Information of www.infonet-biovision.org

Rice

Rice
Scientific name: *Oryza sativa*
Family: Cyperales: Poaceae
Local names: Swahili: mchele / mpunga (upland rice)
Pests and Diseases: African armyworm African gall midge Bacterial leaf blight Blast Brown leaf spot Case worm Damping-off diseases Flea beetles Hispid beetles Leafmining flies (leafminers) Purple witchweed Rice sucking bugs Rice whorl maggots and leafminers Rice yellow mottle virus Root-knot nematodes Spotted stemborer Stalk-eyed shoot flies Storage pests Termites White tip nematode

General Information and Agronomic Aspects

Geographical Distribution of Rice in Africa

The cultivated rice is an annual grass. Depending on the degree of sensitivity to light its growth duration may range from 60 to more than 200 days. Cultivated rice belongs to two species, *Oryza sativa* (which is more widely used) and *Oryza glaberrima* - an African rice. Rice is grown in four ecosystems, which are broadly defined on the basis water regimes. The ecosystems are irrigated, rain-fed lowland and upland, and flood prone.

Uses

Rice is cultivated primarily for the grain, which is a main staple food in many countries, especially in Asia. In

Kenya it is becoming increasingly popular, especially in urban centres. Kenya has a yearly production of about 100,000 metric tons. In 2003, this amount made up 60% of rice consumption in Kenya, in 2006 same amount of rice only covered about 30 % of consumption. This increase in demand and the development of new upland varieties have created an oppurtunity for farmers to venture into rice growing.

Rice will give the same or better yield as maize and fetch the double price on the market at harvest time. Grains are quite nutritious when not polished. Common or starchy types are used in various dishes, cakes, soups, pastries, breakfast foods, and starch pastes; glutinous types, containing a sugary material instead of starch, are used in the Orient for special purposes as sweetmeats. Grain is also used to make rice wine, Saki, much consumed in Japan. Rice hulls are sometimes used in the production of purified alpha cellulose and furfural (an industrial chemical derived from a variety of agricultural by-products, and commonly used as a solvent). Rice straw is used as roofing and packing material, feed, fertiliser, and fuel.

Climate conditions, soil and water management

Rice thrives on land that is water saturated or even submerged during part or all of its growth. Optimal temperatures for rice growing are 20 to 37.7°C, and no growth occurs below 10ºC. Optimal pH is between five and seven, though rice has been grown in fields with pH between three and ten. Rice will grow in altitudes ranging from 0 to 2500 m above sea level, but world wide is mostly grown on the humid coastal lowlands and deltas. Aquatic rice may require a dependable supply of fresh, slowly moving water, at temperature of 21 to 29°C. Rain fed rice requires an average of 800 to 2000 mm of rainfall well distributed over the growing season. If rainfall is less than 1250 mm annually, irrigation is used to make up deficit. The crop is salt tolerant at some stages of growth; during germination but not seedling stages and has even been grown to reclaim salty soils. Terrain should be level enough to permit flooding, yet sloped enough to drain readily. The soils on which rice can grow are as varied as the climatic regime it tolerates, but ideally it prefers a friable loam overlying heavy clay, as in many coastal and delta areas.

Propagation and planting

Seedling production. Steps for producing healthy seedlings:

1. Seed selection. Select plump and healthy seeds.

2. Seed pre treatment. This is practised in order to secure better germination of seeds and better growth of seedlings. It involves:

- **Seed disinfection. Hot water treatment is effective in destroying the nematode *Aphelenchoides besseyi*, which causes the white tip disease. For more information on hot-water treatment click here**
- **Seed soaking. To supply the required moisture for germination, to shorten germination period and reduce seed rotting. During the soaking period change water to remove poisonous substances and allow entry of fresh air.**
- **Pre-sprouting. The seeds are drained and covered with grass for 24 to 48 hours. This ensures uniform seed germination, avoids over sprouting and allows air circulation for germination**

3. Sowing:

- **Sowing 80 to100g/m² is normal practice**
- **Broadcast seed uniformly**
- **Do not submerge the nursery bed after sowing**
- **Use a seed rate of about 20kg/acre**

4. Seed bed preparation (nursery):

- **Plough at least two weeks before sowing and flood**
- **Puddle one week before sowing and prepare raised nursery bed**
- **Drain the nursery bed the day before sowing to stabilize the surface of the soil**
- **If the soil covering the nursery bed is too soft, sown grains are buried into the soil resulting in poor establishment**
- **For one ha of transplanted rice, a nursery of about 350 m² is required**
- **Irrigate a few days after sowing so that the surface is kept moist, and as the seedlings emerge keep submerged conditions with water controlled at 1 to 3 cm according to growth of seedling.**

- **Raise the water level to 10 cm one day before uprooting to ease washing off of soil that sticks to roots. This will make transplanting easy.**

Main land preparation

a) Under Irrigation: Land preparation is carried out by flooding the fields to a depth of 10 cm) and then cultivating them by use of tractor (40 to 75hp) equipped with rotavators. Good timing and quality of land preparation will influence the growth of rice. Poor and untimely land preparation will cause serious weed problems and expose plants to harmful substances such as carbon dioxide and butyric acid, released by decaying organic matter in the soil.

It is recommended that land should be tilled and immediately flooded at least 15 days before transplanting or direct sowing. The purposes of this are:

- **To save the seedling from the effect of high concentration of harmful substances generated by decomposing organic matter rotated into flooded soils.**
- **To prevent loss of nitrogen released by decomposing organic matter through denitrification. The ammonia released during decomposing of organic matter is conserved because ammonia is not converted to nitrate due to the absence of oxygen in the soil. This ammonia is later utilized by the rice plant.**

b) Under rainfed situation: Land should be ploughed twice and harrowed once.

Transplanting

It is important to transplant from the nursery as soon as the seedlings are big enough. Seedlings are said to be ready for transplanting after a period of between three to four weeks depending on daylight, temperatures and the variety. "Basmati 217" will be ready for transplanting 25 days after sowing (4.5 to 5 leaf stage); "BW 196" and others at 28 to 30 days after sowing (5 to 5.5 leaf number).

Spacing: Seedlings are spaced according to the tillering ability of a variety. "Basmati 217" should be planted at

20 cm x 10 cm, "BW 196" and others at 20 x 20 cm.
Seedling number per hill: Two to three for "Basmati" and other low tillering varieties. For "BW 196" one to two seedlings per hill are more suitable for good rooting and tillering. Higher seedling rates increase competition for the available nutrients, hence should be discouraged.

Planting depth: Practice shallow planting of about three cm depth for vigorous initial growth will result in good rooting and tillering. Deep transplanting delays and reduces tillering resulting in a non uniform crop growth and ripening, consequently resulting in yield losses.

Seedlings should be transplanted in an upright position to allow correct tillering and rooting.

Direct sowing method: Trials have been done on direct sowing and have showed that the same level of yields performance as those of transplanting system can be obtained. This method saves substantially on labour input. However it has some disadvantages such as uneven germination rate and more weeding work in the paddy field.

Planting under rainfed conditions: Planting should be done before the onset of the long rains. Farmers are advised to use certified seed and appropriate variety for the region. Drill seed in rows at the rate of 50 kg/ha with a spacing of 25 cm for short varieties and 35 cm for tall varieties. In case of broadcasting, 75 kg/ha is often used.

Main field water management
Water is applied to the rice field for the use of the rice plant and also for suppressing weed growth. For this reason, it is important to practice appropriate water management throughout the growing period of a rice crop.
In lowland rice fields, water comes from rainfall and irrigation. Water is lost by transpiration, evaporation, seepage and percolation. Prevent water loss by:

- **Repairing levees to minimise seepage**
- **Removal of weeds to avoid competition with rice plants for water**

- **increasing the height of levees to prevent surface run-off water**

Critical stages when water is required in large quantities are:

- **For a period of three to seven days after transplanting cover the crop up to 80% of its height. This reduces transpiration and gives the plants a chance to re-establish their roots to be able to take up enough water from the soil**
- **From the stage of booting to 14 days after heading, more water is required because the shedding of pollen and the process of fertilization requires very high moisture content in the air. Low moisture content in the air leads to sterile spikelets.**

Seven to ten days before harvesting, drain the field to harden the soil for good harvesting and also to hasten the drying and ripening of the rice grains.

Varieties in Kenya

"Sindano", highly susceptible to Rice Yellow Mottle Virus (RYMV) and Basmati 217 highly susceptible to blast have been grown since the 1960s. Since then alternative varieties of both irigated rice and rain fed rice have been identified.

Varieties of irrigated rice and their characteristics:

Variety	Height in cm	Maturity days	Yield t/ha	Cooking quality	RYMW2	Blast
"Basmati 217"	118	122	4.6	Very good	Resistant	Susceptible
"Basmati 370"	118	122	5.3	Very good	Resistant	Susceptible
"IR 2035-25-2"	86.2	128	5.5	Good	Moderately susceptible	Moderately resistant

"IR 2793-80-1"	89	142	6.4	Good	Susceptible	
"BW 96"	68	135	9.0	fair	Susceptible	Moderately resistant
"UP 254"	84.2	124	6.4	Good	Moderatley susceptible	Moderately resistant
"AD 9246"	78.2	128	5.1	Good	Moderately resistant	Moderately suscepbible
"IR 19090"	96.6	122	5.8	Good	Moderately susceptible	Moderately resistant

Varieties for lowland (swampy) zones	Varieties for Upland (dry land) zones
"Ci cong Ai"	"Dourado Precose"
"TGR 78"	"2051 A 233/79"
"IR 2793-80-1"	"TGR 94"
"BW 196"	"WAB 181-18"
"WaBis 675"	"Nam ROO"
	"Nerica" (New Rice for Africa)

The upland variety "Nerica" was developed by IRRI. It is resistant to Blast, RYMV stemborers and leafminers. It is high yielding and is doing well from West Africa to Uganda. It is now also being promoted by NIB (National Irrigation Board), Kenya, KARI and JICA. In Kenya it has great potential for medium altitudes with high rainfall or possibility for irrigation. "Nerica" can be planted as other small grains, but does need irrigation especially during flowering, and fertilisation.

Husbandry

Crop rotation

Continuous rice monoculture systems results in decline in soil fertility due to over dependence on chemical fertiliser, and deterioration in physical properties of the soil like texture and microbial existence.
To improve the situation, trials have been carried out on many potential rotation systems. Soybeans and green grams have shown a lot of potential in alleviating the problem. Such legumes can be cultivated during off-season at the time the land used to lie fallow. Crop rotation with bananas or sugarcane is another possibility.
Natural fertilisers commonly used in rice production are rice straw, rice ash, stable manure, buffalo dung, green manure, natural manure, rock phosphate, gypsum etc. The needs of nitrogen varies with varieties. In Kenya, commonly about 80kg N/ha is recommended, along with 58 kg P2O5 (Mwea irrigation scheme). However, the National Irrigation Board (NIB) has found that planting soybean or green gram in the fallow season can halve the need for nitrogen. They further recommend composting of rice straw and manure to further cut down on chemical fertilisers. In organic growing, phosphorous can be applied as rock phosphate, and nitrogen through green manure legumes, which fix the nitrogen from the atmosphere.
See also Mwea Rice Production Manual available from NIB.

Harvesting

Time from planting to harvesting varies between four to six months. Rice is cut, swathed and threshed from windrow. In the tropics it is essential to harvest the crop on time, otherwise grain losses may result from feeding by rats, birds, insects and from shattering and lodging. The crop should be ready to harvest when 80% of the panicles are straw dust coloured and the grain in the lower portion are in the hard dough stage. In a well-grown crop the grain matures evenly and can be harvested in one operation. Cutting can be done with a sickle. The cut stems are bundled for transport to the threshing place, where final drying to around 12% moisture takes place before threshing and storage.

Information on Pests

The African gall midge (*Orseolia oryzivora*)

It is a small reddish-brown midge (similar to a mosquito) 4 to 5 mm long. Females lay up to 300 eggs on rice leaf sheaths. Upon hatching, the small maggots wiggle down to the leaf blade and move between the leaf sheath and the stem until the growing points where they feed for 2 to 3 weeks. Larval feeding induces development of light swellings or galls, which are inconspicuous until larvae are ready to pupate. The galls are long cylindrical, about 3 mm in diameter and from a few cm up to 1 to 1.5 m long. They are often silvery white and resemble an onion leaf, hence they are generally known as 'silver shoots' or 'onion leaf galls'.

Galls generally appear about 20 to 40 days after the crop has been transplanted. Gall midges can cause serious damage from the seedling stage to panicle initiation. Attacked tillers do not produce panicles. Galled plants may tiller profusely to compensate for loss of growing points. A serious attack results in stunted plant growth and poor yields. Gall midges do not attack rice plants that have matured beyond tillering stage. These midges spent some generations on wild grasses and then move to attack young rice plants. They are pests during the rainy season, and are most serious on rainfed lowland and irrigated rice.

What to do:

- **Destroy alternative host plants such as rice ratoon crop, volunteers and wild red rice or longstamen rice (Oryza longistaminata)**
- **Destroy stubble after harvest**
- **Plant resistant and early maturing varieties. Varieties tolerant to the rice gall midge released in West Africa include "Cisadane", "BW 348-1" and "Leizhung". "NERICA L-25" was found to be moderately resistant to this pest in Nigeria. The Oryza sativa japonica sub-species "TOS 14519" has shown moderately resistant to the gall midge across West Africa (WARDA). Embark on early and synchronised planting. Rice fields planted early are less likely to suffer serious damage than those planted late**
- **Avoid close spacing since it provides a suitable micro-environment for the survival of this pest.**
- **Conserve natural enemies. Parasitic wasps (Aprostocetus procerae and Platygaster diplosisae) are very important in the natural control of the African rice gall midge. These wasps provided an important check**

to pest populations, especially late in the season. However, the wasp populations usually build up too late to prevent heavy gall midge infestation.

- **Habitat manipulation such as dry-season cultivation to encourage Paspalum grass (Paspalum scrobiculatum) abundance early in the wet season is suggested as a way of improving the natural biological control of the rice gall midge. Paspalum grass is attacked by a different gall midge, which does not attack rice but is an alternative host for the parasitic wasps. The carry-over of parasitic wasps from gall midges attacking Paspalum grass to the rice field early in the season, could improve the natural control of the rice gall midge. The combination of growing gall midge tolerant varieties with Paspalum grass management at the edge of rice fields had significantly increased farmers? yields (WARDA)**

African gall midge
African gall midge (*Orseolia oryzivora*), onion shoot galls on rice.

Rice-sucking bugs, stink bugs (*Aspavia* spp, *Nezera viridula*), and Alydid bugs (*Mirperus* spp.and *Riptortus* spp.)

Stink bugs produce a strong odour when disturbed. Adult Aspavia bugs are brown bugs with a large triangular shield on the back having three yellow spots and a spine at each side of the thorax. *Nezera viridula* is green and about 1.2 cm long. Alydid bugs have a long slender body and lack a triangular shield on the back. Riptortus is stout and varies from light to dark brown; the hind legs are enlarged.

Both nymphs and adult bugs feed sucking rice grains in the milky stage. When grains have ripened the bugs feed on panicle stalks and pedicels. Riptortus bugs also feed on hard dough rice grains. Bug feeding causes pecky rice that is partially or wholly stained due to infections with bacteria and fungi. The glumes change colour first to light brown, then darker and may turn grey in severe cases. Damage grains are shrivelled and unfilled. Severity of the damage depends on the stage of grain development and on the number of punctures in the grain.

What to do:

- **If necessary spray plant extracts. A number of plants (lantana, garlic, oleander, African marigold, blackjack, goat weed, wormseed, among others) are reported as effective against various species of bugs (Elwell and Maas, 1995).**
  Pyrethrins are recommended for control of sucking bugs in organic production in USA (Layton, 2004).

Green stink bug
Green stink bug (nymphs and adults). Adults are about 1.2cm long. (Host: Pearl Millet)
© Russ Ottens, University of Georgia, Bugwood.org

Storage pests (*Sitophilus oryzae*, *Rhyzopertha dominica*

The most serious pests of stored rice are the rice weevil (*Sitophilus oryzae*) and the lesser grain-borer

(*Rhyzopertha dominica*). Good store hygiene plays an important role in limiting infestation by rice weevil.

What to do:

- **Remove infested residues from last season's harvest**

Rice weevil
Rice weevil (*Sitophilus oryzae*)
© Food Agency and Ministry of agriculture, forestry (Courtesy of EcoPort, www.ecoport.org)

Rice root-knot nematode (*Meloidogyne graminicola*)

Symptoms consist of characteristic hooked-like galls on roots, newly emerged leaves appear distorted and crinkled along the margins, and infested plants are stunted and yellow. Heavily infested plants flower and mature early. The rice root-knot nematode is a damaging parasite on upland, lowland and deepwater rice. It is well adapted to flooded conditions and can survive in waterlogged soil as eggs in egg-masses or as juveniles for long periods.

Numbers of nematodes decline rapidly after four months but some egg masses can remain viable for at least 14 months in waterlogged soil. This root-knot nematode can also survive in soil flooded to a depth of one m for at least five months. It cannot invade rice in flooded conditions but quickly invades when infested soils are drained. It can survive in roots of infected plants. It prefers soil moisture of 32%. It develops best in moisture

of 20% to 30% and soil dryness at rice tillering and panicle initiation. Its population increases with the growth of susceptible rice plants.

What to do:

- **Practice crop rotation with crops that are resistant or poor hosts of the rice root-knot nematode (e.g. castor, cauliflowers, cowpea, common beans, groundnut, maize, onion, sesame, soybeans, sunflower and sweet potatoes). Long rotations, greater than 12 months, will be needed to reduce nematode soil populations to low levels. Rotation crops like marigold (Tagetes sp.) are also effective in lowering root knot nematode populations because of its nematicidal properties.**
- **Amend soil. Experiments with organic soil amendments such as leaves of chrysanthemum, neem and marigold, and oil cakes of sesame, neem and coconut oil cakes, incorporated at the rate of 0.12%, 0.50% and 1.00% (w/w), showed that these amendments decreased root knot severity, caused reduction in nematode populations and increased seedling growth (Hossain et al.1999).**
- **Introducing a fallow into the rotation will also give control of the nematodes but, to be effective, it needs to be a bare fallow free of weed hosts and is therefore impractical. However, the weed, false daisy (Eclipta alba), is toxic to the rice root-knot nematodes and could be grown and incorporated into the field soil to kill the nematodes (CABI, 2000).**
- **Water management. Continuous flooding and raising rice seedlings in flooded soils will help prevent root invasion by the nematodes.**
- **Soil solarisation and planting cover crops such as sesame and cowpea has been reported to decrease nematodes. For more information on solarisation click here**

Root-knot nematodes
Root-knot nematode (*Meloidogyne graminicola*) infestation in rice field
© Roger Lopez-Chaves, Universidad de Costa Rica, Bugwood.org

Root-knot …

Root-knot …

White tip nematode (*Aphelenchoides besseyi*)

Rice is the most important host worldwide. Host plants include; strawberry, onion, garlic, sweet corn, sweet potato, soybean, sugar cane, horseradish, lettuce, millet, many grasses, orchids, chrysanthemum, marigold, Mexican sunflower, African violets, and rubber plant (*Hibiscus brachenridgii*). Feeding of the nematodes at leaf tips in rice results in whitening of the top 3 to 5 cm of the leaf leading to necrosis (described as "White Tip" of rice). There is also distortion of the flag leaf that encloses the panicle. Diseased plants are stunted, lack vigour and produce small panicles. Affected panicles show high sterility, distorted glumes and small and distorted kernels.

What to do:

- **Plant nematode-free seeds**

- **Plant in nematode-free areas**
- **Plant resistant rice varieties if available**
- **Treat seed with hot water. Hot water treatment of seed can be used to destroy this nematode infecting the seeds. Thermal wet treatment was the most effective at 55-60°C for 15 minutes. For more information on hot-water treatment click here.**

White tip nematode
White tip nematode (*Aphelenchoides besseyi*). Left: Characteristic 'white tip' symptom on rice leaf. Right: Necrotic patches and crinkled rice leaves.

The African armyworm (*Spodoptera exempta*)

Armyworms may cause severe defoliation in upland rice plants leaving only the stem. Armyworms are regarded as occasional pests, but during an outbreak they devastate rice crops.

