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Sweet potato
Scientific name: *Ipomoea batatas*
Order/Family: Solanales: Convolvulaceae
Local names: Viazi vya tamu (Swahili); Makwasi (Kikamba, Kenya); Mapwoni (Luyia, Kenya)
Pests and Diseases: African armyworm Aphids Black rot Diplodia black storage rot Domestic and wild animals Eriophyd mites Fusarium wilt Mild mottle virus Millipedes Rats Root-knot nematodes Sweet potato butterfly Sweet potato hornworm or hawk moth Sweet potato moth Sweet potato virus complex Sweet potato weevil Termites Tortoiseshell beetles Whiteflies Termites

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General Information and Agronomic Aspects

Sweet potatoes are perennial vines, with one main season. It is widely grown throughout East Africa on a small scale mainly in subsistence farming and currently gaining popularity again along with other

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 Sweet Potato in Africa

indigenous foods. The roots are eaten either boiled or roasted alone or with other foods such as milk, porridge, soups or meat. Young leaves are used as vegetable. The sweet potato vines are a useful and nutritious fodder crop, especially in the dry season. Some varieties are especially suited for this, producing abundant tops.

Among the great diversity of cultivars grown, two types are commonly recognised. The staple types, grown throughout the tropics, are usually white, red or purple, although yellow-fleshed types are becoming popular in Africa and Asia. The orange-fleshed types, typically have a higher sugar and vitamin A and lower dry matter content. Nutritionists in East Africa are promoting the use of yellow fleshed sweet potato varieties to combat wide spread vitamin A deficiency which decrease children's resistance to infectious diseases, contributing to infant mortality. The young leafy shoots, which are eaten as a green vegetable in some countries, are high in protein (approximately 20% of dry weight), and are also a good source of b-carotene, thiamine (vitamin B1), riboflavin (B2), folic acid and ascorbic acid (Villareal et al., 1985; Woolfe, 1992 quoted from International Potato Center (CIP) information).

Climate conditions, soil and water management

Sweet potato is grown between latitudes 48°N and 40°S. At the equator it is grown at altitudes ranging from sea-level to 3000 m. Its growth is maximum at temperatures above 25°C; when temperatures fall below 12°C or exceed 35°C, growth is retarded.

Sweet potato is a sun-loving crop; however, it can tolerate a 30-50% reduction of full solar radiation. It grows best with a well-distributed annual rainfall of 600-1600 mm during the growing season. Dry weather favours the formation and development of storage roots. Sweet potato is relatively drought tolerant, however, it cannot withstand long periods of drought; the yield is

Teff
Tomato
Wheat
Yam
Zucchini/Courgette
Pests/ diseases/ weeds
Medicinal plants
Fruit and vegetable processing
Natural pest control
Cultural practices

considerably reduced if drought occurs about the time of planting or root initiation.

Maintaining soil organic matter is probably the most important management practice for managing water supply in rainfed crops. Organic matter incorporated through the soil will help it to hold more water and remain moist for longer. Plant mulches applied to the surface of the soil also help to reduce surface evaporation and keep the soil temperature even. They also prevent soil crusting and improve infiltration when it rains. Weeding is also important, as weeds compete with the crop for water and accelerate soil drying. Uprooted weeds can be left on the soil as mulch.

Where irrigation is available, a number of factors should be considered in irrigation management:

- The aim is to keep the soil moisture conditions as constant as possible. In general, more frequent, light irrigations are preferred to larger water applications.
- Sufficient water should be applied to wet the root zone, without causing deep drainage or run-off. Apart from being wasteful of water, overwatering can cause considerable loss of soil nutrients (leaching) while contaminating the groundwater and streams with the nutrients, which may be directly toxic to people or promote algal growth and eutrofication.
- Light-textured (sandy) soils will require more frequent irrigation than soils with high clay or organic matter content. Light-textured soils will also require less water to wet them through, and are more prone to leaching and run-off losses.
- The crop's water needs will be much higher in clear, hot and/or windy weather than in still, overcast weather.

The crop can be grown on a wide range of soil types, but a well-drained, sandy loam with a clayey subsoil is considered ideal. It cannot stand water logging and is usually grown on mounds or ridges. Flooding shortly before harvest may result in storage roots rotting in the soil

or during subsequent storage. The optimum soil pH for sweet potato is 5.6-6.6, but it grows well even in soils with a relatively low pH, e.g. 4.2. It is sensitive to alkaline or saline soils.

Sweet potato grows best and produces smooth, well-shaped storage roots in a well-prepared soil. Good land or soil preparation involves removal or incorporation of crop debris and any vegetation that may compete with the sweet potato crop, and deep manual or mechanical cultivation.
Cultivation aims to turn over the topsoil and loosen the compacted soil below, to achieve a good tilth for forming the hills or ridges, and provide a soft, uniform medium where storage root growth is not impeded. This can be achieved by thorough plowing and harrowing, depending on soil condition. Plant mulches, manures or other additives such as lime, gypsum or rock phosphate, that have been applied to the surface, are mixed into the soil for greatest effect. Loosening up the soil increases the oxygen content, which favours the development of microorganisms.

After cultivation, the land is usually prepared into ridges. Mounds are preferred by farmers working entirely with hand tools. In some areas, broad raised beds are used. On deep, well-drained soil, planting may be done on flat fields.
Ridges should be oriented along contours on sloping land, to maximise rain infiltration and minimise erosion. Ridges are typically about 30-45 cm high, but may be higher in wet areas to maximise soil drainage. They are usually between 90 and 120 cm apart.

Propagation and planting

If there is no critical dry season, sweet potato can be planted at any time. In regions with a critical dry season, planting early in the rainy season is the best. It is usually planted towards the end of the rainy season if this is long and very wet.
Sweet potato planting material is either obtained from vine cuttings, the most common source, or from storage roots.

Use of stem cuttings: Farmers obtain cuttings from an established crop before or just after the harvest of storage roots. The cuttings are either used to establish a maintenance field, or directly for planting the next sweet potato crop. Below are some factors affecting yield, when using stem cuttings:

- **Care should be taken to select 'clean' planting material. This means choosing cuttings that are free of insects, soil, and any symptoms of viruses or fungal diseases.**
- **Generally the apical (tip) portion of the vine is better than the middle or basal portions. This portion is less likely to carry sweetpotato weevils and fungal pathogens, and has been found to establish faster than other portions. For cultivars with long vines, the second or third cut is acceptable. Sometimes, the second cutting is better than the tip portion, if vine growth has been so fast that the stem has not matured in the apical portion.**
- **Length of cutting is less important than the number of nodes. Typical size is 20-40 cm, with 5-8 nodes. The conditions of the field may influence the relationship between cutting length and crop development. Farmers should experiment to decide what length is best under their conditions.**
- **Usually one-third to two-thirds of the cutting is buried. A minimum of 2-3 nodes, but up to about 8 nodes, is placed under the soil.**
- **The delay between cutting and planting may affect yield depending on the storage conditions for the cuttings. Storing cuttings for one to two days in humid conditions may be beneficial, promoting rooting at the nodes. Longer storage may adversely affect establishment by exhaustion of the cuttings' energy reserves. To minimise losses, leaves should be stripped from the lower portion of the cutting, and bundles of cuttings wrapped in a wet cloth or sack and kept in a cool, shady place away from wind. If roots develop during storage, they should be planted carefully to minimise damage to the roots.**
- **If planting material is to be maintained in a multiplication plot before planting of the next crop, plant cuttings at approximately 15 x 20 cm spacing. New growth may be ready for cutting after 45 days.**

Use of storage roots: Storage roots are used when there are insufficient stem cuttings available, or when the level of pest and disease infestation is high so that few healthy vines are left. They may also be used in highly mechanised production, as the sprouts can be harvested mechanically from the seedbed. Healthy storage roots should be selected from plants that produced high yield. The roots are planted densely in a seedbed located away from other sweetpotato crops. Roots are covered with about 3 cm of soil, and the bed covered with straw to help retain moisture. When the sprouts have grown long enough, they are cut near their base and planted directly in the field. To maximise the number of cuttings, remove the tips of the sprouts when they are about 20 cm long to promote branching.

Rapid seed multiplication: When large amounts of cuttings are needed, rapid multiplication may be done. Although the merit of this practice has not been fully acknowledged by sweet potato growers, it can be the easiest way to produce large amount of planting materials. This method involves the following steps:

- **Cuttings of about 30 cm are taken from either established plants or sprouted storage roots. These are then cut into single node cuttings, with the leaf attached. The tip of the vine is discarded.**
- **A seedbed is prepared with a mixture of loose, humus-rich soil and ash. The single-node cuttings are planted at a high density, with the stem section buried and the leaf upright.**
- **The seedbed is regularly watered and is prevented from drying especially during the first week of establishment.**
- **After about two weeks, when the seedlings have developed enough roots, they should be transplanted into the field. They should be removed from the seedbed with care to avoid damaging the roots. Transplanting should be done in the late afternoon to avoid excessive evaporation and wilting.**

Degeneration of planting material

When sweet potato is vegetatively propagated for a number of generations, yield decline is often observed. This is usually due to a build-up of viruses, many of which show no obvious symptoms. This often gives the impression that a new variety (carrying few viruses) yields much better than traditional varieties, when in fact it may be no better after a year or two when viruses have accumulated.

Viruses can be removed by heat treatment and meristem culture (from research institutions). This process usually results in a yield increase from 20 to 200%, of both vines and roots, depending on the severity of the original virus infestation. The higher yield may be maintained for several years in the field, before the virus load has built up again.

Planting method

After ridges or mounds are formed, the sweetpotato cuttings are planted by burying the lower part in the top of the ridge or mound. A hole may be made with a stick or by hand, and the soil gently pressed around the inserted cutting. The stem is usually placed at an angle. Some workers claim that cuttings oriented across the ridge yield better than those oriented along the ridge. In ridge planting systems, ridge spacing is typically 90-120 cm, and in row spacing is 20-30 cm (3-5 plants per meter). Generally, a higher plant density results in lower yield per plant but higher yield per hectare. Close spacing is used with short growing seasons, and wider spacing may be preferred where the market prefers larger storage roots.
For mounds, the size and spacing of the mounds depends on soil conditions. They may be 75-200 cm apart, and may be planted with several cuttings per mound.
Some farmers plant two cuttings at each mound, but there is little evidence that this is advantageous. It has been reported that single cuttings produce a higher proportion of large storage roots.

Varieties

Farmers plant a mixture of varieties, mostly based on yield, performance, maturity, culinary values and tolerance to pests. This strategy reduces the risk of failure since the varieties have different useful characteristics. Sweet potato varieties planted in north-eastern Uganda are presented in the table below.

Variety	Characteristic
"Osukut"	Early maturing, good yield, sweet, good marketability.
"Araka Red"	Early maturing, good yield, tolerant to *Cylas* spp
"Araka White"	Early maturing, good yield.
"Lira Lira"	Early maturing, good yield.
"Ateseke"	Good yield.
"Igang Amalayan"	Early maturing, good yield.
"Latest"	Early maturing, good yield, sweet.
"Osapat"	Good yield.
"Ekampala"	Good yield.
"Tedo Oloo Keren"	Good yield, tolerant to *Cylas* spp.
"Odupa"	Tolerant to *Cylas* spp.

Source: Ebregt et al, 2004.

The varieties grown in Kenya include:

"SPK 013"	Recommended for the western zone including the Lake basin
"SPK 004"	Suitable for most areas in the country
"Kemb 20"	
"Kemb 23"	Suitable for Central and coastal lowlands

"Kemb10"	Suitable for most areas in the country
"KSP20"	Good performance in dry areas
"KSP11"	Good performance in dry areas
"Simama"	
"Japaneese"	
"Mugande"	
"Muibai"	
"Ex-Diani"	Suitable for central and coastal lowlands
"Mafuta"	Best for foliage production. Good for all areas.
"CIP 420009"	Good performance in dry areas

Husbandry

Weed infestation during the first 2 months of growth poses a problem in stand development, and requires adequate control to ensure high yield. Thereafter, vigorous growth of the vines covers the ground effectively and smothers weeds. In the tropics, manual weeding is generally practised.

Sweet potato responds well to fertilisation, particularly if the land has been continuously cropped. However, fertiliser is seldom applied in the tropics. Manure or good compost should be incorporated to improve soil fertility. This is a common practice in smallholdings and traditional agriculture. Sweet potato is used in a wide variety of cropping systems around the world. Rotating sweet potato with other crops such as rice, legumes and maize is desirable to control diseases, pests and weeds. Intercropping sweet potato with other crops is very common in Africa.

Nutritional deficiencies can be determined using the guide provided in the website of the International Potato Center: http://www.lucidcentral.org/keys/sweetpotato

Harvesting

The harvesting period of sweet potato storage roots is not clearly defined; it varies with cultivar, cultural practices and climate. 'Progressive harvesting' (piece-meal harvesting) is common practice in tropical countries where sweet potatoes are grown for home consumption. It is generally recommended to harvest within 4 months to prevent weevil damage. In the tropics, manual harvesting using implements such as a stick, spade or hoe is practised.

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Information on Pests

Sweet potato weevil (*Alcidodes erronus*)

The sweet potato weevil is the most destructive insect pest of sweet potato in the tropics and subtropics. No resistant source is available.

Farmer experience: In Kilifi, Kenya, farmers create planting mounds or ridges incorporating a good amount of fresh leaves of Lantana camara before planting sweet potatoes. This improves soil organic matter and at the same time serves as a repellent of the sweet potato weevil, thus improving both yield

Sweet potato weevil
Sweet potato weevil (*Alcidodes erronus*). Adult

and quality of harvested tubers. The superior quality of sweet potatoes grown using Lantana leaves have been confirmed by Ministry of Agriculture staff in the area.

What to do:

- **Rotation with cereals and forage crops**
- **Eradicate Ipomoea weeds**
- **Use clean planting material, deep planting and regular hilling to fill soil cracks around plants**
- **Flood to drown the weevils**
- **Hill up to prevent or fill soil cracks**
- **Irrigate to prevent soil cracks**
- **Mulch to keep the soil moist and prevent cracks, and provide a more favourable environment for natural enemies**

female, body length 6-8 mm.

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Sweet pota… **Sweet pota…**

More Information on Sweet potato weevil

Root-knot nematodes (*Meloidogyne* spp.)

The nematodes belong to *Meloidogyne* spp.. Symptoms consist of poor growth, yellowing of foliage and or wilting of plants during dry hot weather. Root swellings or galls develop on feeder roots. Harvested roots often are misshapen, cracked, and rotted on the surface.

What to do:

- **Use resistant varieties, if available.**
- **Rotate with cereals and forage grasses.**

Root-knot nematodes Roots infected with Root-knot nematodes. Field symptoms are typically of

stunted, poorly growing plants with yellowing leaves. Infected root systems show characteristic knots or galls.

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More Information on Root-knot nematodes

Millipedes

Apart from insects other pests reported to cause damage to sweet potatoes are millipedes. They are also known as "thousand-legged worms" or "Mombasa train". They have many legs (30-400) with a hard-shelled, round segmented body and are up to 30 cm long. They are brown to blackish brown in colour. They move slowly and curl-up when disturbed. Millipedes lay eggs single or in clusters of 20-100 in the soil. They live in moist soil and congregate around the plants in soil that is rich in organic content. They dry out easily and die. Thus, they seek wet places, such as compost piles, leaves and other plant debris, to hide under during the day.

Millipedes have recently become important pests of sweet potato in some areas of East Africa. Infestation tends to be severe at the beginning of the long rainy season often causing farmers to plant late. According to farmers in Uganda, millipedes generally do not

Millipedes
Millipedes are brown to blackish in colour and curl-up when disturbed.

© Agricultural Research Council of South Africa, EcoPort

affect the roots until 5 months after planting. They may be a problem when harvesting of sweet potato is delayed, especially if the roots are stored 'in-ground on the plants' during the dry season and harvesting is done at the first rains of the following growing season. Millipedes maybe a problem in nurseries located in shady sites (for example under a tree), especially if the nurseries are used for long time.

What to do:

- **In areas where millipedes are a problem, do not rotate sweet potatoes with crops that are also attacked by millipedes, in particular groundnuts, and to a lesser extent cassava and beans.**
- **Some varieties are perceived by farmers in Uganda to have some tolerance to millipede damage: "Araka White","Tedo Oloo Keren", "Latest", "Lira Lira", "Odupa", "Ajara", "Bibi", "Chapananca", "Dyong Bar", "Josi-Josi" and "Acan-Kome-Tek".**

Domestic and wild animals

Domestic animals (e.g. pigs, cows and goats) and wild animals (e.g. wild pigs, porcupines, baboons, monkeys, elephants, hippos, guinea fowl) can cause serious damage to sweet potatoes.

What to do:

- **The presence of hedges or thorn fences may act as deterrents against some of these**

pests.

- **Domestic animals can be tethered. This is particularly important during the planting material production time when there is a high incidence of damage due to grazing by straying livestock.**

Rats

Rats and mole rats occasionally feed on sweet potato storage roots either by digging through the ridges or accessing the exposed roots. They often spoil more roots than they actually eat. Rats and mice breed in burrows, destruction of these burrows can help reduce populations. Rodents like to hide in vegetation and rubbish, as they do not like crossing open spaces where they may be seen and exposed to predation, keeping the field and surrounding areas clean should reduce damage.

What to do:

- **Some farmers dig a deep ditch around the perimeter of their field to deter rodents from digging tunnels straight into their fields.**
- **Traps can be set but care must be taken to ensure they are placed in locations where livestock and children will not interfere or get hurt by them.**
- **In areas of Tanzania farmers reported spreading the leaves of the local shrub 'intwinti' as a repellent.**
- **In Western Kenya a mixture of cow dung and pepper is made, placed in the burrows and then burnt to smoke the rodents out.**
- **Experiments showed that mole rat damage to cassava could be reduced by planting on mounds rather than ridges, and by planting the deep rooted, poisonous shrub Tephrosia vogelii in the field (CIP, the VITAA Partnership).**
- **Farmers in Wangige, Kenya chase away mole rats by pouring fermented cattle urine (one**

week old) into their burrowing holes. They report this method as being very effective.

The sweet potato butterfly (*Acraea acerata*)

It is found in all sweet potato production areas in Eastern Africa, but is only considered an important pest in relatively dry areas. The adults are butterflies with orange wings with black margins. These butterflies are capable of flying distances of several kilometres. They lay small, pale yellow eggs in clusters on leaves. Caterpillars are greenish-black and are covered with short-branched spines. Fully-grown caterpillars are about 25 mm long. Caterpillars feed on leaves of sweet potato. Young caterpillars feed in groups on the upper leaf surface protected by a layer of webbing for the first two weeks.

Older caterpillars become solitary and nocturnal hiding on the ground during the day. They eat the whole leaf leaving only the midribs. Heavy attack may result on complete defoliation. Mature caterpillars crawl up supports such as tall grasses, leaves or walls near the sweet potato field in order to find a site to pupate in vertical position. The pupae are yellowish and hang singly on their support. The total lifecycle takes 27-50 days. Caterpillars are attacked by predatory ants, ladybird beetles, lacewings and dragonflies. The fungus *Beauveria bassiana* has been observed on caterpillars in the field during the rainy season.

Sweet potato butterfly
Sweet potato butterfly (*Acraea acerata*) with orange and black wings with brown margins; 3-4 cm wingspan

What to do:

- **Look for sweet potato butterflies and damage early in the season and destroy caterpillars in webs **Use clean uninfested planting material**Plant and harvest early. This enables the crop to escape heavy attacks**Intercropping sweet potato with onion/ or the silver leaf desmodium (Desmodium uncinatum) might reduce the number of eggs laid by the females (CIP, the VITAA Partnership)**

Beet armyworm (*Spodoptera exigua*)

Armyworms may damage sweet potatoes. Young caterpillars scrape sweet potato leaves, while the older caterpillars feed producing large irregular holes and may leave only the veins. Mature caterpillars measure up to 4 cm long and are generally black, heads faintly mottled with dark brown spots and with light yellow stripes at their backs (IRRI, 2001).

Predatory bugs, carabid beetles, spiders and wasps attack the caterpillars, and many parasitic wasps are also known to attack armyworms. Fungal diseases have been observed infecting caterpillars in the field.

What to do:

- **Eliminate weeds**
- **Collect and destroy leaves containing eggs and caterpillars**
- **Light traps can be hung over basins of water in the field to trap the adults at night**
- **When necessary the biopesticide Bt can be used for control**

Beet armyworm
Fully grown larva of Beet armyworm *(Spodoptera exigua)*

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More Information on African armyworm

of this pest. For more information on Bt click here.

Sweet potato moth (*Omphisa anastomasalis*)

The sweet potato moth is a minor pest in West Africa. Damage to sweet potato plants results from the caterpillar boring into the main stem leading to the roots. Vines with severe tunnelling show weak growth and poor foliage development; this foliage later yellows and wilts. The distal part of the vine above the damage site often dies. Such plants show poor storage root formation. In some cases caterpillars may bore directly into storage roots. This moth is a pest in Asia, but its status in East Africa is unknown.

What to do:

- **Handpick caterpillars or attacked vines and destroy them. This is feasible in small plots.**

Sweet potato moth
Sweet potato vine borer larva (*Omphisa anastomasalis*) on sweet potato (2.5-3 cm long)

Sweet potato hornworm or the hawk moth (*Agrius convolvuli*)

Adults are large grey hawk moths with black lines on the wings and broad incomplete pink bands on the abdomen. The female lays small spherical greenish eggs singly on either surface of the leaves. Caterpillars have a conspicuous posterior horn. They are variable in colour, usually greenish or brownish. Fully-grown caterpillars are large (up to 9.5cm long and 1.4cm broad). They

pupate in the soil.

Caterpillars feed on leaves, causing irregular holes. They may eat the entire leaf, leaving only the petiole. Insect frass can often be found near the infested plant part. One large caterpillar can defoliate a plant on its own. When older caterpillars are present in large numbers they can defoliate a field overnight. Yield losses can occur if heavy defoliation takes place when the crop is young. But, if the young plants are healthy and growing well, they can recover. However, damage to the leaves may delay harvest, increasing the likelihood of attack by the sweet potato weevil.

What to do:

- **Handpick caterpillars from leaves. This is usually sufficient in small areas.**
- **Turning the soil over between crops exposes the pupae to predators and to the sun heat.**
- **Light traps can be used to monitor the population of moths.**
- **Manual removal of small caterpillars can prevent the build-up of a large population of older caterpillars.**

Mature larva of Sweet potato hornworm larvae (*Agrius convolvuli*) on *Merremia peltata*. Mature larvae reach 9 - 10 cm in length.

Tortoiseshell beetles (*Aspidomorpha* spp.)

Adults are broadly oval and shield-like, 6-8 mm long, and may be brightly coloured. They lay eggs singly or in batches on the underside of sweet potato leaves; sometimes the eggs are covered by a papery layer. The larvae are oval, flattened and

spiny. Some species of tortoiseshell beetle larvae hold their tails up over their back, usually with excreta and previous cast skins. The pupa is less spiny than the larva, and is fixed to the leaf.

Both larvae and adults feed on leaves. The young larvae scrape on the upper surface of the leaves leaving the lower surface intact, while older larvae and adults eat large round holes in the leaves. Severe attacks can sometimes skeletonise the leaves and peel the stems. The damage on leaves is conspicuous, but generally is not of economic importance.

What to do:

- **Usually control is not necessary, removal of nearby alternative host plants may reduce the tortoiseshell beetle populations.**
- **Alternatively, planting far away from alternative host plants may help reducing damage to sweet potatoes. Alternative host plants include morning glory, coffee, potatoes, beets, and various flowers.**

Tortoiseshell beetle
Tortoiseshell beetle (*Aspidomorpha* sp.) is 6-8 mm long.

Whiteflies (*Bemisia tabaci*)

Whiteflies feed on the lower leaf surface. Direct damage by adults and nymphs sucking sap from the plant, is generally not economically important. However, high numbers of whiteflies may affect plant development, particularly during period of water stress and drought. They are more damaging as vector of virus diseases.

What to do:

- **Conserve natural enemies. Parasitic wasps and predators such as predatory mites, ladybird beetles, and lacewings are important in natural control of whiteflies.**
- **Spray neem extracts. Neem products inhibit growth and development of immature stages, repel whitefly adults and reduce egg laying.**

Whiteflies under leaf
Whiteflies under leaf. Adults are small (1-3 mm long).

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More Information on Whiteflies

Aphids (*Aphis gossypii* and other species)

Aphids suck sap from leaves and stems. They may cause considerable damage during periods of water stress. Aphids are vectors of virus diseases.

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.**
- **Use reflective mulches. Reflective aluminium mulches deter aphids from landing on plants. The effect is lost once plants are large enough to cover the mulch.**
- **Neem extract and soap sprays have been reported effective against aphids. For more information on neem click here. For more information on soap sprays click here.**

Aphids
Cotton aphid (*Aphis gossypii*) is a small aphid. Adults range from just under 1-1.5 mm in body length.

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More Information on Aphids

Eriophyid mites (*Aceria* sp)

They causes hairiness on sweet potato, a common problem in many parts of East and Southern Africa also known as "erinose". Eriophyid mites are tiny, much smaller than the spider mites (about 0.2 mm long) and look like a speck of dust. They are not visible with the naked eye. The mites feed in the buds and on young foliage of sweet potato plants, injecting growth substances into it, which induce the plant to produce a dense mat of hairs. As a result the stems, leaf petioles, buds and undersides of leaves become covered with a dense layer of white hairs. The leaves and plants are also generally slightly stunted; the leaves and stems thickened, and the plants yield poorly.

Occasionally, whole crops are affected but often the symptoms affect just one or a patch of plants, and often only particular varieties. The mites invade crops by being blown like dust particles in the wind.

