identification. Mexico, D. F.: CIMMYT. ISBN 968-6127-07-0**
- **Songa J.M., Overholt W.A., Mueke J.M., Okello R.O., (2002). Farmers' perceptions of aspects of maize production systems and pests in semi-arid eastern Kenya: factors influencing occurrence and control of stem borers. International Journal of Pest Management, 48 (1):1-11.**
- **Terry, P. J. and Michieka, R. W. (1987). Common weeds of Africa. Food and Agriculture Organization of the United Nations (FAO). ISBN 92-5-002426-6.**
- **The CIMMYT Maize Program (2004). Maize diseases: A guide for field identification. 4th edition. Mexico, D. F: CIMMYT. ISBN 970-648-109-5**
- **The Organic Farmer Feb 2007**
- **WISARD PROJECT INFORMATION (2001). Biology and management of termites and white grubs in smallholder cropping systems. www.wisard.org**
- **Youdeowei, A. (2002). Integrated pest management practices for the production of cereal and pulses. Ministry of Agriculture (MOFA) Plant Protection and Regulatory Services**

Directorate (PPRSD), Ghana, and the German Development Cooperation (GTZ). ISBN: 9988-0-1086-9.

Crops/ fruits/ vegetables

African Nightshade
Amaranth
Avocados
Bananas
Beans
Cabbage/Kale, Brassicas
Carrot
Cashew
Cassava
Citrus plants

more Images

Mango
Scientific name: *Mangifera indica*
Order/Family: Sapindales: Anacardiaceae
Local names: Embe (Swahili)
Pests and Diseases: Anthracnose Aphids Black spot Bugs Fruit flies Helopeltis bugs Malformation Mango gall flies Mango leafcoating mites Mango seed weevil Mealybugs Powdery mildew Scales Spider mites Stem-end rot Termites Thrips Whiteflies

General Information and Agronomic Aspects

Information on Pests
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Fresh Quality Specifications for the Market in Kenya
Information Source Links

General Information and Agronomic Aspects

Cocoa
Coconut
Coffee
Cotton
Cowpea
Cucumber
Eggplant
Green gram
Groundnut
Maize
Mango
Millet
Okra
Onion
Papaya
Passion fruit
Peas
Peppers
Pigeon pea
Pineapple
Potato
Pumpkin
Rice
Sesame
Sorghum
Soybean

The Mango fruit is one of the most important tropical fruits. It is native to the Indian Monsoon region and has been cultivated for the last 4000 years. It was introduced to East Africa in the 14th century. Mango has now become an important domestic and export crop in Kenya.

Mango has many uses: Ripened fruits are eaten fresh and used to make juice or marmalade. They can also be dried and made into candy. All remains from the fruits can be used to feed animals. The young leaves for example are a very good cattle feed.

Geographical Distribution of Mango in Africa

Cultivars

A wide range of mango cultivars is grown in Kenya. Local varieties include Apple, Batawi, Boribo, Dodo, Kiarabu, Kiimji, Kitovu, Mayai, Ngowe, Peach, Sabre and Shikio Punda. Among these, Apple and Ngowe are in high demand for local and export markets, particularly in the Middle East. Apple, Haden, Keitt, Kent, Ngowe and Tommy Atkins are important cultivars for the export markets.

Climate conditions, soil and water management

Mango grows best in tropical summer rain regions, at temperatures between 24°C and 28°C.

Spider plant
Spinach
Sugarcane
Sweet potato
Tea
Teff
Tomato
Wheat
Yam
Zucchini/Courgette

Once a mango tree is well established, it is very resistant to drought. Mango needs a dry period or cooler temperatures to start blossoming and produce fruits. Rainfall during flowering seriously affects fruit setting. In the tropical regions that do not vary in rainfall or temperature, the trees will not produce any fruits. Mangoes grow well below an altitude of 1000m. Above 1200m production is often poor, but some cultivars such as Sabre and Harris are reported to yield well at up to 1800m.

Mango will grow on a rainfall as little as 650 mm per year, but do better on higher rainfall of around 1500 mm.

Mango grow in most soils if they are well drained. Ideal for good growth is a deep (at least three m), fertile soil. Avoid poor, shallow, rocky and alkaline soils. A pH of 5.5 to 7.5 is desirable.

Young trees should be irrigated as soon as the dry season starts. Older trees need a dry period of at least three months to start flowering. When the fruit is developing, it is very important to water the plant regularly. In Kenya, the major production season is December to March.

Pests/ diseases/ weeds

Medicinal plants

Fruit and vegetable processing

Natural pest control

Cultural practices

Propagation and planting

Mango seeds quickly loose their viability. Use healthy, fresh seeds from well-grown, mature trees. Wash the seeds and dry them in the shade for a few days. Sow them at a spacing of 15 x 30 cm and five cm deep. Place them on their sides; the most prominently curved edge upwards, so that they produce a straight stem. To speed up germination, the hard husk can be removed before sowing. The best place to cultivate seedlings is in half-shadow. Transplant them 5 to 6 weeks later, when they are about 10 cm high, into a nursery bed or into poly-bags. Irrigate seedlings during dry periods.

Select the site for the orchard carefully. Deep soil cultivation by ploughing is recommended. Clear the field of trees, bushes and weeds. Transplanting should be done at the beginning of the rains. The planting hole should be 60 x 60 cm big and 100 cm deep. Under dry conditions, the hole should be bigger (about 90 x 90 cm and 100 cm deep). The spacing is 9 x 9 to 14 x 14 m between trees depending on variety and growth habit of the mango variety chosen. Mix a

minimum of two buckets of good compost and a handful of Mijingu rock phosphate with the dug out soil, before returning the soil to the hole along with the young mango plant. Firm the soil around the plant. Water well and mulch. Irrigation should only be necessary to see the young tree through the first year.

Husbandry

Keep the area directly under the tree canopy free from weeds. During the first five years, intercropping with annual crops is recommended to maximise income until an economical mango yield is achieved. In young plantations mulching around the tree helps to suppress weeds and to retain soil moisture. Mango trees normally need pruning in order to shape young trees. Smoking of mango trees, apart from controlling pests also induces good flowering.

Formative pruning is done in the first years of the young tree to guide the tree into the desired shape. In the first year, cap the seedling at 1 m height in order to produce a spreading framework of branches. In the second year, prune to leave 4 to 5 well spaced branches to be the future main branches. Benefits from pruning:

- **Fruit is produced on the outside of parts of the tree**
- **Fruit hold to maturity**
- **Open tree structure allows for easy harvesting**
- **Tree produces larger fruits**
- **Crops can be grown under the trees**
- **Tree benefits from natural conditions of sun and wind movement. This helps in reducing relative humidity within the canopy and also creating environment less conducive to disease development.**
- **It controls tree height and prevents excessive spreading of limbs.**

Structural pruning should be done after fruit harvest: The canopy should be at least one m

above the ground. Remove all dead branches and all sucker branches from the main structural branches. Prune canopy to allow sunlight to penetrate and reach the ground under the tree.

Improve fruit production by:

- **Keeping the orchard area clean**
- **Removing all ripe fruit and weeds from around the tree**
- **Removing 1/3 of fruit after fruit set to get better size of remaining fruit.**

Mango trees are susceptible to wind damage. Therefore, they should be protected from strong winds by windbreaks on the upwind side of prevailing winds.

Weeding. Clear excessive vegetation regularly from beneath the trees and use as mulch.

Mango fruits and farmers inspecting mango tree

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A.A. Seif, icipe

Harvesting

Flowering usually begins after a period of dormancy due to cool or dry weather. Smallholder mango farmers usually induce flowering with smoke.

A mango plantation will supply its first commercially marketable amount of fruit around 4 to 5 years after being planted, and are in good production after eight years reaching full maturity at some 20 years of age. One tree should produce 200 to 500 fruits per year and varieties like Dodo and Boribo can produce 1000 fruits per year. Most varieties show biennial tendencies in production and a poor harvest may follow a good one. Selection should be based on varieties showing annual bearing tendencies.