What to do:

- **Monitor regularly the crop to detect small caterpillars before they cause serious damage. Look in field margins, low areas where plants have lodged, beneath plant debris around the base of plants, on the ground, and underneath the plant leaves**

- **Spray Bt or botanicals such as neem and pyrethrum extracts. Spray when caterpillars are small. Once caterpillars are mature (about 3 to 3.5 cm long) they may have cause serious damage and it may no longer be economical to treat the crop. For more information on (neem click here, for pyrethrum click here and for Bt click here)**
- **Conserve and encourage natural enemies. For more information on natural enemies click here**
- **Practise field sanitation. For more information on field sanitation click here**

African armyworm
African armyworm (*Spodotera exempta*). Mature caterpillars measure up to 4 cm.
© University of Arkansas

Stalk-eyed shoot flies (*Diopsis* spp.)

The dark brown flies are about 8 mm in length, and have the eyes situated on two long stalks projecting from both sides of the head. Flies lay eggs singly on the upper surface of young leaves, or on the leaf sheath of older plants. The whitish maggots that hatch from the eggs penetrate into the growing zone (heart) of the plant. As a result of maggot feeding the central whorl does not open, but dries-up and dies, producing what is commonly known as "dead heart".

Maggots move readily from one tiller to another. One maggot can destroy up to 10 neighbouring tillers. Later generations feed on the developing flower head. Pupation normally occurs in the first three leaf sheath of healthy tillers, generally one pupa per tiller. A severe attack is likely to occur when water levels are low. Such

attacks reduce yields of rice plants. Shoot fly attack rice plants early in the crop growth stage, shortly after emergence in direct-seeded fields or shortly after transplanting. They are present throughout the crop growth period, although infestation is low in the flowering-ripening stages.

What to do:

- **Practice early and synchronised planting**
- **Manage plant spacing. There are indications that damage increase with an increase in plant density (Heinrich and Barrion, 2004).**
- **Apply calcium silicate to strengthen stem tissues.**
- **Avoid panicle harvesting (leaving tall stems) and destroy stubbles after harvest.**
- **Water management: keep basis of stems always under water.**
- **Conserve natural enemies. Spiders are the main natural enemies of these flies.**
- **The cultivars "WAB 1159-2-12-11-6-9-1-2" has been reported in Uganda to trap Diopsis thoracica larvae with their highly hairy leaves (WARDA)**

Stalk-eyed shoot fly
Stalk-eyed shoot fly (*Diopsis* spp.). It is about 8mm long.
© A.M. Varela, icipe

Stemborers: Spotted stemborer (*Chilo partellus*)

Several species of stemborers attack rice. The more important are the striped borer (*Chilo partellus*), *Chilo zacconius, Chilo orichalcocilielus*, the white rice borer (*Maliarpha separatella*), the yellow borer (*Scirpophaga* sp.) and the pink stemborer (*Sesamia calamistis*).
The caterpillars bore into the stem of rice plants. Caterpillars of the yellow borer bore into the stem below the growing point, destroying tillers. The white borer and the pink stemborer attack rice at full tillering stage preventing grains from filling up and ripening. This damage results in empty panicles known as "whiteheads". The striped borer feeding on rice plants at all stages. Young caterpillars cause "dead hearts".

What to do:

- **Practice field sanitation. Burn or feed debris to livestock after harvest.**
- **Plough and flood after harvest. These practices destroy diapausing stemborer caterpillars**
- **Practice early and synchronised planting. Synchronised planting over a large area allows the most susceptible stage of rice to escape from stemborer damage.**
- **Practice proper water management**
- **Conserve natural enemies. Wasps that parasitise eggs and caterpillars, and predators such as ants, dragonflies, assassin bugs, carabid beetles and spiders are important natural enemies of stemborers.**
- **The following cultivars are reported to be resistant to stemborers: Oryza sativa japonica sub-species: "LAC 23", "ITA 121", "TOS 4153", and upland "NERICA"s ("NERICA 1", "NERICA 2", "NERICA 4", "NERICA 5", and "NERICA 7") (WARDA).**

Spotted stemborer

Spotted stemborer (*Chilo partellus*)
© Agricultural Research Council of South Africa. Courtesy of Ecoport (www.ecoport.org)

The case worm (*Nymphula depunctalis / Parapoynx stagnalis*)

The case worm is a common pest on wetland rice. Moths are small (1 to 1.2 cm in wingspan) with white markings and black specks on the wings. Females lay eggs in small batches (about 20) on the lower side of leaves that are floating on the water surface. Upon hatching caterpillars are yellow to green with light brown heads. They climb onto a leaf and begin feeding by scrapping the leaf surface causing linear grazing of leaves giving the leaf tissue a ladder-like appearance. Later caterpillars cut a piece of rice leaf, roll it up into a case and seal the edges with silk material leaving the interior end open. The cut near the tip of a leaf is characteristic.

At all times the caterpillar is likely to be partly or wholly enclosed in its portable leaf case. The caterpillar attacks the food plant only in the vegetative stage, during the first four weeks after transplanting. Caterpillars of the case worm are semi-aquatic, ascending the plants at night to feed. Heavy infestation on small seedlings may completely destroy a rice crop. Damaged plants may recover but crop maturation may be delayed about a week. Yield loss may occur when the caseworm occurs in combination with other non-defoliating insects such as whorl maggots and stemborers. Damaged plants are stunted and produce fewer tillers.

What to do:

- **Practice field sanitation (burning debris or feeding of debris to livestock after harvest.**
- **Practice early and synchronised planting.**
- **Manage plant density. A study in West Africa showed that defoliation due to the caseworm ranged from 16% in seedlings transplanted at a wide spacing (40 X40 cm) to 68% at a spacing of 10 X 10 cm (WARDA).**
- **Practice proper water management. Ensure good drainage for three days, since larvae cannot survive without water.**
- **Handpick and destroy rolled leaves in the nursery.**

Termites (*Microtermes* spp., *Ancistrotermes* spp., *Trinervitermes* spp., *Macrotermes* spp., and *Odontotermes* spp.).

Termites, also known as white ants are common pests of upland rice in West Africa where they may cause serious damage during dry periods. They may also occur in lowland areas in light texture soils. They generally attack plants in their later growth stage by hollowing out their root system and filling it with soil resulting in the lodging of the rice plants. The attacked plants are then predisposed to further damage by ground-dwelling pests such as rodents, ants, and secondary infection by fungi and bacteria. Damaged plants can easily be pulled up by hand because the roots are severed

What to do:

- **Plant resistant varieties whenever available. "LAC 23", "NERICA 1", "NERICA 5" and "NERICA 14" are resistant to termites. In experiments in Nigeria "NERICA"s 5 and 1 had lower levels of termite attack than other rice varieties tested ("NERICA"s 2,3,4, 6 and 7, "LAC 23" and "OS 6"). "NERICA"s 2 and 3 showed some levels of tolerance (WARDA; Nwilene et al., 2008)**
- **Use neem products. They provide effective control of termites on rice fields. In experiments in Nigeria two litres of neem seed oil (Cobeneem) mixed with one litre of water and 10 g of detergent soap (OMO) applied in an area of 900 m2 gave the best protection against termite attack, followed by neem powder (800 kg per ha). Applications were done close to the rice hills along the rows (Nwilene et al., 2008). For more information on neem click here**
- **The application of red palm oil mixed with pawpaw is an indigenous control practice. The mixture attracts soldier ants that attack and drive away the termites.**

Termites
Termites (*Coptotermes formosanus*)
© Scott Bauer, USDA Agricultural Research Service, Bugwood.org

Hispid beetles (*Trichispa* spp., *Dicladispa viridicyanea, Dactylispa bayoni*)

Hispid beetles are serious pests of rice in some countries in Africa, causing severe defoliation and as vectors of the Rice Yellow Mottle Virus. Adult beetles have numerous spines on thorax and abdomen. *Trichispa sericea* is the most common of the hispid beetles. The adult is a dark grey beetle covered with spines, and about 3 to 4 mm long. Females lay eggs singly in slits made under the epidermis of the upper portion of the leaf. Eggs are white, boat-shaped and about one mm long. Upon hatching, the grubs (larvae) mine within the leaf. Grubs are slender, yellow and about six mm long. They pupate in the mine. When infested leaves are held against the light, the grub or pupa may be seen as a dark spot in the mine. Hispid beetles attack the crop in the early growth stages. Larval feeding occurs during the tillering stage. The first attack in a field is highly localised, but the infested area spreads rapidly.

Feeding by adults on the leaves causes characteristic narrow white streaks or feeding scars that run along the long axis of the leaf. Mining by grubs within the leaf shows as irregular pale brown blister-like patches. Feeding results in loss of chlorophyll and the plants wither and die. The most serious damage occurs in nurseries, which may be completely destroyed. Severe infestations sporadically occur on transplanted rice and can kill the plant. When the plants survive, they usually recuperate and produce some grain. However,

damaged plants often mature late. Hispid beetles are prevalent in wetland environments, especially irrigated lowland fields. They are generally most abundant during the rainy season.

What to do:

- **Use close spacing. Populations of adult hispid (T. sericea) are affected by the spacing of transplanted seedlings. Studies in West Africa have shown that population of this hispid beetle were higher in close spacing of 10 x 10 cm) than in wider spacing of 20 x 20cm (WARDA).**
- **Keep bunds and surroundings free of grass weeds.**
- **Destroy stubbles and avoid ratooning.**
- **Ensure balanced nutrition. Avoid excessive nitrogen application.**

Flea beetles (*Chaetocnema* spp.)

Flea beetles make small holes in the leaf when feeding, however, this damage is considered minor. Most important, these beetles are potential vectors of the Rice Yellow Mottle Virus. Flea beetles are small, and have enlarged hind legs and jump when disturbed.

What to do:

- **Use close spacing. Populations of flea beetles are affected by the spacing of transplanted seedlings. Studies in West Africa have shown that population of this hispid beetle were higher in close spacing of 10 x 10 cm) than in wider spacing of 20 x 20cm (WARDA).**
- **Keep bunds and surroundings free of grass weeds.**
- **Destroy stubbles and avoid ratooning.**
- **Ensure balanced nutrition. Avoid excessive nitrogen application.**

Flea beetle
Flea beetle feeding on young okra pod
© A.M. Varela, icipe

Rice whorl maggots and rice leafminers (*Hydrellia* spp)

The rice whorl maggot (*Hydrellia prosternalis*) has been reported from West Africa. Another species *Hydrellia* sp. has been reported in Kenya (NIB, 1995). Adults of the rice whorl maggot and rice leafminers are small flies (1.5 to 3 mm long), grey to black in colour with silvery white or golden brown markings on the lower part of the head. They lay white cigar-shaped eggs on the leaves. Upon hatching the maggots of the leafminers penetrate the leaf tissue and feed in between the two layers of the leaf causing mines parallel to the veins. Maggots may pupate in an existing mine or migrate to a different leaf to form a new mine. High humidity (80-100% relative humidity) is required for leafminer development, therefore, mines are typically observed in leaves close or lying on the water surface. Whorl maggots start feeding on the leaf margins causing large scarred areas giving the leaf a ragged appearance and causing eventual leaf collapse. Eventually the maggots enter the whorl and tunnel the plant's developing stem.

Feeding damage by leafminers retards plant development, reduces plant vigour and renders infested plants less competitive with weeds. Plant vigour and weather conditions affect the extent and seriousness of the damage caused by the rice leafminer. Damage extent is closely related to the speed the plant growths erect and out of the water. Any factor affecting plant growth, which increases the number of leaves remaining lying

on the water, or the length of time they are fully in contact with water will increase damage. The plant is usually able to produce additional leaves, but continued mining can result in reduced tillering, greater susceptibility to later pest attack, delayed maturity, or death of the plant. Once leaves start growing upright above the water, the rice leafminer does not cause economic damage. Attack by the whorl maggot may kill young plants (2 to 6 weeks after emergence) depending on the severity of the damage. Plants that survived damage are eventually drowned by the flood, or plant stands get so thinned that are easily overwhelmed by weeds.

Other leaf-mining fly (*Creodont orbiting*) has been reported as a minor pest in West Africa. This leaf-mining fly is widely spread in the rice-growing region in Ghana, but it is of no apparent economic importance. The adult is a small fly (about 1.6 mm long). Females lay eggs into the leaf tissue, and the maggots feed forming mine towards the leaf tip. Maggots pupate within the mine. Symptoms of damage are the transparent, light brown mines that are elongated along one side of the midrib reaching up to 6 cm in length.

What to do:

- **The rice leafminer can be controlled by managing the water level**
- **Avoid leaf contact with water. However, this practice seems to intensify the whorl maggot problem. Field observations in Louisiana, USA showed that by draining fields, the maggot enters the plant whorl and stems without being drowned (LSU AgCenter).**
- **Drain the water at intervals of 3 to 4 days during the first 30 days after transplanting reduces egg laying as the adult flies are more attracted to standing water.**
- **To reduce the potential for damage by the rice leafminer encourage the rice to emerge quickly and grow erect.**
- **Level the field as accurately as possible and start the crop in 7-10 cm of water. Increase the water depth slowly after the leaves begin to grow upright.**
- **Monitor for rice leafminers to determine the need to lower the water level. Begin monitoring two to four weeks after planting, just after most of the rice plants have emerged from beneath the water and the leaves are lying on the water surface (UC Pest Management Guidelines).**
- **Crop establishment methods that enable the plants to cover the water surface most rapidly usually result**

in insignificant damage.Thus, close planting has been shown to decrease egg laying and subsequent damage by leafminers in several countries in Asia and South America.

Rice leafminer
Hydrella rice miner damage to rice
© Boris Castro, Texas A&M University - Dept. Entomology, Bugwood.org

Information on Diseases

The most serious diseases of rice are: Rice blast disease (*Magnaporthe grisea*) and Bacterial leaf blight (*Xanthomonas oryzae* pv. *oryzae*).

Other diseases of economic importance include Brown Leaf Spot (*Bipolaris oryzae*), Rice Yellow Mottle Virus (Sobemovirus) and White Tip Disease (nematode - *Aphelenchoides besseyi*).

Examples of Rice Diseases and Organic Control Methods

Damping-off diseases

Failure of seedlings to emerge is the most obvious symptom of seed rot and pre-emergence damping off. Examination may reveal a cottony growth of mycelium (mould) in and around seed coats and the emerging seedlings, indicating attack by water mould(s). The growing point or root of germinated seedlings has a dark

brown discolouration or rot. The base of the leaf sheath and the roots of emerged seedlings have a similar dark brown or reddish-brown rot. Affected seedlings appear stunted and yellow and may soon wither and die (seedling blight). Water moulds are particularly severe in water-seeded rice culture. In areas where fields are frequently water-seeded, it has become difficult to obtain adequately dense and uniform stands. Seed rots caused by the water moulds *Pythium* and *Achlya*, and to a lesser extent by the fungus *Fusarium*, have been identified as the causes of the problem. These fungi often act as a complex within affected fields.

Symptoms of water mould can be observed through the flood water as balls of fungal strands radiating from seeds on the soil surface. When the flood is removed using the critical point method of water-seeding, affected seeds are surrounded by a mass of fungal strands. This results in circular, copper brown or dark green spots on the soil surface, about the size of a quarter, with the rotted seed at the centre. The colours of the spots are the result of bacterial and algal growth. Seed rot by water moulds is favoured when the water temperature is unusually high or low. If seedlings are attacked after germination at pegging, seedlings become yellow and stunted and grow poorly.

What to do:

- **Use certified disease-free seeds for planting**

Damping-off
Damping-off on rice
© Jürgen Kranz, Courtesy of EcoPort (www.ecoport.org)

Bacterial leaf blight (*Xanthomonas oryza* pv. *oryza*)

The first symptom of the disease is a water soaked lesion on the edges of the leaf blades near the leaf tip. The lesions expand and turn yellowish and eventually greyish-white and the leaf dries up. High rainfall with strong winds provides conditions for the bacteria to multiply and enter the leaf through injured tissue.

What to do:

- **Plant resistant varieties if available**
- **Use certified disease-free seeds**
- **Practice rotation**
- **Practice good field sanitation. Plough or roll the stubble to hasten decay of the rice debris; this helps to manage the disease by destroying the tissue in which the bacterium is maintained**

Bacterial leaf blight
Bacterial leaf blight (*Xanthomonas oryzae* pv. *oryzae*) on mature rice plants. Lesions begins as water-soaked stripes on the leaf blades and eventually would increase in length and width becoming yellow to grayish-white until the entire leaf dries up.


Bacter Bacter

... ...

Blast (*Pyricularia oryzae* (*Magnaporthe grisea*)

This disease can cause serious losses to susceptible varieties during periods of blast favourable weather. Depending on the part of the plant affected, the disease is often called leaf blast, rotten neck, or panicle blast. The fungus produces spots or lesions on leaves, nodes, panicles, and collar of the flag leaves. Leaf lesions range from somewhat diamond-shaped to elongated with tapered, pointed ends. The centre of the spot is usually grey and the margin brown or reddish-brown. Both the shape and colour of the spots may vary and resemble those of the brown leaf spot disease. Blast differs from brown leaf spot in that it causes longer lesions and develops more rapidly.

The blast fungus frequently attacks the node at the base of the panicle and the branches of the panicle. If the panicle is attacked early in its development, the grain on the lower portion of the panicle may be blank giving the head a bleached whitish colour, giving the name "blasted" head or rice "blast". If the node at the base of the panicle is infected, the panicle breaks causing the "rotten neck" condition. In addition, the fungus may also attack the nodes or joints of the stem. When a node is infected, the sheath tissue rots and the part of the stem above the point of infection often is killed. In some cases, the node is weakened to the extent that the stem will break causing extensive lodging. Blast generally occurs scattered throughout a field rather than in a localised area of the field. Late planting, frequent showers, overcast skies, and warm weather favour development of blast. Spores of the fungus are produced in great abundance on blast lesions and can become airborne, disseminating the fungus a considerable distance. High nitrogen fertilization should be avoided in areas that have a history of blast.

What to do:

- **Plant early**
- **Avoid excessive or high levels of nitrogen**
- **Proper flood management**

- **Plant resistant varieties (e.g. "Nerica". This is the most effective method of controlling rice blast.**

Blast
Dried rice tassels caused by rice blast disease (*Magnaporthe grisea*)
© Jan Breithaupt (Courtesy of EcoPort, www.ecoport.org)

Brown leaf spot (*Bipolaris oryzae*)

This disease was previously called Helminthosporium leaf spot. Most conspicuous symptoms of the disease occur on leaves and glumes of maturing plants. Symptoms also appear on young seedlings and the panicle branches in older plants. Brown leaf spot is a seed-borne disease. Leaf spots may be evident shortly after seedling emergence and continue to develop until maturity.

Leaf spots vary in size and are circular to oval in shape. The smaller spots are dark brown to reddish brown, and the larger spots have a dark-brown margin and reddish brown to grey centres. Damage from brown spot is particularly noticeable when the crop is produced in nutritionally deficient or otherwise unfavourable soil conditions. Significant development of brown spot is often indicative of a soil fertility problem.

What to do:

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

- **Ensure balanced fertilisation**
- **Practice crop rotation**

Brown leaf spot
Brown leaf spot on rice. Symptoms on leaves


Brown leaf…


Brown leaf…

Rice Yellow Mottle Virus (RYMV) (Sobemovirus)

Rice yellow mottle virus is endemic in Africa, was first reported in Kenya in 1966, but is now known to occur in almost all irrigated rice growing areas in Africa. This disease can cause up to 92% yield loss on "super", the most popular rice variety in Tanzania.

RYMV causes severe infections mainly in irrigated rice and is transmitted by beetles (*Sesselia pusilla*, *Chaetocnema pulla*, *Trichispa sericea* and *Dicladispa viridicyanea*) and mechanically. It is not seed transmitted.

Major symptoms of the disease are yellowing of leaves, stunting of affected plants, reduced tillering of the affected plants and sterility of the seed/grain.