What to do:

- **Little is known about them despite their commonness and little is known about how to control them.**
- **Some varieties of sweet potato seem more prone to infestation than others but no research has been done so far. Where hairiness is a problem, farmers could plant varieties that are least affected.**

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Information on Diseases

Black rot (*Ceratocystis fimbriata*)

The disease is caused by the fungus *Ceratocystis fimbriata*. Dark circular spots appear on infected roots. These spots can expand to cover much of the sweet potato. Small black fungal fruiting bodies (perithecia) develop and are visible at the centre of the spots. The diseased tissue is darkened and bitter in taste. On young sprouts black spots develop eventually encircling the plant causing dwarfing, yellowing of the foliage and finally death.

More Information on Black rot

The fungus survives in the soil in diseased plant debris and also in diseased stored roots. The disease is favoured by temperatures near 25° C and moist soil conditions. In storage, decay progresses most rapidly in moist conditions at temperatures of 14 to 27° C.

What to do:

- **Plant disease-free sprouts.**
- **Practice a 3-year rotation and proper weeding.**
- **Do not wash roots in water after harvest as contaminated water may spread the disease from infected roots to healthy.**
- **Follow good sanitary practices in packing and storage buildings.**

Diplodia black storage rot (*Botryodiplodia theobromae* (*Diplodia tubericola*))

The disease is caused by the fungus *Botryodiplodia theobromae* (*Diplodia tubericola*). It

affects sweet potatoes in storage. The inner part of the infected edible root becomes black and brittle. Many tiny black fungal bodies (pycnidia) form just below the sweet potato skin giving the root a pimply appearance. Infection occurs through broken ends and abrasions on storage roots. Wet conditions favour disease spread and development.

What to do:

- **Use disease-free sprouts.**
- **Harvest roots carefully to minimise injuries.**
- **Do not store injured or wounded roots.**
- **Practise good storage hygiene and management.**
- **Ensure good ventilation in the store.**

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

It is caused by the fungus *Fusarium oxysporum* f. sp. *batatas*. Initial symptoms on sweet potato are yellowing of the leaves. Leaves later wilt and fall off, stunting results and eventually death of the plant. Death of the stem vascular bundles occurs with brown to purple discoloration; this may be accompanied by cracking of the stem. The vines may turn tan to light brown. Diseased plants may manage to produce storage roots, but these usually have some discoloured, infected vascular tissues. Rot may follow in storage or the disease may be transmitted to the next crop by infected cuttings. Dying vines often have pinkish fungal growth.

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

What to do:

- **Use resistant varieties, if available.**
- **Use disease-free planting stocks.**
- **Avoid fields with a history of wilt.**
- **To reduce infection near transplanting time is to hold transplants for 24 hours at 29°C to promote suberisation of the injured surface, also yield loss can be reduced by planting more than one transplant per hill. Even though the percent of plants affected is not reduced, yield per unit land is maintained because there is less chance that all plants in a hill will be killed and also because productivity is similar for single-plant and multiple-plant hill.**

from the Crop Protection Compendium, 2005 Edition. © CAB International, Wallingford, UK, 2005.
More Information on Fusarium wilt

Mild mottle virus

It is caused by a potyvirus (sweet potato virus B/ sweet potato virus T/ sweet potato ipomovirus). The virus is transmitted by whiteflies (*Bemisia tabaci*). The virus has a wide host range including tomato, tobacco and ornamental species. Symptoms of the disease include leaf mottling and plant stunting. The wishbone flower (*Torenia fournieri*) is a potential wild reservoir host in East Africa.

Mild mottle virus
Mild mottle virus symptoms on sweet potato leaf

© Alan A. Brunt. Reproduced from the Crop Protection Compendium, 2006 edition. Wallingford,

What to do:

- **Use plant resistant varieties: (e.g. in Uganda the variety "Namujuna").**
- **Use disease-free planting material.**
- **Isolate new plantings from old plantings.**

- **Control the virus vector (whiteflies). For more information on how to control whiteflies click here** **UK**

Sweet potato virus complex

This disease is caused by a combination of sweet potato feathery mottle virus (SPFMV) and sweet potato chlorotic stunt virus (SPCSV).
Symptoms include severe stunting of plants, the production of small distorted leaves, excessive branching, yellowing of vines and dark, brown to blackish corky spots in the roots.
SPFMV is a potyvirus transmitted by aphids in a non-persistent manner whereas SPCSV is a crinivirus transmitted in a semi-persistent manner by the whitefly *Bemisia tabaci*.

What to do:

- **Use resistant or tolerant varieties, if available.**
- **Use disease-free planting material.**
- **Avoid diseased plants as sources of planting material.**
- **Practice proper field sanitation.**
- **Control the virus vectors. For information on how to control aphids click here. For information on how to control whiteflies click here.**

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Information Source Links

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Sorghum
Scientific name: *Sorghum bicolor*
Order/Family: Cyperales: Poaceae
Local names: Mtama (Swahili)
Pests and Diseases: African armyworm African bollworm African maize stalkborer Anthracnose Aphids Birds Charcoal rot Covered kernel smut Crazy top downy mildew Cutworms Damping-off diseases Ergot Head bugs Head smut Leaf blight Loose kernel smut Maize dwarf mosaic virus Other bugs Purple witchweed Rust Shoot fly Sorghum midge Spotted stemborer Storage pests Termites Chafer grubs

General Information and Agronomic Aspects
Information on Pests and Weeds
Information on Diseases
Information Source Links

General Information and Agronomic Aspects

In Africa, a major growing area runs across West Africa south of the Sahara almost to the coast and eastward into Sudan, Ethiopia, and Somalia. It is grown in upper Egypt but is minor along the north African coast. It is commonly grown in Uganda, Kenya, Tanzania, Rwanda, and Burundi and fairly important in Zambia, Malawi, and drier areas of

- 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
- Teff

Geographical Distribution of Sorghum in Africa

Mozambique. It is important in Botswana and Lesotho and common in South Africa, and minor in Namibia.

Sorghum is perhaps the world's most versatile crop. Some types are boiled like rice, some cracked like oats for porridge, some "malted" like barley for beer, some baked like wheat into flatbreads, and some popped like popcorn for snacks. A few types have sugary grains and are boiled in the green stage like sweet corn. The whole plant is often used as forage, hay, or silage. The stems of some types are used for building, fencing, weaving, broom making, and firewood. The stems of other types yield sugar, syrup, and even liquid fuels for powering vehicles or cooking meals. The living plants are used for windbreaks, for cover crops, and for staking yams and other heavy climbers. The seeds are fed to poultry, cattle, and swine. (Lost Crops of Africa, Vol I, 1996) Sorghum plays an important role as a food security crop especially in semi arid lands of Kenya. It can survive drought conditions for some weeks by rolling up its leaves and thus decreasing transpiration. Please also check KARI update: "Sorghum helps provide better food security", July 1997, available in English on http://www.kari.org/ENGLISH/Sorghumfood.htm (click to follow link) or in Swahili http://www.kari.org/KISWAHILI/MtamaChakula.htm

Climate conditions, soil and water management

Sorghum is adapted to a wide range of environmental conditions and will produce significant yields under conditions that are unfavourable for most other cereals. Sorghum is particularly adapted to drought.

Sorghum also tolerates water logging and can be grown in areas of high rainfall. It is, however, primarily a plant of hot, semi-arid tropical environments with rainfall from 250 mm that are too dry for maize but performs best with more than 900 mm annually. It is also grown widely in temperate regions and at altitudes of up to 2500 m in the tropics. Sorghum tolerates a wide

Tomato
Wheat
Yam
Zucchini/Courgette
Pests/ diseases/ weeds
Medicinal plants
Fruit and vegetable processing
Natural pest control
Cultural practices

range of temperatures. Sterility can occur when night temperatures fall below 12-15°C during the flowering period. Sorghum is killed by frost.

Sorghum can be grown successfully on a wide range of soil types. It is well suited to heavy clay soils (vertisols) found commonly in the tropics, where its tolerance of water logging is often required, but is equally suited to light sandy soils. It tolerates a range of soil pH from 5.0-8.5 and is more tolerant of salinity than maize. It is adapted to poor soils and can produce grain on soils where many other crops would fail.

Propagation and planting

Sorghum is normally grown from seed. A fine seed-bed is preferable but is often not achieved. The seed is usually sown directly into a furrow following a plough, but can also be broadcast and harrowed into the soil. Optimum plant spacing depends on soil type and availability of moisture. For favourable conditions, row spacing of 45-60 cm and plant-to-plant spacing of 12-20 cm, giving populations of about 120 000 plants per ha, are normal. For drier or less fertile conditions, wider spacing and lower plant populations are usually optimal. The seed rate varies from 3 kg/ha in very dry areas to 10-15 kg/ha under irrigation. Occasionally, seedlings are grown in a nursery and transplanted into the field early in the dry season, e.g. on the floodplains round Lake Chad in Africa.

Production zones in Kenya and recommended sorghum varieties and their major characteristics:

Eco-zone and area	Variety	Maturity months	Grain colour	Yield potential Bags/acre
Moist-mid-altitude Busia, Siaya, Kakamega, Kisumu, Homabay, Kuria, Migori, Coffee zones of Meru, Embu and Nyeri Districts	Serena Serodo KARI/MTAMA	3 3.5 3-3.5	Brown Brown Brown	12 12 15

Semi-arid low lands Machachos, Kitui, Makueni, Mwingi, Lower Embu and Tharaka Nithi, Kajiado, Parts of Rift Valley, Parts of North Eastern Provinces	**1576 KARI/MTAMA**	**3 3-3.5**	**White Brown**	**10 15**
Cold semi-arid Highlands Nakuru, Baringo, Laikipia, Naivasha, Narok, Parts of Koibatek, Taita Taveta	**E 1291 E 6518**	**7 8**	**Brown brown**	**12 15**
Humid Coast Lamu, Kilifi, Taita Taveta, Kwale, Mombasa	**Serena Serodo**	**3 3.5**	**Brown Brown**	**12 12**

Husbandry

Sorghum is usually grown as a rainfed crop, sown after the onset of the monsoon season. Seeding rates are often higher than optimum to compensate for poor seed-bed or to allow for unfavourable moisture conditions. All sorghum varieties require a fine seed bed for better seedling establishment. If tractor or oxen are used to open up a shamba, it is advisable to harrow after the first ploughing. When jembes (hoes) are used for land preparation, farmers are advised to ensure that large clods are reduced by breaking them to provide a smooth seed bed. The planting field should be prepared well in advance of sowing. Seed rate is 7-10 kg/ ha or 3-4 kg/acre. Dry planting is highly recommended. Thus plant before or at the onset of rains by either drilling in the furrows made by tractor or oxen plough, or hill plant in the holes made by jembe or panga. When dry planted, planting depth should be 5 cm but when planting in a moist soil use planting depth of 2.5-4 cm. Common row spacing is 75 cm and distance between plants about 20 cm. In semi arid areas where the ox plough yoke is fixed at 90 cm especially in Machachos, Makueni, Kitui and Mwingi districts, the recommended spacing between plants is 15 cm.

Subsistence farmers rarely apply fertilizer, as responses depend on moisture availability, which is usually very uncertain. Under more favourable conditions, farmyard manure is used with advantage, but even so the quantities used are usually below optimum. Optimally sorghum needs the availability of about 20 kg N/ha and 20 kg P/ha at planting time, which can be supplied by alternate cropping with legumes and application of compost or manure. Also intercropping with legumes is recommended with grain legumes such as beans, cowpeas, pigeon peas and green gram. Manure and compost improve organic matter content of the soil, soil moisture retention ability and soil structure. Manure can be broad cast in the field or applied in planting furrows and mixed with soil before seeds are planted. The standard farm wheelbarrow when full holds approximately 25 kg of dry manure/compost. At a low rate, two wheel barrows are enough for a 10m by 10m area. This translates into 200 wheelbarrows or 5 tons/ha. When aiming for high rate apply 400 wheelbarrows or 10 tons per ha.

The crop is usually weeded by a combination of inter-row cultivation with animal-drawn implements and hand weeding within rows. Thinning is carried out at the same time as hand weeding, or at intervals during the crop cycle, particularly where thinnings are used to feed livestock. Gapping by transplanting thinnings is encouraged when thinning is done within 2 weeks after emergence and when the soil is moist.

Sorghum ratooning

Ratooning is a practice of getting more than one harvest from a single sowing. Two ratooning systems have been identified. One in the bimodal rainfall zones in semi arid lowlands giving 2 crops and the other in the moist mid altitude coffee zones where the local varieties are the two seasons ratooning type. A ratoon crop compared to a newly sown crop has an established root system which will utilize the available water in the root zone for crop growth early in the season, reduce ploughing and planting labour and avoid migratory quelea birds in August by maturing early.

In bimodal rainfall zones of semi-arid lowlands in Eastern province sorghum is planted in short rains (October- November). When the crop is mature, it is harvested in February and immediately ratooned to take advantage of the long rain season which starts in mid-March. To achieve good yields, the crop is thinned to 2-3 tillers per hill. Weeding and other management practices are done as for a newly sown crop.

Harvesting

Sorghum is usually harvested by hand when it has reached physiological maturity - which means the grain is hard and does not produce milk when crushed. Cut the heads with sickles or a sharp knife from plants in the field or cut the whole plant and remove the heads later. Sun dry the harvested panicles to a moisture level of 12-13 % and thresh and store the grain. For further information on storage, please also refer to datasheets on grains and legumes e.g. green gram (click to follow link).

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Information on Diseases

Anthracnose (*Colletotrichum graminicola*)

The anthracnose fungus damages foliage and stems of grain sorghum. On susceptible hybrids, the stem holding the head (peduncle) becomes infected and a brown sunken area with distinct margins develops. When infected stems are cut lengthwise with a knife, one can see that the fungus has penetrated the soft pith tissue and caused brick-red discolorations. This peduncle infection inhibits the flow of water

and nutrients to the grain causing poor grain development.

The fungus also invades individual grains and the small branches of the panicle. Rapid and severe yield loss can result from panicle and peduncle infections. Leaf lesions are small, elliptical to circular, usually less than 3/8-inch in diameter. These spots develop small, circular, straw-coloured centres with wide margins that may vary in colour from reddish to tan to blackish purple. The spots may coalesce to form larger areas of infected tissue.

What to do:

- **Use resistant hybrids**
- **Rotate with non-cereals preferably with pulses**
- **Good management of crop residues**

Anthracnose (*Colletotrichum graminicola*) on sorghum

More Information on Anthracnose

Damping-off diseases

They are caused by various fungi. Seed may be attacked by one or more seedborne or soil-borne pathogens prior to either germination or emergence. This usually occurs when conditions are not optimum for plant development, such as in poorly-drained, cold, wet soils, or in very dry, crusted soils. Sorghum seedlings are very delicate during the emergence period and are slow to establish a permanent root system. As a result, sorghum depends upon its primary, temporary root system for a period longer than many other crops. Under less than optimal growing conditions, this primary root system is extremely vulnerable to soil-borne pathogens. This is when damping-off in a field is most visible and damaging. Affected seedlings are unthrifty and may show yellowing, wilting and death of leaves. Roots of

diseased plants may be discoloured (whitish grey to pinkish brown) and rotted.

What to do:

- **Use certified disease-free seeds**
- **Avoid planting in poorly drained soils**

Maize dwarf mosaic virus (MDMV)

Maize dwarf mosaic is a virus disease that occurs over all the sorghum producing areas. Its ability to cause damage is dependent on the presence of an over-seasoning virus host (mainly Johnson grass), aphid populations to facilitate virus transmission and the susceptibility of the varieties being grown. Affected plants have mottled (light green blotches) terminal leaves. These alternate light- and darker-green areas in the leaf can be more easily seen when held between the viewer and a light source. Observers should always look at the newest leaves for the most severe symptoms. Highly susceptible hybrids are stunted with chlorotic symptoms in the upper leaves and suffer significant yield losses. Some hybrids produce a red leaf symptom when plants are infected and when night temperatures are below 13° C.

What to do:

- **Use resistant/tolerant hybrids**
- **Control Johnson grass in and around the field**

Covered kernel smut (*Sporisorium sorghi*)

The disease destroys all kernels in a head and replaces them with a cone-shaped gall or may affect only portions of a panicle. At

harvest time, these galls are broken and spores contaminate the outer surface of other kernels.

What to do:

- **Use of certified disease-free seed**
- **Plant resistant hybrids**

Covered kernel smut
Covered kernel smut (*Sporisorium sorghi*) on sorghum

© J. Kranz, www.ecoport.org

Loose kernel smut (*Sphacelotheca cruenta*)

It attacks all groups of sorghum including Sudan-grass and Johnson grass. Galls formed by loose kernel smut are long and pointed. The thin membrane covering the galls usually breaks soon after galls reach full size. The dark-brown spores contained in the galls are wind-blown away leaving a long, dark pointed, curved structure (called columella), in the central part of the gall. As in covered kernel smut, the spores of the fungus are carried on the seed and germinate soon after the seed is planted and invades the young sorghum plant. It continues to grow unobserved inside the plant until heading, when the long pointed smut galls appear in the heads in place of normal kernels. Unlike

Loose kernel smut
Loose kernel smut (*Sphacelotheca cruenta*) on sorghum

covered kernel smut, this disease stunts the infected plants and often induces abundant side branches.

© Kranz J., www.ecoport.org

What to do:

- **Certified disease-free seeds**
- **Plant resistant varieties**
- **Control weeds**
- **Rotation with non-cereals**
- **Practice good field sanitation**

Head smut (*Sporisorium reilianum*)

This disease is characterized by the large, dark-brown smut galls that emerge in place of the panicle. The gall is first covered with a whitish membrane, which soon breaks and allows spores to be scattered by the wind. Plants become infected while in the seedling stage but evidence of infection is not apparent until heading time. The smut gall produces thousands of spores, which become soil-borne and initiate systemic infection of seedlings in subsequent years. Different races of the fungus exist which may result in a sorghum hybrid being resistant in one area but not another.

What to do:

- **Utilize resistant hybrids to avoid losses**
- **Use disease-free seed**
- **Rotation with non-cereals**
- **Plough deep**

Charcoal Rot (*Macrophomina phaseolina*)

Grain sorghum plants affected by the charcoal rot fungus fail to fill grain properly and may lodge in the latter part of the season. Infected stalks show an internal shredding at and above the ground line. 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. Another type of stalk rot (Pythium sp. and Fusarium sp.) may show the shredded condition but the black specks (sclerotia) will be lacking.

Conditions under which charcoal rot is favoured include stressful hot soil temperatures and low soil moisture during the post-flowering period. Host plants are usually in the early-milk to late-dough stage when infection occurs. The fungus is common and widely distributed in nature.

What to do:

- **Avoid moisture stress**
- **Manage properly crop residue**
- **Rotate crop with non-cereals and pulses**
- **Avoid excessive plant populations**
- **Balance nitrogen and potassium fertility levels**
- **Grow drought-tolerant, lodging-resistant hybrids**

Rust (*Puccinia purpurea*)

Rust appears on leaves as small raised pustules or blisters that rupture and release many reddish-brown spores. These pustules occur on both the upper and lower leaf surfaces. This disease

usually appears when plants near maturity and infection are confined primarily to mature leaves. Grain yield losses are usually not serious and occurrence of the disease is sporadic. Forage sorghum yields may be affected most. The rust fungus also attacks Johnson grass and over-seasons on this host.

What to do:

- **Use resistant varieties**
- **Rotate with non-cereals**
- **Control weeds**

Rust
A sorghum rust infection (*Puccinia purpurea*) at this level can cause substantial reduction in yield.

© Nowell DC, EcoPort

Ergot (*Claviceps sorghi*)

Cream to pink sticky droplets "honeydew" ooze out of infected florets on panicles. The droplets dry and harden, and dark brown to black sclerotia (fungal fruiting bodies) develop in place of seeds on the panicle. Sclerotia are larger than seed and irregularly shaped, and generally get mixed with the grain during threshing. Conditions favouring the disease are relative humidity greater than 80%, and 20 to 30°C. The sclerotia falling on the soil or planted with the seed germinate when the plants are flowering. They produce spores that are wind-borne to the flowers, where they invade the young kernels and replace the kernels with fungal growth. The fungal growth bears millions of tiny spores in a

Ergot
Ergot (*Claviceps africana*) on sorghum crop

© Odvody G. (Courtesy of

sticky, sweet, honeydew mass. These spores are carried by insects or splashed by rain to infect other kernels.

EcoPort, www.ecoport.org)

What to do:

- **Plant resistant varieties, where available**
- **Remove affected panicles**
- **Avoid planting seeds from infected panicles**
- **Plough deep**
- **Rotate with non-cereals preferably with pulses**
- **Practice good field sanitation**

Leaf blight (*Helminthosporium turcicum*)

Leaf blight (*Helminthosporium turcicum*) It attacks sorghum, Sudan-grass and maize. The causal fungus is carried on the seed and also lives in the soil on dead or decaying plant material. It may cause seed rot and seedling blight, especially in cool and excessively moist soil. Seedlings then can become infected readily and may either die or develop into stunted plants. Small reddish-purple or yellowish-brown spots usually develop on the leaves of infected seedlings.

The spots may join to kill large parts of the leaves, which then dry to the extent that severely affected plants look as if they have been burnt. A greenish, mould-like growth of spores develops in the centre of the leaf spots during warm, humid weather. The spores are spread by wind or rain and infect other leaves and

Leaf blight
Leaf blight (*Helminthosporium turcicum*)on sorghum

© Nowell DC, Courtesy of EcoPort, www.ecoport.org

plants. Under warm, humid conditions the disease may cause serious damage by killing all leaves before plants have matured.

What to do:

- **Plant resistant varieties**
- **Use certified disease-free seeds**

Crazy top downy mildew (*Sclerophthora macrospora*)

This fungal disease can be troublesome in low lying areas that become flooded. Infected plants have thick, stiff, twisted, pale green leaves with bumpy surfaces. The leaves often turn downward, and the plants produce many shoots or suckers giving a bunchy appearance. Infected plants do not produce heads or produce a proliferation of leafy tissue in place of the head. Wild and cultivated grasses can serve as sources of infection.

What to do:

- **Plant resistant varieties**
- **Remove diseased plants from the field**
- **Rotate with non-cereals**
- **Avoid excess soil moisture in the field**

Crazy top downy mildew
Crazy top downy mildew (*Sclerospora graminicola*)

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Information on Pests and Weeds

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

Several species damage sorghum. They may cut off young plants at or slightly below the soil surface. Some feed on above-ground plant parts, and others feed on the roots. Plants with severed stems die, leaf feeding by cutworms cause ragged leaves and feeding on roots may kill young plants or stunt older plants.

Chaffer grubs (*Schizonycha* spp) also feed on roots and may kill very young seedlings. Stand loss can occur within ten days after plants emerge in severely infested fields.

What to do:

- **Harrow and plough field and remove weeds well ahead of planting the crop in the field. Ploughing exposes caterpillars to predators and to desiccation by the sun. If the field is planted soon after land preparation some cutworms may be alive and attack the new crop**
- **Inspect soil carefully when preparing land for planting for the presence of cutworms or white grubs**
- **Monitor damage by counting damaged and freshly cut young plants**
- **Collect and destroy cutworms. Cutworms are found in the soil close to damaged plants at day time. Monitor cutworm at dawn**

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


Black cutw... **Whiteg**

More Information on Cutworms

Storage pests

Sorghum is very susceptible to damage by storage pests, the main ones being greater grain weevils, in particular the rice weevil (*Sitophilus oryzae*), the flour beetle (*Tribolium castaneum*) and the grain moth (*Sitotroga cerealella*). Heavily attacked grain losses much of its content and become unfit for sale and consumption.

What to do:

- **Damage can be minimized by drying grain adequately before storage. Cultivars with hard grain also suffer less damage.**

Rice weevil
Rice weevil (*Sitophilus oryzae*). The adults are small (2.5 to 4.0 mm long).

© Food Agency and Ministry of agriculture, forestry (Courtesy of EcoPort, www.ecoport.org)


Rice weevi.. **Grain moth**

More Information on Storage pests

Birds

Birds are one of the most important pests of sorghum. They are capable of causing heavy losses. In Africa the most notorious species is Quelea quelea and is found in the Sahel region, from Senegal in West Africa through to Sudan, Uganda, Kenya, Southern Tanzania, Malawi, Zambia and South Africa.

What to do:

- **Damaging birds are mainly controlled by scaring them away from the sorghum fields and attacking their nesting sites. But not all birds are harmful. Some are also important predators and prey on insect pests of crops.**

Purple witchweed (*Striga hermonthica*)

The parasitic weed Striga is a major pest of sorghum, particularly in Africa, where severe infestations can lead to land being abandoned. Striga attaches itself to sorghum roots depriving it of nutrients and preventing them from establishing and growing properly.

Witchweed
Witchweed (*Striga hermonthica*) flowering on a sorghum crop. *S. hermonthica* is a herbaceous annual plant 30-100 cm high, the most robust forms occurring in Sudan and

What to do:

- **Striga can be controlled manually by vigorous uprooting before it produces seeds and/or by intercropping sorghum with fast spreading legumes which deprives the weed of sunlight and exude chemical substances the reduce striga growth. Desmodium for instance has been shown to depress striga almost completely. Considerable efforts have been**

dedicated to develop resistant varieties. Some of the varieties/lines developed or identified with resistance in Africa are: Dobbs, SAR 1 to 34, L.187, ICSV 1002, SRN, Framida, IS938 (ICRISAT).

Ethiopia.

More Information on Purple witchweed

The sorghum shoot fly (*Atherigona soccata*)

Shoot fly
Shoot fly (*Atherigona soccata*) The adults are dark brown, and similar to a housefly, but nearly half the size.