Harvest mango fruit at the mature-green stage, when they are hard and green. A mature fruit has well-developed "cheeks". Pick fruit by hand. Clip them off with a long stalk of about 2 to 3 cm and pack the fruit in a single layer with the stalks facing downwards in the box or crate. It is important that the latex dripping from the stalk drops onto an absorbent material (for example tissue paper placed at the bottom of the container). Although mature mangoes ripen fairly rapidly, they have a poor tolerance to temperatures below 10°C, especially when freshly picked. Ripe fruits can, however, be stored as low as 7 to 8° C without developing chilling injury.

Yield. Fifteen tons/ha per year can be achieved from the seventh year onwards if proper husbandry is followed.

Post-harvest treatment

Hot water treatment (HWT) is an effective post-harvest treatment method for mango. Dipping newly harvested fruits into hot water minimises fruit fly damage and anthracnose. The fruit is

perishable and should be marketed as quickly as possible. For more information on hot water treatment click here.

Mango hygiene by smoking

Mango smoking reduces insect population drastically and improves fruit setting.
Smoke pots with holes in the bottom for air intake, containing wood shavings or sawdust with a topping of aromatic herbs (lemongrass etc) are hung at strategic places within the mango tree and the sawdust lit to produce a good amount of smoke which chases insects away from the tree.

Another option is to place dry grass on the ground below the tree in a position where the wind can blow maximum smoke into the top of the tree, cover it with green aromatic leaves like lantana etc and lit the grass to produce smoke.

Smoking of mango trees is reported both by KIOF and Meru Herbs Farmers, Kenya to be very effective in insect control.

Smoking also induces flowering in mango trees.

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Information on Pests

Biological methods of plant protection

The worst pests for mangoes are cotton scales, mealybugs, cicadas and black flies (create honey dew). These are all sucking insects that live on the leaves, young buds and shoots. They can cause a lot of damage. Yet they all have natural enemies, such as e.g. ladybird larvae, wasps, spiders and other types, such as parasitic fungi e.g. with cicadas and black flies.

An ecological plantation with a variety of crops, enough plots under different crops e.g. forest and a sufficient amount of vegetation to cover the soil and enrich the variety of species (e.g. mulching only right after the plants have flowered), will provide enough enemies to combat the pests that measures against them are usually unnecessary. Cicadas are averse to open, well ventilated soil, also drain the soil well to avoid wet patches.

In emergencies, the following methods should help:

Scale insects can be regulated with a 'winter-spraying', i.e. with paraffin oil (white oil) shortly before the larvae hatch from their eggs. The paraffin oil is sprayed on as a 3 % water emulsion.

Plant spraying mixtures made of stinging nettles or Neem can be against cicadas. The worst damage occurs during blossoming, so the plantation should be checked regularly around this time in order to make up the brew and spray it early enough.

Mealybugs lay their eggs on the ground next to the trunk. By wrapping smooth plastic bands

around the trunk, the larvae can be prevented from infesting too large an area. Should they infest the tree, a solution of 1% soft soap (potassium soap) with 1 % pure alcohol is quite effective.

Black fly can be kept under control by useful insects. A variety of prospatella species can be of use here. This requires a good functioning control system, because the useful larvae need to be made available for release in time. Where this is not possible, spraying white oil shortly before the pests hatch, as such as with scale insects can be sufficient.

Examples of Mango Pests and Organic Control Methods

Mango fruit flies (*Ceratitis* spp./ *Bactrocera invadens*)

Fruit flies lay eggs under the skin of mature green and ripening fruit. Some fruit flies such as *Bactrocera invadens*, a new species recently introduced into East Africa, also lay eggs on small fruit. The eggs hatch into whitish maggots within 1 to 2 days. The maggots feed on the fruit flesh and the fruit starts to rot. After 4 to 17 days, the maggots leave the fruit, making holes in the skin. Adult fruit flies are small, they are about 4-7 mm long.

Fruit fly
Maggots of fruit fly dropping out of mango fruit to pupate.

© A. M. Varela, icipe.



Fruit **Mango** **Fruit**

What to do:

- **Collect and destroy all fallen fruits at least twice a week during the fruit season.**
- **Do not put collected damaged fruits into compost heaps. Instead, burn them or bury them at least 50 cm deep, so that the fruit flies cannot reach the soil surface.**

- **Remove fruits with dimples and those that ooze clear sap. This method is more laborious than picking the rotten fruits from the ground, but it is also more effective.**
- **Whenever possible, wrap fruit in newspaper or paper bags to prevent fruit flies from laying eggs on the fruit. This has to be done well before the fruit matures.**
- **Pick overripe fruits, as they attract fruit flies.**
- **Physical methods include fruit fly traps and fruit bagging, see on fruit-fly datasheet**

fly frui... fly ...

More Information on Fruit flies

The mango gall flies (*Erosomyia mangifera*)

It is a small midge about 1 to 2 mm long with long legs and antenna. The flies lay eggs on young leaves. Eggs hatch into maggots that bore into the leaf tissue to feed. Their feeding induces formation of small galls, which look like pimples on the leaves. Mature maggots leaves the galls and to the soil to pupate, leaving small holes on the leaves. These holes may serve as entrance for fungal infections. Leaves may be covered with galls and the surrounding tissue may die. Heavy infestation may lead to premature leaf drop.

Mango gall fly
Close-up of galls caused by gall flies on mango leaf (*Erosomyia mangifera*).

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What to do:

- **Conserve natural enemies. Mango galls are usually kept under control by parasitic wasps and no control measures are needed.**
- **In other countries, when infestations are heavy, the soil**

around the tree is flooded before flowering to reduce emergence of adult gall flies from the soil.

Whiteflies and black flies (*Aleurocanthus woglumi*)

Whiteflies and black flies suck sap from leaves and may weaken the plants when numbers are high. They produce as excrete large amount of honeydew where sooty mould develops. High numbers of these insects can almost blacken trees, reducing photosynthesis and may cause leaf drop debilitating the tree. Adults are small (1-3 mm long), with two pairs of wings that are held roof-like over the body. They resemble very small moths.

Whiteflies
Whiteflies on a mango leaf

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More Information on Whiteflies

What to do:

- **Conserve natural enemies. They usually provide good control of these pests. For more information on natural enemies click here.**
- **If necessary spray neem extracts. Neem products inhibit growth and development of immature stages, repel whitefly adults and reduce egg laying.**

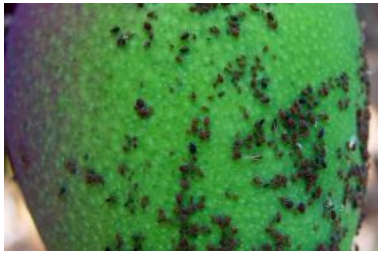
The mango aphid (*Toxoptera odinae*)

It is small (1.1 to 2.5 mm long), brown, black or reddish brown aphid covered with a light powdery dusting. Aphids live in clusters sucking sap on the underside of young leaves, on petioles, young branches and fruit. Their feeding causes slight rolling, or twisting of the leaf midrib. Sooty mould growing on

honeydew produced by the aphids may cover leaves, twigs and fruit. Coating of the fruit with honeydew and sooty mould reduces its market value.

What to do:

- **Conserve natural enemies. Aphids are attacked by a wide range of natural enemies, which are very important in natural control of these pests.**



Mango aphid
Mango aphid (*Toxoptera odinae*) on mango fruit.

© A. M. Varela, icipe


Mango aphi... **Mango aphi...**

More Information on Aphids

The mango seed weevil (*Sternochetus mangiferae*)

It feeds on mango leaves, tender shoots or flower buds. Female weevils lay one egg on the young fruit leaving a small, dark mark on the fruit skin. The larvae burrow through the flesh into the seed and destroy it. The larva develop and grows in the mango seed. When the larva has grown up to an adult beetle, it tunnels through the flesh and leaves a hole in the fruit skin. The tunnel

gets hard and the fruit cannot be sold anymore.