What to do:

- **Plant resistant varieties. The following cultivars are reported as resistant to RYMV: Oryza sativa japonica sub-species: 'LAC 23', 'Moroberekan', 'IR 47686-1-1' for direct seeded rainfed lowlands, and Oryza sativa indica sub-species: "WITA 9", "WITA 11" and "Gigante" (tete) for irrigated lowlands (WARDA)**
- **Avoid / minimise mechanical injuries**
- **Avoid exposing healthy seedlings and plants to virus contaminated and infected material (water, soil, cattle faeces and plants)**
- **Control insect vectors (see above under pests Hispid beetle and Flea beetle)**
- **Transplant early before the outbreak of Hispid beetles occur. Trichispa sericea, with reduction in spacing of plants**
- **Destroy crop residues after harvest and ratoons that harbour the virus and insect vectors.**
- **Synchronous planting. Wide range and non-synchronous planting dates increases the risks of RYMV outbreaks.**
- **Plant diverse varieties on a single plot**
- **Change of site for nurseries**
- **Rough infected plants**
- **Reduce fertiliser application on attacked plots**
- **Weed timely. Early and double weeding helps reduce the weed reservoir of the virus and insect vectors**
- **Withhold irrigation water between plantings to provide a rice free period and so restrict the build-up of the virus and insect population**

Rice yellow mottle virus
Typical symptoms of rice yellow mottle virus: yellow mottle or orange colouration, depending on the genotype.

Information Source Links

- **AIC (2002). Field Crops Technical Handbook.**
- **Acland J.D. (1980). East African Crops. An introduction to the production of field and plantation crops in Kenya, Tanzania and Uganda. FAO/Longman. ISBN: 0 582 60301 3.**
- **Anthony Youdeowei (2002). Integrated Pest Management Practices for the Production of Cereals and Pulses. Integrated Pest Management Extension Guide 2. Ministry of Food and Agriculture (MOFA) Plant Protection and Regulatory Services Directorate (PPRSD), Ghana, with German Development Cooperation (GTZ). ISBN: 9988 0 1086 9.**
- **Bohlen, E. (1973). Crop pests in Tanzania and their control. Federal Agency for Economic Cooperation (bfe). Verlag Paul Parey. ISBN: 3-489-64826-9.**
- **Brunt, A.A., Crabtree, K., Dallwitz, M.J., Gibbs, A.J., Watson, L., Zurcher, E.J. (eds.) (1996 onwards). Plant Viruses Online: Descriptions and Lists from the VIDE Database. Version: 20th August 1996. http://micronet.im.ac.cn/vide/sppindex.htm**
- **Bèye, A. M. and Guei, R. G. (2001). Rice Seed Production by Farmers: A Practical Guide. ISBN: 92-9113212-8. www.warda.org**

- **CAB International (2005). Crop Protection Compendium, 2005 edition. Wallingford, UK www.cabi.org**
- **Elwell, H, Maas, A. (1995). Natural Pest & Disease Control. Natural Farming network, Zimbabwe. The Plant Protection Improvement Programme and The Natural Farming Network.**
- **Heinrich, E. A., Barrion, A. T. (2004). Rice-feeding insects and selected natural enemies in West Africa: biology, ecology and identification. Los Baños (Philippines): International Rice Research Institute (IRRI), and Adbijan (Côte d'Ivoire) WARDA- The Africa Rice Center. ISBN 971-22-0190-2.**
- **Hossain, S. M. M., Mian, I. H., Islam, A. T. M. S. and Haque, M. M. (1999). Organic amendments of soil to control rice root-knot nematode (Meloidogyne graminicola). Bangladesh journal of scientific and industrial research. vol. 34, no3-4, pp. 385-390 . ISSN 0304-9809 . INIST-CNRS, Cote INIST : 13166, 35400012026135.0140**
- **International Rice Research Institute (2006). Biological control of rice insect pests: www.knowledgebank.irri.org/IPM/biocontrol/**
- **International Rice Research Institute (2006). www.knowledgebank.irri.org**
- **LSU AgCenter. First Report of Whorl Maggots in Rice. February 2, 2005, SPDN Network News. By Boris Castro.**
- **Layton B. (2004). Bug Wise. http://msucares.com/newsletters/pests/bugwise/2004/bw1804.pdf**
- **Mississippi State University Extension Service (2001): Rice diseases. http://msucares.com/pubs/publications/p1840.htm**
- **NEMAPLEX (2007). *Aphelenchoides besseyi*. http://plpnemweb.ucdavis.edu/nemaplex/Taxadata/G011s1.htm#Hosts**
- **NIB (1995). Mwea Rice Production Manual.**
- **Nwilene, F.E.; Nwanze, K.F. and Okhidievbie, O. (2006). African Rice Gall Midge: Biology, Ecology and Control. Africa Rice Center (WARDA) ISBN 92 9113 236 5 (PDF); ISBN 92 9113 255 1 (print) www.warda.org**
- **Nwilene, F.E; Agunbiade, T.A.; Togola, M.A. and Youm, O. (2008). Efficacy of traditional practices and botanicals for the control of termites on rice at Ikenne, southwest Nigeria. International Journal of Tropical Insect Science Vol. 28, No. 1, pp. 37-44. journals.cambridge.org/download.php?file=%2FJTI%2FJTI28_01%2FS1742758408944386a.pdf&code=b1ab0e235f5250dec3e652438a6bb5dd**
- **Nyambo, B. (2001). Integrated Pest Management Plan for SOFRAIP. Soil Fertility Recapitalization and Agricultural Intensification Project. SOFRAIP. Ministry of Agriculture and Food Security, Tanzania.**

- **OISAT: Organisation for Non-Chemical Pest Management in the Tropics. www.oisat.org**
- **Oduro K.A. (2000). Checklist of Plant Diseases in Ghana. Vol. 1: Diseases. Ministry of Food and Agriculture. Plant Protection & regulatory Services Directorate, Ghana**
- **Texas A & M University (1996). Texas Plant Disease Handbook**
- **UC IPM Online. Statewide-Integrated Pest Management Program. How to manage pests, UC Pest Management Guidelines. Rice leafminer. http://www.ipm.ucdavis.edu/PMG/r682300211.html**
- **WARDA: www.warda.cgiar.org**

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Soybean

Soybean
Scientific name: *Glycine max*
Family: Fabales: Fabaceae
Pests and Diseases: Anthracnose Aphids Bacterial pustule Bean flies Bean yellow mosaic virus Bugs Cowpea seed beetle Downy mildew Leaf-feeding caterpillars Leafmining caterpillars Pod and stem blight Pod borers Purple seed stain Root-knot nematodes Soybean bacterial blight Soybean mosaic potyvirus Soybean rust Storage moths and bruchid beetles Storage pests White mould Wildfire disease Couch grass, Leafhoppers

General Information and Agronomic Aspects

Soybean is the world's most important legume in terms of production and trade due to its high content of protein (35-40 %) and oil (15-22 %). Soybean products are rich in essential amino acids, vitamins and minerals. Soybeans are used in the preparation of a variety of fresh, fermented and dried food products like milk, tofu, soya sauce and bean sprouts. Soybeans are used not only for food but they serve also as a cure for various diseases and body ailments. Soybeans (preferably black ones) are included in

Geographical Distribution of Soybean in Africa

medicines to improve the action of the heart, liver, kidneys, stomach and bowels. They are also processed to extract oil for food and for numerous industrial purposes. As edible oil, it enters the market as salad oil, cooking oil, margarine and shortening. Soybean meal is extensively used as an ingredient in livestock feed.
Soybean is also one of the crops where many varieties are now genetically modified - especially in the American market.
In sub-Saharan African soybean is mostly grown by small-scale farmers either as a sole crop or mixed with sorghum, maize or cassava.

Climate conditions, soil and water management

Soybean is grown from the Equator to latitude 55°N or 55°S, and from below sea level to altitudes close to 2000 m. Above 2000 m the late maturing varieties take as long as 180 days (6 months) but they out-yield the early maturing varieties. Soybean is a short-day plant. In Kenya, soybeans are grown in the maize growing areas, mainly by small-scale farmers.
Temperatures below 21°C and above 32°C can reduce floral initiation and pod set. Extreme temperatures above 40°C are detrimental for seed production.
If water is available, soybeans can be grown throughout the year in the tropics and subtropics. Soybean requires 400 to 500 mm in a season for a good crop. High moisture requirement is critical at the time of germination, flowering and pod forming stage. However dry weather is necessary for ripening. Soybeans can tolerate brief waterlogging but weathering of seed is a serious problem in the rainy season.

Soybeans are sensitive to low pH. In acid soils, liming is essential to raise the pH to 6.0 or 6.5 and to obtain optimum yield. Mn, Fe and Al toxicity is common with low pH, and deficiency in Mn and Fe with high pH. Cultivars tolerant to iron deficiency are available.

Propagation and planting

Soybeans are propagated by seed. However soybean seed loose viability within 6-10 months depending on the variety and the environmental conditions, especially under hot and damp conditions. Test seed for viability before planting: Take 100 seeds from about 3 places in the seed lot, put each lot of 100 seed in a glass of water for 24 hours, then drain off the water and replace with damp cotton wool or a damp cloth. Keep cloth damp - after 3-4 days young sprouts will have formed on all viable seed, and it is easy to count how many out of the 100 that has germinated (Germination %). They are grown on paddy-rice bunds too. Soybeans are sown without tillage in rice stubble after each harvest in rows with a spacing of 25 x 25 or 20 x 20 cm. In tilled fields, soybeans are sown in rows 40-50 cm apart and within rows the seeds are either drilled or planted 10 cm apart. Seed rate is 60-70 kg / ha. Broadcasting of seed after the rice harvest is also practised.

Examples of different varieties grown in Kenya and their parameters:

Characteristics	"Hill"	"Perry-41"	"Black hawk"	"Red-Tanner"	"Composite"	"Duicker"
Days to flowering	76	61	81	65	62	84
Days to physiological maturity	147	131	151	138	131	180
Plant height (cm)	60	48	60	70	35	43
Seed yield kg/ha	2000	1800	1300	1800	700	1000
Oil content (%)	17	18	16	18	14	16
Protein content(%)	33	35	35	35	37	34

Recommended soybean varieties for different agro ecological zones in Kenya:

Description	Area in Kenya	Varieties
Warm Temperature sites	Homa Bay	"Duicker", "EAI 3600" and "Nyala"
Moderate temperature sites	Bukura, Kakamega, Manor House, Embu	"SCS I", "Duicker", "Nyala" and "Gazelle"

~~Cool temperature sites~~	~~Bahati, Baraton, LH2, Menengai~~	~~"Sable", "SCS I", "Nyala" and "Gazelle"~~
Marginal rainfall sites	Matayos, Gachoka, Makueni, Ol Rongai	"Gazelle", "EAI 3600", "Nyala" and "Sable"

Intercropping

Soybeans are cultivated both as a sole crop and in various intercropping systems with maize, cassava, sorghum, banana, sugar-cane, rubber, oil palm, coconut and fruit-trees. In maize and sorghum, soybeans can be intercropped with two rows.
Intercropping soybean with maize attracts parasitic wasps that control African bollworm (*Helicoverpa armigera*) and at the same time serves as weed cover. Soybeans should not be grown on the same site for more than two years to prevent a build-up of soil-borne diseases. Practice crop rotation of 3 to 4 years as a part of disease control. The plant grows best in a rotation after maize or small grains but should not follow edible beans, rape, or sunflowers because white mould disease can be carried over.

Husbandry

Weed control is essential. Early seed bed preparation with removal of couch and watergrass is the first step to good yields. Irrigation at flowering and during seed filling when rain is failing is essential to gain optimum yield. More frequent irrigation is needed in sandy, well-drained soils than in heavy clay soils. Favourable effects of soybeans are improved soil structure and fertility due to its nitrogen fixing capacity. Soybeans can obtain all of their nitrogen needs from the air when nitrogen-fixing-rhizobia (bacteria) are present in the soil. Nitrogen fixation is a result of the symbiotic relationship of rhizobia and the plants. Where soybeans have not been grown before it may be beneficial to treat the seed with soybean inoculum (*Rhizobium japonicum*, available from University of Nairobi - Kabete campus, Dept. of Soil Science) at a rate of 100g/15kg seed before planting to allow maximum nitrogen fixing throughout the growing season. A well-nodulated plant should have around 5-7 nodules on the primary root. When plants have fewer nodules, monitor the field carefully to determine if the nodule numbers increase. Nitrogen deficiency results in reduced chlorophyll development and a pale-green leaf colour. Do not add nitrogen to well-nodulated soybeans. It is just a waste of time and money.

Nitrogen added during planting delays nodulation and when applied during the vegetative stage results in poor nodule formation in proportion to the rates applied. However phosphorus in the form of rock phosphate at a rate of about 100-150 kg/ha is very beneficial for good root formation.

Harvesting

Early-maturing cultivars can be harvested for grain 70 days after planting and late maturing cultivars need up to 180 days. The plants are cut near the ground or pulled with their roots at physiological maturity when most leaves have aged and turned yellow, and at least one pod per plant have turned brown or black. Vegetable soybeans are harvested when the pods are still green but when the seeds have filled the pod. Most small scale farmers achieve yields of about 500-1000 kg/ha, though 3000 kg/ha is possible with good husbandry practices and recommended varieties.
Soybeans can be harvested by hand or by combine harvesters (this only at full maturity or after windrowing - cutting plants and leaving them in rows for wind and sun to dry properly). Once threshed, dry the soybeans to below 12 % moisture content before storing. Keep in a clean store and prevent weevil attack by any of the means described under storage pests. Seeds meant for seed should not be stored for longer than 1 year due to rapid loss of germination capability. For more information on storage pests click here

Information on Pests

Root-knot nematodes (*Meloidogyne* spp.)

Field symptoms are typically of stunted, poorly growing plants with yellowing leaves. They may cause also wilting and death of plants particularly in hot weather. Roots of affected plants are distorted, swollen and show characteristic knots or galls.

What to do:

- **Plant resistant varieties, where available.**

- **Rotate for at least 3 to 4 years with cereals.**
- **Use bio-products (e.g. neem extracts). Some are commercially available for nematode control.**

Root-knot nematodes
Root-knot nematodes (*Meloidogyne* spp.)
© H.J. Jensen (Reproduced from CABI 2006)

Beanflies (*Ophiomyia centrosematis* and *O. phaseoli*)

Bean flies are tiny (about 2mm long) flies, shiny black-bluish in colour. Female flies lay eggs on young leaves, piercing the leaves and sucking the exuding sap resulting in yellow blotches on the leaves, which are the first signs of bean fly attack and are useful for early detection of this pest. Maggots mine their way from the leaves down to the base of the stem, where they complete their development. Maggot feeding destroys the tissue causing the steam to swell and split and reducing formation of lateral roots.

Young seedlings and plants under stress wilt and die when attacked by bean flies. Older or vigorous plants may tolerate bean fly attack, but their leaves turn yellow, their growth is stunted and their yield reduced. Damage is more severe in plants growing under poor conditions such as infertile soils and drought. Under good conditions, Soybean, however, can compensate for minor stand reductions; thus, small gaps dispersed in a field normally are filled by adjacent plants and no yield reductions are detected.

What to do:

- **Plant early in the season. Bean fly numbers tend to be low during the early stages of the growing season and increase with time.**
- **Provide favourable growing conditions to improve plant vigour and to enhance tolerance to bean fly attack.**
- **Avoid planting beans near cowpea, beans and other leguminous crops, that may be the source of bean flies.**
- **Remove and destroy crop residues and all plant parts with symptoms of damage by bean flies.**
- **Monitor the field shortly after emergence.**
- **Ridge the crop 2-3 weeks after germination. This helps to cover the adventitious roots, which are produced by plants damaged by bean flies. The soil support prevents lodging and improves the survival of the damaged plants.**
- **If necessary, spray neem extracts. Frequent foliar applications of neem extract give satisfactory control of bean flies on beans.**

Bean fly
Bean fly maggot (*Ophiomyia* spp.) in a french bean stem
© A.M. Varela, icipe

Bean fly

Bean fly

The cotton aphid (*Aphis gossypii*)

It is a major pest of soybeans. Adults range from just under 1 to 1.5 mm in body length. Aphids are found in clusters (colonies) on stems, young shoots and pods and underside of leaves. They transmit the Bean Yellow Mosaic Virus on soybeans.

What to do:

- **Monitor regularly build-up of aphid population and natural enemies.**
- **When necessary use neem seed or leaf extracts for control. For further information on neem click here..**

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

---

Leaf-feeding caterpillars

Leaf-feeding caterpillars such as the cotton leafworm (*Spodoptera littoralis*), the beet armyworm (*S. exigua*) and the tomato looper (*Chrysodeixis chalcites*) are generally of minor economic importance, but serious outbreaks occasionally occur. In particular, *S. littoralis* often causes extensive damage to soybeans.

The bean webworm (*Lamprosema indicata*) feeds on leaves, which are spooned together, causing

characteristic windowing as the upper epidermis of leaves remain untouched. This caterpillar may cause considerable damage in soybeans. Natural enemies are important to keep populations at low level.

What to do:

- **Conserve natural enemies. Caterpillars have a wide range of natural enemies (parasitic wasps, predators and pathogens) that are important in their natural control.**
- **Monitor the crop regularly.**
- **Hand pick eggs and caterpillars.**
- **Use botanicals (e. g. neem extracts) and biopesticides (e.g. Bt).**

Damage by beet armyworm
Damage by the beet armyworm (*Spodoptera exigua*) on garden peas, it is about about 2-3cm long.
© A.M. Varela, icipe

The groundnut leafminer (*Aproaerema modicella*)

The adult is a small greyish moth, with a full wing span of up to 18mm. Eggs are laid singly on the underside of the leaves of groundnut, soybean and other leguminous plants. Caterpillars are 6 mm long at the time of pupation, and rarely exceed 8 mm in length. Young caterpillars mine the leaves; later as caterpillars get older they exit the mine to web together several leaflets.

Damaged leaves become brownish, rolled and desiccated, which results in early defoliation and affects the growth and yield of the plants.

This leafmining caterpillar is a pest of groundnut and soybean in South and Southeast Asia and has recently invaded Africa. It has become a major pest of groundnuts in several African countries and has also been reported causing damage to soybeans in Uganda. Some farmers have reported a 30% yield loss.

What to do:

- **Plant during the first short rains when normally the miner population is low**
- **Avoid drought stress by irrigating or sowing so as to avoid periods when drought is likely. Plants that are drought stressed are much more susceptible to leafminer attack than irrigated plants.**
- **Monitor plants regularly, particularly when intercropped with or planted near groundnuts. In India, soybean plants have been recommended as trap crops to divert these leafminers from groundnuts**
- **Treat with neem products as soon as infestation is detected. Early applications of neem products have been effective in India and Uganda**

Leafmining caterpillar
Leafmining caterpillar (*Aproaerema modicella*) on groundnut. They are grey-green with a shiny black head. Caterpillars are 6 mm long at the time of pupation, and rarely exceed 8 mm in length.

Bugs

Sucking bugs are major soybean pests. They feed on pods and soft growing plant parts. While feeding they inject toxins into pods/seeds causing necrosis.

The most important are stink bugs (e.g. *Nezara viridula*, and *Piezodorus hybneri*), Riptortus bugs (*Riptortus dentipes), Mirperus jaculus*, giant coreid bugs (*Anoplocnemis curvipes*), and spiny brown bugs (*Clavigralla* spp.).

Extensive stink bugs feeding may result in pod abortion and the destruction of seeds. Severe pod abortion may induce such plants to remain in the vegetative stage, causing foliar retention, which poses problems at harvest. The green stink bug (*Nezara viridula*) also injects a fungus (*Nematospora coryli*) into the developing seeds, which is the casual agent of the yeast spot disease. A single stink bug puncture may result in the loss of seed germination. Direct pod and seed injury may result in yield loss and decrease in seed quality due to microorganisms, even if plants compensate for considerable injury that occurs during early pod-set. Damage at the end of the seed- development will result in yield loss.

Sucking bugs are difficult to control since they are very mobile and can infest the crop from neighbouring crops.