It is the most important pest of sorghum at the seedling stage. The adult is similar to the housefly, smaller in size (3-5 mm long), and greyish in colour, and abdomen yellow with brown patches. The larvae or maggots are yellowish or whitish in colour, up to 8 mm long. The fly lays eggs either at the base of young shoots near soil surfaces, or in older plants, on the leaves. The maggots crawl inside the sheath and bore into the heart of the young shoot killing the growing point and the youngest leaf, which turns brown and withers. This damage is known as "dead heart". When good growing conditions prevail the young plants are usually able to compensate the damage by producing new tillers, which may partly escape attack, but later the ripening of the earheads will be unequal. In weak plant repeated infestation may cause serious losses. Sometimes the damage is so severe that many seedlings die and the field has to be replanted. Older plants (over 30 days after seedling emergence) are generally not damaged by the shoot fly. However, when shoot flies are abundant (during the


Shoot fly


Sorghu sh...

rainy season under moderate temperatures and high humidity) older plants may be attacked, but they do not produce the dead-heart symptoms. Instead, the damaged leaf becomes thin and papery, and wraps around the other leaves. As a result, the plants may fail to grow normally. Late infestations may also damage the panicle in the formative stage, resulting in rotting or drying up of a portion of the panicle affected by shoot fly damage.

What to do:

- **Conserve natural enemies. A range of natural enemies attacks the sorghum shoot fly: parasitic wasps attack eggs and maggots and predators cause high mortality of eggs. In particular, several species of spiders are important predators on eggs. For more information on natural enemies click here**
- **Field sanitation. Crop residues should be collected and destroyed after harvest to reduce carry-over from one season to another.**
- **Plant resistant/tolerant varieties where available: Trials in Southern Africa has shown significant differences in resistance to shoot fly damage among varieties tested. Although the level of resistance in many of the sorghum varieties was low, several varieties with moderate levels of resistance were identified. Varieties Pirira-1 and Pirira-2 were the most resistant across seasons (van den Berg et al, 2005). In eastern Africa, varieties Serena and Seredo showed high levels of recovery resistance following shoot-fly damage (CABI; ICRISAT).**

- **Early sowing make often possible to have the period of vulnerability (seedling stage) over by the time the flies emerge.**
- **Uniform sowing of the same variety over large areas with the onset of rains reduces the damage by sorghum shoot fly.**
- **High seeding rates helps to maintain optimum plant stands and reduce shoot fly damage. There are reports that shoot-fly damage is higher when plant densities are low (CABI, 2000).**
- **Balanced fertilizer application. Application of fertilizer has been related to lower damage by shoot-fly possibly by increasing plant vigour. However, Shoot-fly damage has been found to be greater in plots treated with cattle manure. This may have been due to the attraction of shoot flies to the odours emanating from the organic manure.**
- **Intercropping. It has been shown that shoot fly damage is reduced when sorghum is intercropped with leguminous crops.**
- *** Fallowing and a closed season reduce the carryover and build-up of the shoot fly from one season to the next. These practices have been successfully used to reduce shoot-fly damage at ICRISAT. However, they may not practical for small-scale growers due to the shortage of land.**

African bollworm (*Helicoverpa armigera*)

It causes damage to sorghum by eating the seeds. Damage is particular serious on compact headed sorghums. The caterpillars appear on the earheads when the grains are in the milkripe stage. These caterpillars also feed on whorl leaves. A

heavy infestation can cause an almost complete loss of yield.

What to do:

- **Inspect field once or twice a week after sorghum begins to bloom. Check for presence of caterpillars by shaking heads over a bucket or sweep net**
- **If necessary spray with Bt or neem extracts. Good spray coverage is very important, particularly in partially opened heads or in varieties that have tight heads where young caterpillars are well protected. 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
Fully-grown caterpillar of the African bollworm (*Helicoverpa armigera*) is 3 - 4cm long.

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

African armyworm (*Spodoptera exempta*)

It is an occasional but seriously destructive pest. It causes serious damage to young plants in years of armyworm outbreaks. The leaves are eaten away often leaving only the base of the stem.

What to do:

- **Monitor regularly field margins, low areas where plants have**

African armyworm
African armyworm

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

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

© University of Arkansas

More Information on African armyworm

Stemborers: Spotted stemborer (*Chilo partellus*)

Sorghum is attacked by several species of stemborers. The most important species include the spotted stalkborer (*Chilo partellus*), the pink stalkborer (*Sesamia calamitis*) and the maize stalkborer (*Buseola fusca*).

The feeding activity of the caterpillars inside the stems causes stunted plant growth, sterile or poorly developed earheads. Plants may dry and die if the infestation is severe.

What to do:

- Early planting to ensure maximum pest escape.

Spotted stemborer
Spotted stemborer (*Chilo partellus*) are up to 25 mm long when fully grown.

© Agricultural Research

- **Use resistant varieties.**
- **Habitat management. Intercropping sorghum with pulses (cowpeas, groundnuts) in alternate rows, may reduce stemborer incidence by 20-30%.**
- **Sanitation (destruction of crop residues, volunteer plants and alternative hosts). Crop residues (stalks and other residues) should be destroyed after harvest through burning the stalks, or fed to livestock. However, burning of crop residues may not be practical in communities where soil fertility is low and no fertilizers are used since crop residue is the only source of organic matter.**
- **Biological control. Recent research work on stemborers has been focussing on the introduction exotic parasitoids in countries where Chilo partellus is wide spread.**

Council of South Africa. Courtesy of Ecoport (www.ecoport.org)
More Information on Spotted stemborer

Head bugs (*Calocoris angustatus* and *Eurystylus oldi*)

Nymphs and adults of the head bug (Calocoris angustatus) and the African head bug(Eurystylus oldi) feed on developing kernels as panicles emerge from the boot. Head bugs are small (3 to 5 mm long, and about 1 mm wide) and variable in colour from yellowish green (C. angustatus), or pale brownish-yellow to dark brown with red markings (E. oldi). Females insert long, cigar-shaped eggs between the glumes or anthers of sorghum florets. Eggs usually hatch in less than a week. Nymphs and adults suck juice from developing kernels as panicles emerge from the boot. Kernels attacked early in development are shrivelled, small, and off-coloured, resulting in yield loss. Bug-damaged kernels become infected by secondary pathogens that further deteriorate grain quality. Feeding punctures are visible on older kernels. The life cycle is completed in about three weeks. At least two generations feed on the same crop when panicles in the field do not mature at the same time.

What to do:

- **Conserve natural enemies. Assassin bugs and lygaeid bugs prey on earhead bugs. For more information on natural enemies click here.**
- **Selection of varieties. Open panicles are less affected than compact panicles.**
- **Resistant varieties. Some sorghum varieties are resistant to bugs.**
- **Timing of planting. Damage is less severe when kernels develop during dry periods.**

Bugs

A number of bugs feed on the milkripe sorghum grains: shield bugs including stink bugs (*Nezara viridula*, *Acrosternum* spp), *Mirperus jaculus*, *Riptortus dentipes*, Lygus bugs, blue bug (*Calidea degrii*) among others. The bugs puncture the seeds and suck the contents. Feeding punctures remain as dark spots on the testa. The seed weight is reduced; the rate of germination may be depressed. Sorghum is most susceptible to bug damage during the milk and soft dough stage. Injury normally is not damaging from hard dough to maturity. The damage is only of economic importance when bugs are present in large numbers.

Green stink bug
Green stink bug (*Nezara viridula*) (nymphs and adults). Adults are about 1.2cm long. (Host: Pearl Millet)

© Russ Ottens, University of Georgia, Bugwood.org

What to do:

- **Use neem-based pesticides. Reportedly they reduce feeding by green shield bugs. For more information on neem click here.**
- **Check for bugs by beating or shaking panicles over a sweep net or bucket**

The sorghum aphid (*Melanaphis saccari*) and the maize aphid (*Rhopalosiphum maidis*)

These are common on sorghum. The sorghum aphid is light yellow in colour, and the maize aphid is dark green to bluish-green in colour. These aphids are often found sucking on earheads or on the underside of leaves. They produce large quantities of honeydew, which enable black sooty moulds to grow. Attacked plants sometimes are stunted, leaves dry up and yield is reduced. Young plants suffering from drought stress maybe killed. Aphids can be a problem during dry periods. Heavy aphid infestations on sorghum at the booting and heading stages seriously reduce both grain quality and yield. The maize aphid transmits the maize dwarf mosaic virus to sorghum.

Maize aphid
Colony on of maize aphids (*Rhopalosiphum maidis*)

© www.inra.fr
More Information on Aphids

Adults are small, 1-4 mm long, soft-bodied insects.

What to do:

- **Conserve natural enemies. Parasitic wasps and predatory insects, including lady bird beetles, damsel bugs, lacewings, and hover fly larvae are important in natural control of aphids**

The sorghum midge (*Stenodiplosis sorghicola*)

It is reported as one of the most important pests of sorghum in some countries, whilst in others (e.g. Ghana) is considered a sporadic pest. Nearly 30% of sorghum grain was damaged by sorghum midge in 1990 in western Kenya. In southern Africa, there are reports of 25% of

sorghum grain damaged by sorghum midge (CABI, 2000). The adults are small (3 mm long), deep-red midges, with transparent wings. Eggs are laid in the flowering heads. The small orange larvae feed in the developing seed. Attacked seeds become shrunken and flat resulting in empty or "chaffy heads" as shrivelled grains fail to develop. The larva pupates inside the spikelet, and before adult emergence, the pupa wriggles its way to the tip of the spikelet. After adult emergence, the pupal case remains attached to the chaffy spikelet. Thus, damaged panicles have small, transparent midge pupal cases attached to the tip of the damaged spikelets.

What to do:

- **Synchronised planting. Epidemics of sorghum midge damage are common within an area, when sorghum is not planted at the same time, or different cultivars are planted that do not mature at the same time. Although landrace varieties often flower uniformly, high-yielding, early-flowering cultivars often do not. Sorghum that is planted and flowers later than normal is exposed to sorghum midge for a longer period and can suffer severe damage.**
- **Planting density and thinning. Midge damage is reported to be higher in crops with low plant density (CABI, 2000).**
- **Selective removal of alternative hosts. Wild species of sorghum (for example, S. halepense and S. sudanense) act as alternative hosts for sorghum midge. Midge populations build up early in the season on wild species of sorghum and infest the sorghum crop later in the season. Removing these alternative hosts from the vicinity of the sorghum crop can reduce the rate of multiplication of sorghum midge populations. However, wild hosts also sustain the natural enemies, and thus may help in increasing the role of natural enemies in population suppression.**
- **Field sanitation. Crop residues should be collected and destroyed to reduce the carryover of larvae in the chaffy spikelets from one season to another.**
- **Fallowing and close season. Fallowing reduces the carryover and build-up of midge**

populations from one season to the next. However, this is not a feasible practice for smallholders due to the shortage of land.

- **Use tolerant/resistant varieties where available. High levels of host-plant resistance are available for sorghum midge. In India, varieties SPH 837 and Pratap Jowar 1430 are claimed to be tolerant to the midge (www.nrcjowar.res.in/aicsip2005/achievements_udaipur.pdf). Also in India, variety DSV-3 is claimed to resistant to midge damage and is recommended to be plant in midge endemic areas (www.uasd.edu/research.htm).**
- **Crop rotations. Sorghum is generally rotated with cotton, groundnuts, sunflowers or sugarcane. This may reduce the damage caused by the sorghum midge.**
- **Mixed cropping. Damage by the sorghum midge is reduced when sorghum is intercropped with leguminous crops (CABI, 2000)**

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Crops/ fruits/ vegetables

African Nightshade
Amaranth
Avocados
Bananas
Beans
Cabbage/Kale, Brassicas
Carrot

more Images

Citrus plants
Scientific name: *Citrus* spp.
Order/Family: Rutales: Rutaceae
Local names: Swahili: Machungwa (oranges), ndimu (limes), limau (lemons), madanzi (grapefruits), chenza (tangerines)
Pests and Diseases: African citrus psyllid Anthracnose Ants Aphids Citrus blackfly Citrus bud mite Citrus rust mite Citrus tristeza virus Damping-off diseases False codling moth Fruit flies Greening disease Leafmining caterpillars Mealybugs Phaeoramularia fruit and leaf spot Phytophthora-induced diseases Red fire or weaver ants Root-knot nematodes Scales

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
Pumpkin
Rice

Swallowtail butterfly Termites Thrips Whiteflies Termites, Couch grass

General Information and Agronomic Aspects

Information on Pests
Information on Diseases

Fresh Quality Specifications for the Market in Kenya
Information Source Links

General Information and Agronomic Aspects

Geographical Distribution of Citrus plants in Africa

The most important species of citrus fruits are:

- Sweet oranges (*Citrus sinensis*)
- Limes (*C. aurantifolia*)
- Grapefruits (*C. paradisi*)
- Lemons (*C. limon*)
- Mandarins (*C. reticulata*). These are often called tangerines.

Citrus varieties of commercial importance include the following:

- Oranges: 'Washington Navel' (alt: 1000-1800 m above sea level), 'Valencia Late', 'Hamlin' and 'Pineapple' (all alt from 0 - 1500 m above sea level)
- Mandarins: 'Kara', 'Satsuma' (0-1500 m above sea level), 'Clementine', 'Dancy' (0-1800 m above sea level), 'Pixie', 'Encore' and 'Kinnow'
- Tango/ Tangelo (hybrids of mandarins): 'Temple' a Tango (mandarin x orange) and 'Minneola' a Tangelo (mandarin x grapefruit)
- Grapefruit: 'Marsh Seedless', 'Duncan' and 'Ruby Red', 'Red Blush' (0-1500 m above sea level) and 'Thomson' (1000-1500 m above sea level)
- Lemons: 'Meyer', 'Eureka', 'Lisbon' and 'Villa Franca' (1000-1500 m

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

Cultural practices

above sea level), Rough lemon (0-1500 m)

- Limes: 'Mexican', 'Tahiti' and 'Bears' (0-1500 m)

Note: All varieties mentioned are available in Kenya, particularly in Kenya prison farms, albeit their commercial availability is a problem due to citrus greening disease, which is prevalent in Kenya in all areas above 900 m asl. Since there is no citrus certification scheme in Kenya, there is no assurance that planting material derived from any Kenyan nursery is greening disease-free.

Climate conditions, soil and water management

Citrus species can thrive in a wide range of soil and climatic conditions. Citrus is grown from sea level up to an altitude of 2100 m but for optimal growth a temperature range from 2° to 30° C is ideal. Long periods below 0° C are injurious to the trees and at 13° C growth diminishes. However, individual species and varieties decrease in suspectibility to low temperatures in the following sequence: grapefruit, sweet orange, mandarin, lemon/lime and trifoliate orange as most hardy.

Temperature plays an important role in the production of high quality fruit. Typical colouring of fruit takes place if night temperatures are about 14° C coupled with low humidity during ripening time. Exposure to strong winds and temperatures above 38° C may cause fruit drop, scarring and scorching of fruits. In the tropics the high lands provide the best night weather for orange colour and flavour.

Depending on the scion/ rootstock combination, citrus trees grow on a wide range of soils varying from sandy soils to those high in clay. Soils that are good for growing are well-drained, medium-textured, deep and fertile. Waterlogged or saline soils are not suitable and a pH range of 5.5 to 6.0 is ideal. In acidic soil, citrus roots do not grow well, and may lead to copper toxicity. On the other hand at pH above 6, fixation of trace elements take place (especially zinc and iron) and trees develop deficiency symptoms. A low pH may be corrected by adding

dolomitic lime (containing both calcium and magnesium)

Zinc deficiency on citrus

© University of Hawaii, www.ctahr.hawaii.edu/nelsons/Misc/

A citrus orchard needs continuous soil moisture to develop and produce, and water requirement reaches a peak between flowering and ripening. However, many factors such as temperature, soil type, location, plant density and crop age influence the quantity of water required. Well-distributed annual rainfall of not less than 1000 mm is needed for fair crop. In most cases, due to dry spells, irrigation is necessary. Under rainfed conditions, flowering is seasonal.
There is a positive correlation between the onset of a rainy season and flower break. With irrigation flowering and picking season could be controlled by water application during dry seasons. Irrigation systems involving mini sprinklers irrigating only soil next to citrus trees have been developed as an efficient and water conserving irrigation method.

Propagation

The most common method of citrus propagation is by budding. When old trees are top-worked,

bark grafting is used. Citrus varieties grown from seed have numerous problems like late bearing, uneven performance due to their genetic variability and susceptibility to drought, root invading fungi, nematodes and salinity. Rootstocks are therefore used to meet all citrus requirements (tolerance / resistance to pests and diseases, suitability to soil and water conditions, as well as compatibility with variety selected). Rootstocks also improve the vigour and fruiting ability of the tree, as well as the quality, size, colour, flavour and rind-thickness of the fruit.

Citrus rootstocks have the following characteristics:

- **Rough lemon (*C. jambhiri*)**

Seedlings produce a uniform and fast growing rootstock, which is easy to handle in the nursery. The plant develops a shallow but wide root system with a vigorous taproot. Trees budded on rough lemon produce an early, good yield but the fruit quality especially during the first years is not satisfactory. Trees are comparatively short-lived. Rough lemon prefers deep, light soil and do not tolerate poor drainage or waterlogging. It is tolerant to citrus tristeza virus but susceptible to *Phytophthora* spp., citrus nematodes and soil salinity. It is drought tolerant. Rough lemon can be budded with oranges, mandarins, lemons, limes and grapefruits. It is the most commonly used rootstock in East Africa.

- **Cleopatra mandarin(*C. reticulate*)**

It is suited to soils of heavier texture. On this rootstock, trees are slow growing with low yields in early years. Trees are long-lived. Its influence on fruit quality is good. It is tolerant to soil salinity. It is susceptible to poor drainage, *Phytophthora* spp and citrus nematodes. It can be budded with oranges, mandarins and grapefruits.

- **Citrus trifoliate (*Poncirus trifoliate*)**

It is a dwarfing stock and is most suitable for heavy and less well-drained soils. Rootstock propagation is slow, but budded trees yield heavily and produce high quality fruits. The plants develop abundant roots and often several taproots, which penetrate the soil deeply. It should not be used in calcareous soils. It is tolerant to *Phytophthora* spp. and citrus nematodes. It

can be budded with oranges, mandarins and grapefruits.

- **Carrizo / Troyer citrange (*P. trifoliate* x *C. sinensis*)**

Rootstocks are somehow difficult to establish. In order to promote fibre roots, young plants should be undercut as long as they are in the seedbed. Citranges are not suitable for very light and strongly alkaline soils. They are sensitive to overwatering but once established produce high quality fruits. They are somehow tolerant to *Phytophthora* spp. and citrus nematodes. They can be budded with oranges, mandarins and grapefruits.

- **Citrumelo (*P. trifoliate* x *C. paradise*)**

Plants produce an expansive root system and therefore have good drought tolerance. They can be used on a wide range of soils and produce an outstanding quality of fruit. They are tolerant to *Phytophthora* spp. but susceptible to citrus nematodes. They can be budded with lemons and limes.

- **Rangpur lime(*C. aurantifolia*)**

This stock is suitable for various soil types, including deep sand. It prefers warm locations. It produces vigorous, well-bearing trees with a high degree of drought resistance. It is susceptible to *Phytophthora* spp. and citrus nematodes. It can be budded with oranges and grapefruits.

- **Sweet orange(*C. sinensis*)**

This rootstock produces large and vigorous trees and is suitable for light to medium soils, which are well drained. It produces good quality fruits and the trees are long-lived. It has low drought tolerance and is very susceptible to *Phytophthora* spp. and citrus nematodes. It can be budded with oranges, mandarins and grapefruits.

- **Sour orange (*C. aurantium*)**

An excellent rootstock in locations where citrus tristeza is not a problem since it is very susceptible to the disease. It is tolerant to poor drainage. It has low tolerance to drought. It produces very good quality fruits. It is tolerant to *Phytophthora* spp. but susceptible to citrus nematodes. It can be buddedwith oranges and grapefruits.

Planting

- **Select seeds from healthy mother trees**
- **Hot water treat seeds at 50° C for 10 minutes**
- **Seeds perform better when planted soon after they are extracted**
- **Sow seeds in seedbeds or polybags (18x23 cm). Seeds germinate in 2 to 3 weeks**
- **Water the seeds regularly, preferably twice a day until they germinate**
- **Seedlings are normally ready for budding when reaching pencil thickness or 6 to 8 months after germination.**
- **T-budding is the most common method**
- **Do budding during warm months. Avoid budding during cold periods and during dry conditions**
- **Budded plants are ready for transplanting 4 to 6 months after budding**
- **Alternatively, obtain budded plants from a registered fruit nursery. These budded plants should be ready for transplanting in the field.**

Transplanting in the field

- **Transplant in the field at onset of rains.**
- **Clear the field and dig planting holes 60 x 60 x 60 cm well before the onset of rains.**
- **At transplanting use well-rotted manure with topsoil.**
- **Spacing varies widely, depending on elevation, rootstock and variety. Generally, trees need a wider spacing at sea level than those transplanted at higher altitudes. Usually the plant density varies from 150 to 500 trees per ha, which means distances of 4 x 5 m (limes and lemons), 5 x 6 m (oranges, grapefruits and mandarins) or 7 x 8 m (oranges, grapefruits and mandarins).**

- **It is very important to ensure that seedlings are not transplanted too deep.**
- **After transplanting, the seedlings ought to be at the same height or preferably, somewhat higher than in the nursery.**
- **Under no circumstances must the graft union ever be in contact with the soil or with mulching material if used.**

Tree management / maintenance

- **Keep the trees free of weeds**
- **Maintain a single stem up to a height of 80-100 cm**
- **Remove all side branches / rootstock suckers**
- **Pinch or break the top branch at a height of 100 cm to encourage side branching**
- **Allow 3-4 scaffold branches to form the framework of the tree**
- **Remove side branches including those growing inwards**
- **Ensure all diseased and dead branches are removed regularly**
- **Careful use of hand tools is necessary in order to avoid injuring tree trunks and roots. Such injuries may become entry points for soil-borne diseases**
- **As a general rule, if dry spells last longer than three months, irrigation is necessary to maintain high yields and fruit quality. Irrigation could be done with buckets or a hose pipe but installation of some kind of irrigation system would be ideal**

Manure and fertiliser

For normal growth development (high yield and quality fruits), citrus trees require a sufficient supply of fertiliser and manuring. No general recommendation regarding the amounts of nutrients can be given because this depends on the fertility of the specific soil. Professional, combined soil and leaf analyses would provide right information on nutrient requirements.

In most cases tropical soils are low in organic matter. To improve them at least 20 kg (1 bucket) of well-rotted cattle manure or compost should be applied per tree per year as well as a handful of rockphosphate. On acid soils 1-2 kg of agricultural lime can be applied per tree spread evenly over the soil covering the root system. Application of manure or compost makes (especially grape-) fruits sweeter (farmer experience).

Nitrogen can be supplied by intercropping citrus trees with legume crops such as mucuna, cowpeas, clover or dolichos beans, and incorporating the plant material into the soil once a year. Mature trees need much more compost/well rotted manure than young trees to cater for the larger production of fruit.
Conventional fertilisation depend on soil types, so it is recommended to consult the local agricultural office.

Husbandry

In windy areas, a windbreak should be provided as citrus is sensitive to strong winds. A windbreak provides protection at orchard tree level for about 4-6 times its height.

- **Plant the windbreak as close as possible and at right angles to prevailing winds.**

Symptoms of mineral deficiency

Nutrient Element	Leaves	Fruit	Tree growth
Nitrogen	Pale yellow to old ivory	Reduced crop	Reduced. May produce abundant bloom.

			Flower buds may fall without opening
Phosphorous	**Small, dull**	**Reduced crop. Large. Puffy, bumpy surface, enlarged core cavity and thick rind.**	**Reduced**
Magnesium	**Yellow mottling along margin Developing a green wedge to "Christmas tree" pattern. Eventual complete yellowing and defoliation.**	**Reduced crop**	**Reduced**
Iron	**Yellow veins, remain green until final stage of general chlorosis. Reduced size**	**Reduced crop**	**Eventually reduced**
Zinc	**Mottled yellow between main veins. Small narrow Early fall. Reduced size**	**Reduced crop, some pale yellow off types**	**Eventually reduced**
Manganese	**Normal green along main veins. Rest of leaf pale green to light yellow**	**Reduced crop**	**Eventually reduced**
Potassium	**Old leaves curl and loose their green colour**	**Small, smooth, thin rind,**	**Reduced**

		drop prematurely	
Copper	Deep green, oversized, then darkened	Splitting and gumming. Dark brown gum soaked eruptions. May turn black. Gum in centre core	Twigs enlarge at nodes, blister and die back. Gum pockets. "Cabbage head" growth

Intercropping

Intercropping with shallow rooted crops such as vegetables, herbs, green manure legumes sweet potatoes etc, is recommended in order to keep the soil cultivated around citrus trees.

Harvesting

- **Harvest fruits when they are mature. Mature fruits change colour where night temperature is about 14°C coupled with low humidity**
- **In low altitude areas where fruits remain green, it is necessary to test a few fruits for maturity**
- **Harvest fruits using a sharp knife, taking care not to bruise the fruits**
- **Fruits can also be plucked. However, plucking causes the stem to break close to the fruit thus increasing the chance of it being infected**
- **Wash, sort and grade fruits under shade. Washing water must be clean or treated**
- **Discard deformed and infected fruits**
- **Pack fruits in aerated containers for transport to the market**

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Information on Pests

General Information

Organic pest and disease management places priority on indirect control methods. Direct control methods are applied as a second priority.