What to do:

- **Keep the orchards clean of all fallen fruit and plant material by collecting, burying or burning it.**
- **Sticky bands applied at the upper end of the trunk before it branches has been recommended to prevent weevils form migrating to branches for egg laying. However, there are some reports that, although these weevils are not strong flyers, they can fly, and could infest the trees in spite of the banding. A method for banding is described in detail under citrus trees/ants.**
- **Scout fruit regularly and remove fruits with egg-laying marks and destroy weevils (larvae, pupa and adults) in seeds (stones).**

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




Mango seed… Mango seed… Mango seed… Egg of man…

More Information on Mango seed weevil

Mealybugs (*Rastrococcus* spp.)

Mealybugs are small, flat, soft bodied insects covered with a distinctive segmentation. Their body is covered with a white woolly secretion. They suck sap from tender leaves, petioles and fruits. Seriously attacked leaves turn yellow and eventually dry. This can lead to shedding of leaves, inflorescences, and young fruit. Mealybugs excrete honeydew on which sooty mould developed. Heavy coating with honeydew blacken the leaves, branches and fruit. This reduces photosynthesis, can cause leaf drop and affect the market value of the fruit.

A wide range of natural enemies attacks mealybugs. The most important are ladybird beetles, hover flies, lacewings, and parasitic wasps. These natural enemies usually control mealybugs. However, mealybugs can cause economic damage to mango when natural enemies are disturbed (for instance by ants feeding on honeydew produced by mealybugs or other insects) or killed by broad-spectrum pesticides, or when mealybugs are introduced to new areas, where there are no efficient natural enemies.

The latter is the case of two serious mealybug pests on mangoes in Africa: *Rastrococcus invadens* in West and Central Africa and *Rastrococcus iceryoides* in East Africa. These mealybugs, of

Mealybugs
Mealybugs (*Rastrococcus* spp.) on a mango fruit

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More Information on Mealybugs

Asian origin, were introduced into Africa, where they developed into serious pests since the natural enemies present were not able to control them. They cause shedding of leaves, inflorescences and young fruits. In addition, sooty moulds growing on honeydews excreted by the insects render the fruits unmarketable and the trees unsuitable for shading. They cause direct damage to fruits leading to 40 to 80% losses depending on locality, variety and season. *Rastrococcus invadens* was brought under control in West and Central Africa by two parasitic wasps (*Gyranusoidea tebygi* and *Anagyrus mangicola*) introduced from India (Neuenschwander, 2003).

***Rastrococcus iceryoides* is a major pest of mango in East Africa, mainly Tanzania and coastal Kenya. Although several natural enemies are known to attack this mealybug in its aboriginal home of southern Asia (Tandon and Lal, 1978; CABI, 2000), none have been introduced so far into Africa (ICIPE).**
Insecticides do not generally provide adequate control of mealybugs owing to their wax coating.

What to do:

- **Destroy affected parts at the beginning of the infestation. Heavily infested branches may be pruned to control the pest, especially on the tender branches before flowering begins.**
- **Conserve natural enemies.**
- **Avoid excessive spraying and the use of broad-spectrum pesticides, since they may kill natural enemies.**
- **Control ants tending mealybugs - see also section on**

mealybugs on citrus datasheet.

- **When necessary spray only the affected branches/trees (spot spraying). Mineral oils, neem products and soapy solutions (1 to 2%) are reported to give satisfactory control of mealybugs.**

Scales

Scales are small (1 to 7 mm long), generally immobile insects, varying in colour and shape according to the species. Female scales have neither wings nor legs. They resemble small shells glued to the plant. Females lay eggs under their scale. Once hatched, the tiny scales (known as crawlers) emerged from under the protective scale. They move in search of a feeding site and do not move afterwards. They suck sap on all above the ground plant parts.

There are two main groups of scales on mangoes: soft and armoured scales. Soft scales excrete honeydew. The most common soft scales on mangoes are soft green scales (*Coccus viridis*), brown soft scales (*Coccus hesperidum*), and wax scales (*Ceroplastes* spp.). The most important armoured scale on mango is the mango white scale (*Aulacaspis tubercularis*). The body of this scale is reddish brown. Females are covered with a white round shell, while males have a small rectangular shell with two groves.
Feeding by scales may cause yellowing of leaves followed by leaf drop, poor growth, dieback of branches, fruit drop, and blemishes on fruits. Heavily infested young trees may die. In

Scales
Soft brown scale (*Coccus hesperidum*). Scales are small, they attain a lenght of 1-7mm.

© Jeffrey W. Lotz, Florida Department of Agriculture and Consumer Services, Bugwood.org \n \n

addition, soft scales excrete honeydew, causing growth of sooty mould. In heavy infestations fruits and leaves are heavily coated with sooty mould, turning black. This reduces photosynthetic capacity. Fruits contaminated with sooty mould loose market value. Ants are usually associated with soft scales. They feed on the honeydew excreted by soft scales, preventing a build-up in sooty moulds, but also protecting the scales from natural enemies. Armoured scales do not excrete honeydew.

What to do:

- **Conserve natural enemies. Scales are attacked by a large range of natural enemies, mainly parasitic wasps and predators (ladybird beetles, lacewings, etc). These natural enemies usually control scales. Outbreaks are generally caused by the use of broad-spectrum pesticides that kill natural enemies, and/or to the presence of large number of ants that feed on honeydew produced by soft scales or other insects (mealybugs, whiteflies, aphids, black flies).**
- **Spray if necessary with light mineral oils. However, care should be taken when using mineral oils, since at high concentrations, they may be harmful to the trees. Oil sprays should be carried out after picking and not during flowering or during periods of excessive heat or drought. Sprays should target young stages of the scales.**
- **To protect natural enemies spray alternate tree rows each season.**
- **At early stages of an outbreak cut and burn affected branches and leaves.**

Bugs

Several species of bugs feed on mangoes. Both adults and nymphs (young stages) feed inserting their needle-like mouthparts in young tissue, causing dieback and tip wilting. Other feed on the fruit, causing fruit fall and fruit deformation.

The coconut bug (*Pseudotheraptus wayi*)
It feed on fruits. Damaged young fruits show dark brown or grey indentations on the skin and normally drop. Bug feeding on mature fruit causes sunken lesions. The coconut bug is reddish brown, about 1.5 cm long. Eggs are laid scattered over the fruit, small twigs, flowers and blossom stems. The young bugs are light brown with long thick antenna.

Tip wilters (*Anoplocnemis curvipes*)
They are large (about 2.5 cm long) bugs, and dark brown in colour. The hind legs of the male are enlarged. Both young and adult bugs feed on young flush, on the mid-vein of young leaves, or on flower stalks, causing wilting and death of new growth. Heliopelthis bugs, also known as mosquito bugs are about 7-10 mm long and have slender bodies and long legs and antenna. Adults and young bugs (nymphs) feed on fruit and young shoots. Feeding on fruit causes dark lesions with a brown dark centre. Young shoots die back, resulting in vigorous secondary branching. Bugs are difficult to control since they usually feed on a wide range of crops and are very mobile.

Coconut bug
Adult coconut bug (*Pseudotheraptus wayi*. Real size 1 to 1.5cm long.

© A.M.Varela, icipe



Coconu bu… **Tip wilter** **Helope**

What to do:

- **Hand pick and kill bugs regularly, especially on young trees during flushing periods and during fruit development.**
- **Conserve natural enemies. Assassin bugs, spiders, praying mantises and ants are important predators of bugs. They kill or deter bugs. Weaver ants, tree-nesting ants common at the coast give effective protection against bugs.**
- **Also tree smoking may help against bugs.**

Helopeltis bugs (*Helopeltis schoutedeni* and *H. anacardii*)

Helopeltis bugs, also known as mosquito bugs or mirid bugs are slender, delicate insects, about 7- 10 mm long with long legs and antennae, the antenna being nearly twice as long as the body. The females are red and the males brown to yellowish red. They lay eggs inserted into the soft tissue near the tips of flowering or vegetative shoots. Nymphs (immature bugs) are yellowish in colour. Both adults and nymphs feed on young leaves, young vegetative and flowering shoots, and developing fruits.