What to do:

- **Sucking bugs are attacked by parasitic wasps and assassin bugs. In Ghana a threshold of 2-bugs/metre row is suggested.**
- **Control strategies should be related to the stage of pod development. It has been shown that early pod fill is the most sensitive stage to attack by green stink bugs (N. viridula), and the only one in which yield, seed weight and oil content was significantly reduced. Bugs should be controlled before this stage is reached, i.e. towards the end of pod elongation. Once pod fill is completed, soybeans are not at risk and control is not warranted unless planting seed or edible seed is being grown (CABI, 2005).**

- **Research in Indonesia has shown that Sesbania rostrata is an effective trap crop, for managing stink bugs and Riptortus bugs on soybeans (Naito, 1981, 1996). Sesbania rostrata is taller than soybean, and since it takes longer to mature, it can also attract stink bugs over a longer period. In addition to attracting adults of N. viridula, it helps to reduce their numbers, since it is not a suitable food plant for nymphal development. Sesbania is usually planted on two opposite sides of a soybean field.**
- **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.**

Stink bug
Green stink bug (*Nezara viridula*) on soybean. Adults are about 1.2cm long.
© Clemson University - USDA Cooperative Extension Slide Series, www.insectimages.org


Stink bug


Tip wilter..


Spiny brow..


Riptort ...

Pod borers (*Maruca vitrata, Etiella zinckenella, Helicoverpa armigera*)

The legume pod borer (*Maruca vitrata*), the lima bean pod borer (*Etiella zinckenella*) and the African bollworm (*Helicoverpa armigera*) are major pests of soybeans. The adults are small moths. They are nocturnal and seldom seen in the field at daytime. Caterpillars of these moths feed on the floral parts and pods of legume

plants, rendering them unmarketable. They scrape or bore through pod walls into the developing seeds.

For more information on African bollworm click here.

What to do:

- **Monitor the crop regularly.**
- **Spray with Bt o neem extracts or other plant extracts. It is very important to apply them 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. Since the period between hatching to entering the pods is very short it is very important to monitor the crop frequently.**

Legume pod borer
Legume pod borer (*Maruca vitrata*)
© Ooi P. Courtesy of EcoPort, www.ecoport.org


Legum pod…


Lima bean …


Africar bo…

Storage moths and bruchid beetles

Larva of storage moths (*Ephestia cautella, Corcyra cephalonica*) and bruchid beetles (*Callosobruchus* spp.) cause extensive damage to soybean grains. The forewings of the adult moth *E. cautella* are greyish-brown with an indistinct pattern. The wing span is 1-2 cm.

What to do:

- **Rice husk ash was found to be effective against bruchid beetles (Callosobruchus analis) in Indonesia. Fresh, dry ash should be used, at a rate of around 1% of the seed weight. The rice husk ash should be spread by hand over well-dried soybean seeds stored in a can with a capacity of 6 - 18 litres. The ash should be gently mixed with the seed by hand, and the lid placed tightly on the can. The can should be kept in a cool, dark place (Naito, 1981).**

Bean bruchid
Bean bruchid (*Acanthoscelides obtectus*) on soybean. Adults are 3-4.5mm long, grey-brown.
© Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org


Bean bruch.


Cowpe see…


Storag mo…

Information on Diseases

Among the diseases, Soybean rust caused by Phakopsora pachyrhizi can reduce yields by as much as 90%.

Other serious diseases are: Bacterial pustule (Xanthomonas axonopodis pv. glycines) /Soybean bacterial blight (Pseudomonas savastonoi pv. glycinea), Soybean downy mildew (Peronospora manshurica), Anthracnose (Colletotrichum truncatum and Glomerella glycines), Purple seed stain (Cercospora kikuchii), Pod and stem blight (Diaporthe phaseolorum var. sojae), Soybean mosaic potyvirus, Bean yellow mosaic virus and various seedling diseases.

Soybean rust (*Phakopsora pachyrhizi*)

The most common symptoms are grey green, tan to dark brown or reddish brown lesions particularly on the undersides of the leaflets. These lesions are called uredia and they contain spores of the fungus. The spores from uredia are called urediniospores. Lesions tend to be angular, are restricted by leaf veins, and reach 2-5 mm in diameter. Lesions may also appear on petioles, pods, and stems. With time uredia turn black and at this stage they are called telia and the spores they contain are called teliaspores.
Lesions are frequently associated with leaf chlorosis, and high lesion densities result in premature defoliation and early maturity. During the early stages of development before the onset of sporulation, rust lesions may be confused with bacterial pustules (see bacterial pustule/bean blight). However, the symptoms of the two diseases can be differentiated by the presence of multiple uredia in the rust lesion and by the irregular cracks that usually appear in host tissue with a bacterial pustule lesion. Rust epidemics are most severe during long periods of leaf wetness when the mean daily temperature is less than 28°C. Urediniospores are the primary means of disease spread. Soybean is susceptible at any stage of development, but symptoms usually appear from the middle to late in the season because a prolonged wet, cool period is required for infection and sporulation. Spread of urediniospores is by windblown rain. The pathogen is not seed-borne in soybean.

What to do:

- **Plant resistant varieties, if available.**

Soybean rust
Soybean rust (*Phakopsora pachyrhizi*) symptoms on lower leaf surface
© Reid Frederick, USDA Agricultural Research Service, www.insectimages.org

Soybean mosaic potyvirus (SMV)

Symptoms vary with host, virus strain, plant age at infection, and environment. Most infected cultivars are slightly stunted with fewer pods that are sometimes dwarfed and flattened, without hairs, and without seeds. Trifoliolate leaves have a mosaic of light and dark green areas that may later become raised or blistered, particularly along the main veins. Primary leaves of some cultivars may show necrotic local lesions, which merge, into veinal necrosis followed by yellowing and leaf abscission.
Seeds from infected plants may be mottled brown or black, depending on hilum colour. Seeds may be smaller and germination reduced as compared to seed from noninfected plants. Mottling does not indicate that the virus is present in seeds as not all mottled seeds contain virus and not all seeds from virus-infected plants are mottled. SMV is sap and graft-transmissible. At least 32 aphid species, belonging to 15 different genera, transmit the SMV in a non-persistent manner. Virus isolates may show some vector specificity. Infected plants resulting from transmission through seed play an important role in SMV epidemiology. Such plants are sources for primary inoculum of SMV. In most cultivars, seed transmission is less than 5%, but no transmission occurs in some cultivars while others can have levels as high as 75%.

What to do:

- **Use certified disease-free seeds.**
- **Practise aphid control to reduce the spread of virus.**
- **Plant resistant cultivars, if availale.**

Soybean mosaic potyvirus
Soybean mosaic potyvirus
© Mike Pearson (Courtesy of EcoPort, www.ecoport.org)

Bean yellow mosaic virus (BYMV)

Leaves of infected plants are not distorted as in SMV. The younger leaves show a yellow mottling scattered in random areas over the leaflets or sometimes an indefinite yellow band along major veins. Rusty necrotic spots develop in the yellowed areas as the leaves mature. Infected plants are not noticeably stunted. The disease is transmitted by aphids and infected seeds.

What to do:

- **Use certified disease-free seeds.**
- **Control aphids. For more information on aphid control click here.**

Soybean bacterial blight (*Pseudomonas savastonoi* pv. *glycinea*)

Blight lesions are most conspicuous on leaves but also occur on stems, petioles, and pods. Small, angular, translucent, water-soaked, yellow to light brown spots appear on leaves. The centres soon dry out, turn reddish brown to black, and are surrounded by a water-soaked margin bordered by a yellowish green halo. Young leaves are most susceptible. Infected young leaves are distorted, stunted, and chlorotic. The angular lesions enlarge in cool, rainy weather and merge to produce large, irregular dead areas. *P. savastonoi* pv. *glycinea* over seasons in surface crop residue and in seeds. Seeds can be infected through the pods during the growing season, or they may be invaded during harvesting. Primary infections on cotyledons often result in secondary lesions on seedlings. The bacterium is spread during windy rainstorms and during cultivation while the foliage is wet. It is seed-borne.

What to do:

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

Bacterial blight
Soybean bacterial blight

Bacterial pustule (*Xanthomonas axonopodis* pv. *glycines*)

The symptoms are much like those of bacterial blight. At first they appear as small, yellow-green spots with reddish-brown centres, more conspicuous on the upper surface of the leaf. A small, raised pustule usually develops at the centre of the lesion, especially on the lower leaf surface. This is the stage at which the disease is most readily distinguished from bacterial blight. The pustule and the absence of water soaking serve to distinguish bacterial pustule from bacterial blight. The latter shows water soaking at the centre or the margin of the dead area in the early stages of infection. In bacterial pustule, small infections may run together and cause large, irregular brown areas surrounded by a yellow margin. Parts of the brown dead areas may crack, giving the leaf a ragged appearance. The bacteria causing bacterial pustule over-season in diseased leaves and are seed-borne. Some strains infect common bean and cowpea.

What to do:

- **Disease management is the same as in the case for bacterial blight.**

Bacterial pustule
Soybean bacterial pustules caused by *Xanthomonas axonopodis* pv. *glycines*.

Wildfire disease of soybeans (*Pseudomonas syringae* pv. *tabaci*)

Symptoms consist of light-brown necrotic spots of variable size, surrounded by broad yellow halos on the leaves. In damp weather the spots enlarge forming large dead areas on the leaf. Wildfire disease is commonly associated with bacterial blight and bacterial pustule infections. The bacteria causing wildfire are seed-borne and also are carried over in crop debris.

What to do:

- **Disease management is the same as in the case for bacterial blight and bacterial pustule.**

Wildfire disease
Wildfire disease (*Pseudomonas syringae* pv. *glycinea*) symptoms.

Soybean downy mildew (*Peronospora manshurica*)

Early stages of the disease are characterised by indefinite yellowish-green areas on the upper surface of the leaves. As the disease progresses, those infected areas become greyish brown or dark brown and have yellowish-green margins. Severely infected leaves fall off prematurely. A greyish mould-like growth develops on the under surface of the spots when weather is wet and temperatures are cool. The disease also attacks the pods and infects the seeds. The disease is favoured by cool temperatures and wet conditions.

What to do:

- **Plant certified disease-free seeds.**
- **Use resistant varieties, if available.**

Downy mildew
Soybean downy mildew (*Peronospora manshurica*)

Pod and stem blight (*Diaporthe phaseolorum* pv. *sojae*)

It kills the plants in the later stages of crop development. Stems, petioles, pods, seed and less frequently leaf blades may be infected. It can be easily identified by the numerous, small, black fugal fruiting bodies (pycnidia) that appear on the stems and pods of infected plants. On the pods, the pycnidia are scattered while on the stems they are usually arranged in rows. The disease is favoured by wet weather. The disease is seed-borne and can over-season on diseased stems in the field.

What to do:

- **Use certified disease-free seeds.**
- **Use resistant varieties, if available.**
- **Practise sanitation.**
- **Practise crop rotation with non-legumes.**

Pod and stem blight
Pod and stem blight on soybean (*Diaporthe phaseolorum*)

White mould (*Sclerotinia sclerotiorum*)

It is characterised by a rot at the base of the plant stem. The rot is covered by a cottony, fungal (mycelial) growth on which black irregularly shaped fungal bodies (sclerotia) are produced. Size of sclerotia varies from 2 to 22 mm in diameter. The disease infects the stem and pods. Large, black, round to irregularly-shaped sclerotia of varying size form on stems, which are partially covered with dense white mycelium. Sclerotia are also formed in the stem pith and are conspicuous when the stem is opened. Seeds may become infected within diseased pods. If infected early, seeds are flattened and shrivelled and sometimes replaced by black sclerotia. Attacked plants die prematurely, sometimes before seeds have formed. Infection occurs at flowering. Moderate air temperatures and frequent rains just prior to flowering to the pod development stage of growth favour the disease.

What to do:

- **Use certified disease-free seeds.**
- **Plant resistant varieties, if available. Early maturing cultivars tend to escape infection because of their usually short stature and early flowering. In contrast, late maturity cultivars are believed to have more disease because of lush vegetative growth and later flowering.**

- **Avoid planting soybean directly after common bean, sunflower and rape.**
- **Avoid planting highly susceptible cultivars if row spacing is less than 76 cm in fields with a history of the disease.**
- **Avoid excessive irrigation until flowering has ceased.**
- **Use good weed control practices.**

White mould
White mould on bean pods (*Sclerotinia sclerotiorum*).
© David B. Langston, University of Georgia, Bugwood.org

Damping-off diseases and Anthracnose (*Colletotrichum truncatum* and *Glomerella glycines*)

They are caused by an array of fungi including *Colletotrichum truncatum* and *Glomerella glycines* (cause of anthracnose). The diseases cause rotting of seeds before emergence from the soil or death of seedlings after emergence.

The two species of fungi produce similar symptoms on the petioles, stems and pods particularly when plants are nearing maturity. Diseased areas have dark sunken lesions. Under moist weather the lesions become covered with a pink spore mass. The disease is seed-borne. When infected soybean seeds are planted, many of the seeds rot in the soil. Those that emerge from the soil often have brown, sunken cankers on the cotyledons (seedling leaves). The fungi may grow from them into the young stems. The damping-off seedling losses are probably more serious phases of soybean anthracnose than symptoms on older plants. The

disease is favoured by cool wet weather.

What to do:

- **Use certified disease-free seeds.**
- **Plant resistant varieties, if available.**
- **Practise crop rotation with non-legumes.**
- **Practise proper water management.**

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


Anthra Brown blot…

Purple seed stain (*Cercospora kikuchii*)

Symptoms of purple stain are most evident on the seeds, but the fungus also attacks leaves, stems and pods. On the seeds, discolouration varies from pink or light purple to dark purple and ranges from a small spot to the entire seed coat. Cracks often occur on the discoloured areas giving the seed coat a rough, dull

appearance. When infected seeds are planted, the fungus grows from the seed coats into the cotyledons (seedling leaves) and into the hypocotyls (seedling stem). The fungus produces spores abundantly on infected seedlings and these spores serve as source of infection to leaves, stems and pods. The spores are spread by wind and rain splash.

What to do:

- **Use certified disease-free seeds.**
- **Plant resistant varieties, if available.**
- **Avoid overhead irrigation.**

Purple seed stain
Purple seed stain (*Cercospora kikuchii*) on soybean

Information Source Links

- **AIC (2002). Field Crops Technical Handbook. Nairobi**
- **Blay, E., Cudjoe, A. R., Braun, M. (eds) (2000). Handbook of crop protection recommendations in Ghana: An IPM approach Vol:1 Cereals and pulses. Plant Protection & Regulatory Services Directorate and Integrated Crop Protection Project (ICP) German Development Co-operation (GTZ/PPRSD.**
- **Bohlen, E. (1973). Crop pests in Tanzania and their control. Federal Agency for Economic Cooperation (bfe). Verlag Paul Parey. ISBN: 3-489-64826-9.**

- **Brier H.B. and Rogers, D.J. (1991). Susceptibility of soybeans to damage by *Nezara viridula* (L.) (Hemiptera: Pentatomidae) and *Riptortus serripes* (F.) (Hemiptera: Alydidae) during three stages of pod development. Journal of the Australian Entomological Society, 30(2):123-128.**
- **CABI. (2005). Crop Protection Compendium, 2005 Edition. © CAB International Publishing. Wallingford, UK. www.cabi.org**
- **Major Soybean Pests of the World. www.nsrl.uiuc.edu/news/nsrl_pubs/insectbooks/guidelines/sectionIII.pdf**
- **Naito, A. (1981). Low-Cost Technology for Controlling soybean insect pests in Indonesia. Association for International Cooperation of Agriculture and Forestry (AICAF). http://www.agnet.org. African Entomology. 102: 97-99. IITA. 1981.**
- **Naito, A. (1996). Insect pest control through use of trap crops. Agrochemicals Japan, 68, 9-11.**
- **Participatory evaluation of the distribution, status and management of the groundnut leafminers in the Teso and Lango farming systems. Final technical report. NARO/DFIFD COARD Project. October 2004. By George Epieru Naro Saari.**
- **Paulraj, M.P. and S. Ignacimuthu. (2006). Integrated control of groundnut leaf miner. Entomology Research Institute Loyola College, Chennai. www.thehindu.com**
- **Suzuki N, Hokyo N, Kiritani K. (1991). Analysis of injury timing and compensatory reaction of soybean to feeding of the southern green stink bug and the bean bug. Applied Entomology and Zoology, 26(3):279-287.**
- **The New Vision (2004). Uganda's leadings website. http://www.newvision.co.ug**
- **Todd J.W. (1989). Ecology and behavior of *Nezara viridula* Annual Review of Entomology, 34:273-292.**
- **University of Illinois National Soybean Research Centre: www.soydiseases.uiuc.edu**

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Cucumber

Cucumber
Scientific name: *Cucumis sativus*

Family: Violales: Cucurbitaceae
Pests and Diseases: Angular leaf spots Anthracnose Aphids Damping-off diseases Downy mildew Epilachna beetles Flea beetles Fruit flies Fruit rot Fusarium wilt Powdery mildew Root-knot nematodes Scab Spider mites Virus diseases Whiteflies Leafminer

General Information and Agronomic Aspects

Cucumber is a member of the Cucurbitaceae family, which includes pumpkins, squash, gourds and zucchini. Cucumber is grown for the immature fruits, which are eaten fresh (slicing cucumber), or used for pickles (pickling cucumber) . The slicing cucumbers are peeled, sliced and served with vinegar or dressing, or as an ingredient of salads. The large, yellow, round types are boiled and eaten as an ingredient of stews. Pickling cucumbers are preserved or marinated with vinegar, salt, or spices. They can also be used fresh. Cucumbers are a good source of Vitamin C.

Geographical Distribution of Cucumber in Africa

Nutritive Value per 100 g of edible Portion

Raw Vegetable	Food Energy	Protein (g)	Carbohydrates (g)	Ash (g)	Calcium (g)	Phosphorus (mg)	Iron (mg)	Potassium (mg)	Vitamin A	Thiamine (mg)	Ribof (mg)

Cucumber	15 (Calories)	0.9	3.4	0.5	25	27	1.1	160	250 (I.U)	0.03	0.04

Climatic conditions, soil and water management

Cucumber requires a warm climate. The optimum temperature for growth is about 30°C and the optimum night temperature 18-21°C. In the tropics, elevations up to 1700 m appear to be suitable for cucumber cultivation. A lot of light tends to increase the number of staminate (male) flowers. Cucumbers need a fair amount of water but they cannot stand waterlogging. High relative humidity encourages downy mildew. The soil should preferably be fertile and well-drained, with a pH of 6.5-7.5. Long and medium long slicing cucumber varieties are grown in greenhouses where climate and other growing conditions can be controlled.

Propagation and planting

Cucumber is propagated by seed. Soil preparation requires generous incorporation of well rotted manure. About 30 t/ha or 15 tons/ha should be applied inside the planting holes together with a spoonful of rock phosphate (3 tea spoons) for each planting hole. Sowing is done directly in the field with several seeds per hill, 90-120 cm apart, then thinned to 2-3 plants per hill, or seeds are sown in nursery beds and seedlings transplanted to the field at the 2-true-leaf stage at 30-40 cm within and 1-2 m between the rows. Sowing rates per ha are about 2.5-3 kg for direct seeding and 1 kg when transplanted. Cucumber cultivated for pickles is planted closer, up to 250,000 plants/ha. For greenhouse varieties plants are started in individual pots and transplanted to permanent position when they have 2-3 permanent leaves.

Cucumber varieties are categorised into four types on basis of fruit length:

- **Long cucumbers: Fruit length over 30 cm. Examples: Berlin RZ / Bologna RZ / Cumlande RZ / Myrthos RZ / Pluto RZ / Virginia RZ)**

- **Midi cucumbers: Fruit length between 18 -24 cm Examples: Media RZ**
- **Mini cucumbers: Fruit length between 15 -19 cm. Examples: Khassib RZ / Gianco RZ**
- **Cocktail cucumbers: Less than 15 cm. Examples: Rania RZ**

Other varieties include:

- **Ashley**
- **Poinsett. Poinsett is a variety with a very high yield potential, good disease and heat resistance.**
- **Long Fellow**
- **Hybrid Victory**
- **Kande (new variety produced in Tanzania)**

Because varieties change all the time, please ask your local seed company to give information about the available varieties.

Marketable cucumbers: The two long varieties shown on the left are green house types that need protected environment and careful staking so as not to damage fruits. The two short types on the right can be grown in open fields and without staking. Pickling varieties are even smaller, but also baby fruits of the two field varieties are good for pickling.