Indirect Control Methods:

- **Promotion of beneficial insects and plants by habitat management: organic orchard design, ecological compensation areas with hedges, nesting sites etc.**
- **Soil management: Organic compost and plant slurry to improve soil structure and soil microbial activity**
- **Pruning: good aeration of the orchard**

Direct Control Methods:

- **Biological control: release of antagonists, natural predators and entomophagous fungi**
- **Mechanical control methods**
- **Organic pest and disease control products**

Examples of Pests and Organic Control Methods

Most mites, insects and nematodes that attack citrus cause economic damage only occasional. Many pest problems in conventional citrus production are related to the almost complete elimination of natural enemies through the excessive use of synthetic pesticides. Organic growers make use of natural control agents to the maximum. Many pest problems can be

controlled effectively with biological control methods. Generally, bio-control methods and agents usually help to decrease the level of pests rather than to eradicate them. The following list of important pests is not complete and shows just one important species for some pest families.

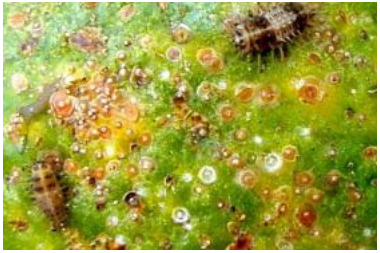
In some cases, preventive and bio-control measures are not sufficient and the damage by a pest or a disease may reach a level of considerable economic loss. This is when direct control measures with natural pesticides, such as pyrethrum, derris, neem, soaps, mineral and plant oil as well as mass trapping and confusion techniques may become appropriate.

Scales

Scales are small insects (1.0 to 7 mm long), which resemble shells glued to the plant. There are many species (types) of scales on citrus, which vary in shape (round to oval) and colour according to the species.

There are two main groups: hard (armoured) and soft (naked). The armoured scales are the most serious pests.
The most important armoured scales attacking citrus are the red scale (*Aonidiella aurantii*), the mussel purple scale (*Lepidosaphes beckii*), and the circular scale (*Chrysomphalus aonidum*).
The most important soft scales are the soft brown scale (*Coccus hesperidum*) and the soft green scale (*Coccus viridiis* or *C. alpinus*).

Female scales have neither wings nor legs. Females lay eggs



Scales and ladybird larvae on orange
Larvae of ladybird beetles *(Cheilocorus sp)* feeding on red scales on an orange fruit

© A. M. Varela, icipe



Scales and... Scale dama.. Armour s...

under their scale. Some species give birth to young scales directly. Once hatched, the tiny scales, known as crawlers, emerge from under the protective scale. They move in search of a feeding site and do not move afterwards. They suck sap on all plant parts above the ground. Their feeding may cause yellowing of leaves followed by leaf drop, poor growth, dieback of branches, fruit drop, and blemishes on fruits. Leaves may dry when heavily infested, and young trees may die.

Soft scales excrete honeydew, causing growth of sooty mould. In heavy infestations fruits and leaves are heavily coated with sooty mould turning black. Heavy coating with sooty mould reduces photosynthesis. 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:

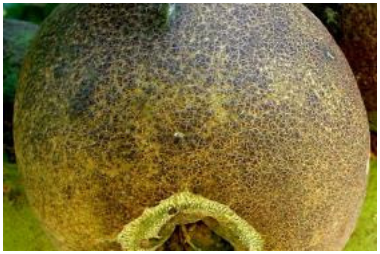
- **Scales are attacked by a large range of parasitic wasps and predators. These natural enemies usually control scales. Outbreaks are generally related to the use of broad-spectrum pesticides that kill natural enemies, and or to the presence of large number of ants.**
- **Chemical control is possible with light mineral oils, at low concentrations, mixed with other insecticides. At high concentrations, mineral oils may be harmful to the trees.**

Sprays should target young stages of the scales.

- **Oil sprays should be carried out after picking and not during flowering or during periods of excessive heat or drought.**
- **To protect natural enemies alternate tree rows can be sprayed each season.**
- **At early stages of an outbreak cut and burn affected branches and leaves.**

The citrus rust mite (*Phyllocoptruta oleivora*)

The yellow tiny citrus rust mite attacks mainly the fruit. Its feeding causes the rind of the fruit to turn silvery, reddish brown, or blackish. One result of mite damage is small fruit, which deteriorates rapidly. This damage lowers the market value of the fruit. Heavy populations of the rust mite cause bronzing of leaves and green twigs, and general loss of vitality of the whole tree. Warm and humid conditions favour the development of this rust mite.



Citrus rust mite
Damage by the citrus rust mite (*Phyllocoptruta oleivora*) on an orange fruit

© A. A. Seif, icipe

What to do:

- **Some predatory mites feed on the rust mites, but they cannot control heavy infestations.**

The citrus bud mite (*Aceria sheldoni*)

It is a tiny, worm-shaped, creamy white mite. It has only two pair of legs, and is is hardly visibly without a magnifying glass. These mites occur in

protected places such as under the bracts of buds. They attack the growing points of the twigs, causing malformation of the young leaves and flower buds. As a consequence, the growth of the trees is retarded.

The fruit set can be seriously reduced and infested fruit may be malformed. Bud mites are more abundant during the hot season. Commonly found in developing and leaf buds. Damage under the bracts causes the death of the buds. Flower bud development is reduced, growth is retarded, branches become stunted and deformed, and rosette-shaped leaves are formed. The fruits, particularly in lemons are deformed. Almost all deformed fruits fall off at an early stage of development. Even light infestations may cause damage and control measures should be applied on time and regularly. Spots decrease the market value of the fruit and provide entry for fungal infection.

Citrus bud mite
Citrus bud mite damage (*Aceria sheldoni*)

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Damage fruits loose moisture rapidly and do not keep well. Infestation on ripe fruits causes light yellow or silver discolouration. These mites attack all citrus species, but damage is usually worst in lemons. Damaged fruit could drop prematurely or assume abnormal shapes. The juice content of damaged fruit is significantly lower than that of normal fruit.

What to do:

- **The bud mites are not well controlled by natural enemies, and use of biopesticides is necessary for their management.**
- **Sulphur at a concentration of 2% controls both the rust and bud mites. However, sulphur kills also beneficial mites and may disrupt the natural control of other potential citrus pests. Sulphur must not be used at a temperature exceeding 30° C. A four-week interval must be**

maintaned between sulphur and oil sprays. No other pesticides or mixtures may be added to sulphur.

Mealybugs

Several species of mealybugs attack citrus. They suck sap from tender leaves, petioles and fruit. Feeding on the fruit results in discolored, bumpy, and scarred fruit, with low market value, or unacceptable for the fresh fruit market. Mealybugs excrete honeydew, which leads to the growth of sooty mould on fruit and leaves. Fruit cover with sooty mould at harvest must be washed. The most important is the citrus mealybug (*Planoccous citri*).

Mealybugs
Mealybugs on citrus (*Planoccous citri*)

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More Information on Mealybugs

What to do:

- **Mealybugs frequently are under effective control by a wide range of natural enemies (parasitic wasps, lacewings, ladybird beetles. etc) and do not cause economic damage. However, if the natural balance is disturbed by application of pesticides or by presence of ants, mealybug populations may increase to damaging levels.**

Ants

Certain ants are major indirect pests in citrus orchards. Although they do not damage the trees, they are associated to honeydew-producing insects such as soft scales, aphids, whiteflies, blackflies and mealybugs. Natural enemies often keep these insects under control; however, ants

feeding on the honeydew give them indirect protection by disturbing natural enemies. As a result numbers of these honeydew producing insects, and indirectly other pests such as armoured scales, may rise to damaging levels.

Ant management does not imply eradication of all ants. There are many different types of ants in citrus orchards. Many of them are important predators of other insects, including pests of citrus. Some of the species that could be a problem due to their association with honeydew-producing insects (e.g. the big headed ant *Pheidole megacephala* and the pugnacious ant, *Anoplolepis custodiens* are also beneficial preying on a variety of insects, and are valuable predators on the ground. Therefore these ants should not be destroyed but kept off the trees.

What to do:

- **Undesirable ants can be kept out of the citrus trees by banding the stems with sticky stripes, or by spraying the tree trunks with insecticides.**
- **To keep these ants out of the trees low branches on the tree must be pruned and all weeds that touch the canopy must be removed, so that they do not provide access to the tree for the ants.**
- **When using sticky bands, they must go completely around the stem. In addition, they should be checked regularly for efficiency. Sticky bands (strips) soon become non-adhesive in dusty and windy conditions. Moreover, over time insects get stuck to the bands clogging them and forming bridges, which the ants can cross. Therefore regular applications of the sticky substances are needed.**
- **Sticky substances (grease and others) may burn the bark, particularly, in**

Pheidole megacephala Brown house ants streaming up and down the white-washed trunk of an orange tree

young trees under direct sunlight. Therefore, it should not be applied directly to the trunks, but using polyurethane stripes as a base.

Red fire ants or weaver ants (*Oecophylla longinoda*)

Weaver ants
Weaver ant nest on a citrus tree

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A particular case is that of the red fire ants or weaver ant swhich nest on citrus and other fruit trees (guava, soursop, cashewnuts, coconut palms among others). These ants are present in many countries in Africa. They are common in the coastal regions in East Africa.
They built nests on trees by joining leaves with silk produced by the larvae. These ants are very active moving on the trees and on the ground in search of food. They are highly voracious feeding on a large range of insects visiting the trees, and are important in controlling many insect pests in fruit trees and coconut palms. In spite of these benefits, weaver ants are considered by some as a pest due to their aggressiveness combined with painful bites, which makes fruit picking difficult, and to their association with honeydew-producing insects. They can foster the build-up of these insects, but it has been observed that they do kill some of them when the amount of honeydew produced by these insects is bigger than the amount required by the colony of weaver ants.

The benefits provided by predatory ants feeding or deterring insect pests must be outweighed against the damage they may cost indirectly. As a whole weaver ants are considered beneficial. They have been used actively in China for the control of citrus pests for centuries (Way and Khoo, 1992). Experienced farmers

in Asia and Africa have developed their own methods to deal with the inconvenience of weaver ants during harvesting.

What to do:

- **A common practice among farmers is to throw wood ash on the branches of the tree they want to climb. The ants fall down of the branches and have difficulties to return giving time to the farmer to harvest.**
- **Other farmers rub their hands and arms with wood ashes, to prevent the ants from attacking them.**
- **Other rub their arms and feet with certain repellent products before climbing the tree, use protective clothing or harvest at times of the day when weaver ants are least active (Van Mele and Cuc, 2007)**

Nematodes

More than 40 nematode species have been associated with citrus worldwide. The economically important species are the citrus nematode (Tylenchulus semipenetrans) and the burrowing nematode (Radopholus similis).

1) The citrus nematode *(T. semipenetrans)*
It causes a slow decline of citrus trees. Affected trees show reduced vigour, small yellow leaves, defoliation, die-back of twigs, and small fruits. The citrus nematodes are ectoparasitic and sedentary. Only females are parasitic on roots. They are

Nematodes
Lemon tree infested with citrus nematodes (*Tylenchulus semipenetrans*)

found on the surface of fibrous roots under debris-covered egg masses embedded in a gelatinous matrix. The life cycle, from egg to egg, is completed within 6-8 weeks at temperatures of 24-26° C. Optimal reproduction occurs at 28-31° C. Soil salinity increases the population density of citrus nematode. In affected orchards, populations of the nematode are concentrated in upper soil layers. Movement of plant material and soil is responsible for the spread of the nematode. Also agricultural implements and water (irrigation or rain) spread the nematode in a citrus orchard or in growing region.

2) The burrowing nematode *(Radopholus similis)*
It is called "burrowing nematode" on account of the cavities and tunnels it produces in the root tissues. Symptoms are generally present on groups of trees that increase in number with time, hence, the name, spreading decline. Symptoms are much more severe than in the case of T. semipenetrans and the spread is much quicker. Affected trees show fewer and smaller leaves and an abundance of dead twigs and branches. Trees wilt during periods of lack of moisture but generally the trees are not killed. It is an endoparasitic and migratory. Two distinct races of the nematode are known: the banana and citrus race. The former is known to attack banana roots but not citrus. The citrus race attacks bananas and citrus. The life cycle requires 18-21 days at 24-26° C, the optimum temperature being 24° C. Burrowing nematodes migrate through roots and from root to root to feed. The nematodes are rarely found in the top 10 cm of the soil, highest populations being between 30 and 180 cm. Primary spread is thorough propagating infested seedlings.

More Information on Root-knot nematodes

What to do:

- **Use certified nematode-free planting stocks**
- **Use tolerant / resistant rootstocks**
- **Use cultural practices that enhance plant growth.**

The citrus woolly whitefly (*Aleurothrixus floccosus*)

The citrus woolly whitefly was reported for the first time in East and Central Africa in the early to mid 90s. Serious attacks on citrus were observed in Kenya, Malawi, Tanzania and Uganda. The adults of this whitefly resemble small white moths, covered with mealy white wax. Eggs are laid on the lower surface of young leaves. The young stages resemble soft scale insects and have a woolly appearance. They produce large quantity of honeydew that leads to the growth of sooty mould on the infested trees. This may cause defoliation, loss of fruits and dwarfing of trees. Small, mottled fruits are produced.

Citrus woolly whitefly Immature stages of the citrus woolly whitefly (*Aleurothrixus floccosus*)

© B. Loehr, icipe


Citrus woo…


Damag by …


Citrus woo…

What to do:

- **The citrus woolly whitefly is kept under control by its natural enemies in its area of origin. In the mid to late 90s, one of the most efficient parasitic wasp (Cales noacki), which has controlled this pest in many countries, was introduced and released in Kenya, Malawi, Tanzania and Uganda. Data collected in Kenya and Uganda showed that this parasitic wasp is effectively controlling the citrus woolly whitefly.**

More Information on Whiteflies

- **Use of pesticides should be avoided since it may kill this parasitic wasp. Moreover, chemical control is not economical feasible. Pesticides are often inefficient since the immature stages are covered by wax. When effective, pest resurgence commonly occurs within a few weeks of application.**

The citrus blackflies (*Aleurocanthus woglumi* and *A. spiniferus*)

Adults of the citrus blackflies resemble tiny (1.3 to1.7 mm in length) greyish moths. Eggs are usually laid in a spiral pattern on the lower surface of leaves. The immature stages are shiny black scale-like insects and are up to 1.2 mm in length. A white fringe of wax surrounds the body of older larvae and the pupae.
The insects are most noticeable as groups of very small, black spiny lumps on leaf undersides. They produce a large amount of honeydew, which accumulate on leaves and stems and usually develop black sooty mould fungus, which cover the leaves blackening the foliage and sometimes the whole plant. Ants may be attracted by the honeydew. Heavy infestation causes general weakening and eventual death of plants due to sap loss and the development of sooty mould on leaves. Infested leaves may be distorted.

Citrus blackflies
Immature stages of blackflies on a citrus leaf (*Aleurocanthus woglumi*) and (*A. spiniferus*)

© A. A. Seif, icipe

Citrus bla...

Citrus bla...

What to do:

- **Citrus blackfly has been effectively controlled by natural enemies. This is the most cost-effective and sustainable method of control, and the parasitoids available are capable of controlling it wherever it becomes established (e.g. Encarsia**

opulenta, Eretmocerus serius as natural enemies in Kenya).

- **Spraying with neem seed extract (4%) at the emergence of new flush and repeated at 10 days intervals once or twice is recommended in India (Tandon, 1997).**
- **In case of localised infestations affected shoots should be removed and destroyed.**

Citrus aphids (*Toxoptera citridus* and *T. aurantii*)

They are small (1 to 3mm in length), brown to black in colour, and may be winged (having two pair of wings) or wingless. They feed by sucking on new growth and blossoms. High numbers are found on the leaf surfaces during the period of flushing (production of new shoots) and stems of attacked young shoots die back. Attacked leaves are curled and distorted. Flower buds are damaged or drop. Aphids excrete large amounts of honeydew. Leaves and fruits may turn black due to the growth of sooty mould. Symptoms can be severe on flush growth during dry periods following rainy spells.
Citrus aphids transmit tristeza and other virus diseases in citrus. The black citrus aphid *T. citridus* is the most efficient vector of the Citrus Tristeza Virus.

Citrus aphids
Heavy attack of the citrus aphid (*Toxoptera citridus* and *T. aurantii*)

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More Information on Aphids

What to do:

- **Citrus aphids are frequently kept in check by natural enemies, especially ladybird beetles, lacewings, hoverflies and parasitic wasps. Aphids are likely to become less of a problem if their natural enemies are not destroyed by pesticides.**

- **Management of ants may increase the efficiency of these natural enemies.**
- **Insecitides should be applied only when heavy aphid populations are developing on the new flush. Only infested shoots should be treated, especial attention should be given to the lower leafsurface.**
- **Neem products are reported to give good control of this aphid. The application of a 2% Neem Seed Kernel Extract (NSKE) at the beginning of the infestation on lime to kept this aphid below the economic threshold level in the field in India. For more information on neem click here (Jotti et al., 1990).**

The citrus leafminer *(Phyllocnistis citrella)*

The caterpillar of the citrus leafminer usually attacks young leaves and shoots. It mines the undersurface of young leaves, but it can attack both leaf surfaces, in heavy infestations, and occasionally the fruit. Its feeding causes serpentine mines that have a silvery appearance and reach a length of 5 to 10 cm. The middle of the mines is marked by a light or a dark coloured stripe, which consist of the excreta of the caterpillars. The caterpillars are greenish yellowish and are to 4 mm in length. Caterpillars pupate within the mine, near the leaf margin, under a slight curl of the leaf. The moths are tiny (2 to 3 mm long), greyish white in colour with fringed wings.

Eggs look like small dew drops and are usually laid on the underside of the leaves. Attacked young leaves are twisted, show brown patches of dead tissue and eventually fall off.

Citrus leafminer
The caterpillar of the citrus leafminer *(Phyllocnistis citrella)* usually attacks young leaves and shoots.

© A.A. Seif, icipe\n


Citrus lea...


Citrus lea...

Heavy infestations can interfere with photosynthesis because of the reduction in leaf surface. This pest is especially troublesome in citrus nurseries. It can kill young nursery plants. This leafminer was a frequently observed pest during a survey of major citrus pests conducted in Kenya, Malawi, Uganda, Tanzania and Zambia in 1995 (B. Löhr, personal communication).

What to do:

- **In Asia, mineral oils and neem extracts (neem seed extract 2%) are recommended for control of the citrus leafminer (Tandon, 1997).**
- **Neem water extracts (1kg neem cake / 10l water) has given protection against this pest for up to two weeks (Zebitz, in Schmuttererr, 1995). In South China 1.4% emulsified neem oil gave protection against this pest in the nursery and also in young and old citrus trees (GTZ, 2001). For more information on neem click here.**

The African citrus psyllid (*Trioza erytreae*)

It prefers cool climates and it is found in Kenya only at elevations above 800 m. The adult is about 2 mm long, brownish yellow with long transparent wings with market veins. They resemble winged aphids. The adults jump and fly short distances when disturbed. When feeding, adults take up a distinctive position, with the abdomen raised. The orange-yellow eggs are laid on the edges of

tender young leaves. They can be distinguished with the naked eye as a yellow fringe to the leaf. After hatching the nymph moves only a very short distance and settles down to feed on the underside of leaves. Once settled, it does not move again unless disturbed. They resemble small green or yellow scale insects, and are up about 1 mm long. Parasitised nymphs are dark brown to black in colour. Pit-like depressions are formed beneath the nymphs-bodies. These depressions look like raised bumps on the upper side of the leaves, and remain even after the nymphs have become adults.

Adult of the African citrus psyllid *(Trioza erytreaea)*

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As result of these pock marks young leaves may be severely deformed, and flush growth depressed. They also cause damage by sucking sap from the leaves. However, in general, these types of damage do not seriously affect infested trees. The main damage caused by the citrus psyllid is as the vector of the greening disease, a major disease of citrus. A few psyllids in an orchard can spread the greening disease, but when high numbers are present, the spread is particularly rapid. It is therefore necessary to manage the citrus psyllids to retard the spread of the greening disease.

What to do:

- **Several natural enemies attack the citrus psyllid. Predators such as lacewings, spiders, predatory mites, ladybird beetles and hover flies feed on the citrus psyllid, but often they cannot control this pests effectively. Parasitic wasps play an important role in the control of citrus psyllids. Psyllaephagus**

pulvinatus attacks nymphs in Kenya and South Africa, and Tamarixia (Tetrastichus) dryi attacks nymphs in South Africa. In Reunion, the African psyllids has been successfully controlled by the introduction of T. dryi, from South Africa.

- **Prevention of the spread of the citrus psyllids is crucial for managing greening disease. Drenching should be preferred method of pesticide application to avoid killing of the natural enemies. This should be done at onset of rains.**

The citrus thrips (*Scirtothrips aurantii*)

Citrus thrips are tiny insects (0.7 to 1 mm in length), and orange yellow in colour. Young stages are wingless, but adults have two pairs of narrow wings. Damage is caused by larvae and adults feeding on young twigs, leaves and fruits. Thrips feeding produces brown blemishes on the rind. Typical damage is the presence of rings of brown russet marks around the stem of the fruit. The damage is cosmetic and does not affect eating quality. However, external fruit blemishes can be so severe that the fruits are unmarketable. New shoots can be severely damaged. If thrips are abundant on young twigs, their feeding causes deformation of the twigs, which become thickened and distorted. In severe infestations, the leaves are deformed; young leaves are underdeveloped and drop when touched.

Thrips
This is a close-up of a related thrips species (Frankinella occidentalis). Immature thrips (left) and adults. Very much enlarged. Real size 0.9 to 1.1 mm.

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More Information on Thrips

What to do:

- **Neem is effective against this thrips species.**

The false codling moth (*Cryptophlebia leucotreta*)

It is small (wingspan of 16-20 mm), dark brown to grey in colour. The moths are active at night. Female moths lay single eggs on ripening citrus fruits. The young caterpillar mines just beneath the surface, or bores into the pith causing premature ripening of the fruit and fruit drop.
The initial symptom on the fruit is a yellowish round spot with a tiny dark centre where the insect entered the fruit. In a later stage brown patches appear on the skin, usually with a hole in the centre. The young caterpillar is creamy-white with a dark brownish head. With age the body turn pinkish red. The fully-grown caterpillar is 15 to 20 mm in length. When mature the caterpillar leaves the fruit and pupates in the soil or beneath surface debris. Navel oranges seem to be the most heavily attacked. Grapefruit is less susceptible. In lemons and limes larval development is rarely, if ever, completed.

The false codling moth Caterpillar of the false codling moth (*Cryptophlebia leucotreta*)

© A. M. Varela, icipe

The false ...

The false ...

What to do:

- **Proper orchard sanitation in combination with egg and larval parasitoids normally keep this pest under control.**
- **Infested fruits (both on the tree and fallen fruits) should be removed regularly (twice a week), and buried at least 50 cm deep, or dump in a drum with water mixed with a little used oil. The fruits should be left in the drum for one week.**
- **This moth also attacks cotton, maize, castor, tea, avocado, guava and carambola fruits. Other host plants include wild**

guava plants, oak trees and wild castor among others. These other host plants should be included in the sanitation programme.

- **If possible wild host plants should be removed from around the orchard. This pests is recorded in many African countries.**

Fruit flies (*Bactrocera invadens, Ceratitis capitata* and *C. rosa*)

Several species of fruit flies are pests of citrus in Africa. In East Africa the most important are *B. invadens*, a new species of fruit fly recently introduced in the region, and *C. capitata* (Sunday Ekesi, personal communication). The female fly lays eggs within the sking of ripening fruits. Spots develop on the skin where eggs were laid and the hatching larva enters the fruit. The attacked area becomes soft, turns brown and decays as a result of secondary infection.

Fruit flies
Egg laying marks by fruit flies on an orange fruit

© A.A Seif, icipe

Fruit flie…

Fruit flie…

More Information on Fruit flies

What to do:

- **These pests are controlled by orchard sanitation and application of baits.**
- **Monitoring fruit flies to determine when they arrive in the orchard is very important for the management of these pests.**

The swallowtail butterfly (*Papilio demodocus*)

The caterpillars of the swallowtail butterfly are also known as "orange dog". The butterfly is black with yellow markings on the wings, and has a wingspan of about 10 cm. They are common during the rainy season. Female butterflies lay whitish/grey eggs mainly on the tender terminal twigs and leaves. The caterpillars are white-brown, or green in colour. Most spines disappear as the caterpillar grows. Young caterpillars are brownish with white patches and are spiny. They resemble fresh bird droppings. Older caterpillars are green with some light markings and two eye-like spots at both sides of the front part of the body. When disturbed caterpillars shoot out a fleshy, forked retractable organ, through a slit behind the head, which gives off a repulsive smell.

Fully grown caterpillars are about 5 cm long. Caterpillars feed specially on the new growth of citrus trees. They can cause extensive damage to young trees, especially in citrus nurseries where their feeding can cause complete defoliation of the plant.

What to do:

- **Control is usually necessary on the nursery and on young trees (up to 2 years old). Several natural enemies such as parastitic wasps, and birds attack the caterpillars.**
- **Hand picking and destruction of caterpillars and eggs usually provides satisfactory control on small trees provided the plants are regularly checked.**
- **Neem products have been shown to provide satisfactory control of this pest (Schmutterer, 1995). In particular weekly**

Orange dog buterfly
The swallowtail butterfly (*Papilio demodocus*) also known as orange dog. Adult moth.

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Orange dog… **Orange dog…**

applications of neem water extracts effectively controlled this pest on sweet orange seedlings in Gambia (Rednap, 1981).
For more information on neem click here

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Information on Diseases

General Information

Organic pest and disease management places priority on indirect control methods. Direct control methods are applied as a second priority.