Attacked leaves are deformed and show angular lesions, particularly along the veins, which may drop off, so that the leaves appear as if attacked by biting insects. Feeding on the stalks of the tender shoots causes elongated green lesions, sometimes accompanied by exudation of gum. Severely damaged shoots die back due to the effect of bug saliva in combination with fungi, which enter the plant tissue through the feeding lesions; the subsequent development of numerous auxiliary buds

Helopeltis bug
Helopeltis bug. Real size: 6 to 10 mm long.

© F. Haas, icipe


Helope **Helope**

causes a bunched terminal growth known as 'witches broom'. In case of serious infestations the trees may appear as if scorched by fire. Bug feeding on developing apples and nuts causes brown sunken spots. The growth of trees is seriously retarded and fruit formation of attacking flowering shoots is reduced.

What to do:

- **Monitor the crop regularly. Helopeltis attack occurs very suddenly and great vigilance is very important to control this pest, particularly during the rainy season or when water is available leading to flushing (production of young shoots) when Helopeltis populations normally build up.**
- **Conserve natural enemies. Weaver ants build nests on cashew trees providing good protection against this and other bug pests.**
- **Do not interplant mango with crops that are host for Helopeltis bugs, such as cotton, tea, sweet potato, guava and cashew.**

Mango leafcoating mite (*Cisaberoptus kenyae*)

The mango leafcoating mite is tiny (about 0.2 mm), light coloured and cigar shaped. It cannot be seen with the naked eye. The mites leave in groups under a white coating on the upper leaf surface. The white coating can be easily rubbed off by hand. Leaves covered with the white coating tend to turn yellow and drop prematurely. In general, the coating has minimal effect on

fruit yield.

What to do:

- **Remove and destroy leaves with white coating.**
- **Usually no further control measures are needed.**

Leaf-coating mite
Mango leaves showing symptoms of (*Cisaberoptus kenyae*) attack.

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Thrips (*Selenothrips rubrocinctus*)

The adult of the red banded thrips is reported as a pest of mangoes in Kenya (AIC, 2003). Adult thrips are dark brown thrips, about one mm long. Immature thrips (nymphs) are yellow with a bright red band around the base of the abdomen. Nymphs and adults feed together, normally on the underside of the leaves. Attacked leaves become dark stained and rusty in appearance with small shiny black excreta present. Leaf edges are curled.

Several other species of thrips are found on mango flowers. However, not all of them are pests. Their role varies according to the species. Some species are present in large numbers in mango flowers, but there is no evidence of damage or crop loss. Some thrips species are considered important pollinators. Other species of thrips attack the mango fruit. Thrips feeding on the fruit surface cause a rough, greyish white discolouration.

Red-banded thrips
Immature stage of the red banded thrips (*Selenothrips rubrocinctus*). Note a bright red band across the abdomen of immature thrips. Real size: about 1mm long.

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More Information on Thrips

What to do:

- **Conserve natural enemies. Predatory thrips and mites, anthocorid bugs among other natural enemies are important in natural control of thrips.**

Bark eating termites

They are generally associated with old mango trees. They may damage branches and other parts by tunnelling the wood, but usually are not of economic importance. Sickly, injured plants are more likely to be damaged than healthy, vigorous plants.

What to do:

- **Provide good growing conditions for the trees. 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.**
- **Conserve natural enemies**
- **Inspect trees, especially pruned trees, for termites attack. Remove affected plant and kill the termites, they are normally found inside the hollowed parts**

Termites
Close-up termites on mango stem.

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Termite Termite

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Information on Diseases

Biological methods of plant protection

The most usual diseases with mango trees are fungus and bacterial diseases. The first

important preventative measure is make sure that the propagation segments are healthy. The scions that were raised in tree nurseries and whose origins are maybe unclear, should be carefully examined. They shall not have been treated with any synthetic or chemical agents.

Anthracnose, caused by the fungus *Colletotrichum gloeosporioides*, is the most wide-spread disease among mangoes. The varieties vary in susceptibility. *Colletotrichum gloeosporioides* causes anthracnose on fruits, and drop of flowers on young branches. Anthracnose always appears as a result of scurvy (*Elsinoe mangiferae*). Fruits stricken with anthracnose can be plunged into a hot water bath (3- 5 min./55°C), in order to kill off the fungus. Preventative measures are nevertheless preferable, to preclude injuries and an infection with scurvy, because anthracnose can usually only take a hold on damaged fruits that are also affected by scurvy. A case of scurvy can usually be prevented by removing all dead plant material (branches, leaves and fruit). In exceptional cases, the fungus can be brought under control again with 1% Bordeaux Mixture.

While anthracnose generally attacks ripe fruits (only seldom the blossoms), a bacterial infection from *Erwinia* sp. can also affect young fruit. The symptoms are very similar to the flecks caused to the leaves and fruit by anthracnose. The bacteria usually survive in the ground - a heavy rainfall will then splash the spores against the lower leaves and fruits. Covering the ground can therefore help to protect against this. Active life in the soil will also help to prevent an explosive growth of bacteria. Sites where it can rain inside the blossoms can also be a problem.

Young fruit and also blossoms can be damaged by powdery mildew (*Oïdium mangiferae*). This fungus grows during warm and moist weather, during blossoming and when the fruit appears. A case of powdery mildew can dramatically affect the harvest. An open, well-ventilated population and regular cutting back of the coronets can best help to prevent mildew. In acute cases, mildew can also be brought under control with sulphur. When carrying this out, there should be no wind blowing, and the leaves should still be moist with dew.

The leaf spot disease (*Cercospora mangiferae*) on mangoes is visible as dented spots on leaves and fruit. The same applies for this fungus, an open and quick-drying population is the best protection against infection. Fruit infected with Cercospora can no longer be sold, furthermore, both the leaf spot disease and scurvy prepare the way for a case of anthracnose. In exceptional cases, the leaf spot disease can be brought under control again with 1% Bordeaux Mixture (Copper). For more information on Bordeaux Mixture click here

Examples of Mango Diseases and Organic Control Methods

Anthracnose (*Colletotrichum gloeosporiodes*)

The most serious and widespread fungus is anthracnose. Anthracnose initially appears as small black spots. On leaves, the spots can grow to form an irregular patch. On young fruit, pin-sized, brown or black, sunken spots develop. Sometimes, a "tear stain" pattern develops on fruit. It is an important problem after harvesting the fruit, especially during transport and storage, where fruit can develop round, blackish sunken spots. The fungus is spread by rain splash and survives from season to season on dead leaves and twigs. Rainy weather during blooming and early fruit set will favour the development of anthracnose.

Anthracnose
Anthracnose on mango *(Colletotrichum gloeosporioides)*. Anthracnose initially appears as small black spots. On leaves, the spots can grow to form an irregular patch. On young fruit, pin-sized,

What to do:

- **Use tolerant varieties. Tommy Atkins is less susceptible to anthracnose than Haden, Sensation and Zill.**

- **Cut-out dead branches and twigs and dead leaves. Completely remove them from the mango orchard.**
- **Monitor for the disease weekly.**

brown or black, sunken spots develop.

More Information on Anthracnose

Powdery mildew (*Oidium mangifera*)

Another fungal disease is the powdery mildew. It appears as a white, powdery growth on leaves, flowers and young fruit. Infected leaves curl and flowers fail to open and drop from the tree without forming a fruit. The disease is spread by wind and can spread very rapidly. It is more prevalent in dry weather when humidity is high and nights are cool. The fungus survives from season to season in dormant buds. The flowering stage is the most critical stage for infection.

Powdery mildew
Powdery mildew (*Oidium mangifera*) on young mango leaves

More Information on Powdery mildew

What to do:

- **Consider appropriate cultivars that grow in cool, dry areas. Alphonse, Kent and Zill are highly susceptible to mildew. Haden and Keitt are moderately susceptible and Sensation and Tommy Atkins are tolerant.**
- **Monitor for the disease weekly.**
- **Spray a solution of: baking powder (six teaspoonfuls), white oil (three teaspoonfuls) and white bar soap foam in 15 litres**

of water. This solution has been shown to control powdery mildew.