© A. Bruntse

Husbandry

Weed control is necessary until the plants cover the soil entirely. Support (stakes) should be provided for some cultivars, and the tip of the main stem can be nipped off to encourage branching. Irrigate at frequent intervals, and maintain a high level of soil moisture throughout the growing period. Lateral shoots can be pruned after the first fruits have formed to limit leaf and flower production. Greenhouse varieties are staked

according to preferred practices, usually by means of twisting the growing stem around a string attached to an overhead strong wire. There are indications that irrigation water containing applications of effective micro-organisms (EM) can prevent damping off and early attacks of diseases on leaves. Irrigation should preferably be applied in the form of drip irrigation in order to prevent water splashes and spread of diseases. Staked cucumbers are very susceptible to wind, so if grown in open land should be carefully protected from wind.

Harvesting

Cucumbers for fresh consumption are harvested before they are fully mature, usually starting about 50- 60 days after planting, and thereafter every few days. For pickling, immature fruits of several stages are harvested. Only for seed production are cucumbers allowed to mature on the plant. Cucumbers should be handled with care as they get damaged easily during transport. Depending on variety one plant may yield up to 10 fruits, and total yields with good plant care can easily reach 50 tons/ ha of the larger fruit types. More common yields are 25-30 tonnes/ha. Fruits should not be left to ripen on the vines as the plants will cease to bear. The marketed fruit must be firm, green and the size typical of the cultivar.
Some of the long slicing cultivars of cucumber are packed individually before marketing and cooled.

Information on Pests

Aphids (*Aphis gossypii*)

The cotton aphid (*Aphis gossypii*) is common on cucurbits, including cucumber. Colonies of green to blackish aphids are found on tender shoots, mainly on the lower leaf surface, where they suck sap. The growth of the attacked shoots is stunted and the leaves are curled and twisted. Aphids excrete honeydew, which leads to growth of sooty mould, and may attract fruit flies. Aphids, in particular winged aphids, transmit virus diseases (e.g. cucumber mosaic virus) when moving from plant to plant.

What to do:

- **Plant barrier crops**
- **Apply sticky traps**
- **Use botanicals (e.g. neem extracts)**
- **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**

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

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

Fruit flies are important pests of cucumber and other cucurbits.

Fruit flies are about 4-7mm long, they pierce the fruits and lay eggs in fruits. 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, causing fruit rot.

What to do:

- **Avoid continuous cultivation of cucumbers at the same place since this may lead to fruit fly outbreaks.**
- **Destroy all infested fruit**
- **In small plots, wrap individual fruits or bag them with newspaper or paper bags to prevent fruit flies from laying eggs fruits. 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 minimum.**
  For more information on neem click here.

Fruit fly maggots
Fruit fly maggots in watermelon fruit, the larvae are about 1cm long
© A.M. Varela, icipe


Fruit

Fruit

Fruit

Fruit

fly … fly … fly … fly …

Whiteflies (*Bemisia tabaci*)

They suck plant sap and excrete honeydew where moulds grow, which may affect plant growth and vigour. The tobacco whitefly is considered a major pest due to its ability to vector various virus diseases, which cause considerable damage to cucurbits.
(*Bemisia tabaci*)

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 in 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)**
- **Whenever 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.
© Clemson University, Department of Entomology

Epilachna beetles (*Epilachna chrysomelina*)

Adults of this beetle, also known as the African melon ladybird, are 6-8 mm long, reddish in colour with a number of black spots on the wing cases. The larvae are 7-9 mm in length, soft and covered with dark coloured spines. Adults and larvae feed on leaves leaving a fine net of veins. Damaged leaves shrivel and dry up. Young plants can be entirely destroyed. Older plants can tolerate considerable leaf damage. This beetle is a vector of squash mosaic virus. Epilachna beetles attack all cucurbits.

What to do:

- **Spray neem extracts. Simple neem-based pesticides have given control of this pest in Togo. Thus, feeding by Epilachna beetles in squash and cucumber could be reduced significantly by weekly applications 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 (Ostermann and Dreyer, 1995).**

Epilachna beetle
Larvae of Epilachna beetle (*Epilachna chrysomelina*) and damage caused (here on water melon).
© A. M. Varela, icipe


Epilacl Epilacl
...

Flea beetles (*Podagrica* spp)

They are tiny to small (1.5 to 3 mm) long leaf beetles with well-developed hind legs. They are named for their habit of jumping like fleas when they are disturbed. The colour of the adult beetles varies from black, brown, black and yellow striped or metallic blue-green depending on the species. Adult flea beetles chew small round holes (shot holes) in leaves, giving them a sieve like appearance. On rare occasions, they may feed directly on ripe fruit, just below the calyx. This damage is usually seen only in plants that show extreme foliar stress resulting from lack of water or powdery mildew. The larvae of flea beetles live in the soil and feed on roots, but the damage caused is not of economic importance. Adult flea beetles can be particularly damaging to young plants. Seedlings are most vulnerable to flea beetle feeding when stressed, particularly by inadequate moisture. Older plants can withstand considerable leaf perforation.

What to do:

- **Monitor the crop frequently, particularly during the first stages of the crop. Even a small flea beetle population can cause significant damage to a crop in the cotyledon or first-leaf stages**
- **Provide good nutrition and favourable growing conditions. This helps to avoid plant stress from diseases and moisture, and helps plants survive flea-beetle attack.**
- **Weed in and around fields. This may help to eliminate flea beetle shelter and breeding grounds, reducing crop damage.**
- **Keep plant diversity in the farm. Living mulches or polycultures are known to reduce flea-beetle damage. Diversity in the farm support populations of natural enemies.**
- **When necessary spray botanicals or other alternative products. Extracts of neem, rotenone, pyrethrin, sabadilla, garlic, onion and mint alone or in combination have been recommended for control of flea**

beetles. Insecticidal soap is reported to give partial control of flea beetles. However, sprays combining rotenone with insecticidal soap are considered very effective. Diatomaceous earth and rock powders have been observed to reduce flea-beetle populations but applications must be renewed regularly after rainfalls.

Flea beetle
Flea beetle (*Podagrica* spp) feeding on young okra pod
© A.M. Varela, icipe

Red spider mites (*Tetranychus* spp.)

Red spider mites attack leaves of cucumber. Adults are about 0.6 mm long. Attacked leaves have a stippled appearance, turn yellowish to whitish and dry up. Often young plants are entirely destroyed. In older plants growth can be severely stunted and the fruit set considerable reduced. Spider mites can be a problem in dry and hot conditions. Plants under water stress (drought) are more likely to suffer damage by spider mite.

What to do:

- **Conserve natural enemies. Predatory mites and anthocorid bugs are important in natural control of mites**
- **Avoid use of broad-spectrum pesticides. They may kill natural enemies and may lead to mite outbreaks**
- **Provide good growing conditions for plants. Healthy plants are more likely to withstand mite attack. Adequate irrigation is particularly important. Apply mulch and incorporate organic matter into the soil to**

improve the water holding capacity and reduce evaporation

Spider mites
Spider mites (here on tomato). Note the mites and their webbing visible beetween the leaves.
© Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org

Spider mit…

Spider mit…

Root-knot nematodes (*Meloidogyne* spp.)

Symptoms of infestation by root-knot nematodes are similar in all crops: wilting of plants and if infested plants are pulled from the soil the roots can be seen to be distorted, swollen and bearing knots. The infested roots eventually rot and affected plants die.
(*Meloidogyne* spp.)

What to do:

- **Use resistant varieties, if available**
- **Practice mixed cropping. Mixed cropping with African marigold (Tagetes spp.) minimise root-knot nematode damage. Intercrop with different mustards (e.g. Brassica juncea var. integrifolia or Brassica**

juncea var. juncea) on infested fields. As soon as mustards are flowering they are mulched and incorporated into the soil. While incorporated plant parts are decomposing in a moist soil, nematicidal compounds of this decomposing process kill nematodes. Two weeks after incorporating plant material into the soil a new crop can be planted or sown (phytotoxic effects are usual if the crop is planted before two weeks).

- **Maintain high levels of organic matter in the soil (manure or compost)**
- **Use biofumigation where possible (biofumigation involves incorporation into the soil of crop residues of crucifers, resulting in high levels of organic matter).**
- **Use neem extracts**

Root-knot nematodes
Root-knot nematode (*Meloidogyne* spp.) galls (here on tomato roots). Root-knot nematodes 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.

Information on Diseases

General Information

Many viruses affect the cucumber family. The important viruses include cucumber mosaic virus, watermelon mosaic virus and squash mosaic virus. Field symptoms of these three diseases are similar and therefore it is very difficult to separate them by symptoms alone. Leaf symptoms include a prominent light and green mosaic

pattern, mottling (yellow with green islands or blisters), and in severe cases, leaf distortion whereby affected leaves appear fern-like. Diseased fruits are malformed (slightly to severely misshaped with wart-like lumps).

Examples of Cucumber Diseases and Organic Control Methods

Damping-off disease

Damping-off disease - *Phytium* sp. on Cucumber

Damping-off disease - *Phytium* sp. on Cucumber
© Gerlach W. (Courtesy of EcoPort, www.ecoport.org)

Downy mildew (*Pseudoperonospora 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 through 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.

What to do:

- **Use resistant varieties, if available**
- **Leave wide spacing between plants**
- **Avoid overlap cucumber plantings**
- **Copper fungicides at 0.1% can provide control**

Downy mildew on cucumber
Downy mildew (*Peronospora* sp.) attacking the upper leaf face
© Jürgen Kranz (Courtesy of EcoPort, www.ecoport.org)

Powdery mildew (*Sphaerotheca fuliginea* and *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%.

What to do:

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

Powdery mildew
Severe powdery mildew attack (*Sphaerotheca fuligenea*) on cucumber
© Jürgen Kranz Courtesy of EcoPort

Angular leaf spot (*Pseudomonas syringae* pv. *lachrymans*)

Spots on leaves angular in shape and variable in size due to leaf veins that limit their enlargement. Initially, spots are water-soaked. In moist weather, bacteria ooze from the spots in tear-like droplets, which dry making the tissue white. Affected leaf dries and shrinks, and it may tear away from the healthy portion leaving irregular holes. Leaves approaching maturity are more susceptible than older leaves. Fruits may also be attacked. Fruit spots are small, nearly circular and superficial. The bacteria survive in association with seed. When infected cucumbers are used for seed extraction, the seed can be contaminated during fermentation process.

The bacteria can also survive in soil or infected crop debris. Drainage water can spread the bacteria in the soil. Angular leaf spot disease is favoured by wet conditions, frequently associated with rainfall and overhead irrigation. Optimum temperature for disease development is 23.9 to 27.8º C. The disease attacks gherkin, muskmelon, pumpkin, squash, vegetable marrow and watermelon.

What to do:

- **Use resistant varieties, if available**
- **Use disease-free seed**
- **Practice crop rotation. A crop rotation of 1 to 2 years is recommended**
- **Avoid run-off water from nearby cucurbit fields and overhead irrigation**

Angular leaf spot
Angular leaf spot (*Pseudomonas syringae* pv. *lachrymans*) on cucumber

Anthracnose (*Colletotrichum orbiculare*)

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 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.

What to do:

- **Use resistant varieties, if available**
- **Use disease-free seeds**
- **Practice crop rotation**
- **Destroy volunteer cucurbits and weeds**

Anthracnose
Anthracnose (*Colletotrichum orbiculare*) damage to pumpkin leaf (*Cucumis sativus*).
© Clemson University - USDA Cooperative Extension Slide Series, www.insectimages.org

Fusarium wilt (*Fusarium oxysporium* f.sp. *cucumerinum*)

In seedlings, the cotyledons lose their healthy look (luster) and wilt. This is followed by complete collapse of the plants. Older plants initially exhibit wilting and yellowing of leaves near the crown. Later individual vines and then the whole plant wilt and dies. If the taproot and stem are split open, an orange-brown discolouration of the water conducting tissues will be seen. Fruits from affected vines are small with poor flavour and colour.

The fungus is a soil inhabitant. It enters the roots and grows in the water conducting tissues thereby blocking water movement. The fungus is also carried on the seeds and in soil adhering to farm implements. It can persist in soil for long periods. The disease is favoured by warm weather (optimum soil temperature for infection is about 27.8º C) and air humidity of more than 80% over a long period.

What to do:

- **Use resistant varieties, if available**
- **Use disease-free seeds**
- **Avoid spread of the fungus through contaminated farm implements and furrow irrigated water**

Fusarium wilt
Wilting (here of okra plant) due to fusarium wilt
© A.M. Varela & A.A.Seif, icipe

Fruit rot

Fruit rots are of minor importance in Africa; they are primarily post-harvest problems during storage. In most African countries, cucumbers are sold fresh from farm, consumed and are hardly stored for long (exception could be supermarkets in urban areas where fruits are kept on shelves).

What to do:

- **Avoid injuries during harvesting**
- **Store fruits properly after harvest**

Mosaic Virus diseases

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.

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**

Virus diseases
Virus on cucumber leaf
© A.A. Seif, icipe


Virus dise…


Virus dise…

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.

What to do:

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

Scab
Scab (here on citrus leaf) symtoms on leaf
© www.ecoport.org

Information Source Links

- **AIC, Nairobi (2003). Fruits and Vegetables Technical Handbook**
- **AVRDC International Cooperators' Factsheet on Cucurbits www.avrdc.org/LC/cucurbits/publications.html**
- **Beije, C.M., Kanyangia, S.T., Muriuki, S.J.N., Otieno, E.A., Seif, A.A., Whittle, A.M. (1984). Horticultural Crops Protection Handbook.National Horticultural Research Station, Thika KEN/75/028 and KEN/80/017/**
- **Blay, E., Cudjoe, A. R., Braun, M. (editors) (2000). Handbook of crop protection recommendations in Ghana: An IPM approach. Vol 2; vegetables. Plant Protection & Regulatory Services Directorate (PPRSD) and the Integrated Crop Protection Project, German Development Cooperation (GTZ).**
- **Bohlen, E. (1973). Crop pest in Tanzania and their control. Federal Agency for Economic Cooperation (BFE). Veralgh Paul Parey. ISBN 3-489-64826-9.**

- **CAB International (2005). Crop Protection Compendium, 2005 edition. Wallingford, UK www.cabi.org**
- **Ekesi, S., Billah, M.K. (Eds) (2006). A field guide to the management of economically important tephritid fruit flies in Africa. ICIPE. ISBN: 92-9064-179-7.**
- **Kuepper, G. (2003). Flea Beetle: Organic Control Options. NCAT Agriculture Specialist. Published ATTRA Publication #CT114. National Sustainable Agriculture Information Service.**
- **Ministry of Agriculture and Rural Development (Kenya) (MoARD) & Japan International Cooperation Agency (JICA) (2000). Local and Export Vegetables Growing Manual. Reprinted by Agricultural Information Resource Centre, Nairobi, Kenya. 274 pp.**
- **Ostermann, H., Dreyer, M. (1995). Vegetables and grain legumes. In ?The Neem tree *Azadirachta indica* A. Juss. and other meliaceous plants sources of unique natural products for integrated pest management, industry and other purposes?. Edited by H. Schmutterer in collaboration with K. R. S. Ascher, M. B. Isman, M. Jacobson, C. M. Ketkar, W. Kraus, H. Rembolt, and R.C. Saxena. VCH. pp. 392-403. ISBN: 3-527-30054-6**
- **Sherf, A.F., Macnab, A.A.(1986). Vegetable Diseases and Their Control. 2nd. Edition. John Wiley & Sons Inc. USA. ISBN: 0-471-05860-2**
- **Summers, C.G. and Stapleton, J. J. (2002). Use of UV reflective mulch to delay the colonization and reduce the severity of *Bemisia argentifolii* (Homoptera: Aleyrodidae) infestations in cucurbits. Crop Protection. Volume 21. Pages 921-928. www.sciencedirect.com**
- **UCANR. UC helps pumpkin farmers produce pumpkins without pesticides. October 2003. www.ucanr.org**
- **East African Seed Co. Ltd. Africa's Best Grower?s Guide www.easeed.com**

Contact Links

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

HYGROTECH EAST AFRICA, LTD
Region :KENYA / TANZANIA - Location: NAIROBI
Address :P.O.Box 41446, Nairobi, Tigoni Centre, Limuru Road, KENYA
Phone :+254 (0) 20 205 3916-8
Fax :+254 (0) 20 205 3921
E-Mail: andrew@hygrotech.co.ke

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Potato

Potato
Scientific name: *Solanum tuberosum*
Family: Solanales: Solanaceae
Local names: Kiazi, egiasi, mbatata, potato, enkwashei (Kenya) / batata reno (Mozambique)
Pests and Diseases: Aphids Bacterial soft rot Bacterial wilt Cutworms Early blight Epilachna beetles Late blight Millipedes Potato Spindle Tuber Viroid Potato tuber moth Root-knot nematodes Scab Storage pests Viral diseases Weeds

General Information and Agronomic Aspects

Geographical Distribution of Potato in Africa

Potato originated in the highlands of South America, where it has been consumed for more than 8000 years. Spanish explorers brought the plant to Europe in the late 16th century as a botanical curiosity. By the 19th century it had spread throughout the continent, providing cheap and abundant food.

The potato arrived in Africa around the turn of the 20th century. British farmers introduced it to East Africa in the 1880s.The potato has grown in importance - both as a staple food and as a source of farmer incomes in medium to high altitudes in Kenya over the past 30 years.

Nearly all of Kenya's potatoes are consumed locally, at an average rate of almost 25 kg per capita a year. Potato is relished not only by the rural people who grow them, but by higher-income urban dwellers as well - while in some African countries potato is considered a "poor person's food", in Kenya it is considered a high quality and prestigious food item.

Climatic conditions, soil and water management

Potato requires well-distributed rainfall of 500 to 750 mm in a growing period of 3 to 4.5 months. Most commercial cultivars of potato tuberise (form tubers) best in cool climates with night temperatures below 20°C. Optimum day temperatures are within the range of 20 to 25°C. Short daylengths (12 to 13 hours) lead to earlier maturity. In the short daylength conditions of the tropics and subtropics, maximum yields can usually be obtained in cool highland areas and in cooler seasons. Cultivation is concentrated in highland areas from 1200 to 3000 m above sea level.In regions with a critical dry season, planting early in the rainy season is best. If the rainy season is long and excessive, time of planting is usually towards the end of the rainy season.

Potato is tolerant of a rather wide variety of soils, except heavy, waterlogged clays. Good drainage is of great importance. Impermeable layers in the soil limit rooting depth and the amount of available water, and so greatly reduce yields. Deep soils with good water retention and aeration give best growth and yields. The most suitable soil pH is between 4.8 and 6. At higher pH, tubers are liable to suffer from scab disease.

Propagation

Potato is normally propagated vegetatively by small (40 to 100 g) tubers, called 'seed tubers' or 'seed potatoes'. It can also be propagated by pieces of tuber ('seed pieces') or by true seed. The seed rate (tubers) ranges from 1.5 to 4.0 t/ha. The first problem facing growers in developing countries is obtaining supplies of healthy planting material of a suitable cultivar at an acceptable price. Some countries undertake traditional propagation of the seed tubers on sites in the highlands with suitable cool but frost-free climates and where the population of insect vectors of diseases can be kept at an adequately low level.

Recently, the use of true potato seed for propagation has aroused great interest. True seed does not transmit most of the potato diseases, is very light and is easy to transport. Promising methods to grow potatoes from true seed include raising seedlings in a nursery and transplanting them to the field.

Planting

In regions with a critical dry season, planting early in the rainy season is best. If the rainy season is long and excessive, time of planting is usually towards the end of the rainy season. Potato subjected to heavy rainfall during growth or harvest is prone to diseases.

Tubers planted to produce potatoes for consumption should generally be planted in rows 75-100 cm apart with a spacing of 30 to 40 cm within the row (25 to 44,000 plants per ha). The closer spacing should be used in fertile soils and good rainfall areas to avoid the production of very large tubers. Seed potatoes are planted at a spacing of 15 to 20 cm within the row (about 80,000 plants per ha).