Indirect Control Methods:

- **Promotion of beneficial insects and plants by habitat management: organic orchard design, ecological compensation areas with hedges, nesting sites etc.**
- **Soil management: Organic compost and plant slurry to improve soil structure and soil microbial activity**
- **Pruning: good aeration of the orchard**

Direct Control Methods:

- **Biological control: release of antagonists, natural predators and entomophagous fungi**
- **Mechanical control methods**
- **Organic pest and disease control products**

Examples of Diseases and Organic Control Methods

There are a large number of citrus diseases caused by bacteria, mycoplasma, fungi and viruses. The following list contains some important examples. The organic citrus disease management consists in a three-step system:

- **Use of disease-free planting material to avoid future problems**
- **Choosing rootstocks and cultivars that are tolerant or resistant to local diseases**
- **Application of organic fungicides such as and copper, sulfur, clay powder and fennel oil. Cu can control several disease problems. However, it must not be forgotten that high Cu accumulations are toxic for soil microbial life and reduce the cation exchange capacity**

Damping-off (*Rhizoctoni solani*) and *Phytophthora* spp.

Damping-off of citrus is most often caused by *Rhizoctonia* spp. *Phytophthora* spp. are also a common cause of damping-off of citrus. The typical symptom of damping-off is dying of seedlings just after emergence from the soil. However, damping-off fungi can also cause seed rot, resulting in sparse stands of seedlings in nursery beds.

Citrus tree
Phytophtora on citrus tree

© A.A. Seif, icipe
More Information on Damping-off diseases

What to do:

- **Damping-off diseases are favoured by abundant moisture in the soil. Adequate control of damping-off diseases can be achieved by avoiding infested soils and overwatering.**
- **In case of Phytophthora spp., seeds must be hot water treated. For more information on hot water treatment click here.**
- **Contaminated soil, tools or irrigation water should not be**

used in or near seedbeds.

Greening disease

Citrus greening disease
Greening disease

© A.A. Seif

Citrus gre...

Citrus gre...

It is caused by the bacterium (*Candidatus Liberibacter africanus*). The disease is transmitted by citrus psyllids (*Trioza erytreae*) and through use of budwood obtained from diseased trees. The disease is not soil-borne. It is not seed-borne and it is not mechanically transmitted.

Symptoms on the leaves show mottling, yellowing of veins or zinc defiency (i.e. small leaves, interveinal chlorosis and brush-like growth). Zinc deficiency induced by greening is confined to one or several branches within a tree (sectoral infection).
Trees infected by greening are distributed within the orchard randomly. Affected branches bear few fruits and in some cases do not fruit. The affected fruits are usually under-developed, reduced in size, lopsided, start to colour from the stem end instead of the stylar end as in the case with healthy fruits. Affected fruits drop prematurely. In seedy citrus varieties, seed abortion occurs. Severely diseased trees exhibit open growth, sparse chlorotic foliage, dieback of branches and severe fruit drop.

In Kenya, the disease is not found below 800 m above seas level because both the bacterium causing the disease and citrus psyllids are sensitive to high temperatures. Optimum temperature for symptom expression is 21 to 24°C; symptoms are masked above 26° C. The disease is especially destructive to sweet

oranges and mandarins. It is less severe on lemon, grapefruit, citron and West Indian lime.
Rootstocks have no effect on greening disease.

What to do:

- **Use disease-free budwood**
- **Strict control of citrus psyllids.**
- **Very severely infected trees not producing economical yield should be up-rooted. If only a few branches are affected, they can be pruned out.**
- **Diseased young citrus trees should be replaced, as they will never bear fruit.**

Phaeoramularia fruit and leaf spot

The disease is caused by fungus *Phaeoramularia angolensis*. The disease is favoured by wet, cool conditions. On leaves, the fungus produces circular, mostly solitary (single) spots that are up to 10 mm in diameter with light brown or greyish centres. Each spot is usually surrounded by a yellow halo. Occasionally, the thin necrotic tissue in the centres of old spots falls out, creating a shot-hole effect. During rains, leaf spots on young leaves often join together ending in generalized chlorosis. Premature defoliation takes place when leaf petioles are infected. On fruit, the spots are circular to irregular in shape or joining together and surrounded by yellow halos. Most spots measure up to 8 mm in diameter. On young fruits, symptoms often start

Phaeoramularia fruit spot on orange
Orange fruits infected by (*Phaeoramularia angolensis*)

with nipple-like swellings without yellow halos.

Spots on mature fruits are normally flat, and often a dark brown to black sunken margin similar to anthracnose around the spots is observed. Fruits of more than 40 mm in diameter are somehow resistant to the disease. The disease has been observed on all citrus species including grapefruit, lemon, lime, mandarin, pummelo and orange. Grapefruit, mandarin, pummelo and orange are very susceptible. Lemon is less susceptible and lime is least susceptible.

What to do:

- **The disease can be effectively be controlled by a number of fungicides including copper based products.**
- **Successive use of coppers may cause stippling (dot-like marks) on the fruits. The disease can reduce yield by 50 to 100%.**

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Phaeor Phaeor Phaeor

Citrus tristeza virus (CTV)

It has been found in all citrus growing areas of the world. It is spread by infected propagative material and several species of aphids (*Toxoptera citricidus, T. aurantii, Aphis gossypii, A. craccivora, A. spiraecola* and *Myzus persicae*).
***T. citricidus* is the most efficient vector of CTV. The virus has also been transmitted from plant to plant by the use of dodder (*Cuscuta americana* and *C. subinclusa*). CTV is not transmitted**

Citrus tristeza virus

through citrus seeds. Most species of Citrus are hosts for CTV. The virus has naturally occurring field strains, which vary considerably in their ability to cause symptoms on different host plants and in the intensity of the symptoms expressed.

Citrus tristeza virus

© Richard Lee (Courtesy of EcoPort, www.ecoport.org)

Symptoms caused by these strains include:
Seedling yellows (SY): This symptom consists of leaf yellowing and stunting in sour orange, grapefruit and lemon seedlings. This is a field problem when trees infected with SY strains of CTV are top-worked with grapefruit or lemon.
Decline on sour orange: Sweet orange, grapefruit or tangerine scions on sour orange rootstock become dwarfed, yellow (chlorotic), and often die. The decline may occur over a period of several years or very rapidly (quick decline). Trees that decline slowly generally have a bulge (swelling) above the bud union, and honeycombing (many fine holes or pitting) is present on the inner face of bark flaps removed from the sour orange rootstock. When trees decline rapidly, honeycombing does not occur, but a brown line may be observed at the bud union after the bark is removed. When budwood infected with decline-inducing strains is propagated on sour orange seedlings, the trees produced are stunted and unthrifty.
Stem-pitting on limes, grapefruit and sweet orange. Severely affected trees are stunted and may have bushy appearance. Leaves are yellow, and the twigs are brittle and break easily when bent. When the bark is removed from the affected twigs, elongated pits are seen in the wood. Trees affected by stem pitting have reduced yield and fruit quality is poor. Some strains cause longitudinal pits in the trunk, resulting in ropey

appearance, and when bark is removed from the depressed parts deep pits can be seen in the wood.

What to do:

- **A practical safeguard against CTV is to use only disease-free budwood and to ensure that they budded onto tolerant rootstocks.**
- **In Brazil, where CTV has been the major problem of citrus, its control has been achieved by use of budlines pre-immunized with mild strains of the virus to protect against severe strains.**
- **It is, economically, impossible to prevent CTV spread by aphid control. However, selected control, at early stages of infection and during periods with high aphid populations, reduces the rate of spread.**
- **Remove infected trees;**
- **Rootstock varieties generally considered tolerant to CTV are Sweet orange, Cleopatra mandarin, Rough lemon, Rangpur lime and Trifoliate orange.**

Phytophthora-induced diseases (*Phytophthora* spp.)

They cause the most serious soil-borne diseases of citrus. These fungi are worldwide in distribution and cause citrus production losses in irrigated, arid areas as well as in areas with high rainfall. Diseases caused by *Phytophthora* spp. include damping-off in seedbeds, gummosis and brown rot of fruits. The most widespread and important *Phytophthora* spp. are *P. nicotianae*

and *P. citrophthora*. Others of lesser importance in the tropics are *P. citricola, P. hibernalis*and *P. palmivora*. The most serious disease caused by *Phytophthora* spp. is gummosis (also known as foot rot).

Gummosis: An early symptom of gummosis is gum oozing from small cracks in the infected bark around the bud-union giving the affected trees a bleeding appearance. Citrus gum, which is water soluble, disappears after heavy rains. Severely affected tress have yellow foliage that eventually drops and twigs die-back often with a crop of small-sized fruits still hanging from bare branches. The feeder roots are destroyed when the root cortex is attacked; turn soft and easily separate giving the root system a stringy appearance. In an advanced stage, the trunk becomes girdled (encircled) and the affected trees decline and eventually die.

Gummosis is favoured by high moisture in the soil. Infection of fruit by *Phytophthora* spp. produces brown rot. The affected area is light brown, leathery and not sunken compared with the adjacent rind. Under humid conditions, white fungal growth (mycelium) forms on the rind surface. In the orchard, fruits on or near the ground become infected when they are splashed with water or come in contact with soil that is infested by *Phytophthora* spp.

Most of the infected fruits drop, but those that are harvested may not show symptoms until after they have been held in storage for a few days. Brown rot epidemics are usually restricted to areas

Gummosis disease *Phytophthora*-gummosis on grapefruit tree

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where rainfall coincides with early stages of fruit maturity. It is important to note that most *Phytophthora* spp. are seed-borne.

What to do:

- **Treat citrus seeds with hot water at 50° C for 10 minutes (just too warm to keep a finger in for any amount of time)**
- **Soil drenches of copper based fungicide (allowed under organic farming in East Africa) are useful in preventing Phytophthora diseases in the nursery.**
- **Use tolerant or resistant rootstocks. Trifoliate orange is resistant. Swingle citrumelo, sour orange, rough lemon, and citranges (Carrizo and Troyer) are tolerant.**
- **Bud seedlings at a height of 25 cm and above, which will keep the bud union well above ground level.**
- **Avoid transplanting on heavy or poorly drained soils.**
- **Do not heap soil around the tree base.**
- **Avoid basin and flood irrigation. Do not over irrigate and ensure water does not contact the bud union.**
- **Avoid injuries to roots and trunks when cultivating.**
- **Gummosis can be halted by bark surgery before 50% of the trunck is affected. Scrape away dead bark tissue, remove about 10 mm margin of healthy tissue and paint the wound with a slurry of copper based fungicide (allowed under organic production) or under non-organic production with metalaxyl or fosetyl-Al.**
- **Do not replant citrus into planting sites where other citrus has been grown and proven unhealthy.**

Anthracnose *(Colletotrichum* spp.)

There are three anthracnose diseases of citrus caused by *Colletotrichum* spp. Postbloom fruit drop, which affects flowers of all citrus species and induces drop of fruitlets and is caused by *C. acutatum*. Lime anthracnose, which attacks all juvenile tissues of only Mexican lime, is also caused by this *Colletotrichum* species. *C. gloeosporioides* causes a rind blemish on fruit, especially grapefruit, in the field.

Postbloom fruit drop
Description: *C. acutatum* infects petals and produces water-soaked lesions that eventually turn pink and then orange brown as the fungus sporulates. Infected fruitlets abscise at the base of the ovary, and the floral disk, calyx, and peduncle remain attached to the tree, forming structures commonly referred to as 'buttons'. Leaves surrounding an affected inflorescence are usually small, chlorotic, and twisted and have enlarged veins. Warm, wet weather favours disease development.

Lime anthracnose
Description: It affects only Mexican lime. It attacks flowers, young leaves, young shoots and fruits. Infected fruitlets abscise, and 'buttons' are produced as in postbloom fruit drop. In severe cases, young leaves become totally blighted and drop, and shoot tips die-back, producing wither tip symptoms. The fruit lesions are often large and deep, and cause fruit distortion. The disease is favoured by warm, wet weather.

Anthracnose
Anthracnose (*Colletotrichum* spp.) on Key lime leaves

© Courtesy of www.aspnet.org



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More Information on Anthracnose

Rind blemish on fruit
Description: The disease is caused by *C. gloeosporioides*. It is particularly severe on grapefruits. The blemish appears as a superficial, reddish brown discolouration, often in the form of tear stains, that usually appears following prolonged light rains in warm weather.

What to do:

- **Avoid overhead irrigation (opt for under-tree sprinklers where feasible)**
- **Wide tree spacing**
- **Pruning of dead tree tissues**
- **Copper preventive sprays**

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Fresh Quality Specifications for the Market in Kenya

The following specifications constitute raw material purchasing requirements.

PRODUCE:	Lime
IMAGE:	
VARIETY:	Various
General appearance criteria	
COLOUR:	Bright green skin, nil with very dark green skin; pale green flesh with white core and small seeds, or seedless.
VISUAL APPEARANCE:	Skin with small oil glands and shiny sheen, no foreign matter.
SENSORY:	Green, tangy, strongly flavoured juice; highly aromatic when cut; no foreign odours/tastes.
SHAPE:	Round as well as oval fruit.
SIZE:	As per pre-ordered size requirements, generally 5 –10cm length; max 10% variation within lot.
MATURITY:	Juicy and not dry
INSECTS & PHYSICAL DAMAGE:	With no insects (e.g. mealy bugs), especially in navel or button. With no cuts holes, splits, bruises and cracks (that break the skin).

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Bananas
Scientific name: *Musa* spp.
Order/Family: Zingiberales: Musaceae
Local names: Plantain, ndizi, matooke
Pests and Diseases: Anthracnose Aphids Bacterial wilt Banana bunchy top disease Banana weevil Black leaf streak Cigar end rot Fruit flies Fusarium wilt Root-knot nematodes Snails (Giant East African Snail) Thrips

General Information and Agronomic Aspects

Bananas are perennial tropical plants whose fruits are used both for cooking and as table fruits. They may also be processed into starch, chips, purée, beer (in Africa), vinegar, or may be dehydrated and sold as dried fruit. Flour is produced from both plantains and table bananas, which can then be used in soups, baking or as a drink.
The flowers can be used as a vegetable, but they have to be heated

- 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
- Teff


Geographical Distribution of Banana in Africa

briefly in salty water to remove the bitterness. The fresh leaves have a high content of protein and cattle and chicken like them because of their taste. The leaves are also used as packing material and for roofing. Together with the stem (its actually a pseudo-stem) it also offers an excellent mulching material. Bananas can also be planted as a windbreak to a vegetable garden. Bananas are a staple food in many of the lower altitude, wetter areas of East Africa. They are mostly grown as a subsistence crop, although there is much internal trading.

Climatic conditions, soil and water management

The ancestors of the commercial bananas originated from the Malaysian Peninsula, New Guinea and South-East Asia. They grow in alluvial and volcanic soils, as well as in river deltas and forest perimeters, where the soil is rich in organic matter. They are found at the top or the middle of secondary forests, according to variety. This means that they are more or less adaptable to shade, according to variety.

Banana grows well in fairly hot and humid areas that is within an altitude of 0-1800 m above sea level with the exception of "Dwarf Cavendish" which can grow well up to 2100 m.a.s.l. (meters above sea level). For survival a rainfall of at least 1000 mm per year is necessary, but in order to achieve good yields bananas should receive 200-220 mm water per month as a regular supply. For most commercial banana growers this means irrigating during the dry months. Commercially used varieties cannot endure stagnant water conditions, so flood irrigation should only be used if the soil has good drainage.

Temperature is a major factor; the optimum for growth is about 27°C and the maximum 38°C. Plant growth is retarded and chilling injury occurs below 13°C.

Tomato
Wheat
Yam
Zucchini/Courgette

Banana is sensitive to strong wind, which shreds the leaves, causes crown distortions and blows plants over, and are susceptible to lodging in the absence of windbreaks. Planting in wind sheltered positions and in blocks rather than strips is recommended. If planted in blocks the plants protect each other against wind.

Pests/ diseases/ weeds

Medicinal plants

Fruit and vegetable processing

Natural pest control

Cultural practices

The best soil for banana is a deep, friable loam with good drainage and aeration. High fertility is a great advantage and organic matter content should be 3% or more. Bananas therefore respond well to application of well decomposed good quality composts. The plant tolerates pH of 4.5-7.5 and optimun pH is between 6 and 7.5. Plantains require more fertile soils than table bananas. Agricultural lime or preferably dolomitic lime (Ca + Mg content) can be added to soils that are very acidic in order to make them less acidic and better suited for banana production.

Propagation and planting

Bananas are propagated by vegetative means. There are several types of vegetative planting material. Selection is done according to availability, required amounts and transport possibilities. Smallholders propagate banana mostly by corms / rhizomes (the bottom part of the plant that remains underground and bears several buds which develop into suckers) and suckers. Corms / rhizomes can be used as a whole or in pieces each bearing one or more buds. Using whole corms is laborious, requires a large amount of starting / planting material and generates high transport costs. Using corm pieces is less expensive.

Suckers are produced profusely at the base of each plant. Very young suckers just appearing above the ground, known as peepers, are easy to transport, but will produce first yield after two years. Sword suckers, about 75 cm high with corm diameter of about 15 cm, have a well-developed base with narrow sword-shaped leaves. They will produce the first yield about 18 months after planting. Maiden suckers are tall suckers normally 5-8 months, which have not yet

set a bunch. They will produce a bunch in the first year. Water suckers, which have broad leaves should not be used for propagation since do not produce healthy banana clumps and the survival rate after planting is low.

Banana plants are also propagated through tissue culture (TC). Normally disease and pest free plantlets are multiplied under controlled conditions. Plantlets are supplied in pots and are planted in the field after hardening them off. These tissue culture bananas yield considerably better than traditionally propagated bananas when planted in clean soil that has not been previously used for banana production in the recent past. They are commercially available in Kenya from both Kenya Agricultural Research Centre, Thika, Jomo Kenyatta University of Agriculture and Technology, Juja and several private companies. The TC banana plants should be minimum 200-300 mm high at planting and have at least five healthy dark leaves and wider internodes at time of transplanting.

Planting material should be selected from healthy plants, free of diseases and pests (e.g. bunchy top virus, nematodes and banana weevils), having all the desirable bunch qualities and high yielding ability. It is very important that the planting material is undamaged. Prior to planting, the roots and any damaged part of the rhizome should be removed with a sharp knife. Rhizomes or suckers showing symptoms of disease or pest attack (in particular nematodes or banana weevils) must be discarded.

Planting holes should be at least 2 feet (0.6 m) deep and 2 feet in diameter and should be filled with topsoil mixed with organic manure. In areas with marginal rainfall larger pits of about 5feet 1.5 m) in diameter and 3 feet deep (1 m) are recommended.

The spacing depends on variety, soil conditions and type of planting system. Short varieties, such as the *'Dwarf Cavendish'*, can be planted in a density of 2500 plants/ha, but more commonly in holes with spacing of 3m x 3m. The taller varieties *'Giant Cavendish'*, *'Robusta'* or other strongly developing varieties are set at 600-1200 plants/ha or in planting holes spaced at

3m x 4m. Experiences in the different regions have led to various recommendations regarding size and depth of hole required, which should be followed. It is recommended to cover the planted rhizome with mulch.

The most suitable planting period is towards the end of the dry season, or at the beginning of the rainy season.

Intercropping

Bananas can be combined with practically any type of cultivated or wild plant, which has similar requirements. Young banana plants are excellent nurses for other crops and forest plants (cocoa, coffee, black pepper etc.), which can be planted very close to the bananas. During the first year bananas should be intercropped with shallow rooted crops for ease of weeding. Following illustrations show 3 examples how to intercrop bananas:

Diversification strategies, Example 1

1. year	2. year	3. year	5. - 10. year	from 11. year
Maize				
Papaya	Papaya			
Banana	Banana	Banana	Banana	
Cocoa	Cocoa	Cocoa	Cocoa	Cocoa
Forest trees	Forest trees	Forest trees	Forest trees	Forest trees

These *diversifications strategies* are suitable for the common eating (table) banana. Because of their high demands on soil, an intensive accompanying vegetation is required. With sufficient foresight and planning, this can later be used to replace the bananas.

Diversification strategies, Example 2

1. year	2. year	3. year	5. - 10. year	from 11. year
Hibiscus				
Banana	Banana	Banana	Banana	
Coffee	Coffee	Coffee	Coffee	Coffee
Forest trees	Forest trees	Forest trees	Forest trees	Forest trees

If no other crops are to be integrated into the system, then it is sufficient to combine the bananas with forest trees and native fruit trees. If other crops are to be introduced onto an existing monoculture plantation, the fruit carrying pseudo-stems will need to be thinned out.

Diversification strategies, Example 3

1. year	2. year	3. year	5. year	6. - 10. year	from 11. year
Maize/Manioc					
Pineapple	Pineapple	Pineapple	Pineapple		
Banana	Banana	Banana	Bananas	Bananas	
Forest trees	Forest trees	Forest trees	Forest trees	Forest trees	Forest trees

A wide variety of species and high density of plants should be striven for. The high plant density can be useful for example in suppressing the growth of other vegetation (like grasses, etc.) It also provides sufficient mulching material,

which needs to be continually cut and added to the soil. Satisfactory banana production can only be achieved with a large amount of organic material produced on the plantation itself.

Husbandry

Around 4-6 weeks after the bananas and additional crops have been planted, a primary selective weeding should be done. Frequent shallow weeding is required until the plants shade out weeds. Weeds are controlled by mechanical means (slashing, hoeing, etc.) or by hand. Grasses should be pulled up, and replaced by other non-creeping plants, for instance jack beans (*Canavalis ensiformis*) and *Crotalaria* spp.

Surplus shoots need to be regularly cut away from the planted bananas. The number of plants to leave per stool depends on the farmer's preferences. Many plants on a stool will result in a large number of small bunches per stool. Fewer suckers per stool will result in less but bigger bunches than are readily marketable. A common practice is to allow one flowering or fruiting stem and two to three suckers of different size for continuous banana production.

Tissue culture bananas produce large numbers of suckers 1-2 months after planting. These suckers should be cut off at the ground level to allow the development of the mother plant or until the mother plant reaches 1 m in height, at which time one following sucker is selected to continue. For good yields it is extremely important to follow the correct sucker selection:
a) Selection should be done when the mother plant is 1 m tall.
b) When the mother plant is 1 m tall 3 vigorous sword suckers facing eastward up to the slope (on slopy land) should be selected. All other suckers should be cut at base, gorged out in the middle and growing point destroyed. After 1-2 months, the most vigorous sucker should be selected and the rest removed. This will be the first ratoon crop and the first sucker. The first sucker that is produced by the first ratoon sucker should be selected as the second ratoon

crop. If the sucker selection is properly done, a large daughter sucker and a small grand daughter, a peeper all aligned in one direction will be seen.

Mulching

Mulch vegetation (bushes and trees) shoul be cut back, and the resulting material chopped up and spread around the surface as a mulch. This should be carried out once or twice a year, according to growth.

Regular mulching with organic matter derived from pruning and weeding help to maintain a layer of humus and also enhances microbiological activity in the soil. Pruning and weeding also helps in improving the general hygiene of the plantation, increase light penetration and air circulation, thus stimulating new growth. It also results in a continuous supply of organic matter for mulching.

It is important that the material is spread evenly throughout the entire plantation. However, mulching material should be placed away from the stool (about 60 cm) to ensure that the roots bury themselves deep in the ground at the base of the corm in search of moisture giving good anchorage to the plants. In addition, thrash/mulch may give shelter to banana weevils and should not be left near to the stool.
Addition of Mijingu rock phosphate will promote strong root formation and intercropping with legumes such as mucuna, dolichos or cowpeas for green manure will help supply nitrogen from the atmosphere. These measures will suffice to maintain the fertility of the soil even in situations of continuous banana growing.

The majority of banana varieties cultivated for export purposes require a high soil quality. In natural forest ecosystems, banana plants must be replaced by other species about every 10-15 years. If this is not done the soil will be depleted of nutrients and incidence of pests and diseases may build-up thereby necessitating application of fertilisers and pesticides.

Banana stems are liable to break under the weight of a heavy bunch. As the fruits develop and the weight of the bunch increases, the fruiting stem should be supported with a wooden pole to prevent the whole stem from breaking. Forked poles are used to keep the stems upright and support the weight of the bunch.

Irrigation is necessary in areas with a long dry season but also if rainfall is less than 220mm per month.

Harvesting

Harvesting banana bunches is usually spread evenly throughout the whole year. Whilst still green, the fruits have a distinctly edged appearance, which gradually becomes almost round as they ripen. The stage of maturity is judged by the angularity of the fingers: The more rounded a finger is in a cross-section, the more mature it is. The fingers are considered mature for harvesting when they are ¾ round (75% maturity) and still green.

The fruits in a bunch do not ripen at the same pace. If some fruits have begun to turn yellow on the plant, then it is already too late to transport them any great distance, as they quickly become too soft and rot.
Bunches are harvested by cutting them away from the plant just above where the fruit begins. The stem is cut-off with a clean cut at ground level after harvesting the bunch. It is very important that bunches do not fall or bump during transport, as this causes them to blacken and rot. To avoid damaging the bunches during harvesting at least two people should be involved in harvesting, in particular heavy bunches or tall varieties, one to do the cutting and the other one to support the bunch so that it does not fall to the ground. An experienced worker, however, can harvest alone.

Harvested bunches should be kept in the shade. It is advisable to handle and transport banana hands rather than the whole bunches because this reduces physical damage. Bunches are dehanded and the hands are deflowered, washed, sorted and packed in carton boxes.

Storage life of green bananas ranges from 21 to 30 days at 13-15°C.

Ripening is increased when bunches are packed in closed chambers with restricted air circulation.