- **Sulphur based fungicides can effectively control powdery mildew if appropriately used.**

Bacterial black spot (*Xanthomonas campestris* pv. *mangiferaeindicae*)

Bacterial black spot is rain related and is spread through rain splash within an orchard. Long-distance spread is by infected planting material. Important factors in infection are very small wounds that are easily caused by wind and wet weather. On leaves, spots are angular, dark, shiny in appearance and delimited by veins.
Fruit spots start off as water soaked and then become raised and black. Later they crack open in the centre in form of a star. In wet weather, these spots exude gum. Fruit becomes more susceptible with age.

Bacterial black spot Bacterial black spot (*Xanthomonas campestris* pv. *mangiferaeindica*) symptoms on mango fruit. Note star-like cracks on the fruit

© A.A.Seif, icipe


Bacteri... Bacteri...

What to do:

- **Consider which cultivars are appropriate to grow in wet, humid areas. Heidi, Kensington, Sensation and Tommy Atkins are tolerant to Bacterial black spot. Keitt and Kent are highly susceptible to the disease. No varieties are immune.**
- **Prune off diseased twigs and establish windbreaks around the orchard.**
- **Copper sprays are the only method of combating the disease**

and are not always successful when disease pressure is high. One or two post-harvest copper sprays to cover the post-harvest flush and tail end of the rain season are effective in reducing inoculum (disease) pressure for the following season.

- **Monitor for the disease weekly.**

Malformation (*Fusarium subglutinans*)

The fungus produces compounds that have hormonal effect on the plant. The fungus is easily spread by grafting and infected nursery trees. In the orchard the disease spreads slowly despite of masses of spores produced on the panicles.
Symptoms consist of affected flowers taking on, to a greater or lesser extent, the appearance of a cauliflower head. The axes of the panicles are shorter and thicker than normal, branch more often, and a profusion of enlarged flowers is produced. The affected panicles retain their green colour, are sterile and produce no fruits. In the nursery, vegetative malformation can occur. Eriophid mites are believed to be vectors of the disease and their damage symptoms are similar to those caused by *F. subglutinans*. Symptoms consist of buds producing short shoots and small brittle leaves creating a compact "witches broom" appearance.

What to do:

- **Remove affected parts. These could either be burned or placed in plastic garbage bags and exposed to the sun for a day or two to be burned.**

Stem-end rot (*Dothiorella dominicana, Botryodiplodia theobromae*, and/or *Phomopsis mangiferae*)

Symptoms consist of a dark-brown, firm decay starting at the stem-end of the fruit and developing rapidly to involve the whole fruit. The fungi survive on dead twigs and branches where they produce large numbers of spores. During wet weather, these spores are spread to adjacent fruits where infection occurs. The rot generally does not develop until the fruits begin to ripen. Chemical sprays are neither recommended nor necessary.

Stem end rot
Mango stem end rot (*Dothiorella dominicana, Botryodiplodia theobromae*, and/or *Phomopsis mangiferae*)

What to do:

- **Prune dead twigs and branches**
- **Avoid harvesting immature fruits**
- **Cool fruits immediately after harvesting**
- **Store fruits in well-ventilated containers**

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Fresh Quality Specifications for the Market in Kenya

The following specifications constitute raw material purchasing requirements

PRODUCE:	MANGO
IMAGE:	
VARIETY:	Various
GENERAL APPEARANCE CRITERIA	
COLOUR:	Green yellow skin with red blush.
VISUAL APPEARANCE:	Pale yellow to orange flesh.
SENSORY:	Firm, yields slightly to finger pressure; smooth skin; sweet flavour, with some acid; pleasant aroma; no unpleasant odours/flavours (abnormal ripening).
SHAPE:	Round to oval heart shaped.
SIZE:	In pre-ordered size per requirements; uniform per tray, box or crate.
MATURITY:	Fully coloured ripened fruit.
INSECTS:	With no evidence of live insects.

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Information Source Links

- **AIC, Ministry of Agriculture, Nairobi Kenya (2003). Fruits and Vegetables Technical Handbook**
- **CAB International 2000 and 2005. Crop Protection Compendium. Wallingford, UK**

http://www.cabi.org/

- Griesbach, J. (1992). A guide to propagation and cultivation of fruit trees in Kenya. Schriftreihe der GTZ, No. 230. Eschborn, Germany. ISBN: 3-88085-482-3.
- Griesbach, J. (2003). Mango Growing in Kenya. World Agroforestry Centre (ICRAF). ISBN 92 9059 149 8. www.worldagroforestry.org
- Institute for Tropical and Subtropical Crops (ARC-LNR) (1998). The Cultivation of Mangoes. Compiled and edited by E.A. de Villiers. ISBN: 0-620-22320-0
- Naturland e.V. http://www.naturland.de/
- Neuenschwander, P. (2003). Biological control of cassava and mango mealybugs. In Biological Control in IPM Systems in Africa. Neuenschwander, P., Borgemeister, C and Langewald. J. (Editors). CABI Publishing in association with the ACP-EU Technical Centre for Agricultural and Rural Cooperation (CTA) and the Swiss Agency for Development and Cooperation (SDC). pp. 45-59. ISBN: 0-85199-639-6.
- OISAT (Online Information Service for Non-Chemical Pest Management in the Tropics) http://www.oisat.org/
- Tandon PL, Lal B. (1978). The mango coccid *Rastrococcus iceryoides* Green (Homoptera: Coccidae) and its natural enemies. Current Science, 47(13):467-468.
- Varela, A.M., Seif, A., Nyambo, B. (2006). A Guide to IPM in Mango Production in Kenya. ICIPE. Modern Lithographic Ltd., Nairobi, Kenya. http://www.icipe.org/

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Crops/ fruits/ vegetables

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Cocoa
Coconut
Coffee
Cotton
Cowpea
Cucumber
Eggplant
Green gram
Groundnut
Maize
Mango

more Images

Onion
Scientific name: *Allium cepa*
Order/Family: Aspargales: Alliaceae
Local names: Kitunguu, (Swahili, Kenya and Tanzania), Gitunguru (Kikuyu, Kenya)
Pests and Diseases: Anthracnose Bacterial soft rot Botrytis leaf blight Downy mildew Fusarium basal rot Leafmining flies (leafminers) Onion fly Onion rust Purple blotch Slippery skin Sour skin Thrips White bulb rot

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General Information and Agronomic Aspects

Onion is a biennial vegetable grown in temperate zones as an annual. In the tropics the varieties that do well are in effect annuals as they can produce seed within the first year of growing. Nutrient-wise 100g of onion provides about 30 g calcium, 0.5 mg of iron, vitamin B, 0.2 mg of riboflavin, 0.3 mg nicotinamide, and 10 mg ascorbic acid (vitamin C).

In general, onions are used for salads (bunching onion or sliced full-grown bulbs), pickling (for example, silverskin onions), cooking (such as in soups) and frying (for example, with meat). Onions are particularly suited to smallholder farming in most countries. It also plays an important

- Millet
- Okra
- Onion
- Papaya
- Passion fruit
- Peas
- Peppers
- Pigeon pea
- Pineapple
- Potato
- Pumpkin
- Rice
- Sesame
- Sorghum
- Soybean
- Spider plant
- Spinach
- Sugarcane
- Sweet potato
- Tea
- Teff
- Tomato
- Wheat
- Yam
- Zucchini/Courgette

role in traditional medicine (for example, as a diuretic). In the tropics onions can be grown year round where irrigation is possible.