Potatoes are planted at a depth of 5 to 15 cm (measured from the top of the tuber). Planting depth is greater under warm, dry conditions than under cool, wet conditions. Shallow plantings should be avoided, because the lower nodes of the stem must remain covered to encourage tuberisation (tuber initiation) and to avoid greening of tubers and tuber moth damage. Earthing up or hilling is carried out to control weeds and to avoid greening of the tubers. Potatoes are normally planted by hand in developing countries, but mechanical planters are available.

Plough-under or incorporate available organic manures in the soil before planting to enhance the water-holding capacity and texture of the soil as well as to provide enough nutrients for a healthy crop. A high yielding potato crop under conventional farming removes 95 to 140 kg N/ha, 35 kg P/ha, 125 to 170 kg K (Potassium)/ha and has relatively high needs for Mg (Magnesium) and Mn (Manganese). Organic farmers will need to identify organic sources for similar amounts of nutrients. Potatoes respond well to large amounts of compost or well-rotted animal manures.
Fertiliser recommendations based on soil analysis offer the very best chance of getting the right amount of fertilizer without over or under fertilising. Ask for assistance from the local agriculturist office for soil sampling and soil analysis procedures.

Sources of seed potatoes

In Kenya certified healthy seed potatoes are available from KARI Research Station, Ol Joro Orok and Tigoni Research Station (CIP).

Varieties in Kenya and their characteristics

Variety	Yield	Storage	Drought resistance	Late blight	Viruses	Maturity	Eco-zone
"Kenya Baraka"	High	Good	Some resistance	Some resistance	Some resistance	Medium	Medium High
"Roslin Eburu"	Medium High	Very good	Resistant	Some resistance	Some resistance	Medium	Medium High
"Feldelslohn"	High	Fairly good	Some resistance	Very susceptlible	Some resistance	Medium late	High
"Annet"	High	Good	Some resistance	Some resistance	Some resistance	Early	High Medium Low
"Dutch Robjn"	High	Very good	Some resistance	Susceptible	Some resistance	Medium	High Medium
"Roslin Tana"	High	Fair	Some tolerance	-	-	Medium	High Medium
"Roslin Gucha"	Medium	Good	Tolerant	-	-	Medium	High Medium
"Desiree"	Medium	Fairly good	Some tolerance	-	-	Medium	High Medium
"Roslin Ruaka"	High	Good	Some tolerance	-	-	Medium	High Medium

"Cardinal"	Medium	Good	Some tolerance	-	-	Medium	High Medium
"Pimpernel"	Medium	Good	Some tolerance	-	-	Medium	High
"Arka"	High	Good	Tolerant	-	-	Medium	High Medium
"Kerr's Pink"	Medium	Good	Tolerant	-	-	Medium	High Medium

Note:
High eco-zone = 2300m altitude
Medium = 1500-2300m altitude
Low = below 1500m altitude
High yield = 12-15 tons/ha
Medium yield = 8-10 tons/ha
Low yield = 4-6 tons/ha
(Source: Ministry of Agriculture & Rural Development and Japan International Development Agency (2000)).

Adoption of potato varieties (CIP Nairobi)
Total area harvested in hectares (Has) in 2005: 120,842

Variety Name	Estimated area harvested (%)	Trend in area*	Strengths of variety	Weakness of variety	Main uses of variety
"Tigoni"	30	Increasing	High yielding, resistant to late blight, big tubers	Sensitive to bacteria wilt	Market
"Nyayo"	25	Declining	Early maturing, tasty	Sensitive to late blight	Market, home use
"Ngure"	8	Increasing	High price, early maturing, tasty	Sensitive to late blight	Market and home use

"Tana Kimande"	7	Increasing	Big tubers, good price	Low yields, late maturing	Market
"Asante"	6	Increasing	High yielding, resistant to late blight, big tubers	Not good for mashing	Market
"Dutch Robijn"	5	Increasing	Storage long, crisping	Sensitive to late blight	Market/ Crisps
"Kerr's Pink"	3	Declining	High price, early maturing, tasty	Sensitive to late blight	Market, home use
"Desiree"	3	Constant	Storage long, tasty	Sprout very early	Market
"Tigoni Red"	3	Increasing	High yielding, resistant to late blight	Sprout very early	Market
"Komesha"	2	Constant	High yield	Sensitive to bacterial wilt	Market
"Meru Mugaruro"	2	Increasing	High yield, big tubers	Sensitive to late blight and bacterial wilt	Market
"Roslin Tana"	2	Declining	Good for chips	Low yields, sensitive to late blight	Market
Others	4	Increasing	-	-	Home, market

(Source of estimate: CIP)

Husbandry

Adequate control of weeds is required to ensure high yields. In the tropics, manual weeding is generally practised in small-scale production, but herbicides are sometimes used in large-scale production.

Potato responds well to high soil fertility. Manure or compost is needed if the land has been continuously cropped. Well-decomposed animal manure or compost is recommended.
Ridging soon after emergence helps control weeds, prevents greening of developing tubers and prevents spores of late blight fungus from reaching the tubers.

Intercropping
Wide ridges or mounds are required for intercropping. Potatoes can be intercropped with a wide range of annual crops such as sweet potato, maize or even pyrethrum. Potatoes planted in rotation or intercropped with barley, maize, peas, or wheat prevent soil exhaustion. In this case, intercrops are planted at the bottom or at the edge of the furrows and the potatoes in the ridge.

However in order to get full benefit from a potato crop such as high yields, weed suppression and ease of management, without building up high levels of soil borne diseases: it is recommended to grow potatoes in a separate field and rotate the crop with others. Interplanting with a short season legume such as beans can increase total crop yield and help prevent spread of diseases.

Crop rotation
Avoid planting potatoes in the same field for several consecutive seasons. Proper crop rotation enhances soil fertility, increases soil organic matter, conserves soil moisture and helps maintain soil structure. In addition, it avoids build-up of soil-borne pathogens affecting potato, and reduces the level of soil infestation once the soil has been contaminated. Rotations should not include crops that are common hosts for diseases and pests of potatoes (e.g. tomato, eggplant, pepper). Rice, maize and legumes are recommended for crop rotation practices. Planting brassicas such as broccoli, cabbage and mustard plants before the potato crop helps reducing incidence of bacterial wilt and nematodes. Control volunteer potatoes and weeds in the rotation crop.

Harvesting
Time of harvesting of potato varies with cultivar, cultural practices, climate and price. Tubers harvested while

still immature tend to have low dry matter content and to suffer more skin damage, resulting in easier infection by fungal and bacterial pathogens. However, seed potatoes are often harvested early, to avoid virus infection that may occur during the latter part of the growing season. Late blight attack may also be a reason for early harvesting.

The harvesting operation involves destroying the aboveground parts (haulm), lifting and collecting the tubers. A general practice to avoid excess mechanical damage of tubers at harvesting is to cut the tops 10 to 14 days before lifting the potatoes to give them time to develop matured and hardened skins. The haulm is destroyed either by manual or mechanical cutting.

In small-scale farming in the tropics, lifting is done manually using simple implements such as sticks, hoes and spades. Mechanical harvesting is carried out only in large-scale farming areas using various types of potato diggers, for example, ploughs, spinners or elevator diggers. Semi-automatic diggers lift the tubers from the soil for hand-picking or collection. Harvesting should not be done during or immediately after rain.

Yield

In 1996, the average yield of storage potato tubers throughout the world was about 16 tonnes per hectare (t/ha). Average yields (t/ha) for different continents in 1996 were: Asia (14.5), Africa (11.3), North America (39.1), South America (12.6), Europe (16.2) and Oceania (28.8). In many tropical and subtropical regions potential yields are much higher than actual yields due to constraints (environmental, seasonal, propagation, crop protection, economic and social) that prevent the full expression of this potential, but individual farmers in Kenya have reported yields up to 35 t/ha.

Post harvest handling

Harvesting or any other handling to which potato tubers are subjected may cause damage ranging from external injury to internal bruising. After harvesting it is advantageous to allow the tubers to dry in heaps for about 1 to 2 weeks at 10 to 20°C (or in cold store) under high humidity before further handling. During this time the skin hardens, wounds heal, adhering soil dries and disease symptoms become more visible, which facilitates the removal of the infected tubers. Grading should not be started before the curing and hardening

have taken place, otherwise further damage occurs. If the hardening has taken place in the soil before harvesting, grading for sale can be done immediately to avoid greening and sprouting.

Before the tubers go into storage, rotten and infected tubers, which may become sources of post-harvest disease infection, should be removed. Potato tubers are usually delivered into stores in bags, baskets or crates. To facilitate handling, containers should not be too large; if they are large they should not be filled completely. Storage of ware potatoes for the market is associated with undesirable quality changes (mainly sprouting, high sugar content, and weight loss due to evaporation and respiration). For short-term storage (1-2 weeks) in the tropics, ware potatoes may be stored at ambient temperatures in the dark, in well-ventilated buildings. Small-scale farmers can keep potatoes in on-farm storage using inexpensive, well-ventilated constructions.

Storing of seed potatoes

After cold storage, seed potatoes should be pre-sprouted in diffuse light to ensure optimal development of sprouts prior to planting. By storing seed tubers in diffused light at ambient temperatures, excessive sprouting is avoided and seed potatoes can be kept in good physiological condition for a long period of time. If potatoes are stored in bulk without cold storage in the tropics for more than a couple of weeks, they completely loose appeal and will start rotting.

Information on Pests and Weeds

Root-knot nematodes (*Meloidogyne* spp.)

Potatoes are very susceptible to root-knot nematodes. Root-knot nematodes prefer warm temperatures and are likely to become established in potato crops grown in relatively warm areas. Generally, they are not a major problem in cool climate potato production areas, but can become a problem when potatoes are grown intensively or rotated with other susceptible crops. Infested potato plants may show varying degrees of stunting, yellowing of leaves and a tendency to wilt under moisture stress. Roots have swellings or galls.

Affected tubers have blisters or swellings.

On potato tubers, galls may or may not be produced on the tuber surface, depending on cultivars. When galls are produced, they appear as small, raised lumps above giving the skin a rough appearance. Galls may be grouped in a single area or scattered near the tuber eyes. Infestations are difficult to detect in freshly harvested potato tubers.

Symptoms may develop when tubers are stored, particularly when exported to warmer climates where nematode numbers can rapidly increase. Symptoms are most severe when crops are grown on sandy soils and warm climates above 25°C. Nematode attack reduces the quality, size and number of tubers.

Infested potatoes can become more susceptible to bacterial wilt, and symptoms are more severe when plants are also infected with fungal pathogens such as *Verticillium* and *Rhizoctonia*.

Root-knot nematodes are mainly spread in potato tubers and in infested soil. Egg masses may be transported into clean fields via soil adhering to farm machinery. Spread within fields occurs during cultivation and in water, during irrigation or natural drainage.

What to do:

- **Practice proper crop rotation (e.g. potato - brassicas - cereals).**
- **Use mixed cropping or grow marigolds (Tagetes spp.) or sunn hemp (Crotalaria juncea).**
- **Maintain high levels of organic matter in the soil (manure and compost).**
- **Bio-fumigation (incorporating fresh plant mass, especially mustard or radish plants, in large amounts into the soil before planting tomatoes or potatoes) helps against root knot nematodes. Decomposing plant parts release compounds, which kill nematodes. Two weeks after incorporating plant material into the soil a new crop can be planted (phytotoxic effects are usual if the crop is planted before two weeks). For more information on biofumigation click here**

Root-knot nematodes
Root-knot nematodes *Meloidogyne incognita* damage on potato
© DAFF Archives, www.insectimages.org. Courtesy of www.ecoport.org

Aphids (*Myzus persicae*, *Macrosiphum euphorbiae*, *Aulacorthum solani*, *Aphis gossypii*)

Many aphid species attack potatoes. The most important are the green peach aphid (*Myzus persicae*) the potato aphids (*Macrosiphum euphorbiae, Aulacorthum solani*) and the cotton aphid (*Aphis gossypii*).
Aphids are mainly found on young shoots on the underside of leaves. Feeding by aphids causes irregular curling of young potato leaflets and hinders growth of the leaflet. Potato aphids can attack potato sprouts in stores.
Direct damage caused by aphids sucking sap from the plant is usually of little importance. Most damage is caused by honeydew production on foliage and virus transmission.

Aphids are important pests as vectors of potato viruses such as the Potato Leaf Roll Virus, a serious disease affecting potatoes. Seed potatoes are particularly susceptible to this virus and even low aphid populations can be very damaging.

What to do:

- **Conserve natural enemies. They are important in natural control of aphids. (Link to natural enemies datasheet).**

- **Control aphids in potato planted for seed production.**
- **Site seed production areas in locations with low temperature, abundant rainfall and high wind velocity. Aphid populations are generally low under these conditions.**
- **Within a potato growing area, locate seed potato fields upwind from commercial potato fields and alternative host crops to reduce dissemination of viruses through infected aphids.**
- **Keep seed production areas separated from commercial potato production.**
- **Check the field regularly. Monitoring of aphid build-up is important.**
- **Protect young plants from aphid attack. Virus spread early in the season is more serious than later on, as young plants are generally more susceptible. Moreover, plants that are infected early become more efficient sources for further virus spread than plants infected later in the season.**
- **Harvest seed potatoes no later than 8 to 10 days after a critical aphid build-up or increased virus infection rates are noted. This may help to avoid infection since the virus requires time to infect the tubers after a virus-carrying aphid has fed on potato foliage.**
- **Remove yellow flowering weeds and any other host plants within and around the field. Aphids are attracted to yellow colour.**
- **Protect potato tubers during storage by preventing access of aphids. Potato aphids readily colonise tuber sprouts. Seed potatoes are very susceptible to infection at this stage.**
- **Neem products are useful for reducing aphid populations on potatoes. In Sudan, two applications of seed extracts at a rate of one kg seed kernels/40l water at a 14 days interval reduced aphid (A. gossypii) population to 60% compared to the control (Zebitz, 1995).**
- **Extracts of the weed Artemisia vulgaris have also shown toxicity to potato aphids (Metspalu and Hiiesar, 1994).**

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

Cutworms (*Agrotis* spp)

Cutworms are caterpillars of some moths. The caterpillars live in the soil and eat into tubers boring a wide shallow hole. They are also serious pests of newly sprouted potato plants, and can leave great empty patches in a potato field.

What to do:

- **Protect plants by wrapping them with collars. A simple collar can be made from cardboard tubes from paper towels or toilet paper (cut to size). This practice is time consuming, but it is effective and practicable in small fields.**
- **If necessary spray neem extracts. Neem leaf extracts and neem seed extracts (1 kg/40 l water) have been effective against cutworms attacking potatoes reducing damage significantly in Sudan.**

Black cutworm
Black cutworm (*Agrotis ipsilon*). Early instars are about 7 to 12 mm long. Fully grown caterpillars are 3.5 to 5 cm long.
© Ooi P., Courtesy of Ecoport (www.ecoport.org)

The potato tuber moth (*Phthorimaea operculella*)

This moth is the most serious pest of potatoes in the region. It occurs in Africa wherever potatoes are grown, and it also attacks tobacco, eggplants and tomatoes. The moth is small (measuring about one mm at rest and with 12 to 16 mm wingspan), brownish grey in colour with narrow fringed wings. The moths are active mainly at dusk, but occasionally they can be seen flying within potato plants. Female moths lay eggs singly or in small batches on sheltered places of the foliage (leaf and stems) and near the eye buds on exposed tubers through cracks in the soil or in the store.

The caterpillars are up to 12 mm long and whitish to pale greenish in colour. They feed as leafminers between the upper and the lower epidermis and bore into the petiole, or a young shoot or main leaf vein and later into the tuber. When eggs are laid on tubers, caterpillars begin feeding on the tubers immediately upon hatching. They pupate in a silken cocoon covered with soil particles and debris among dead potato leaves, soil litter, eyes of tubers, and storage walls and floors.

Caterpillars burrowing in the tubers cause major damage by making long irregular black tunnels filled with

excreta, where disease-causing microorganisms grow. These tunnels provide an entry point for various plant pathogens and make the potatoes unfit for human consumption. The pest is transferred with the harvested tubers to the potato store, where it can reproduce and infest other tubers. This may lead to total destruction of the stored crop.

What to do:

- **Conserve natural enemies. They are important for natural control of the potato tuber moth. Ladybird beetles prey on eggs and young caterpillars. Larvae of lacewings, big-eyed bugs, ground beetles, earwigs and rove beetles prey on all stages of the pest. Several native parasitic wasps attack this pest. A granulosis virus has also been found infecting caterpillars in the field (diseased caterpillars have a milky white colouration and are sluggish). However, in many cases control is not satisfactory, therefore several parasitic wasps, native from South America, the area of origin of the pest, have been introduced to several countries in Africa. The most important are Copidosoma koehleri and Apanteles subandinus. These wasps have provided effective control of the pests in several countries, particularly in Southern and Eastern Africa**
- **Use healthy, clean seed, since infested seed tubers are the main cause of re-infestation in the field.**
- **Avoid planting in rough soil. Plant as deeply as possible (10 cm deep) and ridge at least three times during the growing season. Experiments in Sudan showed that increasing the sowing depth from 2.5 cm practiced by farmers to 7.6 cm, significantly reduced damage by the cutworms and the potato tuber moth and resulted in an increase of 3.7 t/ha in marketable yield (Siddig, 1987).**
- **Ensure compact hilling. This is very important to prevent moths reaching the tubers to lay eggs. It also makes it difficult for caterpillars to reach the tubers. In addition, emerging moths from infested tubers will not be able to emerge through deep soil.**
- **Provide enough water to prevent soil cracks.**
- **Mulch the plants with rice straw and/or with leaves. Mulching with neem leaves during the last four weeks before harvest significantly reduced insect damage in Sudan. (Ali, 1993).**
- **Intercrop potatoes with hot pepper, onions or peas.**
- **Harvest the crop immediately as it matures, as tubers left in fields for longer periods are highly infested.**

- **At harvesting, ensure that the tubers are not exposed to moths before they are properly protected in the store. All harvested tubers have to be bagged and removed before late afternoon every day.**
- **Destroy all infested potatoes immediately and remove all plant residues from the field. Caterpillars pupate in the tubers and dry stems left in the field.**
- **Destroy all volunteer potato plants before planting new potato crops.**
- **Use alternative pesticides to protect potatoes in store.**
- **Neem can be applied to reduce damage by the potato tuber moth. For instance, in India a four months protection was achieved when harvested potatoes and the covering material were sprayed with five and 10% enriched neem seed extract (Saxena, 1995). In Sudan spraying neem seed and leaf extracts (1 kg/40 l water) and then placing tubers in jute sacks reduced post harvest losses by the potato tuber moth compared with traditional methods such as leaving the tuber unprotected or covering them with banana leaves only (Siddig, 1987). A neem seed extract was also effective for control of the potato tuber moth on potatoes in a store in Egypt (Salem, 1991) . Storage loss after 6 months in potatoes treated with 100ppm neem oil was 25% (compared to 10% with the insecticide carbaryl). Adults from larvae treated with neem oil were deformed. Work in Yemen confirmed the beneficial effect of neem; neem oil and sunflower oil halted the development of caterpillars of the potato tuber moth in storage. However, caution is needed since the oil seemed to interfere with potato respiration, leaving the potatoes very soft with dark tissue (Kroschel, 1995).**
- **A Bt (Bacillus thuringiensis) preparation in powder form mixed with fine sand (1:25) dusted was very effective in controlling this pest in the store in Yemen and Kenya (Kroschel, 1995). Tuber infestation was also reduced by bedding the potatoes in the leaves of the Peruvian pepper tree (Schinus molle), also known as mpilipili in Swahili, and Eucalyptus sp. (Kroschel, 1995).**
- **Storing potatoes in layers with branches of lantana is recommended by KIOF in areas where this pest is present Lantana is reported to repel tuber moths.**
- **Application of plenty of wood ash or diatomite earth may also prevent rapid build up of tuber moth.**

Potato tuber moth
Potato tuber moth adult (*Phthorimaea operculella*) is about 12-16mm long.
© J. Kroschel, CIP


Potato tub…


Potato tub…


Potato tub…


Parasi …

Epilachna beetles (*Epilachna* spp.)

Several species of Epilachna beetles feed on the leaf tissue in between the veins leaving a network of veins intact. The adult beetles are oval, about 6 mm in length and reddish brown to brownish yellow in colour with black spots on their backs. They look very similar to the beneficial ladybird beetles (predators), but the body of this pest ladybird beetle is covered with short, light coloured hairs, which give them a non-glossy or matt appearance.