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Fresh Quality Specifications for the Market in Kenya

The following specifications constitute raw material purchasing requirements

PRODUCE:	Banana
IMAGE:	
VARIETY:	Various
	General appearance criteria
COLOUR:	Good yellow colour with minimal black markings
VISUAL APPEARANCE:	Shiny plump looking fingers
SENSORY:	Firm, not soft; nil foreign smells or tastes.
SHAPE:	Slightly arched, with blunted butt end and intact, undamaged necks.
SIZE:	Finger length: measurement is over curvature, pulp to pulp, across the back of the Banana X Large: 22 – 26 cm; Large: 20 - 22 cm Clusters - 3 to 9 fingers (ideal 5 to 9 fingers).
MATURITY:	Yellow colour will determine maturity and not green in colour
PHYSICAL DAMAGE	splits, holes, deep bruises or cuts through the peel into the pulp. With no severed / broken necks.

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Information on Diseases

Bacterial wilt

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

Bacterial wilt
Banana Xanthomonas Wilt Disease

© Dr. Simon Eden-Green (Courtesy of EcoPort, www.ecoport.org)

What to do:

- **Use resistant varieties, if available**
- **Use certified disease-free seeds**
- **Remove infected plants from fields and destroy affected plants.**


Bacteri... Bacteri...

More Information on Bacterial wilt

The bunchy top disease

It is a virus disease transmitted by aphids (for more information on aphids click here .) The typical symptoms of bunchy top of banana are very distinctive and readily distinguished from those caused by other viruses of banana. Plants can become infected at any stage of growth and there are some initial differences between the symptoms produced in aphid-infected plants and those grown from infected planting material.

In aphid-infected plants, a few dark-green streaks or dots usually appear on the minor veins and the midrib of the second leaf to emerge after inoculation. They are best seen from the underside of the leaf in transmitted light. The 'dot-dash' symptoms can sometimes also be seen on the petiole. The following leaf may display whitish streaks along the secondary veins when it is still rolled. These streaks become dark green as the leaf unfurls. Successive leaves become smaller, both in length and in width of the lamina, and often have chlorotic, upturned margins. The

Banana bunchy top
Banana bunchy top virus

© Pearson, M.N. Courtesy of EcoPort, www.ecoport.org


Banana bun... Banana bun...

leaves become dry and brittle and stand more erect than normal giving the plant a rosetted 'bunchy top' appearance.
Suckers from an infected stool can show severe symptoms in the first leaf to emerge. The leaves are rosetted and small with very chlorotic margins that tend to turn necrotic. Dark-green streaks are usually evident in the leaves.
Infected plants rarely produce a fruit bunch after infection and do not fruit in subsequent years. Plants infected late in the growing cycle may fruit once, but the bunch stalk and the fruit will be small and distorted. On plants infected very late, the only symptoms present may be a few dark green streaks on the tips of the flower bracts.

Banana bunchy top virus

What to do:

- **Eradicate diseased plants. The whole stool, including rhizome/corm and all associated suckers, must be destroyed by uprooting and chopping into small pieces, as the virus can ultimately spread to all parts of the mat. Control must be practiced across the whole production area to avoid the rapid re-infection.**
- **Use of virus-free planting material**
- **Genetic resistance to black leaf streak is a long-term goal for disease management, especially for smallholders who cannot afford to purchase chemicals.**
  Cultivars with high levels of resistance include 'Yangambi Km 5' (AAA), 'Mysore' (AAB), 'Pelipita' (ABB), 'Saba' (ABB) and 'Pisang Awak' (ABB).
  However, these do not suit all local tastes and some are susceptible to Fusarium wilt (Fusarium oxysporum f.sp. cubense).

Black leaf streak (*Mycosphaerella fijiensis*) (also called black Sigatoka)

It is a very serious disease that affects the leaves of banana. The spores of this fungus are carried in the wind. The spores germinate in moisture and infect the leaves. The lesions gradually grow larger and kill large areas of the leaf. This results in lower

yields and causes the premature ripening of the fruit.

What to do:

- **Remove and destroy diseased leaves, as this will reduce source of infection. If diseased leaves cannot be removed from the plot and burnt, they should be deeply buried.**
- **Overhead irrigation encourages the disease. Under-canopy micro-irrigation or drip-irrigation is preferable. Plants are also more vulnerable to black leaf streak in sheltered areas where the humidity is high. Good drainage systems that take surface water rapidly out of plantations can reduce humidity.**
- **Avoid overcrowding of plants.**

Black leaf streak
Black leaf streak on banana leaf (also called black Sigatoka)

Fusarium wilt (*Fusarium oxysporum* f.sp. *cubense*) (also called Panama disease)

This is a soilborne fungus that attacks the roots and blocks the vascular system in the banana, so that the plant wilts. Diseased leaves turn yellow from the margins, dry up and collapse leaving a skirt of dead leaves draped around the plant.
There is no effective control for *Fusarium* wilt, which is spread on infected suckers and in ground water.

Fusarium wilt
Fusarium wilton banana. Banana with yellowing symptoms on lower leaves, caused by Fusarium wilt

What to do:

- **Sanitation and cultural methods can minimize spread of the disease.**
- **In areas where Fusarium wilt is endemic resistant varieties**

such as 'Cavendish', 'Kisigame', 'Mararu' and 'Uganda green' (plantain) should be grown.



Fusariu w... Fusariu w... Fusariu w...

More Information on Fusarium wilt

The cigar end rot disease (*Trachysphaera fructigena*)

It is a fungal disease that can attack the ripening fruit of banana, causing a dry rot of the flower end that produces an ash grey wrinkled lesion similar to the burnt end of a cigar. In storage or during transport the disease may progress to involve the whole fruit. Symptoms are: lesions, abnormal shape, visible mould. The disease is usually of minor significance and seldom requires targeted control.

What to do:

- **Practise sanitation**
- **Avoid damage to the fruit and deflowering 8-11 days after fruit bunch emergence**

Cigar end rot
Cigar end rot disease on banana

- **Bagging of maturing banana stems**

Anthracnose

It is an important post-harvest problem of bananas especially during transport and storage. On green fruit, pin-size brown or black sunken spots develop. Infection in young fruit is not always manifested until the fruit ripens, when black, round, slightly sunken spots appear. The centres of the spots become dark because of the formation of small black fruiting bodies of the fungus. Under moist conditions, masses of spores are produced having a characteristic salmon (pinkish) colour. Pulp of diseased fruit is usually not affected unless the fruit is over-ripe.

Anthracnose
Anthracnose fruit rot on banana

More Information on Anthracnose

What to do:

- **Practise good field sanitation**
- **Minimize bruising during fruit handling**
- **Hot water treat the fruit for 5 min at 50°C. For more information on hot water treatment click here**
- **Proper sanitation of handling facilities**
- **Reports from Philippine claim that sprays of jathropa oil extract at 5000 ppm (5 ml of oil extract in 5 litres of water) significantly controlled anthracnose on bananas and ripening was delayed by 12 days (Philippine Organic Agriculture Information Network, 2004).**

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Information on Pests

The burrowing nematode (*Radopholus similis*)

The burrowing nematode is the most destructive nematode species attacking bananas. Dark patches or spots on the roots indicate nematode infestation. Severely infected plants may show only stubs of rotted roots and may fall down when the bunch has formed. Bananas are also attacked by other nematode species such as *Pratylenchus* spp., *Helicotylencus* spp. and *Meloidogyne* spp.

What to do:

- **Remove infested plants**
- **Use nematode-free planting material**
- **Plant resistant cultivars**
- **Biological control is possible by Paecilomyces lilacinus, a fungus, which parasitizes the egg, larva and adult of the nematode.**
- **All nematode species can also be controlled incorporating neem cake powder into the soil near the banana plants. In Uganda neem extracts spread around the banana plant are recommended for control of nematodes (Karubaga and Kimaru, 1999). For more information on neem click here.**

Burrowing nematodes Toppled bananas due to root damage caused by *Radopholus similis*, the burrowing nematode.

Burrow... Burrow...

More Information on Root-

knot nematodes

Banana weevil borer (*Cosmopolites sordidus*)

The banana weevil It is the most important insect pest of banana. It is about 1-1.5 cm long. The larva (grub) is most destructive: It bores irregular tunnels in the rhizome/corm and pseudostems at ground level. A large proportion of the tissue is destroyed, this reduces the amount of water and nutrients the plants can take up as well as lessening their anchorage. Heavy infestation may kill young plants. Older plants are easily blown over by the wind.

Banana weevil
Banana weevil (*Cosmopolites sordidus*) in banana corm. Adults attain a body lenght of 1-1.6 cm.

© A.M. Varela, icipe
More Information on Banana weevil

What to do:

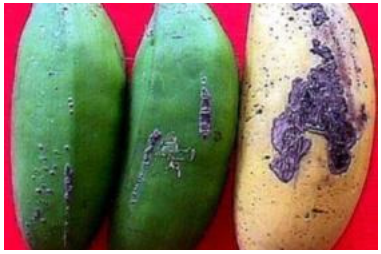
- **Chop up the rhizome/corm and pseudo-stem to hasten decomposition, trapping and collection of the adults**
- **To prevent an infestation, use non-infested planting material, destroy the shelter and feeding places of the adult weevil and maintain a clean area around the mat**
- **Some ants are important natural enemies of the banana weevil and are being used for its control**
- **Applications of neem powder effectively controlled weevils and nematodes in on-farm trials and in farmers' fields in Kenya. Application of 60 to 100 g of neem seed powder or neem cake at planting and then at four months intervals significantly diminished pest damage and increased yields. Application of over 100 g or neem oil was phytotoxic and uneconomical. Neem applications were economical in fertile**

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

- **Hot-water treatment of banana suckers helps against banana weevils. For information on hot-water treatment click here**

Banana silvering thrips (*Hercinothrips bicinctus*)

Banana-silvering thrips are small (1.5 mm long), slender, brown insects with pale yellow hind wings that appear as a yellow line down the back of the body when the insect is at rest. Adult thrips have characteristic wings; the transparent wings have a fringe of hairs around the outside edge standing out in the same plane as the wing. The tiny eggs are laid just into the plant tissue on the pseudostem or where two fruit touch. The nymphs hatch after 7 or 8 days, are pale yellow or white in colour and often have a black globule of excrement at the end of the abdomen. The larval stage lasts about 10 days after which the nymphs move down into the soil to pupate. Adults emerge after a further



Banana silvering thrips
Banana silvering thrips (*Hercinothrips bicinctus*) damage on banana fruits

7 to 10 days.

The banana silvering thrips is found in tropical and subtropical regions, it is polyphagous, in particular found on bananas. They feed on the skin of the fruit causing silvering patches (hence the common name of the insect), which turn brown and may cover the whole fruit and deep longitudinal cracks may appear as a result.

What to do:

- **To prevent this insect spreading, do not use planting bits and suckers from areas infested with silvering thrips.**
- **Bagging of bunches has been found to prevent thrips infestation. Click here for more information on bagging**
- **Conserve natural enemies. Thrips are attacked by predatory thrips, lacewings and predatory bugs. Avoid use of pesticides that kill natural enemies**
- **Whenever necessary spot spray the crop with botanicals or other biopesticides. Some plant extracts (e.g. garlic, rotenone, neem, pyrethrum, and a mixture of garlic and pepper) are reported to control thrips. Spinosad, a bacterial derivative, is effective in controlling thrips**

© A. M. Varela, icipe

Banana Thrips sil...

More Information on Thrips

Fruit flies (*Bactrocera invadens* and *Ceratitis rosa*)

Two species of fruit flies (*Bactrocera invadens* and *Ceratitis rosa*) attack banana in Kenya. *Bactrocera invadens* is a new

species recently discovered in Africa, its 2-3mm in size. This fruit fly is reported attacking banana in Sudan and Kenya and it is a major threat since it leads to rejection of banana in the export market.

One of the most effective control techniques against fruit flies in general is to wrap fruit, either in newspaper, a paper bag, or in the case of long/thin fruits, a polythene sleeve. This is a simple physical barrier to oviposition but it has to be applied well before the fruit is attacked. Little information is available on the attack time for most fruits, but few *Bactrocera* spp. attack prior to ripening.

Infected fruit on the ground will act as reservoir for re-infection. If infected fruit reaches the market then maggot infested fruit will be discarded, so allowing emerging adults access to new crop areas.

What to do:

- **Bagging of young banana fruits is an effective method, used in the Pacific and South East Asia for protection against fruit flies. (Personal communication S. Ekesi, AFFI, icipe; Ekesi and Billah, 2006). Click here for more information on bagging**

Fruit fly damage
Fruit fly (*Bactrocera invadens*) attack on green banana

© M. K. Billah, icipe


Fruit fly ...


Fruit fly ...


Fruit fly

More Information on Fruit flies

The banana aphid (*Pentalonia nigronervosa*)

It is a small aphid about 1-2mm long and blackish-brown in

colour. Colonies are usually present on the base of young leaves. The direct damage caused by aphids sucking the plant sap is negligible. However, they are important pests as vectors of the virus causing the bunchy-top disease.

Large colonies of aphids can occur around the base of pseudostems of Musa, down to 7-8 cm below the soil surface. Dense colonies can also occur between the sheath of outer leaf and pseudostem. During drought, aphids seek sheltered locations on the plant. In dull and humid weather, however, aphids may spread to foliage generally, and to the bases of maturing hands of fruit and all over the hands of young fruit.

Colonies of *P. nigronervosa* are attended by ants, which feed on the large quantity of honeydew produced. Many species of ant are involved worldwide. Stechmann et al. (1996) described how ant-attendance reduced the density of indigenous predators of P. nigronervosa considerably, which has implications for biological control (e.g. Wellings et al., 1994). Ants also transport aphids from plant to plant, establishing new infestations.

***P. nigronervosa* is not normally found on plantains, suggesting that they may have resistance to the aphid.**

Banana cultivars are all thought to be susceptible to Banana bunchy top virus (BBTV); although wide variations in the onset and severity of symptoms have been observed,

Banana aphids
Banana aphids (*Pentalonia nigronervosa*) often gather on the youngest leaves of young plants. They may form large colonies where they are uncontrolled and protected by ants. They feed by piercing the plant cells with a syringe-like mouthpart.

© www.ctahr.hawaii.edu


Banana aph... Banana aph...

More Information on Aphids

What to do:

- **Conserve natural enemies. They are important in natural control of aphids. For more information on natural enemies click here**
- **Monitor regularly the crop.**
- **Banana bunchy top virus (BBTV) is best controlled by quick and efficient early detection in banana, with frequent surveys by trained inspectors. Diseased plants should be removed and destroyed. Replanting is increasingly done with virus-free tested material.**

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Contact Information

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- **Green Dreams admin@organic.co.ke 0721 100 001**
- **Kalimoni Greens kalimonigreens@gmail,com 0722 509 829**
- **Karen Provision Stores karenstoresltd@yahoo.com 020885552**

- **Muthaiga Green Grocers**
- **Nakumatt Supermarket info@nakumatt.net 020551809**
- **Uchumi Supermarket**
- **Zuchinni Green Grocers 0204448240**

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Crops/ fruits/ vegetables
African Nightshade
Amaranth
Avocados
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Beans
Cabbage/Kale, Brassicas
Carrot
Cashew
Cassava

more Images

Pigeon pea
Scientific name: *Cajanus cajan*
Order/Family: Fabales: Fabaceae
Local names: Swahili: Mbaazi
Pests and Diseases: Aphids Blister beetles Bugs Cercospora leaf spot Cowpea seed beetle Cutworms Fusarium wilt Jassids Macrophomina stem canker Phytophthora blight Pod borers Pod fly Pod weevil Powdery mildew Purple witchweed Root-knot nematodes Rust Spider mites Termites Thrips Whiteflies Cutworms, Termites, Purple witchweed

General Information and Agronomic Aspects
Information on Diseases
Information on Pests
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General Information and Agronomic Aspects

Geographical Distribution of Pigeon pea in Africa

Pigeon pea is an important grain legume crop of rain-fed agriculture in the semi-arid tropics. Main pigeon pea producing regions are the Indian sub-continent, Central America and Southern and Eastern Africa. Pigeon pea is produced as a vegetable or export grain crop in southern and eastern Africa. In Kenya, pigeon pea is the third most widely grown pulse crop, and it is one of the fastest growing cash crops with an annual growth rate of 3% in the last decade. Green pigeon pea is being exported from Kenya to Europe (Snapp et al, 2003). The dry grain is also an important local pulse and export commodity in several African countries (Kenya, Malawi, Mozambique, Tanzania and Uganda) (Minja, et al, 1999).

Pigeon pea is a perennial shrub that is commonly grown as an annual crop. It has very slow initial development (up to 2 months after planting). With a deep taproot, pigeon peas are able to take up nutrients and water from lower subsoil layers. Therefore, in crop mixes they hardly compete with the companion crops. This crop grows and yields well under conditions of low rainfall and poor soil.

Pigeon pea is well balanced nutritionally and an excellent source of protein. It is eaten as a vegetable (immature pods or green pea) or as dried grain (cooked and eaten as dhal, dry split cotyledons). The crop has many other uses: the wood is used as fuel, and the leaves and husks provide livestock feed.

Pigeon pea is useful as tall hedges on dry soil and on the bunds of paddy fields. The branches and stems can be used for baskets and firewood. It is often grown as a shade crop, cover crop or windbreak. After establishment, pigeon pea improves the soil by its extensive root system. The bacterium *Rhizobium* that lives on the roots of the pigeon pea is able to fix nitrogen and

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

thus to improve soil fertility. Fallen leaves are used as mulch. Traditional uses as medicine are many, e.g. young leaves are applied to sores, herpes and itches.

Climatic conditions, soil and water management

Optimum temperatures range from 18 to 38°C. Pigeon pea does not tolerate frost. Above 29°C, soil moisture and fertility need to be adequate. Rainfall optimum is 600-1000 mm/year. Pigeon pea is a short day plant. Flowering is triggered by short days, whilst with long days plants grow vegetative. It is sensitive to high salinity and to water logging. It flowers well where rainfall is 1500 to 2000 mm. On deep, well-structured soil it will grow where rainfall is 250 to 370 mm. Pigeon pea is rarely found above altitudes of 2000 m. Drained soils of reasonable water-holding capacity and with pH 5-7 are favourable for its growth. Pigeon pea does not tolerate shallow soils or water logging.

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

Propagation and planting

Propagation is by seed, stem cuttings rarely succeed. Pigeon pea varieties differ not only in form of seeds, colour and taste, but also in growth habit, time of flowering and susceptibility towards pests and diseases.

Pigeon pea varieties (available in Kenya) and their characteristics:

Variety	Maturity period (days)	Potential yield (bags/acre)	Characteristics	Sole cropping plant density
Kat 60/8	135-150	5-7 for one season (13 for 2 seasons)	Grains are white with brown spots and smaller seed size than local races. Grows between 0-1800 m above sea level and performs well where temperatures are high.	75 cm between rows and 50 cm between seeds
Kat	170-185	6-11	Tolerant to wilt, pod sucking bugs and pod	90 cm

81/3/32			**borers. Cream white grain with large brown patches. Adapted to medium and higher altitudes (over 900 m above sea level)**	**between rows and 50 cm between seeds**
Kat 777	**160-180**	**6-10**	**Oval white seeds. Adapted to medium and higher altitudes (above 900 m above sea level)**	**90 cm between rows and 50 cm between seeds**
ICPL 89091	**120**	**4 for one season, 8 for 2 seasons**	**Is grown in the same range of altitude as KAT 60/8 but is more adapted to the more humid coastal zones. Performs best in pure stands at quite high density.**	**50 cm between rows and 10 cm between seeds**
Local varieties				**1,2 m between rows and 650 cm between plants**

Seed rate: 20-25 kg per ha (8-10 kg per acre)

Land preparation
Pigeon pea thrives best in seedbeds prepared by deep ploughing and cultivations to reduce weeds. Seeds should be sown in rows with spacing of 30-50 cm x 75-150 cm and 10cm deep. There is no standard spacing - spacing depends on variety, soil type and production system. See table above for spacing recommended for different varieties. In dry areas, and especially in coarse-textured, infertile soils, farmers use wide spacing between plants to limit competition.

Plants are fairly slow to start and weed control for the first two months is important in crop establishment. Once plants are established they grow vigorously.

Husbandry

Weeds must be controlled to facilitate slow initial growth. Wind may bend the plants but staking is not practised. Response to fertilisers is seldom economic. In Eastern Africa, the crop is cultivated on marginal lands by resource-poor farmers, who traditionally grow landraces. Inputs such as fertilisers, irrigation and pesticides are hardly used.

Intercropping

In intercropping, the crop performs well with two rows of cereals (e.g. sorghum, millets), cotton or groundnut. After harvest of the intercrop, long-duration pigeon pea continues to grow and protects the soil. Pigeon pea is regarded as a good plant for restoration of fertility and is used in a rotation with crops such as maize-groundnut-tobacco-pigeon pea for three to four years in Uganda. One of the advantages of pigeon pea is the increased growth of the grass interplanted with it. In Uganda, it is usually sown in alternate rows with sesame or African finger millet (*Eleusine coracana*), and in Malawi with maize. In Tanzania, the main intercrop is cassava. In Kenya, sorghum and maize are the most common intercrops with pigeon pea. However, due to its high demand, there is a tendency to move away from traditional intercropping to monocropping. In Ukambani and Coastal strip, Kenya, the crop is grown commercially in large plots.

Harvesting

The crop is usually cut near the ground when most pods are mature, or mature pods are picked individually. Green pods are picked over a long period in home gardens or hedge crops. Ratoon cropping is mostly practised in pigeon pea producing areas in Kenya. After harvest the stems are cut back to facilitate re-growth and a second crop is harvested in the subsequent season. Entire air-dried plants or pods are threshed, usually by hand or with cattle, and seed is cleaned.

Clean bins prevent insect attack, which can be considerable. Storage as split peas reduces bruchid attacks. Processing includes dhal making, either wet (after sprinkling heaps of seed) or dry, by milling.

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Information on Pests

General information

The most important pests of pigeon peas are insects feeding on pigeon pea pods and seeds. Surveys in Kenya, Malawi, Tanzania and Uganda have shown that the most important pests of pigeon pea pods and seeds in the region are:

- **pod sucking bugs,**
- **pod and seed boring caterpillars,**
- **pod flies**

(Minja et al., 1999).

Varieties that mature during the dry season have low damage levels (Snapp et al., 2003). A number of caterpillars (e.g. hairy caterpillars and semiloopers), and beetles (e.g. weevils, and foliage beetles) that feed on foliage of other legumes and grain legumes also attack pigeon peas, but they are usually not important.

Examples of Pigeon Pea Pests and Organic Control Methods

Leafhoppers or Jassids (*Jacobiasca lybica*)

Jassids (Leafhoppers) have been reported to cause damage to pigeon peas in Kenya. These small (2.5 mm) green and very mobile insects occur on the upper and lower leaf surface. The adults fly or hop away when disturbed. Nymphs resemble adults, but have no wings, and run sideways when disturbed. The eggs are inserted in the veins on the underside of leaflets. Adults and nymphs feed by sucking on the leaflets. Attacked leaves become cup shaped and yellow at the edges. Heavy attacks result in the leaflets turning red-brown, with subsequent defoliation and stunting.

Leafhopper (Jassid) Leafhopper. Adults are small, about 2.5 mm long. Picture shows *Empoasca fabae*

© Steve L. Brown, University of Georgia, Bugwood.org

What to do:

- **Use neem kernel extract and other neem products**
  Neem treatments against aphids should be enough to control jassids at the same time. For more information on neem click here

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Storage pests: Bruchids (*Callosobrochus* spp.)

They are the most common and widespread insect pests in storage. Adults are 2-3.5 mm long. 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%.

What to do:

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

Cowpea seed beetle
Cowpea seed beetle (*Callosobruchus maculatus*) adults are 2.-3.5 mm long. The adults emerge through windows in the grain, leaving round holes that are the main evidence of damage.

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More Information on Cowpea seed beetle

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.

What to do:

- **Plant resistant varieties / lines, if available**
- **Plant in fields with no previous record of nematode infestation**

Root-knot nematodes
Root-knot nematode galls (here on tomato roots). Affected plants are normally

- **Rotate with cereals**
- **Amend soil with neem extracts**
- **A number of bio-products for control of nematodes are going through registration process in Kenya. For more information on nematodes click here**

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

Red spider mites (*Tetranychus* spp.)

Red spider mites are about 0.6 mm long. They feed on the lower leaf surface causing white or yellowish spots on the upper leaf surface. Heavy infestation results in partial defoliation.

What to do:

- **Red spider mite attack is seldom severe enough to merit control.**
- **Use resistant cultivars. Most widely used cultivars appear to be relatively resistant to these mites.**

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

© Warwick HRI, University of

Warwick.

More Information on Spider mites

Thrips (*Megalurothrips* spp. and *Frankliniella schultzei*)

Thrips are small (1.5 mm long), slender, brown insects with pale yellow hind wings that appear as a yellow line down the back of the body when the insect is at rest. Adult thrips have characteristic wings; the transparent wings have a fringe of hairs around the outside edge standing out in the same plane as the wing.

Several species of thrips are common on pigeon peas in Eastern Africa and are considered important pests. These thrips feed on leaves and flowers. Main damage is due to thrips feeding on flower buds and flowers. Heavy infestation can lead to shedding of buds and flowers. However, according to reports from India, pigeonpea plants produce more flowers than the plant can sustain, so many are lost naturally and it is difficult to assess thrips damage (Ikisan, 2000).

Thrips
The Western flower thrips (*Frankliniella occidentalis*). Close-up, immature thrips (left) and adults. Very much enlarged. Real size (0.9 to 1.1 mm)

© M. Billah, icipe

More Information on Thrips

What to do:

- **Conserve natural enemies. Predatory mites and pirate bugs are important for the natural control of thrips. For more information on natural enemies click here**
- **Monitor the crop regularly. Early detection is particularly**

important at the onset of flowering

- **Whenever necessary spot spray the crop with botanicals. Some plant extracts (e.g. garlic, rotenone, neem, pyrethrum, and a mixture of garlic and pepper etc.) are reported to control thrips. Spinosad, a bacterial derivative, is effective in controlling thrips.**

Aphids

Several species of aphids have been reported feeding on pigeon pea. The black legume aphid (*Aphis craccivora*) is the most common.