Geographical Distribution of Onion in Africa

Nutritive Value per 100 g of edible Portion

Raw Vegetable	Food Energy (Calories)	Protein (g)	Carbohydrates (g)	Ash (g)	Calcium (g)	Phosphorus (mg)	Iron (mg)	Potassium (mg)	Vitamin A (I.U)	T (
Onion, Mature, Dry	38	1.5	8.7	0.6	27	36	0.5	157	40	0
Onion, Green Bunching	36	1.5	8.2	0.7	51	39	1.0	231	2000	0

Climate conditions, soil and water management

In temperate zones onion is cool-season biennial, and is tolerant to frost. They produce bulbs with growing day lengths. Optimum temperatures for plant development are between 13 and

Pests/ diseases/ weeds

Medicinal plants

Fruit and vegetable processing

Natural pest control

Cultural practices

24°C, although the range for seedling growth is narrow, between 20 and 25°C. High temperatures favour bulbing and curing. In the tropics only short day or day neutral onion varieties will form bulbs. These thrive in warm to hot climates of 15-30°C. If the temperature greatly exceeds that required for bulbing, maturity is hastened and bulbs do not grow to maximum size, consequently lowering the yields.

Onions can be grown on any fertile, well-drained, non-crusting soil. The optimum pH range is 6.0 to 6.8, although alkaline soils are also suitable. Onions do not grow well in soils below pH 6.0. On light sandy soils irrigation is necessary. Irrigation could be either overhead or on drip. Onions at the bulbing stage need a substantial amount of water, but excessive moisture must be avoided during the growing season. Avoid application of fresh manure to the crop, as this will cause the plants to develop thick necks and too much leaf at the expense of bulb formation.

Propagation and planting

Prior to planting, soils should be ploughed and disked sufficiently to eliminate debris and soil clods. In most commercial areas, beds 0.9 to 1.0 m wide are common, and two to six rows are seeded or planted on the bed. If two rows, they may be two-line (twin) rows with plants staggered to achieve proper spacing and high population density.

Proper seed selection is recommended to minimise problems of splits and doubles. Over-fertilization, uneven watering, and temperature fluctuations also influence bulb formation. Onion is propagated by seed (most common in the tropics) or sets (immature bulbs ripened during the previous season - temperate zones).

In the tropics the seed is usually sown in a nursery under a mulch cover. In the nursery prepare raised beds maximum 1 m wide and incorporate plenty of well-decomposed compost as well as additional rock phosphate. Make rows about 15 cm apart, sow the

seeds and cover lightly with soil and mulch. Irrigate liberally for the first 10 days. Seed rate is 2-3 kg per ha. After the seed emerges, the mulch is removed. About 6-8 weeks after sowing, when the seedling has a base as thick as a pencil and is approximately 15 cm tall, the seedlings are transplanted to the field.
The ultimate yield of onion is determined by the number of leaves that are formed prior to bulbing.

Common varieties grown in Africa (short day or day neutral varieties)

- **'Red Creole'. This is a popular standard variety in high demand because of its good keeping quality. It produces mainly single onions from transplants, red, flat-round and with a pungent taste.**
- **'Red Tropicana': Red bulbing type**
- **'Red Tropicana F1 Hybrid'. Produces large, red, thick flat onions with firm pungent flesh. It is highly productive and therefore demands high levels of management. It keeps well in dry aerated store.**
- **'Bombay Red'. It is a variety for dry and warmer conditions. It is small to medium sized, globe shaped, purplish red and pungent.**
- **'Yellow Granex FI Hybrid'. This is an early maturing high yielding attractive, thick flat onion with thin yellow scales. The flesh is medium firm, crisp and mild in flavor. The shape and size is uniform leading to higher market prices, and the storage quality is good.**
- **'Texas early Grano'. This is a fresh market, early maturing variety with a rather short shelf life. It is yellowish, mild and not very pungent. The bulbs are high top shaped with dry yellow scales. It is a heavy yielder for altitude regions.**
- **'White Creole'. This is a white variety normally used for dehydration.**
- **'Green bunching': Non-bulbing spring onion**

When buying seed and not recognizing the variety name as one of the above, ask if it has been grown in Africa before. If not, better stick to a known variety in order not to lose the whole production.

Planting systems

- **Nursery seeding and transplanting is the most common and practical option in the tropics. Transplants normally have three to five well-formed leaves at transplant time. Roots are pruned during planting, in order not to be bent upwards when transferred to the field. This facilitates early establishment of the plant.**
- **Any germinated bulb of above mentioned varieties would produce 3-6 good size bulbs in about 3 months when planted with the rains. Choose only healthy bulbs for propagation.**
- **Sets are used in some areas in the temperate zones to ensure large bulb size and uniform maturity. Sets are small dry bulbs, approximately 12 mm in diameter, which have been produced the previous season by seeding thickly or growing under conditions that favor rapid bulbing.**
- **Direct seedling is possible and gives excellent results where herbicides can be used and the season is sufficiently long to provide early pre-bulbing growth. In the tropics this method is impractical due to enormous weeding costs in an organic system.**

Husbandry

Do not plant onions after the field has been planted with other Allium plants (for example, garlic). Mulching onions with composted leaves and straw is highly recommended to maintain soil organic content, prevent soil borne diseases, and suppress weeds. Planting onions in raised beds improves drainage and prevents damping-off diseases.
Weeding and harvesting are mostly done by hand, although chemical weed control is possible

but not organic. Crop rotation is important to avoid the build-up of pests and diseases such as nematodes, *Sclerotium* and *Fusarium*.

Nutrient management

Onions respond very well to well decomposed organic manure. Organic manure at 25 to 40t/ha is recommended to obtain high bulb yield.

Harvesting

Harvesting takes place 90-150 days after sowing. Onions are ready for harvest when the leaves collapse. Alternatively the leaves can be bent over and left to dry for 10-12 days. The crop is pulled out by hand and kept for some days in the field with the bulbs covered by the leaves (= windrowing). The leaves are then cut off and the mature bulbs are bagged or packed in crates if they are to be stored.

Freshly harvested onions are dormant and will not sprout for a variable period of time (this depends on the variety). Storage will extend the dormant period. Sprouting will increase in storage temperatures above 4.4°C. It will decrease again as temperatures exceed 25°C.

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Information on Diseases

Purple blotch (*Alternaria porri*)

Purple blotch attacks onion, garlic, leek and other *Allium* crops. Initially, small white sunken spots develop on the leaves. These enlarge and under moist conditions, turn purple with a yellowish border and are often

covered with a sooty deposit of spores. After 3-4 weeks the leaves turn yellow and collapse. Bulbs may also be attacked, mainly at the neck. This can be seen as a yellow to reddish watery rot.
A good timing of sowing or transplanting can minimize purple blotch attack by *A. porri*, depending on the local environmental conditions. The fungus requires rain or persistent dew for reproduction. It can grow through a wide temperature range of 6 to 33.8° C. Optimum temperature of fungal growth is 25° C.

Purple blotch
Purple blotch on onion. Leaf-tip dieback is a typical symptom of infection by *Alternaria porri* on onion and shallot.

© Gerlach W. (www.ecoport.org)

What to do:

- **Varieties with waxy foliage are generally more resistant than those with glossy leaves.**
- **Increased ploughing between seasons may reduce the disease.**
- **Increased spacing between plants also may reduce disease development.**
- **]Other good practices include seed treatment, rotations, removal of crop debris and planting in well-drained soil.**
- **Under conventional production system fungicides are used when the disease is severe. In organic production systems no direct measures are allowed.**

Downy mildew (*Peronospora destructor*)

It attacks young plants, appearing as white specks, usually confined to the oldest leaves of young plants. A greyish white mould develops rapidly in cool damp weather and progresses down the sheath, and plants eventually fall over and dry up.

Optimum temperatures for fungal growth are between 13 and 20° C. Because of the temperature requirements of the fungus, the disease is more serious in higher cooler areas.
The fungus survives in seeds, bulbs, sets, and on plant debris. Spores are carried long distances by air currents. The fungus can infect onion, Welsh onion, Egyptian onion, garlic, shallot, leek and possibly some other species of *Allium*.