They lay eggs in clusters (20 to 50 eggs), usually on the underside of the leaves and placed vertically. The larvae (grubs) are pale yellow and easily recognisable by the strong branched spines covering their body. Generally, these beetles are minor pests of potatoes, but occasionally the infestation is so severe that control measures are needed.

What to do:

- **Handpick and destroy adults and larvae of Epilachna beetles. This is feasible in small plots.**

- **Spray neem extracts. Simple neem-based pesticides have been reported to control Epilachna beetles on several crops. Thus, sprays with an aqueous neem seed extract (10g/l) at 10 days intervals showed repellent effect on these beetles in India. In Togo, feeding by Epilachna beetles in squash and cucumber could be reduced significantly by weekly applications 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 (Ostermann and Dreyer, 1995).**

Epilachna beetle
Epilachna beetle (*Epilachna* spp.) and damage caused on water melon
© A. M. Varela, icipe

Millipedes or "thousand-legged worms"

Millipedes are not insects, but are related to them. They have many legs (30 to 400) with a hard-shelled, round segmented body. They are brown to blackish brown in colour. They move slowly and curl up when disturbed. Millipedes lay eggs singly or in clusters of 20 to 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. They tunnel into potato tubers.

What to do:

- **Clear hiding places. Remove volunteer plants, crop residues, decaying vegetation, dead leaves, grass,**

compost piles, excess mulch or other similar debris. Litter under trees, abandoned termite hills, and neglected home nurseries can also harbour large populations of millipedes.

- **Eliminate wet areas**
- **Trap millipedes. They like hiding during daytime. therefore they can be attracted by placing flat objects (such as pieces of plywood) on the ground collecting them subsequently.**

Millipedes
Potato tubers damaged by millipedes.
© A. M. Varela, icipe

Weeds

The major weeds in potato crops are annuals. Weeds can reduce yields through direct competition for light, moisture and nutrients. They may harbour pests and diseases that attack potatoes. Early season competition of weeds is very critical. When properly grown, the crop normally covers the ground and smothers any weed competition. Weeds present at harvest increase mechanical damage to the tubers, and reduce harvesting efficiency by slowing down harvesting operations and leaving undug tubers in the ground. The most important weed in potatoes worldwide is pigweed or fat hen (*Chenopodium album*).

What to do:

- **Practice crop rotation. Rotation of two or three years is an important strategy to control perennial weeds.**

Weeds tend to thrive with crops of similar growth requirements as their own and may benefit from practices directed to the crop. When diverse crops are used in a rotation, weed germination and growth cycles are disrupted by variation in cultural practices associated with each crop.

- **Control weeds early in the season. It is important to stop broadleaved weeds or annual grasses from appearing above the crop and competing strongly for nutrients and moisture when tubers are enlarging.**

Pigweed
Pigweed (*Chenopodium album*)
© Photography courtesy of Western Weeds CD-ROM. Web version by R. Randall. www.ecoport.org

---

Information on Diseases

Bacterial wilt (*Ralstonia solanacearum*)

Bacterial wilt can be very destructive at the lower altitude, warmer extreme of the potato's range in Kenya. This disease causes rapid wilting and death of the entire plant without any yellowing or spotting of leaves. All branches wilt at about the same time. The pathogen is transmitted through tuber seed into the soil. Also infested soil can be important source of disease inoculum (infection).

What to do:

- **Use clean certified disease-free seed.**
- **Plant resistant varieties where available.**

- **Remove wilted plants to reduce spread of the disease from plant to plant.**
- **Bio-fumigation (incorporating especially mustard or radish plants in large amounts into the soil immediately before planting tomatoes or potatoes) helps in reducing and the long-term elimination of bacterial diseases from the soil. This practice is reported to reduce incidence of bacterial wilt by 50 to 70% in the Philippines (ACIAR 2005/6). For more information on biofumigation click here**
- **Do not grow crops belonging to the same family as potatoes (e.g. tomatoes; peppers; or eggplant) in succession in the same land. Rotation is not effective against bacterial wilt because the pathogen can survive for several years in the soil and also can infect a wide range of crops and weeds. However, the disease incidence can be reduced if crop rotation with non-susceptible crops is combined with the other above-mentioned control components.**

Bacterial wilt
Bacterial wilt of potato tuber
© Courtesy of EcoPort, www.ecoport.org


Bacter … Bacter …

Bacterial soft rot (*Erwinia carotovora* pv. *carotovora* / *E.c.* pv. *atroseptica*)

The bacteria enters through wounds and cause extensive rotting of potatoes due to degradation of tuber cell

walls, often reducing tubers to a smelly pulp. They may also be carried over on tubers, and shoots (stems) emerging from infected tubers. These are blackened and commonly referred as blackleg, and the affected stems subsequently die.

What to do:

- **Use resistant varieties where available. This constitutes the best management strategy.**
- **Use healthy seed tubers and avoid injury to the tubers.**
- **Avoid excess watering.**
- **Store and transport tubers in dry, well ventilated conditions.**
- **Practice field hygiene.**

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

Late blight (*Phytophthora infestans*)

This disease is favoured by cool, cloudy, wet conditions. Symptoms of late blight are irregular, greenish-black, water soaked patches, which appear on the leaves. The spots soon turn brown and many of the affected leaves wither, yet frequently remain attached to the stem.

What to do:

- **Plant resistant varieties where available. In Kenya, varieties "Tigoni", "Kenya Baraka", "Roslin Eburu", "Annet" and "Asante" are claimed to have some resistance to late blight.**
- **Practice rotation with non-solanaceaous crops (do not rotate with tomatoes and eggplants).**
- **Practice good field hygiene. Pull up and discard infected plants.**
- **Select only, certified, disease-free seed potatoes and never plant table-stock potatoes**
- **Keep foliage dry; avoid overhead irrigation.**
- **Plant potatoes in sunny, well-drained locations.**
- **KARI has also conducted studies to evaluate lower cost measures used by farmers to control Late blight, including the application of a mixture made of stinging nettle (possibly Urtica massaica, though not indicated) and Omo (presumably the commercial brand of laundry detergent). Although this treatment was not as effective as a commercial fungicide, Ridomil, blight scores were nevertheless lower and yields higher than observed for the control. On a benefit to cost basis, the stinging nettle treatment was impressive, at over two to one (KARI 2000, p. 83). This treatment is apparently not a common practice in Kenya, at least not yet, but an example of using stinging nettle (Urticaria dioica) as a treatment against late blight in Sweden is reported in Ecology and Society.**

Late blight
Symptoms of late blight (*Phytophthora infestans*) on potato stem.


Late bligh..


Late bligh..


Late bligh..

Early blight (*Alternaria solani*)

Leaf spots of early blight are circular, up to 12 mm in diameter, brown, and often show a circular pattern.

On the potato tuber early blight results in surface lesions that appear a little darker than adjacent healthy skin. Lesions are usually slightly sunken, circular or irregular, brown and vary in size up to 1-2 cm in diameter. There is usually a well defined and sometimes slightly raised margin between healthy and diseased tissue. Internally, the tissue shows a brown to black corky, dry rot, usually not more than 6 mm. Deep cracks may form in older lesions.

Early blight thrives best under warm wet conditions.

What to do:

- **Use certified disease-free seeds**
- **When using own seeds, hot water treat the seeds. For more information on hot water treatment click here**
- **Practice rotation with non-solanaceaous crops.**
- **Practice good field hygiene. Remove infected leaves during the growing season discard all badly infected potato plant debris at the end of each season.**
- **Avoid overhead irrigation and lay down a thick organic mulch to prevent soil splashing onto lower leaves.**

Early blight on potato tubers
Early blight results in surface lesions that appear a little darker than adjacent healthy skin. Lesions are usually slightly sunken, circular or irregular, and vary in size up to 2 cm in diameter. There is usually a well defined and sometimes slightly raised margin between healthy and diseased tissue. Internally, the tissue shows a brown to black corky, dry rot, usually not more than 6 mm. Deep cracks may form in older lesions.

Fungal diseases and Scab

Black scurf (*Rhizoctonia solani*), powdery scab (*Spongospora subterranea*) and common scab caused by the bacterium (*Streptomyces scabies*).

These diseases may cause similar symptoms. Black scurf and scab cause skin blemishes (russeting; rough corky tissue) on tubers.

These lesions may be so numerous as to involve the entire surface of affected tubers. Such lesions spoil the appearance of the tubers and cause waste in peeling and reduction in grade. These fungi live in the soil and survive in infected tubers. In most cases infection occurs whilst the tubers are still in the ground.

What to do:

- **Practice crop rotation.**

- **In case of scab use healthy certified seed tubers.**
- **Disinfect seed tubers from infected field through heat-treatment (10 min in water at 55°C). The same treatment of naturally or artificially contaminated seed tubers gave complete absence of blackleg infection in the field and decreased the amounts of powdery scab (Spongospora subterranea) and black scurf (Rhizoctonia solani) on progeny tubers. For more information on heat treatment click here**
- **Avoid excessive liming and continuous cropping with potatoes.**
- **Maintain soil pH at about 4.8 if continuous cropping cannot be avoided.**

Scab
Scab symptoms (here on citrus leaf)
© www.ecoport.org

Viral diseases

Viral diseases of importance include:

- **Potato Leaf Roll Virus (PLRV)**
- **Potato X Potexvirus (PVX)**
- **Potato Virus Y Potyvirus (PVY)**
- **Potato Spindle Tuber Viroid (PSTVd)**

Under field conditions, there is often a composite infection with the three viruses (PLRV; PVX; PVY) and it becomes very difficult to distinguish the three on the basis of symptoms.
These viruses are transmitted by aphids. PVX causes distinct leaf mottling and crinkling. PVY causes dwarfing of plants, with a rough, mosaic appearance to the leaves and affected plants give a poor crop of small tubers. PVY is also tuber-borne. Potatoes infected with PLRV show an upward and inward rolling of leaflet margins and plants are dwarfed. Affected leaflets become thick and dry, and the lower leaves may become completely brown. Infected plants produce tubers smaller in size and numbers. PLRV also infects other solanaceous crops and weeds (e.g. tomato, tobacco, jimson weed).

What to do:

- **Use virus-free seed tubers.**
- **Plant resistant varieties where available. In Kenya, the following potato varieties are claimed to possess some resistance to viral diseases: "Kenya Baraka", "Roslin Eburu", "Feldelslohn", "Annet" and "Dutch Robjn".**
- **Uproot infected plants plants to reduce the incidence of infection and spread of the disease within a field. For maximum effectiveness remove the diseased plant, the three plants on each side of the diseased plant in the same row, and the three closest plants in adjacent rows. This is most important in seed fields.**
- **Control insect vectors. This may reduce virus spread.**
- **Control of insect vectors may reduce virus spread.**
- **Do not overlap potato crops.**
- **Practice good field sanitation.**
- **Control nightshades and volunteer potatoes because these plants are reservoirs for viruses**

Potato Spindle Tuber Viroid (PSTVd)

It is particularly destructive for seed production. Potato plants severely infected are upright, stunted and much thinner than normal plants. Leaves of infected plants are smaller and may be grey or distorted. The affected stems are often more branched and branches are at very sharp angles to the stem. Symptoms are more obvious on tubers. Affected tubers are small, narrow and spindle shaped (oblong).
In some varieties tubers develop knobs and swellings. In other varieties eyes on tubers are numerous, shallow and more prominent, and affected tubers are often cracked. This viroid is easily mechanically transmitted. An infection can be introduced by sowing infected seed tubers, by insects such as aphids, grasshoppers and flea beetles, and through pollen. Tomato and capsicum are additional hosts for PSTVd.

What to do:

- **Plant certified disease-free seed tubers.**
- **Plant whole seed tubers instead of cut pieces.**
- **Remove infected plants from the field.**

Fresh Quality Specifications for the Market in Kenya

The following specifications constitute raw material purchasing requirements

PRODUCE:	Red and White Potato
IMAGE:	
VARIETY:	Various
General appearance criteria	
COLOUR:	Reddish purple skin; rich golden yellow flesh. (Red)Creamy to pale tan skin; creamy to pale yellow flesh. Creamy to white skin and flesh.(White)
VISUAL APPEARANCE:	Shallow eyes; clean skin; free from foreign matter.
SENSORY:	Firm when tested with finger pressure, not soft or spongy; no 'off' or foreign odours or tastes.
SHAPE:	Uniform oval to slightly flatten; Nil with deformed shape. Approximately oval to long oval. Approximately round to oval.
SIZE:	Weight range grading : **Small ; 60 - 110 g Medium: 111 – 350g; Large ≥ 350g**
INSECTS AND PHYSICAL DAMAGE:	With no obvious live insects (e.g. potato moth, potato wireworm) With no evidence of insect, rodent, or nematode damage. With no cuts or [illegible] Constricted tubers, or tubers with advanced sprouting, growth With no green areas of the skin or an overall green tinge (exposed to light toxic compounds may form) With no evidence of bacterial wilt (when cut and squeezed milky ring appears around potato edge) or black/brown [illegible]

© S. Kahumbu, Kenya

Information Source Links

- Acland, J.D. (1980). East African Crops. FAO / Longman. ISBN: 0 582 60301 3
- Ali, M.A (1993). Effects of cultural practices on reducing field infestation of potato tuber moth (*Phthorimaea operculella*) and greening of tubers in Sudan. Journal of Agricultural Science, 121(2): 187-192; 19 ref.
- Berg, G. (2006). Agriculture notes. Root-knot nematode on potatoes. AG0574. ISSN 1329-8062. State of Victoria, Department of Primary Industries.
- Bohlen, E. (1973). Crop pests in Tanzania and their control. Federal Agency for Economic Cooperation (bfe). Verlag Paul Parey. ISBN: 3-489-64826-9.
- CAB International (2005). Crop Protection Compendium, 2005 edition. Wallingford, UK www.cabi.org
- CIP Nairobi (2005). Estimates of Currently grown potato cultivars.

- **Centipedes and millipedes. Later's Pest Info Bulletin. www.laters.com**
- **Department for Environment, Food and Rural Affairs (DEFRA) (2002). *Meloidogyne chitwoodi* (the Columbia root-knot nematode) and *Meloidogyne fallax* www.defra.gov.uk**
- **Godfrey,L. D., Davis, U.C., Haviland, D. R.(2003). UC Pest Management Guidelines. How to Manage Pests. Potato Aphids, green peach aphid (*Myzus persicae*), potato aphid (*Macrosiphum euphorbiae*)]. UC IPM Pest Management Guidelines: Potato. UC ANR Publication 3463. Insects. UC Cooperative Extension, Kern Co. (Reviewed 6/03, updated 6/03). Statewide IPM Program, Agriculture and Natural Resources, University of California.**
- **Karren, J. B. Millipedes. Fact sheet No. 21. Revised April 2000. extension.usu.edu**
- **Kfir, R. (2003). Biological control of the potato tuber moth *Phthorimaea operculella* in Africa. In: Neuenschwander, P. - Biological Control in IPM Systems in Africa.**
- **Kroschel, J. (1995). Integrated pest management in potato production in the Republic of Yemen- with special reference to the integrated biological control of the potato tuber moth (*Phthorimaea operculella* Zeller). Tropical Agriculture 8.GTZ. Margraf Verlag. ISBN: 3-8236-1242-5.**
- **Ministry of Agriculture and Rural Development (Kenya) & Japan International Cooperation Agency (2000). Local and Export Vegetables Growing Manual. Reprinted by Agricultural Information Resource Centre, Nairobi, Kenya. 274 pp.**
- **Oisat. Organisation for Non-Chemical Pest Management in the Tropics. www.oisat.org**
- **Ostermann, H. and Dreyer, M. (1995). Neem Products for Pest management. Vegetables and grain legumes. In: The Neem tree *Azadirachta indica* A. Juss. and other meliaceous plants sources of unique natural products for integrated pest management, industry and other purposes? Edited by H. Schmutterer in collaboration with K. R. S. Ascher, M. B. Isman, M. Jacobson, C. M. Ketkar, W. Kraus, H. Rembolt, and R.C. Saxena. VCH. pp. 392-403. ISBN: 3-527-30054-6.**
- **Potatoes. Kenya Overview research.cip.cgiar.org**
- **Saxena, R. C. (1995). Neem Products for Pest management. Pest of stored products. In: The Neem tree *Azadirachta indica* A. Juss. and other meliaceous plants sources of unique natural products for integrated pest management**
- **Zebitz, C. P. W. (1995). Neem Products for Pest management. Root and Tuber Crops. In "The Neem tree *Azadirachta indica* A. Juss. and other meliaceous plants sources of unique natural products for integrated**

pest management, industry and other purposes". (1995). Edited by H. Schmutterer in collaboration with K. R. S. Ascher, M. B. Isman, M. Jacobson, C. M. Ketkar, W. Kraus, H. Rembolt, and R.C. Saxena. VCH. pp. 403-407. ISBN: 3-527-30054-6.

- **Zitter, T.A., Gallenberg, D.J. (2002). Virus and viroid diseases of potato. Department of Plant Pathology, Cornell University. www.vegetablemdonline.ppath.cornell.edu**
- **International Year of the potato www.potato2008.org**

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Coffee

Coffee
Scientific name: *Coffea* spp. (*C. arabica* / *C. canephora*)
Family: Gentianales: Rubiaceae
Pests and Diseases: Antestia bugs Armillaria root rot Bacterial blight of coffee Capsid bug Coffee berry borer Coffee berry disease Coffee berry moth Coffee leaf rust Coffee wilt Cutworms Damping-off diseases Fruit flies Fusarium bark disease Fusarium root disease Giant looper Lace bug Leaf skeletonizer Leafmining caterpillars Mealybugs Root mealybug Root-knot nematodes Snails (Giant East African Snail) Soft green scale Spider mites Star scale Termites Thrips White coffee borer Cutworms, Anthracnose, Fruit flies, Stemborers, Botrytis warty disease

General Information and Agronomic Aspects

Coffee is one of the most important cash crops in Kenya. It is grown in large-scale plantations (42,000 ha from 2001-2005) as well as by small-scale holders (128,000 ha from 2001-2005) giving a total production of about 50,000 tons annually. The main variety in Kenya is Arabica coffee.

Geographical Distribution of Coffee in Africa

The stimulating effect of the coffee beverage is largely derived from the alkaloid caffeine, but cured beans have to be roasted and finely ground to bring out the characteristic coffee aroma. In some producer countries, roasting of locally available coffee in the home is very common and the brew is prepared by pouring hot water over freshly roasted and ground coffee beans.

An important constituent of the coffee bean is caffeine. The free caffeine content in a bean is dependant on the coffee type, variety, the site conditions and other factors, and can be more than 2.5%.

Economically, the most important coffee varieties are *Coffea arabica* called "Arabica" and *Coffea canephora* called "Robusta". The latter yields about 30% more than ? Arabica?, albeit its price is around 30% lower.

Coffee is mainly grown as a beverage, though the plant residues can provide fuel (coffee charcoal or wood) and a good mulch.
Until now, organic cultivation has been of less importance in such regions as Ethiopia, Kenya and Mozambique. It is mostly organic "Arabica" that is being cultivated. "Robusta" is currently barely available in certified organic quality.

Climate conditions, soil and water management

The ideal temperature range for Arabica coffee plants lies between 18 and 24º C. Maximum day temperatures should not exceed 30ºC and night temperatures should not fall below 15°C. At higher temperatures, bud formation and growth are stimulated. Low temperature or wide daily temperature variation may result in distortion, yellowing and cracking of the leaves and tip growth, a condition known as "Hot and Cold" or crinkle heat. Arabica coffee is normally grown at altitudes from 1400 to 2000 m (4,500-6,800 ft) with a rainfall of not less than 1000 mm per year. Where coffee is grown under conditions of minimum rainfall, mulching is

essential to conserve moisture.