What to do:

- **Aphids seldom are a problem on pigeon pea, probably due to the effect of natural enemies.**

Aphids
Black legume aphids *Aphis craccivora*) on cowpea

© David Riley, University of Georgia, Bugwood.org
More Information on Aphids

Bugs

Pod sucking bugs are primary pests of pigeon peas.

The most common pod-sucking bugs are: giant coreid bugs

(*Anoplocnemis* spp), spiny brown bugs (*Clavigralla* spp), Riptortus bugs (*Riptortus* spp) and green stink bugs (*Nezara viridula*).

These bugs suck developing seeds through the pod wall. The seeds become shrivelled with dark patches. Attacked seeds do not germinate and are not acceptable as food. Fungal spores are sometimes transmitted with the mouthparts during feeding, resulting in rotting of the seeds. The spiny brown bug *Clavigralla tomentosicollis* is one of the most important pests of pigeon peas in Eastern Africa.

Sucking bug adults are difficult to control since they are very mobile and can invade crops from neighbouring sites.

What to do:

- **Immature bugs can be handpicked and destroyed.**
- **Adults can be collected with insect nets and destroyed.**
- **The main natural enemies of bugs are egg parasitoids, assassin bugs, ants and birds**
- **Spraying with aromatic plants (e.g. gums, lantana, khaki weed etc.) has been suggested to repel bugs (Elwell and Mass, 1995).**
- **Neem-based pesticides reportedly reduce feeding by green shield bugs. For more information on neem click here.**

Tip wilter
Tip wilter / giant coreid bug (*Anoplocnemis curvipes*) is about 2.5cm long.

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Tip wilter.. | Spiny brow... | Riptort ... | Green stin...

Pod borers

The African bollworm (*Helicoverpa armigera*), the legume pod borer (*Maruca vitrata* = *testulalis*) the lima bean pod borer (*Etiella zinckenella*) are major pests of pigeon peas in East Africa. They feed on leaves, flowers and pods, destroying them.

The African bollworm (*Helicoverpa armigera*)
Caterpillars are 1.5 to 4cm long. They bore holes on pods and feed on the seeds. Usually developing and partly mature seeds are eaten completely.
For more information on the African bollworm click here.

The legume pod borer (*Maruca vitrata*)
The adult of the legume pod borer is a moth with a wingspan of 15-30 mm. It has light-brown forewings with white markings and pearly white hindwings. Though mainly nocturnal, the moth may also be seen during the day. They lay eggs in the flowers or buds, or on the pods. Caterpillars are whitish with black head and rows of conspicuous brown to black spots on the dorsal, lateral, and ventral surfaces of each body segment. Fully-grown caterpillars measure about 15mm in length. They pupate in the soil. Caterpillars web together leaves, flower buds and pods and feed inside the web. Flowers usually show little sign of damage until they wilt and drop. They typically attack pods at the point of contact between two pods, or between a pod and a leaf or stem.

The lima bean pod borer
Adults of the lima bean pod borer are brown moths with a wing

African bollworm
African bollworm (*Helicoverpa armigera*) damage on beans

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African bo...


Legume pod...


Lima bean ...

span of about 20-25 mm. They lay eggs singly or in small groups on immature pods. Young caterpillars bore into the pod. They feed inside the pod reaching a length of 12 to 17 mm and are generally found in maturing and dried pods. Young caterpillars are green, turning red later. They feed inside the pod reaching a length of 1.4 cm and are generally found in maturing and dried pods. Faeces in the form of granules are found inside the damaging pods.

What to do:

- **Apply biopesticides such as Bt or neem products. They usually give good control of pod borers, provided they are applied to pods before the young caterpillars enter into the pods. Once the caterpillars have entered the pods they are difficult to control and by then they have caused damage. Other plant derivatives reported to control pod borers are tephrosia and chilli/garlic. For more information on Bt click here. For more information on neem click here**
- **Monitor regularly the crop to detect eggs and young caterpillars before they enter the pods**
- **Conserve natural enemies. Ants, parasitic wasps and pirate bugs are important in natural control. Bird perches placed just above the crop canopy are also reported to reduce the numbers of pod borers**

The pod fly (*Melanagromyza chalcosoma*)

It is a small black fly that lays eggs through the walls of developing pods. The maggots (white in colour and about 3 mm long) feed inside the green seed. The brown barrel shaped pupa is formed inside the pod but outside the seed.

There are no obvious external symptoms of attack till the fully-grown maggot chew holes in the pod walls leaving a window through which the flies emerge after pupation in the pod. Damaged seeds are of no value. The pod fly causes most damage on pigeon pea maturing during cool weather and pigeon pea planted at altitudes higher than 500 m above sea level.

Pod fly
Pod fly *Melanagromyza chalcosoma*) damage on pigeon pea

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

What to do:

- **In areas where the pod fly is a problem, it is best to avoid growing a mixture of cultivars of differing duration in one area because this will provide pods over a long period and allow several generations of the pod fly to develop.**
- **Neem has given control of a related pod fly (M. obtusa) on pigeon pea in India. Four weekly applications of aqueous neem seed extract (ANSE) 50g/l and fortnightly sprays of aqueous neem kernel extract (ANKE) 80g/l have given effective control (Ostermann and Dreyer, 1995). For more information on neem click here.**

The pod weevil (*Apion clavipes*)

It has been regarded as a major pest of pigeon pea in East Africa. Adults

are small black weevils. The larvae are creamy white. Larvae damage the green seeds in pods but the damage is usually noticed only after adults emerge cutting the way out of the pod. The beetles also chew small holes in leaflets and flowers.

Pod weevil
Pod weevil *Apion* species on bean pod.

© Frank Peairs, Colorado State University

What to do:

- **Use neem extracts. Research in India has shown some efficacy of neem extracts against this pod weevil. For more information on neem click here.**

Blister beetles (*Coryna* spp. and *Mylabris* spp.)

Adults feed on the flowers and reduce the number of pods that are set. In location where pigeon pea is grown over large areas blister beetles cause little damage. However, in small pigeon pea plots that are in the flowering stage during the period of peak adult activity, most of the flowers may be eaten by the beetles and crop losses maybe substantial. The adults are medium to large sized beetles (2 to 5 cm in length), usually black and yellow or black and red in colour. The immature stages (larvae) do not feed on plants. They live in the soil and eat grasshopper eggs, and are therefore beneficial.

Blister beetle
Blister beetles (*Mylabris oculata*) Adults are 2 to 5 cm in length.

© Botha AD (Courtesy of

What to do:

- **The adult beetles can be handpicked and destroyed. However, care should be taken, since when disturbed, they can release a liquid that burns the skin.**
- **Whenever possible wear gloves to protect the hands. Many types of essential oils extracted from eucalyptus and aromatic herbs can have repellent effects (caution: phytotoxic side effects are possible).**
- **In addition, rock powder or clay powder (kaolin) could have a repellent effect on these beetles. Since the larvae are beneficial, the aim should not be to destroy all adults, but to keep the numbers in check.**

EcoPort, www.ecoport.org)

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Information on Diseases

Examples of Pigeon Pea Diseases and Organic Control Methods

Fusarium wilt (*Fusarium udum*)

It is a fungal disease. Symptoms include partial or total wilting of plants at flowering and podding, a purple band of stems extending from the base upwards, browning of the stem tissue in the purple band area, and browning or blackening of internal tissue when the main stem or primary branches are split. Infected young plants may not show the purple band symptom but have conspicuous internal browning and blackening. Affected fields show patches of dead plants. *F. udum* is seed and

Fusarium wilt
Fusarium wilt on beans

soilborne. The fungus survives on infected crop debris in the soil for about three years.

© A.M. Varela

More Information on Fusarium wilt

Crop rotation is advisable against diseases such as Fusarium wilt. Pigeon pea is generally grown in inter- and mixed-cropping systems in rotation with other crops, particularly cereals. However, since the fungus-causing agent of wilt of pigeon pea survives on deep-seated roots of the host, the success of rotation will depend upon the field sanitation (removal of affected plants with their roots). A 4-5-year rotation has been found to free the field completely of the wilt pathogen (causing fungal agent). However, in smallholder scenarios this is not practical due to land restriction. One-year breaks with either sorghum or fallow reduced wilt in the following pigeon pea crop from more than 50 to below 20%.
Pigeon pea rotation with tobacco has been recommended as a possible means of control because of the adverse effect of tobacco root exudates on the pathogen. For more information on fusarium wilt click here.

What to do:

- **Plant of resistant varieties / lines. For instance, the long duration varieties (cultivar) ICP9145 and ICEAP00040 are resistant to Fusarium wilt and have superior productivity on-farm (Snapp et al, 2003).**
- **Use disease-free seeds**

- **Plant in fields with no previous record of wilt for at least three years**
- **Uproot wilted plants (and use them for fuel wood)**
- **Collect and burn plant residues after harvesting**
- **Crop rotation with cereals**
- **Soil amendment with Trichoderma products. These are commercially available in Kenya**

***Cercospora* leaf spot (*Mycovellosiella cajani*)**

Small circular necrotic spots (lesions) usually appear on older leaves. These spots join up causing leaf blight and leaf drop. The African isolates of the fungus produce concentric areas on the leaf spots. The disease causes severe losses when defoliation occurs before flowering and podding. The disease usually appears when plants are flowering and podding. The fungus is seed-borne. It is favoured by cool temperatures (25º C) and humid rainy weather. The disease is more common in the long-duration and perennial varieties in eastern Africa.

Cercospora leaf spot
Cercospora leaf spot on soybean

© Clemson University, USDA (EcoPort, www.ecoport.org)

What to do:

- **Plant resistant varieties / lines, if available**
- **Use disease-free seeds**
- **Plant in fields away from perennial varieties, which could be a source of inoculums (infection).**

***Macrophomina* stem canker (*Macrophomina phaseolina*)**

Initial symptom on stems and branches are spindle-shaped spots with light grey centres surrounded by brown margins. The centres of the spots have scattered dots (pycnidial bodies - fungal spores). The spots may join up and cause the branches or whole plants to dry up and die. Diseased plants suddenly wilt. When diseased plants are uprooted their roots are rotten and shredded. The fungus mainly attacks secondary finer roots. These roots have dark, blackened streaks underneath their barks with dots (pycnidial bodies - fungal spores). The disease could be a serious problem in late-sown and in perennial or rationed pigeon peas. Disease development is favoured by hot dry weather (30º C). Crops are more susceptible to the disease in the reproductive than in the vegetative stage.

Stem canKer
Stem canker (*Macrophomina phaseolina*)

© D. C. McGee/Iowa State University (Reproduced from CABI 2006)\n

What to do:

- **Plant resistant varieties / lines, if available**
- **Plant in fields with no previous history of the disease**
- **Avoid late planting**
- **Rotate with cereals and fodder grasses**

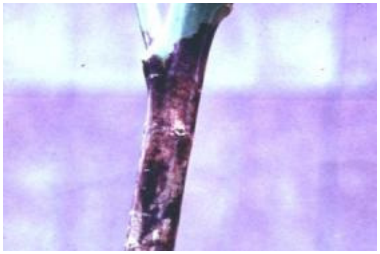
***Phytophthora* blight (*Phytophthora dreschsleri* f.sp. *cajani*)**

The disease causes sudden death of seedlings. Infected leaves have water-soaked spots that turn brown to black. Infected leaves lose turgidity and finally become desiccated. On stems and leaf petioles the spots are slightly sunken. Affected stems or branches are girdled and foliage above dries up. Plants that are

attacked but not killed often form large galls on their stems especially at the edges of spots. The fungus does not infect the root system. The fungus is soil-borne and it also survives on infected crop debris. The disease is favoured by cool temperatures around 25º C, cloudy humid weather and rain. Plants develop tolerance to the disease with age.

What to do:

- **Plant resistant varieties / lines, if available**
- **Plant in fields with no previous record of blight**
- **Avoid fields prone to waterlogging**
- **Use wide inter-row spacing.**



Phytophtora blight
Phytophtora blight (*Phytophthora dreschsleri* f.sp. *cajani*) on pigeon pea

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Powdery mildew

The disease can infect all aerial parts: leaves, flowers and pods. Characteristic of the disease is white greyish powdery fungal growth on affected plant parts. Small chlorotic spots develop on the upper surface of leaves and the corresponding lower surface develops white greyish powdery fungal growth. With time the powdery growth covers the entire lower leaf area. Severe infection causes heavy leaf drop. The fungus develops at temperatures ranging from 20 to 35º C, but 25º C is the optimum. The fungus survives on perennial pigeon peas and volunteer plants, and on the ratoon growth of the harvested plants. Plants with thicker leaves, as most varieties in Kenya are more tolerant

Powdery mildew
Powdery mildew (*Leveillula taurica*) of pea

to the disease than those with thin succulent leaves (Indian varieties).

What to do:

- **Plant resistant varieties / lines, if available**
- **Plant in fields away from perennial pigeon peas.**

CABI 2006)

More Information on Powdery mildew

Rust (*Uredo cajani*)

Symptom appears as dark brown raised spots full of brown spores (uredia) on the lower leaf surfaces. Infected leaves dry and drop off. When disease is severe, it causes extensive defoliation. The disease is favoured by rain and wind that facilitate spore release, dispersal and development.

What to do:

- **Plant resistant varieties / lines, if available**
- **Avoid planting of pigeon peas close to bean fields**
- **Avoid dense planting.**

Rust
Rust on beans

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Pumpkin
Scientific name: *Cucurbita* spp. (*Cucurbita maxima, Cucurbita moschata* etc.)
Order/Family: Cucurbitales: Cucurbitaceae
Local names: Budho (Luo), malenge (Kiwahili), lisiebebe (Luhya), marenge (Kikuyu), risoa (Kisii), ulenge (Kamba)
Common names: Squash / giant squash / summer squash / giant pumpkin / butternut
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Geographical Distribution of Pumpkin in Africa

Pumpkin refers to certain varieties of Cucurbita moschata, C. maxima, and C. mixta. They are native to North America. These and other related cucurbits provide pumpkins and butternuts (*Cucurbita moschata*), squashes (*C. maxima*), gourds (*C. argyrosperma*), and zucchini or courgettes and ornamental gourds (*C. pepo*). Distinguishing them is often difficult. Pumpkins have long-running, bristled stems, large deeply-lobed leaves often containing white blotches and yellow or orange flowers separated into male and female types on the same plant. The fruit is variable in shape and colour but is often white, cream or green, containing about 70% flesh and several large white seeds.

Fruits, leaves and flowers of these cucurbits are used as vegetables, and their seeds are consumed roasted as a snack food. Pumpkin fruit contains 1% protein and 8% carbohydrates, and the dried seeds contain 23% protein, 21% carbohydrates and up to 50% oil, but little information is available about the nutritional characteristics of cooked leaves (Woomer and Imbumi, 2005).

There are numerous types and cultivars, which differ greatly in composition and therefore in their suitability for certain culinary uses. The younger leaves are collected and the outer tough skin of petioles (stalk of leaf) removed (together with the large leaf veins) then washed, chopped and boiled.

Immature and mature fruits of *C. moschata* are used as a blanched, steamed or fried vegetable and as an ingredient of soups. Various desserts are made from the fruits: steamed flesh with grated coconut and sugar, crisps made from steamed mashed flesh mixed with cassava flour, pumpkin custard, pumpkin pudding, pumpkin in coconut milk and sweet pumpkin paste.

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

Pests/ diseases/ weeds

Medicinal plants

Fruit and vegetable processing

Natural pest control

Cultural practices

Ornamental gourds are cultivars of *C. pepo* with small, bitter and inedible fruits in many shapes, sizes and colours.

The potential of the seeds as a source of vegetable fat and protein has not been fully exploited. Fresh seeds have been reported to be used as a vermifuge, and seed decoctions as diuretic and to reduce fevers.

The pumpkin has been much used as a medicine in Central and North America. It is a gentle and safe remedy for a number of complaints. The seeds are widely used as an anthelmintic. The complete seed, together with the husk, is used to remove tapeworms. They are especially useful effective as tapeworm treatment for children and pregnant women for whom stronger and toxic remedies are unsuitable. The seeds are ground into fine flour, then made into an emulsion with water and eaten. It is then necessary to take a purgative afterwards in order to expel the tapeworms or other parasites from the body. The fruit and seed decoctions have been reported to be used as diuretic and to reduce fevers, and are used for curing indigestion. The pulp is applied to burns and scalds, inflammation, abscesses and boils. It is also used in the treatment of migraine and neuralgia (Plants for a Future 2003; CAB 2006).

Recently a new pumpkin relative, butternut has captured the market in Kenya. It was originally imported from South Africa and sold at very high prices in the upper level market, but is now widely grown by small farmers. Butternut has smooth yellow-orange flesh, is very nutritious and is widely used cooked and mashed as baby food. As the price came down this vegetable has gained wide popularity all over the country.

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 (

Pumpkin	26	1.0	6.5	0.8	21	44	0.8	340	1600	
Squash	19	1.1	4.2	0.6	28	29	0.4	202	410	

Climate conditions, soil and water management

Pumpkins and squashes (various *Cucurbita* spp.) are grown in the tropics from the lowlands up to 2500 m altitude. They are warm-season crops adapted to monthly mean temperatures of 18-27°C. *C. maxima* is the most tolerant of low temperatures, *C. moschata* and *C. argyrosperma* the least, with *C. pepo* intermediate. *C. maxima* and *C. pepo* have long been cultivated in temperate regions. Butternut appreciates part shade in very hot conditions, such as can be obtained when intercropped with other crops or grown under fruit trees.

Pumpkins and squashes respond very well to medium to heavy applications of compost or well-decomposed manure. They can be cultivated on almost any fertile, well-drained soil with a neutral or slightly acid reaction (pH 5.5 to 7). They are drought-tolerant, requiring relatively little water, and are sensitive to waterlogging. Excessive humidity is harmful because of the development of leaf diseases, so none of the species do well in the humid tropics.

Propagation and planting

Pumpkins and squashes are grown from seed. Seeds may be sown in containers and transplanted to the field when they are 10 cm high. Direct seeding of two to three seeds per hill is commonly practised. Trailing types are planted at distances of 2-3 m either way; the seed requirement is 2 to 3 kg/ha. The bushy types (mainly *C. pepo*) are planted closer, for example, plants spaced 60 to 120 cm in rows 1 to 1.5 m apart; the seed requirement is 3 kg/ha for pumpkin and 7 kg/ha for summer squash (*C. pepo*). Do not use seeds from plants where edible pumpkins and ornamental gourds are grown close together. Offspring will be bitter or even inedible.

Husbandry

Sole cropping is sometimes used for commercial production. Pumpkins and squashes are also planted in home gardens or mixed with field crops such as maize. Cultural practices to improve growth and development include the removal of growing tips (in trailing varieties) to check growth, and the bagging of fruits in paper to protect against fruit fly and other pests. Fruit setting may be stimulated by manual pollination. The fruit may rot when in contact with moist soil, so often cut grass or leaves are placed beneath the fruit.

Harvesting

Winter squashes and pumpkins are picked when mature in an once-over harvest or in several rounds, about 90 to 120 days after planting depending on variety.

Pumpkins are considered to be among the most efficient of vegetable crops when evaluated on nutritional yield in relation to land area and labour needed. Indicative figures for seed yield of *C. pepo* are 400 to 1500 kg/ha. A valuable source of oil and protein is thus neglected if the seeds are left unutilised. In seed production, isolation between fields of different *Cucurbita* species is recommended, not only for reason of purity but also for obtaining maximum yields (pollen of other species may cause reduced fruit set).

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Information on Pests

Pumpkin and butternut are affected by similar pests and diseases as other cucurbits; this is plants belonging to the family Cucurbitacea, including melons, squash, zucchini (courgettes) and cucumber.

For more information on pests attacking cucurbits refer also to page on cucumber click here

Examples of Pumpkin Pests and Organic Control Methods

Aphids (*Aphis gossypii*)

Colonies of green to blackish aphids are found on tender shoots, mainly on the lower leaf surface, where they suck sap. Under heavy attack the growth of attacked shoots is stunted and leaves are curled and twisted. Aphids excrete honeydew, which leads to growth of sooty mould, and may also attract fruit flies. Aphids transmit virus diseases such as the watermelon mosaic virus to pumpkins.

Cotton aphid
Cotton aphid (*Aphis gossypii*) is a small aphid. Adults range from just under 1-1.5 mm in body length.

© Mississippi State University Archive, Mississippi State University, Bugwood.org
More Information on Aphids

What to do:

- **Use reflective mulch (e.g a polyethylene sheet covered with a thin layer of aluminium that is spread out on the growing bed at planting time). Covering the ground with a material like aluminium foil repel winged aphids, delay aphid colonisation and may delay virus infection**
- **Place sticky traps to detect arrival of winged aphids into the crop.**
- **Conserve natural enemies. Aphids have a wide range of natural enemies which usually keep them under control.**
- **If necessary spray with botanicals (e.g. neem extracts). Spray only attacked plants (spot spraying).**

Whiteflies (*Bemisia tabaci*)

Whiteflies suck plant sap and excrete honeydew where moulds growth and may affect plant growth. However, the major damage is caused as vectors of various virus diseases, which cause considerable damage to cucurbits.

What to do:

- **Conserve natural enemies. Parasitic wasps are important in natural control of whiteflies.**
- **Use reflective mulches (see aphids). Reflective mulch repels whitefly adults in pumpkin, cucumber and zucchini squash, resulting in delayed and reduced attack by this pest with consequent reduction in damage as shown in experiments USA. Whitefly density on pumpkins and cucumbers plants growing over reflective mulch was reduced 10- to 14-fold as compared to plants growing on bare soil. This was reflected in significantly higher yields in plants grown over reflective mulch than in those grown over unmulched soil (UCANR, 2003; Summers & Stapleton 2002)**
- **If necessary spray crop with neem products. Neem-based pesticides are reported to inhibit growth and development of immature stages, and to reduce egg laying by adult whiteflies.**

Whiteflies
Whiteflies (*Bemisia tabaci*) under leaf. Adult whiteflies are about 1mm long.

More Information on Whiteflies

The Epilachna beetle (*Epilachna chrysomelina*)

Adults of the Epilachna beetle, also known as the African melon ladybird are 6 to 8 mm long, reddish in colour with a number of black spots on the wing cases. The larvae are 7 to 9 mm in length, soft and covered with dark coloured spines. They pupate on leaves. Both adults and larvae feed on the leaves leaving a fine net of veins. Damaged leaves shrivel and dry up. They may also gnaw stems and eat holes in fruits.

These beetles are most likely to be a problem during establishment when plants are small; young plants can be entirely destroyed. Older plants can tolerate considerable leaf damage, but during flowering fruit set maybe affected. This beetle is a vector of squash mosaic virus. The Epilachna beetle attacks all cucurbits. They often fly into a crop from nearby crops.

Epilachna beetle
Epilachna beetle (*Epilachna chrysomelina*) and damage caused on water melon

© A. M. Varela, icipe

What to do:

- **Do not grow pumpkins near crops attractive to the Epilachna beetle (e.g. other cucurbits, potatoes, maize)**
- **If necessary apply neem products. Simple neem-based pesticides are effective controlling this pest. For instance, weekly foliar sprays of aqueous neem kernel extracts at concentrations of 25, 50 and 100 g/l and neem oil applied with an ultra-low-volume (ULV) sprayer at 10 and 20 l/ha significantly reduced feeding by Epilachna beetles in squash and cucumber in Togo (Ostermann and Dreyer, 1995)**

Fruit flies (*Bactrocera cucurbitae*, *Dacus* spp and *Ceratitis capitata*)

Fruit flies are important pests of cucurbits including pumpkins. Fruit flies pierce the fruits and lay eggs in them. The fruit fly maggots feed inside the fruit causing sunken, discoloured patches, distortions and open cracks. These cracks serve as entry points for fungi and bacteria, which cause fruit rot.

What to do:

- **Avoid continuous cultivation of cucurbits at the same place.**
- **Destroy all infested fruit**
- **Wrap or bag individual fruits with newspaper or paper bags to prevent fruit flies form laying eggs on the fruit. Wrapping or bagging should be started shortly after fruit set.**
- **Spray with a pyrethrum solution in the evenings after the bees are mostly back in their hives (after 6 pm). There is a product commercially available called Flower-DS, made of natural pyrethrum and acceptable in Organic certified systems (see Hygrotech Company, contact-addresses below).**
  - Precautions: Be careful to spray late in the evening, follow the spraying instructions. Wear masks and skin protection. All insect poisons are also poisonous to humans even if coming from natural sources.
  - Frequency of spraying: start shortly after beginning of flowering, and repeat approx every 5 days or according to counts.
- **Frequent applications of neem can keep fruit fly attack to a**

Fruit fly
Mediterranean fruit fly (*Ceratitis capitata*). Adult fruit flies are 4-7 mm long, brightly coloured, usually in brown-yellow patterns. The wings are spotted or banded with yellow and brown margins.

© Scott Bauer, USDA Agricultural Research Service, www.insectimages.org
More Information on Fruit flies

minimum.
For more information on neem click here.

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Information on Diseases

Pumpkin and butternut are affected by similar pests and diseases as other cucurbits; this is plants belonging to the family Cucurbitacea, including melons, squash, zucchini (courgettes) and cucumber.

For more information on diseases attacking cucurbits refer also to page on cucumber click here

Examples of Pumpkin Diseases and Organic Control Methods

Anthracnose (*Colletotrichum lagenarium (= C. orbiculare)*)

It is a very destructive disease. It causes defoliation and lesions on the fruits.