What to do:

- **Use healthy seeds or sets**
- **Use resistant varieties, if available**
- **Rotate at least 3-years free of onions**
- **Wider spacing of plants help reducing humidity**
- **Preventative treatments with rock powder can reduce the attack of this disease.**

Downy mildew
Downy mildew (*Peronospora destructor*) on onion



Downy mild... **Downy mild...** **Downy mild...**

More Information on Downy mildew

Bacterial soft rots (*Erwinia carotovora* subsp. *carotovora*)

This is a big cause of loss in storage onions. Bacteria *Erwinia carotovora* subsp. *carotovora*) can enter the neck tissue as plants mature and then invade one or more scales. At this stage, the

affected tissues are water-soaked and pale yellow to light brown. As the rot progresses, the invaded fleshy scales become soft.

Diseased bulbs can be diagnosed by pressing on the bulb: a watery, foul-smelling fluid often can be squeezed from the neck of diseased bulbs.

Bacterial soft rot bacteria enter only through wounds. Onion maggots (*Delia antiqua*) may carry the bacteria and introduce them while feeding. Onions with mechanical injuries, bruises or sunscald under warm, humid conditions are particularly susceptible to bacterial soft rot. Soft rot can affect many vegetables including carrots, celery, potato and parsnip.

What to do:

- **Onion tops should be allowed to mature well before harvesting**
- **Care should be taken to avoid bruising during harvesting and packing**
- **Storage places should be well ventilated to avoid accumulation of moisture on the surfaces of bulbs**
- **Onions should be stored at 0° C and a relative humidity (RH) of 65 - 70%.**

Soft rot on carrot
Bacterial soft rot caused by (Erwinia carotovora var. carotovora) - here on carrot

© Oregon State University

Soft rot o...

Onion fly

Slippery skin (*Pseudomonas allicolai* pv. *allicola*)

There are no symptoms on the outer surface of bulbs during early stages of disease

development. When the bulb is cut open lengthwise, one or more of the inner scales can be found water-soaked or appears as if it has been cooked. The rot does not progress crosswise in the bulb. After the decay has progressed, the tissue begins to dry, the onion shrivels and secondary organisms can enter and cause a wet rot. The base of the bulb can be pressed hard enough to cause the centre core to slip out at the top, and for this reason the disease is known as slippery skin. The disease is favoured by high moisture.

What to do:

- **Proper maturing of the crop**
- **Quick drying after harvest**
- **Proper storage as in the case of bacterial soft rot**

Sour skin (*Pseudomonas cepacia*)

In contrast to soft rot and slippery skin, infected scales are not water-soaked but are slimy and yellow. Symptoms usually visible only after onions are dug. The upper portion of the bulb shrinks, and in advanced stages of the disease, the outer dry skin readily slips off during handling while the centre of the bulb still remains firm. Outer layer of scales often becomes darkened and almost orange. Decay of inner scales leads to a soft rot that has a sour, vinegar-like odour. The disease is favoured by wet warm conditions.

Sour skin
Sour skin (*Pseudomonas cepacia*) of onion.

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

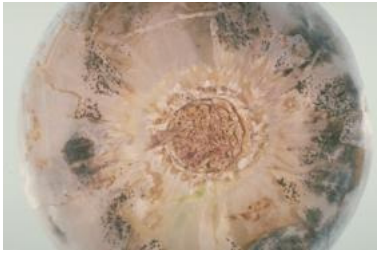
What to do:

- **Management measures for the disease are the same as for slippery skin.**

More Information on Sour skin

Anthracnose (Onion smudge) (*Colletotrichum circinans*)

It usually appears in fields just before harvest and continues to develop during storage period. Under warm and wet soil conditions, it can cause seedling damping-off. The most common symptom is the small dark green or black stains (dots) on outer scales of bulbs. The dots develop concentric rings. In severe cases, the fungus attacks the living tissue causing a collapse of fleshy scales. On colored onions, the fungus is restricted to the neck of the bulbs making the flattened leaves colorless. The fungus survives on onions, sets and in the soil. Warm moist conditions favor development of the disease.
Optimum temperature for infection is from 23.9 to 29.4° C. White onions are very susceptible to the disease. Reduced market value results from marred bulb appearance and bulb shrinkage. It also attacks leeks and shallots.



Anthracnose
Anthracnose (*Colletotrichum circinans*) on onion

© Denis Persley, www.ecoport.org

What to do:

- **Disease management involves growing coloured varieties where smudge is a persistent problem.**
- **Harvesting the crop promptly**
- **Avoiding exposure to rain between harvest time and storage.**

White bulb rot (*Sclerotium cepivorum*)

The disease occurs mainly in the field and seldom causes injury in storage. The disease is called white rot because of characteristic basal bulb rot where the tissue is covered with white mat of fungal growth. Later numerous rounded black fungal bodies (sclerotia), each about the size of a pin's head, develop. The leaves of diseased plants decay at the base, turn yellow, wilt, fall over and die. The older leaves are the first to die. The roots of affected plants are usually rotted making the plants easy to pull.
Optimum temperature range for infection is from 15 to 18.3° C. The fungus survives in the soil as sclerotia and also in diseased onion sets and wild onion. It is most severe in light cool moist soils. Its host range includes Welsh onion, garlic, leek, shallot and some species of wild onion.

White rot
White (bulb) rot (*Sclerotium cepivorum*). Symptoms on onion bulbs. Infected onion bulbs displaying sclerotia (black) and hyphae (white) on the base.

What to do:

- **Plant tolerant / resistant varieties, if available.**
- **Use healthy seeds**
- **Practice long rotation (8-10 years)**
- **Destroy wild onions and leeks**
- **Manure from animals fed on diseased plant material should not be used on onion fields.**

Onion rust (*Puccinia porri*)

Affected leaves show small reddish to dusty orange spots (pustules). These later turn black and are covered until maturity

by leaf epidermis. Leaves that are heavily infected turn yellow and die prematurely. A new crop of leaves may develop and the bulb size is usually reduced. The fungus attacks also leek, shallot and some wild species of *Allium*. The disease is favoured by high humidity coupled with moderate to low temperatures. Also excessive nitrogen in the soil favours disease development.

What to do:

- **Disease management involves rotation, and removal of weed hosts.**

Rust
Rust (*Puccinia porri*) on onion

© A.M. Varela, icipe

Fusarium basal rot (*Fusarium oxysporium* f.sp. *cepae*)

The above ground symptoms constitute yellowing of leaf blades at the tip. The yellowing at later stages cover the whole blade. The affected leaves shrivel and decay. Diseased plants can be easily pulled out because the root system is rotted. Affected roots are dark brown, flattened, hollow and transparent. When diseased bulbs are cut vertically, a brown discoloration is evident. The fungus survives in any soil moisture that permits crop growth. Infection is facilitated by injuries to root system, Losses can occur in the field and in storage.

The disease is most prevalent where onions are grown under high temperature conditions. Although of no economic importance the disease could attack garlic, shallots, chives and

Fusarium basal rot
Fusarium basal rot (*Fusarium oxysporium* f.sp. *cepae*) on onion

© David B. Langston, University of Georgia,

leeks. It also can survive in weed, *Oxalis corniculata*. **Bugwood.org**

What to do:

- **Rotate with non-related crops**
- **Avoid root injury**
- **Carefully harvest the bulbs**
- **Proper cure the bulbs before storage**
- **Store the bulbs at 0° C / 65-75% relative humidity is recommended**

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Information on Pests

Onion thrips (*Thrips tabaci*)

The onion thrips are major pests of onions throughout Africa. The onion thrips attack an extensive range of crops, including cereals and broadleaved crops. They are tiny (1 mm in length), slender and very mobile insects. Adult thrips are pale yellow to brown in colour. Immature thrips are whitish to pale yellow. Both immature and adult thrips pierce the upper surface of the leaves and feed on the plant sap, generally on the developing leaves, deep inside the plant. This results in white and silvery patches on the leaves.

Thrips
Thrips (*Thrips tabaci*) on onion. Leaf scaring injury.