The fungus can attack all the above-ground plant parts. Cotyledons (seed leaves) of affected seedlings droop and wilt. Lesions (elongated spots) may form on stems of affected seedlings near the ground. Spots on leaves start as small yellowish areas that enlarge and turn brown. The affected tissue dries, breaks and the whole leaf dies. On vines, the spots are elongated and may kill the vines. Symptoms are most noticeable on fruits. Spots on fruits are circular, black, and sunken. When

Anthracnose Anthracnose (*Colletotrichum orbiculare*) damage to pumpkin leaf (*Cucumis sativus*).

wet, the centres of the spots become salmon coloured due to a mass of fungal spores. Affected fruits can be destroyed by secondary soft-rot organisms, which enter through broken rind. The fungus is seed-borne. It can survive in crop debris and in weeds belonging to the cucurbit family. Fungal development is promoted by wet conditions, high relative humidity and moderate temperatures (20 to 23.9º C). Its host range includes cucumber, gherkin, gourd, muskmelon, and watermelon. Cucurbit weeds can also be attacked.

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More Information on Anthracnose

What to do:

- **Use certified disease-free seeds**
- **Treat own seeds in hot water for 20 minutes at 135° F (43° C)**
- **Plant resistant varieties, if available**
- **Practice crop rotation with non-cucurbits**
- **Destroy volunteer cucurbits in the field**

Choanephora fruit rot (*Choanephora cucurbitarum*)

- **Powdery mildew (*Erysiphe cichoracearum*)**
- **Downy mildew (*Peronospora cubensis*)**
- **Scab (*Cladosporium cucumerinum*).**

Choanephora fruit rot
Choanephora fruit rot

What to do:

- **Destroy crop residues after harvest.**
- **Control cucumber beetles, which are responsible for fungal**

spread.

- Spray copper when the disease is observed
- Avoid humid conditions during storage.

(*Choanephora cucurbitarum*) on *Cucurbita maxima*.

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Powdery mildew (*Erysiphe cichoracearum*)

Symptoms first develop as a whitish talcum-like powdery growth on lower leaf surface. The powdery growth is composed of fungal spore mass. These areas covered by white powdery growth may enlarge and join up to cover both lower and upper leaf surfaces. Severely affected leaves dry, turn brown and become brittle. Vines can be also attacked. Secondary effects of the disease include sun-burning and premature ripening of fruits.

Powdery mildew affects cucumber, gourd, muskmelon, pumpkin, squash and watermelon. Other hosts include African violets and pawpaws. The powdery mildew fungi are influenced by plant age, humidity and temperature. Foliage is most susceptible 16 to 23 days after unfolding. The fungi reproduce under dry conditions. Infection increases as humidity increases, but does not occur when leaf surface is wet. Optimum temperature for infection is about 27.4º C. However, infection can take place at a temperature as high as 32º C and relative humidity as low as 46%.

Powdery mildew
Severe powdery mildew attack (*Sphaerotheca fuligenea*) on cucumber

© Jürgen Kranz Courtesy of EcoPort

More Information on Powdery mildew

What to do:

- **Use resistant varieties, if available**
- **Spray with sulphur based organic fungicides, which provide good control**
- **Destroy weeds belonging to the cucurbit family**

Downy mildew (*Peronospora cubensis*)

Symptoms on leaves appear as small, pale-yellow areas on upper leaf surface. Under humid conditions, a purplish, grey whitish growth may be seen on the underside of the yellowish spots. Affected leaves curl, shrivel and die. Most downy mildew fungi require cool weather for reproduction and development. This is not true of the cucurbit downy mildew fungus. Optimum temperature for infection is at 16 to 22º C. It can survive when temperatures are over 37.8º C. The most critical factor for infection is a film of moisture and / or long dew periods on leaves.

Disease spread is primarily thorough by wind and rain splash. The fungus attacks only members of the cucumber family, mostly those that are cultivated, although it can infect wild cucumber and a few other weed hosts.

Downy mildew on cucumber
Downy mildew (*Peronospora cubensis*) attacking the upper leaf face

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Scab (*Cladosporium cucumerinum*)

It attacks all aboveground plant parts. Initial symptoms on leaves

appear as light water-soaked or pale green spots. The spots are numerous and can appear on and between veins. Elongate spots may develop on petioles and stems. The spots later turn grey to white and become angular. The fine veinlets in the spots may be brown and are distinct against a white background. Dead leaf tissue cracks and breaks away until the whole leaf is ragged. Fruits can be attacked at all stages of growth. However, young fruits are most susceptible. Plant tissue near the spots may produce sap, initially watery but later becomes gummy to hard.

The fruit spots are cankerous and with time become darker, sunken until a pronounced cavity is formed. Under moist weather, a dark-green velvety layer of fungal growth appears on the cavities. The fungus survives in crop debris, soil and on seed. It is spread by insects, farm tools and wind. The disease is most severe at 100% relative humidity and at relatively cool temperatures (21-25ºC). Its host range includes cantaloupe, gherkin, muskmelon, pumpkin, squash and watermelon.

Scab
Scab (here on a citrus leaf) symptoms on leaf

© www.ecoport.org
More Information on Scab

What to do:

- **Use resistant varieties, if available**
- **Use disease-free seeds**
- **Practice crop rotation with non-related crops**

Virus diseases

Many important virus diseases affect cucurbits. These include:

- **Cucumber mosaic cucumovirus (CMV)**
- **Watermelon mosaic 2 potyvirus (WMV-2)**
- **Watermelon mosaic 1 potyvirus**
- **Zucchini yellow mosaic potyvirus (ZYMV)**
- **Squash leaf curl bigeminivirus (SLCV)**

Cucumber mosaic virus
It is not seed transmitted except through seed of perennial wild cucumber (*Echinocytis lobata*) and chickweed (*Stellaria media*). It is mechanically transmitted and in nature it is spread by various species of aphids. It has a very extensive host range including such varied species as bananas, carrots, cowpeas, lupine, lilies, onions, passion fruit, potatoes and tomatoes.

Watermelon mosaic virus
This virus is mechanically transmitted and also spread by several species of aphids. It is not seed transmitted. Its host range is primarily restricted to cucurbits although one of its strains infects peas.

Squash mosaic virus
It is mechanically transmitted. It is transmitted through seeds of melons and squash. It is also transmitted by spotted, striped and banded cucumber beetles, which attack cucumbers in the Americas. The Epilachna beetle (*Epilachna chrysomelina*) a pest of cucumber in Africa, is also vector of squash mosaic virus. Its host range includes cucurbits, peas, coriander, and salad chervil.

Virus diseases
Virus on cucumber

Virus dise... **Mosaic vir...**

What to do:

- **Use tolerant / resistant varieties if available**
- **Remove infected plants (disinfect hands and tools with 70% alcohol after contact with infected plants)**
- **Do proper weeding**
- **Control insect vectors. A sustainable approach of controlling aphids is important to prevent aphids reaching the crops and transmitting virus.**
- **In case of squash mosaic virus use disease-free seeds**

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Fresh Quality Specifications for the Market in Kenya

The following specifications constitute raw material purchasing requirements

PRODUCE:	Pumpkin
IMAGE:	
VARIETY:	Various
GENERAL APPEARANCE CRITERIA	
COLOUR:	Blue-green and orange to yellow mottled skin with yellow-orange flesh.
VISUAL APPEARANCE:	Slightly ribbed and smooth. Stem with clean cut. With no evidence of discolouration or disfigurement. Free from foreign matter.
SENSORY:	Smooth skin; smooth, dry and slightly sweet flavoured flesh. Free from foreign and 'off'smells or tastes.
SHAPE:	Squat to well rounded
SIZE:	2.5 kg to 5 kg weight; as per pre-ordered size requirements.
MATURITY:	Not undersized; with firm, hard skin.
INSECTS AND PHYSICAL DAMAGE:	With no evidence of live insects (eg whitefly, insect larvae). With no unhealed cuts, holes or splits that break the skin. With no loss of stem.

© S. Kahumbu, Kenya

PRODUCE:	Butternut
IMAGE:	
VARIETY:	Various
GENERAL APPEARANCE CRITERIA	
COLOUR:	Cream to very light brown colour
VISUAL APPEARANCE:	Small gourd shaped bulbing at end away from stem
SENSORY:	Smooth skin; slightly sweet flavoured flesh. Free from foreign and 'off'smells or tastes.
SHAPE:	Small gourd shape
SIZE:	0.7 kg to 1.5 kg weight; as per pre-ordered size requirements.
MATURITY:	Not undersized; with firm, hard skin.
INSECTS AND PHYSICAL DAMAGE:	With no evidence of live insects (eg whitefly, insect larvae). With no unhealed cuts, holes or splits that break the skin. With no loss of stem.

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more Images

Millet

Scientific name: *Panicum miliaceum*

Order/Family: Cyperales: Poaceae

Local names: Mawele (Swahili)

Pests and Diseases: African armyworm African maize stalkborer Blast

Bananas
Beans
Cabbage/Kale, 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

Crazy top downy mildew Downy mildew Ergot Fusarium wilt Grasshoppers Long smut Mealybugs Millet head miner Purple witchweed Shoot fly Spotted stemborer Stemborers Storage pests

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General Information and Agronomic Aspects

Geographical Distribution of Millet in Africa

Millets refers to a group of annual grasses mainly found in the arid and semiarid regions of the world. These grasses produce small seeded grains and are often cultivated as cereals. The most widely cultivated species are:

- Pearl millet (*Pennisetum glaucum*)
- Foxtail millet (*Setaria italica*)
- Common millet or proso millet (*Panicum miliaceum*)
- Finger millet (*Eleusine coracana*)

The husked grain of millet has a slightly nutty flavour and can be eaten whole after roasting or after cooking or boiling like rice. Millet flour is used for making mush, porridge, flat bread or chapatti. The flour is also used for making wine or beer. The grain is a feed for animals. The green plant is used as forage, but the quality of the straw is poor. Brooms are made from the straw. Starch from the grains is used for sizing textiles. Millet plays a vital role as a food security crop especially in semi arid lands of Kenya. Some millet varieties will survive drought conditions where maize crops often fail to reach maturity. The popularity of millet fell for some years due to introduction of maize, wheat and rice, but is again on the rise with millers being able to sell far more than is delivered. Millet is fast becoming a popular baby food as the grains are rich in calcium and have a pleasant flavour.

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
Medicinal plants
Fruit and vegetable

Due to unpredictable rainfall patterns, Kenya has been experiencing frequent maize crop failure (the main staple) leading the Government of Kenya to encourage the production of indigenous, drought tolerant crops like millet.

Climate conditions, soil and water management

Millet is mostly grown in temperate and subtropical regions. It is adapted to conditions that are too hot and too dry, and to soils too shallow and poor for successful cultivation of other cereals. It is tolerant of a very wide temperature range but susceptible to frost. Cultivation occurs up to 3000 m altitude in the Himalayas. In Kenya millet is grown from 0 - 2400 m above sea level. Proso millet has one of the lowest water requirements of all cereals. An average annual rainfall of 200 - 450 mm is sufficient, of which 35 - 40% should fall during the growing period. Most soils are suitable for its cultivation, except coarse sand.

Varieties in Kenya

A lot of work has been done to identify improved varieties of millet to be grown under different ecological zones of Kenya.

Some recommended varieties and their characteristics:

Crop	Variety	Maturity (months)	Grain colour	Grain Yield Potential (bags/acre)
Finger millet	"P224"	4	Brown	10
	"Gulu E"	4	Brown	8
	"KAT/FM/FM-1"	3	Brown	7.5
	"LANET/FM-1"	4	Brown	7
Pearl millet	"KAT/PM-1"	2.5-3	Grey	12
	"KAT/PRO-1"	2.5-3	Grey	10

~~Proso millet~~	~~"KAT/PRO-1"~~	~~2.5~~	~~Cream~~	~~8~~
Fox tail millet	"KAT/FOX-1"	3-4	Yellow-cream	8

processing

Natural pest control

Cultural practices

Proso and fox tail millet can be grown in all areas whereas Gulu E does best on coast and moist mid altitude. KAT/FM1 is recommended for semi-arid lowlands and Lanet/FM1 for cold semi arid highlands.

Propagation and planting

Selection of healthy seeds, free from bird and insect damage and diseases, is important to produce vigorous seedlings that could fare well in case of attack by pests or diseases. Prepare seed for sowing by threshing it (if at all stored on the head) and removing all admixtures such as glumes, bits of the rachis and peduncle, etc. This can be done by winnowing and occasionally by sieving. These processes also remove light and small seeds. A fast, easy and efficient method of quality seed selection uses a 10% salt solution to separate good seeds from bad seeds. The salt solution enhances the flotation of light and damaged seeds, fungal spores and light foreign matter. The good and heavy seeds and pebbles drop to the bottom. The floating portion is decanted and discarded and the sunken portion subjected to flotation one or two more times, after which the good seeds at the bottom are rinsed with clean water to remove excess salt. This portion is then sun-dried. After drying, the pebbles are removed by hand picking (DFPV, Niger).

Early land preparation is recommended. Millet requires a fine seedbed suitable for small grains, to ensure good germination, plant population density and effective weed control. If tractors or oxen are used to open up land for planting, it is advisable to harrow it after the first ploughing. When jembes (hand hoes) are used for land preparation, farmers are advised tobreak large clods to provide a smooth seedbed. Plant before or at the onset of rains by either drilling in the furrows made by oxen plough or tractor or by using a panga (cutlass) for hand planting in hills.

Spacing and seed rate. If the population is too high at emergence, thin when plants are about 15 cm tall, 2 weeks after emergence. Seed rate (when planted in furrows):

- **Finger millet - 3 kg/ha**
- **Pearl millet - 5 kg/ha**
- **Fox tail millet - 4 kg/ha**
- **Proso millet - 4 kg/ha**

For sole cropping the following distances should be followed:

- **Pearl millet varieties: 15 cm between seeds and 60 cm between rows**
- **Finger millet, foxtail and Proso millet: 10 cm between seeds and 30 cm between rows.**

Husbandry

Millet benefits from intercropping with such legumes such as green gram and cowpeas. It can also be rotated with legume crops to benefit from the soil improvement facilitated by these crops or intercropped with other non-cereal crops. Application of farmyard manure at 8-10 tons/ha is recommended in order to improve the soil organic matter content, moisture retention ability and soil structure. Phosphorous should be applied in the form of rock phosphate. For conventional farmers please use the fertilizer recommendations of the local extension office. Weeding should be done twice, first time 2-3 weeks after emergence and second weeding about two weeks later.

Harvesting

Harvest takes place 2-4 months after sowing, when the grain has a moisture content of 14-15%. Avoid delayed harvesting, as the seed shatters easily. If Millet is harvested during the rainy season with high relative humidity, the grain must be dried to 14% moisture content. In households, millet is usually dried above the domestic fire. Millet is threshed immediately after

harvest. The grain stores well for up to five years. Sometimes the grain is mixed with ash or slightly baked before storage. Because of its small size, the grain is barely susceptible to insect attack.

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Information on Pests

The African armyworm (*Spodoptera exempta*)

It is usually an occasional pest, but when outbreaks occur damage to millet can be devastating. The caterpillars eat the above-ground parts of the plants leaving only the base of the stem.

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

More Information on African armyworm

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

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Stemborers

Spotted stemborer
Spotted stemborer (*Chilo partellus*)

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

Spotte(st...

Millet ste...

Several species of stemborers attack millet including the millet stemborer (*Coniesta ignefusalis*), the maize stalkborer (*Busseola fusca*), the spotted stalkborer (*Chilo partellus*), and the pink stalkborer (*Sesamia calamitis*).
Stemborer caterpillars bore into stems of millets disrupting the flow of nutrient from the roots to the upper parts of plants. Attack on young millet plants causes damage known as "dead hearts". In older plants the top part of the stem dies as a result of tunnelling by the borers.

The millet stemborer (*Coniesta ignefusalis*)
It is the dominant stemborer of millet in the Sahelian zone of Africa, and also attacks sorghum, maize, and wild grasses. Major damage has been reported in West Africa. It has also been found causing considerable damage to millet in Western Eritrea, being considered as the major pest of millets in Eritrea (B. Le Ru, icipe, personal communication). The moths have golden brown forewings. They are active throughout the night and during the day rest on the lower surface of leaves or along stems. Caterpillars are cream-coloured with black spots along the body. However in the dry season, when caterpillars enter in diapause (a resting period) they change colour to

pale yellow or uniform cream white. They stay in this resting period from six to seven months, but occasionally for more than a year.

Moths lay eggs between the leafsheat and the stem in batches of 20 to 50 eggs. Caterpillars tunnel in the leafsheats and in the underlying stem. They normally pupate within the stem. Small plants on which eggs are laid may be thoroughly riddle with caterpillars and soon collapse, but in larger plants external symptoms show two to three weeks after stems have been infested.
Economic damage results from early plant death (deadheart) stem tunnelling, disruption of nutrient flow, steam breakage, poor or no grain formation and empty heads. Crop losses have been estimated at $91 million a year.
For more information on the African maize stalk borer click here. For more information on the spotted stalkborer click here.

What to do:

- **Sow early, soon after first rains. Delayed planting tends to increase the incidence of diapause, resulting in significantly higher numbers of diapausing larvae in millet stalks at the end of the growing season. Burn all crop residue left in the field after harvest. When using millet stalks for constructions, burn partially them immediately after harvest.**
- **Use resistant varieties if available**
- **Monitor the millet stemborer. In West Africa, pheromone technology has proved to be highly effective in monitoring this stem borer. These pheromones can also be used to reduce stemborer populations.**

Mass trapping using pheromones has been tried in farmers' fields in Niger. These traps were particularly effective along fences and granaries, areas that harbour borers. Results indicate that inexpensive, locally made pheromone-baited traps are efficient and well adapted to local conditions (ICRISAT).

The millet head miner (*Heliocheilus albipunctella*)

It is the most important insect pest of pearl millet in the Sahel. Moths deposit their eggs on the heads of millet, preferring half-emerged and fully-emerged flowering heads. The caterpillars mine into the seeds of the millet head, damaging the millet panicle (i.e. the flower head, where the grain is formed). It has been reported to cause complete crop loss. Pupation takes place in the soil.

What to do:

- **Plough deeply to expose residual larval populations and pupae to natural enemies and desiccation.**
- **Conserve natural enemies. Efforts in artificial augmentation (rearing and releases) of an effective parasitic wasp (Habrobracon hebetor), and identification of other useful, complementary natural enemies, are going on in West Africa. (IITA, The McKnight Foundation). A two-week delay in planting of short cycle millet varieties (75 days to maturity) to desynchronise the peak flight period of the susceptible phenological stage of the crop has been reported to be effective against this pest (DFPV, Niger).**

The shoot fly (*Atherigona soccata*)

Sorghum shoot fly, (*Atherigona soccata*), is a particularly nasty

pest of sorghum in Asia, Africa, and the Mediterranean area. Females lay single cigar-shaped eggs on the undersides of leaves at the 1- to 7-leaf stage. The eggs hatch after only a day or two of incubation, and the larvae cut the growing point of the leaf, resulting in wilting and drying. These leaves, known as 'deadhearts', are easily plucked. When a deadheart is plucked, it releases an obnoxious odor.

Adult resemble small houseflies. They are about 0.5 cm long. The shoot fly has been reported as attacking pearl millet.

Damage occurs 1-4 weeks after seedling emergence. The damaged plants produce side tillers, which may also be attacked. The shoot fly's entire life cycle is completed in 17-21 days. Infestations are especially high when sorghum planting is staggered due to erratic rainfall. Temperatures above 35°C and below 18°C reduce shoot fly survival, as does continuous rainfall.

What to do:

- **Conserve natural enemies. Parasitic wasps and several species of spiders are important predators on eggs.**
- **Collect and destroy crop residues after harvest to reduce carry-over from one season to the other.**
- **Use shoot-fly resistant varieties, if available**

Shoot fly
Shoot fly (*Atherigona soccata*) The adults are dark brown, and similar to a housefly, but nearly half the size (about 0.5 cm long).

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


Shoot fly **Sorghu sh...**

Grasshoppers

Several species of grasshoppers attack millets. Short-horned grasshoppers include *Zonocerus* spp, *Oedaleus senegalensis, Kraussaria angulifera, Hieroglyphus daganensis, Diabolocantatops axillaris* among others. The long horned edible grasshopper (*Homorocoryphus niditulus*) is a pest in East Africa. Grasshoppers defoliate and eat the panicles. They are not of economic importance when present in low numbers. However, invasion by a swarm of grasshoppers may result in serious grain losses.

Grasshopper
Variegated grasshopper (*Zonocerus variegatus*). The size of adult grasshoppers may vary between 3 - 5 cm.

What to do:

- **Conserve natural enemies. Important natural enemies include ants, larvae of blister beetles, parasitic flies, assassin bugs, predatory wasps, birds, lizards, snakes, frogs, and fungi. Robber flies are also 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, enclose the birds in wire fencing along the perimeter to avoid damage to 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.**
- **Dig 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 click here

- **IITA (the International Institute of Tropical Agriculture) researchers and partners have developed an environmental friendly biopesticide "Green Muscle" for control of grasshoppers and locusts (www.iita.org).**

Storage pests: The lesser grain borer (*Rhyzopertha dominica*) and the khapra beetle (*Trogoderma granarium*)

Grains of pearl millet are attacked by major pests such as the lesser grain borer and the khapra beetle. For this reason, the popular concept that millets are hardly susceptible to damage by storage insect pests is erroneous, except for the very small-grained millets such as tef and fonio. The lesser grain borer and the kapra beetle are relatively well adapted to extremely dry conditions and will cause serious damage to millet. Other secondary storage pests do not thrive in semi-arid climates where millets are grown, where stored grain is typically very dry.

Other non-insect pests such as rats and birds may destroy a considerable part of the harvest.

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

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More Information on Storage pests

What to do:

- **Keep millet in sealed storage e.g. in drums or underground storage. Lower the temperature during drying of millet. The**

optimum reproduction temperature for these pests is 30-35°C , thus lowering the temperature around 21°C could check reproduction (Kajuna).

- **Following some farmer?s practices to manage millet storage pests in the Sahel (see reference: Sankung Sagnia):**
- **1. Hang millet heads over kitchen fires to repel storage pests with the smoke.**
- **2. Store millet on the head. This reduces damage by pests as opposed to storing it in the form of threshed grains because the glumes on the in-threshed head act as protective devices**
- **3. Mix seeds with inert substances such as sand and wood ash. These substances fill the endorsed spaces and thus prevent movement and dispersal of insects inside the stored seeds. They also act abrasive to enhance water loss through the insect cuticle, thus killing the insect.**
- **4. Mix seeds with plant materials such as leaves of Boscia senegalensis, and mint, Hyptis spp, and pulverised pepper. These materials show a repellent action against storage pests.**

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Information on Diseases

Ergot (*Claviceps* spp.)

Cream to pink sticky "honeydew" droplets ooze out of infected florets on

panicles. Within 10 to 15 days, the droplets dry and harden, and dark brown to black sclerotia (fungal fruiting bodies) develop in place of seeds on the panicle. Sclerotia are larger than seed and irregularly shaped, and generally get mixed with the grain during threshing. Conditions favouring the disease are relative humidity greater than 80%, and temperatures between 20 to 30°C. The sclerotia falling on the soil or planted with the seed germinate when the plants are flowering. They produce spores that are wind-borne to the flowers, where they invade the young kernels and replace the kernels with fungal growth. The fungal growth bears millions of tiny spores in a sticky, sweet, honeydew mass. These spores are carried by insects or splashed by rain to infect other kernels.

Ergot
Ergot (*Claviceps* spp.) on millet

What to do:

- **Plant resistant varieties, where available**
- **Remove affected panicles**
- **Avoid planting seeds from infected**

panicles.

- **Plough deep.**
- **Rotate with non-cereals preferably with pulses.**
- **Practice good field sanitation.**

Blast (*Pyricularia grisea*)

Lesions on foliage are elliptical or diamond-shaped, approximately 3 x 2 mm. Lesion centres are grey and water-soaked when fresh but turn brown upon drying. Lesions are often surrounded by a chlorotic halo, which will turn necrotic giving the appearance of concentric rings. The disease is favoured by hot, humid conditions.

Blast
Blast (*Pyricularia grisea*) on millet

What to do:

- **Plant resistant varieties, if available.**
- **Practise good field sanitation.**

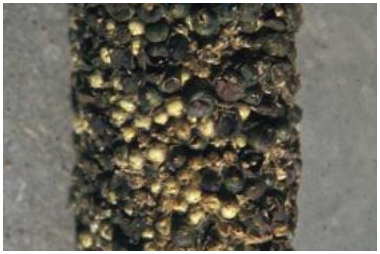
Long smut (*Tolyposporium penicillariae*)

Immature, green fungal bodies (sori) larger than the seed develop on panicles during grain fill. A single fungal body (sorus) develops per floret. As grain matures, sori change in colour from

green to dark brown. Sori are filled with dark spores. Infection takes place at temperature range of between 21 and 31°C, and at relative humidity greater than 80%. The disease is spread by wind-borne spores and rain.

What to do:

- **Plant resistant varieties, if available.**
- **Rotate with non-cereals.**
- **Plough deep.**
- **Practise good field sanitation.**



Long smut
Long smut (*Tolyposporium penicillariae*)

Crazy top downy mildew (*Sclerospora graminicola*)

Symptoms often vary as a result of systemic infection. Leaf symptoms begin as chlorosis at the base and successively higher leaves show progressively greater chlorosis. On the lower leaf surface of infected leaves greyish white fungal growth may be observed. Severely infected plants are generally stunted and do not produce panicles. Green ear symptoms result from transformation of floral parts into leafy structures. The disease is prevalent during rainy seasons.

What to do:

- **Plant resistant varieties, if available**

Crazy top downy mildew
**Crazy top downy mildew (*Sclerospora*

- **Remove diseased plants from the field**
- **Rotate with pulses**

***graminicola*) on millet**

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