© Whitney Cranshaw,

The excreta of the thrips are clearly visible as small black dots

on the silvery leaves. Severe infestations can cause browning of the leaf tips, slowing of plant growth, distortion of leaves and bulbs, and reduction in bulb size. Although thrips feeding during the early bulbing stage is the most damaging to yields, thrips must be controlled before onions reach this stage so that populations do not exceed levels that can be adequately controlled. Onions can tolerate higher thrips populations closer to harvest.

Colorado State University, www.insectimages.org (Courtesy of EcoPort, www.ecoport.org)
More Information on Thrips

What to do:

- **Thrips infestations are more severe in dry seasons, and entire fields may be destroyed. To prevent infestation, keep plants well irrigated. Dry plants are more susceptible to thrips damage than well watered ones.**
- **Remove weeds, as the thrips population builds up on them.**
- **Remove heavily infested plant material.**
- **For control, neem extracts can be sprayed on attacked plants. However, care should be taken, since some neem preparations, in particular those with high oil content, can be phytotoxic to onions, specially at high concentrations (Schmutterer, 1995).**
  Therefore, when using a neem-based pesticide for the first time, it should be first tested for phytotoxicity on some plants. For more information on neem click here.
- **Also a garlic bulb extract can be sprayed thoroughly on the whole plant, preferably early in the morning. Spraying should be particularly directed to the neck area of the plant for good penetration into the plant. For information on garlic bulb**

extract clik here.

- **Spray with insecticide 'Spinosad'. When using pesticides, read product label and ensure preharvest interval is observed**

Onion fly (*Delia antiqua*)

The larvae of the onion fly, also called onion maggot is a major pest of onions. The maggot is small (about 8 mm in size when fully grown), white-cream coloured. It eats the lateral roots, then tunnels into the taproot and sometimes bores into the base of the stem. Attacked leaves wilt and the leaves turn bluish. The plants become shrivelled or eventually die. The maggots feed just above the base of seedlings killing them. A maggot can attack several seedlings in succession. This causes poor plant establishment resulting in many gaps in the field.
The maggots are also found inside developing onion bulbs. Their feeding exposes the plant to infection by diseases such as bacterial soft rot. Pupae are light to dark-brown in colour, and about 7 mm in length. Pupae are found in the soil near the base of the plant. The adult is a brownish grey fly, somewhat smaller than house flies. When at rest, they keep their wings folded one over the other. Adult flies do not cause damage. They lay eggs in the soil surface near the germinating plants.
Onion maggots are adapted to cool, wet weather, so usually they are less of a problem during hot dry periods. They prefer soils heavy in organic matter. The onion maggot attacks plants related to onion such as leeks, shallots and garlic.

Onion fly
Onion fly maggot (*Delia antiqua*) on onion

© Jarmo Holopainen

Onion fly

Onion fly

What to do:

- **Avoid planting in soils that are high in undecomposed organic matter, such as fields just coming out of pasture or in very weedy conditions. Flies prefer to lay eggs in soil that is moist and with high organic matter. Do not plant onions unless the plant residues are dry and completely decomposed.**
- **In soils amended with animal manures, allow adequate time for the manure to break down before planting.**
- **Avoid planting successive onion crops. Practice rotation with crops not related to onions.**
- **Keep onion fields well separated. Onions grown in the season following an attack by onions flies should be sown as far away from infested land as possible.**
- **emove and destroy infested plants and burn them.**
- **To prevent an infestation with onion flies, carefully plough-under crop residues immediately after harvest.**
- **Turn soil to destroy pupae.**
- **Powdered hot pepper or powdered ginger placed around the stems helps when the onion fly population is moderate.**
- **Neem-based products have a deterrent effect on egg-laying. For more information on neem click here.**

Leafminers (*Liriomyza* spp.)

Leafminers may cause damage to green onions. Damage is largely cosmetic, and mining on leaves may cause rejection of marketed onions, but generally does not affect plant growth. Damage in dry onions and garlic is of little concern unless

populations become so high as to prematurely kill foliage.

What to do:

- **Leafminers are usually controlled by natural enemies, especially parasitic wasps. They can become a problem in areas with a high use of pesticides that kill natural enemies. Leafminers have the ability to develop resistance to pesticides in a short time. For more information on natural enemies click here**

Leafminer
Leafminer (*Liriomyza* spp.) symptoms on onion

© Ooi P. (Courtesy of EcoPort, www.ecoport.org)
More Information on Leafmining flies (leafminers)

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Fresh Quality Specifications for the Market in Kenya

The following specifications constitute raw material purchasing requirements

PRODUCE:	ONION
IMAGE:	
VARIETY:	Various Red
OTHER NAMES:	Creole
GENERAL APPEARANCE CRITERIA	
COLOUR	With purple-red skin and purple-red edges on the white fleshy scales.
VISUAL APPEARANCE	Well-formed shape with smooth double layer of papery skin covering the overlapping concentric layers of flesh. Remnant cut stem not >50mm and roots not >10mm in length Free from foreign matter.
SENSORY	Firm, crisp texture; sharp flavour, not too pungent. Free from foreign and 'off' smells or tastes.
SHAPE	Squat to rounded squat.
SIZE	Loose 60 - 75 mm
MATURITY	Well cured, no greenery, with tight necks.
[illegible]	[illegible] of live insects.

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Information Source Links

- **Foster, R., Flood, B. (Eds) (1995). Vegetable Insect Management with emphasis on the Midwest. Purdue Research Foundation. ISBN: 0-931682-52-5.**
- **AIC, Ministry of Agriculture and Livestock (2003). Fruits and Vegetables Technical handbook.**
- **Beije, C.M., Kanyagia, S.T., Muriuki, S.J.N., Otieno, E.A., Seif, A.A., Whittle, A.M. (1984). Horticultural Crops Protection Handbook. KEN/75/028 and KEN/80/017. National Horticultural Research Station, Thika, Kenya.**
- **Bohlen, E. (1973). Crop pests in Tanzania and their control. Federal Agency for Economic Cooperation (BFE), Germany. ISBN: 3-498-64826-9.**

- **CAB International (2005). Crop Protection Compendium, 2005 edition. Wallingford, UK www.cabi.org**
- **How to Manage Pests. Onion and Garlic. UC Pest Management Guidelines. UC IPM Online. Statewide Integrated Pest Management Program. University of California. Agriculture and Natural Resources. http://ipm.ucdavis.edu**
- **Kuepper, G. (2004). Thrips Management Alternatives in the Field. National Sustainable Agriculture Information Service- ATTRA. http://attra.ncat.org**
- **Ministry of Agriculture and Rural development and Japan International Cooperation Agency (2000). Local and Export Vegetables growing Manual. Agricultural Information Resource Centre, Nairobi, Kenya**
- **Oisat: Organisation for Non-Chemical Pest Management in the Tropics www.oisat.org**
- **Schmutterer, H. (1995). Effects on Viruses and Organisms. Thysanoptera: Thrips. In: The neem tree Azadirachta indica A. Juss. and other meliaceous plants sources of unique natural products for integrated pest management, industry and other purposes. (1995). Edited by H. Schmutterer in collaboration with K. R. S. Ascher, M. B. Isman, M. Jacobson, C. M. Ketkar, W. Kraus, H. Rembolt, and R.C. Saxena. Pages VCH. Pages 251-254. ISBN: 3-527-30054-6.**
- **Shanmugasundaram, S. (2001). Suggested cultural practices for onion. Edited by T. Kalb. AVRDC Training guide, AVRDC.**
- **Sherf, A.F., Macnab, A.A. (1986). Vegetable Diseases and Their Control. 2nd. Edition. John Wiley & Sons Inc. ISBN: 0-471-05860-2.**
- **The World Vegetable Center Learning Center (Onion) www.avrdc.org**
- **Youdeowei, A. (2002). Integrated pest management practices for the production of vegetables. GTZ. Integrated Pest Management Extension Guide 4. Published by The Ministry of Food and Agriculture (MOFA) Plant Protection and Regulatory Services Directorate (PPRSD), Ghana with the German Development Cooperation (GTZ). ISBN: 9988-0-1088-5.**
- **East African Seed Co. Ltd. Africa's Best Grower?s Guide www.easeed.com**

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