Robusta coffee is more resistant to pest infestation and is well adapted to warm and humid equatorial climates with average temperatures of 22-26°C, minimum not below 10°C at altitudes of 100-800 m, and well-distributed annual rainfall of 2000 mm or more. The ideal amount of rainfall lies between 1500 and 1900 mm. Coffee plants react positively to a drought period, which should nevertheless not be longer than 3 months. The rainfall should be evenly spread throughout the rest of the year. Irregular rainfall causes uneven blossoms and fruit maturity. Coffee is a half-shade plant, which can only utilise around 1% of the sunlight for photosynthesis. At leaf temperatures over 34º C, assimilation is practically zero, meaning that the rate of photosynthesis of a shaded plant is actually higher than that of a plant fully exposed to the sun.

As a rule: Grow iln lower regions Robusta and in higher regions Arabica. The borderline is variable, and lies around 1400 m in Kenya. The berry borer and coffee rust are important indicators as to whether the coffee variety is suited to the site conditions. For example, an Arabica plantation at 1200 m, which is heavily infested by coffee rust and berry borer, despite sufficient shade, is an indication that the variety is ill-suited to the site, and should, in time, be replaced with Robusta.

Coffee plants prefer well-drained and airy soils. They need free drainage to a depth of at least 1.5 m and 3 m in drier areas. Humus-rich, lightly acidic soils (pH range 4.4-5.4) are beneficial; the best conditions are those to be found on virgin soils of volcanic origin. The topsoil should contain at least 2% humus.

Propagation and planting

Variety	Altitude	Spacing Density	Attributes
'Ruiru	All coffee growing areas	2 x 2 m	• Resistant to coffee berry disease

Il'		**(6 x 6 ft)** **2500 trees/ha**	**and leaf rust** • **Early maturing (18-24 months)** • **Cost effective - reduces costs by 30%** • **High yielding, high quality**
'SL 34'	**High altitude with good rainfall**	**2.75 x 2.75 m (9 x 9 ft)** **1330 trees/ha**	• **High yielding** • **High quality**
'Sl 28'	**Medium to high altitude coffee zones without serious leaf rust**	**2.75 x 2.75 m (9 x 9 ft)** **1330 trees/ha**	• **High yielding** • **High quality**
'K7'	**Low altitude**	**2.75 x 2.75 m (9 x 9 ft)**	• **Tolerant to coffee leaf rust** • **Tolerant to drought** • **High yielding** • **High quality**

Vegetative propagation can be done by rooting of cuttings, grafting, top-working and micropropagation (tissue culture). Major considerations for vegetative propagation are:

- **Choice of mother trees. These trees are derived from seedlings that have undergone a pre-selection test for coffee berry disease and coffee leaf rust resistance.**
- **Establishment of a clonal garden. The selected mother trees are established in the field as per the**

recommended spacing of 1m x 1m. After 12-18 months, the primary branches are removed and the stems bent and pegged down in a horizontal position to encourage growth of orthotropic (vertical) shoots.

- **Construction of a propagator:**
  - **The propagators whose width measures 0.75 m (2.5 ft) are constructed on a 60 cm foundation with a wall that rises another 50 cm above the ground.**
  - **To achieve good drainage, the first 15 cm from the ground level are filled with gravel covered by a layer of sand of about 7.5 cm. Finally a 15 cm rooting medium is placed on top of the sand. Recommended rooting media is either of the following: a) sawdust from cypress trees, b) Pure river sand or c) Sub-soil, all free from any contamination.**
  - **The propagator should be provided with a watering system (mini sprinklers) with emitters at 150 cm spacing.**
  - **To regulate relative humidity, the propagators are covered with clear polythene sheeting, gauge 1000 suspended 1 m above the rooting medium on steel or wooden frames. Shade is normally erected about 2.75 m (9ft) from the ground. The recommended materials for shade are sisal/bamboo poles, shadenet (75% shade) or interwoven nets.**
- **Propagation of rooted cuttings:**
  - **Suckers are harvested from the mother trees when they are 6 months old and bearing 6 internodes. Harvesting is done early in the morning when the atmospheric relative humidity is high.**
  - **Single node cuttings are prepared by making a cut at an angle below the node but retaining the pair of leaves.**
  - **The cuttings are planted in propagators at a depth of 2-4 cm and a spacing of 4 cm x 4 cm. Callus formation begins 3 weeks after planting and is complete in 5-6 weeks. (callus formation is the healing of the cut edge of the cutting in the rooting media)**
  - **Root development follows after 8-10 weeks**
  - **The rooted cuttings are transplanted at 12-14 weeks into black polybags measuring 12.5 x 22.5 cm (5x9 in), 200 gauge filled with rich composite soil mixture consisting of top soil, river sand and well rotted manure at a ratio of 3:2:1 respectively, all free from any contamination. For organic propagation rock phosphate is added and if insects normally pose a problem, try incorporate chopped leaves of *Lantana***

camara **or Mexican marigold.**

- **The potted seedlings are returned to the propagators for a period of 1-2 months to develop more foliage and feeder roots under the same environmental conditions.**
- **The planting materials are then taken care of as per the nursery recommendations.**

- **Grafting: This is the successful healing of the union between the scion and the rootstock. Grafting requires 10-12 month old seedlings (or pencil thick) to be used as rootstock. Rootstocks of the commercially existing Arabica varieties are compatible with 'Ruiru II'. The graft union is tied with a polythene tape and the entire seedling is placed in a propagator to heal.**
- **Topworking: This is a cheaper method of converting mature old trees of traditional Arabica coffee into 'Ruiru II' without uprooting and replanting. Sucker growth is induced on the trees to be converted by side pruning. Six month old healthy suckers are selected and grafted with single node scions of 'Ruiru II' bearing a pair of leaves. The graft union is tied with polythene tape to keep the scion in place. Advantages of Topworking:**
  - **A farm can be converted from the traditional cultivars ('SL 28', 'SL 34' or 'K7') to 'Ruiru II' without interfering with normal cropping pattern.**
  - **The farmer saves on cost of uprooting old bushes and establishment costs.**
  - **The well-established root system of old stumps prevents lodging, which may occur when young Ruiru II trees carry a heavy crop.**

Coffee Nursery Management

Most cultivars of the self-pollinating Arabica coffee are practically pure lines, propagated by seed. In Kenya, F1 hybrid seeds are produced by hand-pollination of new disease-resistant Arabica cultivars, and certified seed can be obtained from the Coffee Research Foundation in Ruiru.

- **The nursery site should be selected on level to gently sloping ground. On sloping ground of 4-5 % it should be bench terraced, sheltered from strong winds, near a permanent reliable water source, accessible and free from weeds.**
- **The bed construction should be 1m (3 ft) wide with a shade 60 cm (2 ft) above the bed.**
- **Plant only certified disease free seed from the Coffee Research Foundation (CRF). Sow immediately after**

collection to avoid loss of viability in order to ensure high germination rate. Remove the husks to reduce germination period. 1 kg seed contains an average of 3,000 seeds.

- **Germinate in river sand beds of 5-7 cm (2-3 in) depth with a spacing of 2.5x2.5 cm (1 in) and 1 cm (1/2 in) deep. Apply a thin mulch cover. Shade 60 cm above the bed. Water adequately (avoid waterlogging).**
- **Remove mulch when seeds have germinated.**
- **Seedlings emerge after 4 weeks and take another 4 weeks before they are transplanted to polybags**
- **Transplant pre-germs at the leaf stage into polybags. Avoid deep planting. This ensures minimal disturbance to roots during transplanting, and makes long distance transportation more convenient. Also field establishment can wait till the weather is favourable.**
- **Renew seed bed and river sand every time new seeds are being planted**
- **Potting mixture: Top soil: 3, sand: 2, well rotted manure or compost: 1. To this mixture add Phosphorous, for organic farming a handful of rock phosphate to about 6 "debes" (debe = 20 litre bucket) of mixture as well as neem cake or chopped up leaves of Mexican marigold or *Lantana camara* for insect control.**
- **Water seedlings at least twice a week and control weeds by hand weeding. Control diseases (Damping off, leaf rust and Brown eye spot) using 0.5 % Copper solution, and control insect pests when noticed.**
- **Shading. Put a shed at 120 cm (4 ft) above the polybed, and provide dense shade initially. Harden the seedlings by gradually reducing the shade. Reduce the shade by half when the seedlings are 8-9 months old and completely one month before transplanting.**

Land preparation

Land cleared of trees within 6 months should not be used for coffee because of the risk of *Armillaria* , a fungal disease which causes root rot.

Clear land well in advance, digging out all stumps, bushes and grasses such as kikuyu grass and couch grass. If the land has steep slopes, make terraces or other conservation structures. Protect bench terraces by planting grasses e.g. *Paspulum notatum* on the bench faces. Planting holes should be dug 3 months before the onset of rains to allow weathering.

Fill the holes 4 weeks before planting with a top soil mixed with 1 "debe" (20 litre bucket) farmyard manure or well rotted coffee pulp plus 200 g rock phosphate. If the soil is acidic add 100 g dolomitic limestone (CaCO3

MgCO3).

Planting

Dig holes of size 60cm x 60cm x 60 cm at a spacing of 2.75m x 2.75m for the traditional varieties (SL28, SL34 and K7). A closer spacing of 2m x 1 m on flat land for small holders without spray roads is recommended. Spacing for Ruiru II hybrid is 2x2 m or 2x1 m giving a population density of 2,500 - 3,300 trees/ha for small holders. Transplant potted seedlings when they are about 30-40 cm high with maturing bark about 15 cm (6in) and 2-3 pairs of lateral branches at about 12-15 months old.

Mulching

Mulching has several benefits to coffee e.g. conservation of moisture during dry spells, suppression of weed growth, nutrient supply, improvement of soil structure and water infiltration, checking of soil erosion and top soil temperature as well as reduction of thrips incidence. Mulching also enhances root development in the fertile top soil and thus a general yield increase. Examples of mulching material include napier grass (half an acre of napier grass gives enough mulch for 1 ha (2.5 acres) of coffee land), sisal waste, coffee prunings, maize ans banana trash etc. When using coffee prunings, take care that no pests (leafminers, mealybugs, etc.) are on the prunings otherwise they could reinfest the trees.

Shade trees and windbreaks

Plant shade trees one year before coffee transplanting is required. Common shade trees are leucaena (*Leucaena leucocephala*) and mother of cocoa (*Gliricidia sepium*)). Also *Grevillea robusta, Albizia* spp and *Cordia abyssinica* are recommended shade trees. (See also below under Diversification Strategies). With intensive cultivation and optimum inputs, higher yields are obtained with unshaded coffee, but shade will prevent overbearing and shoot dieback under lower standards of crop management or suboptimal ecological conditions.

Husbandry

Coffee grows best with shade trees. Shade trees reduce stress in coffee. Avoid extracting timber at random for short-term gains. Maintain a two-layer canopy consisting of temporary and permanent shade trees like coconut, Ficus species, Albizzia species, jackfruit, and citrus, etc. At higher altitudes temporary shade trees may be phased out once the coffee is well-established. Regulate shade every year instead of once in 3-4 years to minimize damage to coffee bushes. Shade tree selection and management are important because better shade may decrease the incidence of some important pests and diseases. Suppressing of weeds, particularly East African couch grass (*Digitaria scalarum*) and Kikuyu grass, by careful tillage (not damaging the superficial feeder roots of the coffee), mulching and/or leguminous cover crops, is very important.

Fertilizer requirements depend on crop level and nutrient status of the soil. Nutrients removed by harvesting 6 t of fruits of Robusta coffee, equivalent to 1 t of green beans, are: 35 kg N, 6 kg P2O5, 50 kg K2O, 4 kg CaO, 4 kg MgO, 0.3 kg Fe2O3 and 0.02 kg Mn3O4. Return coffee pulps and hulls as organic fertilizer in coffee fields. These are rich in nutrients. A 60 kg bag of coffee pulps/hulls contains: 1 kg N; 0.60 kg P; .09 kg K and other trace elements.
Mulching using dried banana leaves and cut dried grass conserves soil moisture, protects soil from compaction, and reduces soil acidity.

Pruning

Pruning is essential in coffee production: (a) to determine the shape of the tree, (b) to maximize the amount of new wood for the next season's crop, (c) to maintain a correct balance between leaf area and crop, and (d) to prevent over-bearing and thus reduce biennial production or death of trees. Unpruned coffee usually produces a heavy crop one year and a lighter crop the next season. Pruning makes trees more manageable and easier to pick and spray. Diseases and insect pests can also do more damage in unpruned coffee, as they tend to build up in the older branches. Advantages include:

- **Suitable crop : leaf ratio**

- **Uniform yearly cropping**
- **Good light and air penetration and circulation for better fruiting and bringing vigour to the tree.**

When to prune: Immediately after main crop harvesting. Sick-looking trees due to die back to be pruned only after new growth. Trees attacked by star scales to be pruned after the main crop to avoid carrying the scales to other trees.

Multiple Stem Pruning: The tree normally has 3 stems and the crop is borne on laterals. Each lateral bears two crops and is then pruned. The crop is therefore borne higher up the tree each year. Every 4-6 years a new cycle is started. This is done by selecting 3 new suckers, which will replace the original stems. In multiple stem pruning, 4 basic operations are carried out: 1. Main pruning: Regulating the number and spacing of primary branches.
2. Secondary pruning: Also known as "handling", involves regulating number and spacing of secondary branches.
3. Sucker control: Removal of unwanted growing shoots called "suckers" (remove them with the meristem, otherwise you multiply suckers)
4. Change of cycle: Selection of some "suckers" to grow into new bearing stems.

How to prune: Please discuss with a CRF (Coffee Research Foundation) field officer or read CRF Technical Circular No 301: Canopy Management in Coffee, as the recommendations differ from different ecological zones.

Diversification strategies

1) Crops of the upperstorey (shade)
They create large amounts of organic material and humus and at the same time protect the coffee plants against too much sun. The alternation in yield can be reduced, and the life-time of the plantation increased.

Shade also has an immense influence on the quality of the coffee, but it also reduces the yield (fewer coffee plants per surface unit). Shading trees also reduce weeds: When an optimum density of coffee and shading trees is reached, tilling weeds is hardly necessary anymore. Shading trees protect against soil erosion and improve the micro-climate on the plantation. By choosing the correct varieties and cultivation method for the shading trees, the micro-climate can be influenced at any point in time. This is very important to regulate pests. Fruit trees offer a diversification for the farmer's diet and economic base. Precious woods can provide a long-term increase in value of the site: along with other varieties, they can provide wood for construction and fuel. Shading trees also create more pleasant working temperatures on the plantation.
No figures can be offered for the optimum shade density, as this depends on the local site conditions and the state of the plantation. A rule of thumb says that the shade should be around 50%. The higher in altitude the coffee plot lies, the less the distances should be between the coffee bushes and start of the shading roof. At the upper growth limits for coffee plants, the shading plants are therefore at around the same height as them. Care should be taken to trim the shading plants synchronously to the coffee blossoming (6-8 weeks before the blossom). Blossom formation can thereby be assisted and synchronised.

2) Crops of the middle storey
As with the shading plants, the variation of varieties used for the middle crop should be adapted to the local site conditions. They can be chosen according to the need for fruits and additional products for each individual plantation. Bananas should, if possible, always be integrated as an additional crop. They are well suited to providing temporary shade, and for 'drying out' of the wetter parts of a plantation. Their ability to mobilise potassium reserves in the soil, and to make them available for the coffee plants is very important. A whole diversity of combinations with other fruit trees can be integrated into the system: Citrus- varieties, planted together with avocado, are especially good for sites that enjoy intensive sunlight.

3) Crops of the understorey
On sites which are not optimal (e.g. too dry or poor in nutrients), it makes sense to replace the natural vegetation in the understorey with green manuring plants (legumes). The bottom crops should never be allowed to dominate and completely displace the natural vegetation. Many varieties are suitable as bottom crops. They should be selected according to the amount of shade they provide, soil conditions and rainfall. In

principle, bottom crops should be sown on new plantations, or when the shading trees and coffee bushes are being trimmed. Otherwise there will not be enough light on an organic coffee plantation for the bottom crops. It is very important to sow perennial, non-climbing and not very aggressively growing legumes. Otherwise there is a danger of the coffee plantation becoming overgrown (e.g. with tropical kudzu (*Pueraria phaseoloides*)).

Harvesting

Each year coffee is harvested during the dry season when the coffee cherries are bright red, glossy, and firm. To maximize the amount of ripe coffee harvested it is necessary to selectively pick the ripe beans from the tree by hand and leave behind unripe, green beans to be harvested at a later time. Selective picking of coffee "berries" at 10-14-day intervals is common where harvesting extends over a period of 7-9 months. Where the harvesting season is shorter, whole branches are stripped when the majority of "berries" are ripe. Costs of harvesting will be 2-3 times higher for selective picking than strip picking. Deliver berries for processing the same day they are picked.

Pulping must be done on the day coffee is picked as coffee left in the sun will start to ferment. Pulping is done to remove exocarp and mesocarp through the wet processing method after which coffee parchment is obtained. The parchment is then dried in shallow layers on raised tables or trays to moisture content of 10-11%. For more information on processing, please contact Coffee Research Foundation (CRF), Ruiru.

Quality problem

Stinkers are a severe form of "over fermented" bean. This defective bean will give a bad (unclean, over fermented, pulpy, sour, foul) taste to brewed coffee and will be sure to downgrade the delivered coffee with several classes, causing loss of considerable earnings. Long fermentation times (more than 4 days) and hot

temperatures are the main culprits producing these unpleasant beans.

Storage

Coffee stores should be dry, clean and well ventilated. Never store or keep chemicals in a coffee store. Keep fully dry coffee on wooden tables or floors or even in ventilated bins. Coffee should be stirred or turned every day for 10 days before bagging. The coffee must be put in sacks as it comes from the drying tables. Place bags on wooden battens 15 cm above the ground or concrete floor and away from walls. Do not store close to corrugated iron sheets. Store for a minimum of 4 weeks and a maximum of 6 months. After that beans become woody. A relative humidity in the store of 60% at 20°C is suitable.

Information on Diseases

General information

Conventional coffee plantations are generally confronted with many pests and diseases. In practice, on ecological coffee plantations, the following may be of relevance. An infestation of either pests or diseases is always an indication that the coffee eco-system is not balanced, and that the causes must be investigated.

Possible causes are:

- **The site is not suitable (too low altitude, too warm, too humid, stagnant water, too dry, wrong variety)**
- **Soils are degenerated and poor, they lack organic material (humus).**
- **Too little diversity and too few shading trees.**
- **Not following the correct succession of the forest system, the trees are too old or the wrong variety**
- **Varieties too close together, which have an identical status in the system.**
- **Failure to trim the shading trees (too much shade).**

Examples of Coffee Diseases and Organic Control Methods

Coffea leaf rust (*Hemileia vastatrix*)

It is the major disease in Arabica coffee. Yellow to orange powdery blotches appear on the underside of leaves, chlorotic patches appear on the upper side. They grow from 2-3 mm diameter to several centimetres. On older leaves, several lesions can merge together. This produces irregular diseased areas covering much of the leaf. However, diseased leaves are usually shed before this stage. A major effect of coffee leaf rust is that it causes defoliation. The disease is spread by spores from lesions on the underside of leaves by wind and rain. Under humid conditions, hyperparasitic fungi such as *Verticillium lecanii* grow over the lesions, which produce a pale mycelial growth. Leaf rust is favored by wet, warm weather. Rainstorms of 7.5 mm or more are needed to cause disease outbreak.

What to do:

- **Plant resistant varieties. In Kenya, varieties 'Ruiru 11' and 'K 7' have been found resistant to leaf rust. Robusta coffee is resistant to leaf rust.**
- **Spray with copper before the onset of rains, open pruning and good weeding.**
- **Convert by top-working to disease resistant variety such as 'Ruiru II'. Meanwhile carry out timely pruning, handling and desuckering and regular change of cycle (young bearing heads have some resistance to disease).**
- **For emergencies use copper sprays at 21 days intervals starting just before flowering.**

Coffea leaf rust
Coffee rust (*Hemileia vastatrix*)
© A.M. Varela, icipe

The coffee berry disease (*Colletotrichum kahawae*)

***Colletotrichum kahawae* of Arabica coffee only occurs in Africa, and causes major damage in East Africa and Cameroon. Other names of this disease are "coffee berry anthracnose" and "brown blight of coffee". The characteristic symptom is a progressive blackening of young, expanding coffee berries. This begins as small water-soaked lesions. They rapidly become dark and sunken. As they grow they cause the whole berry to rot. Under humid conditions, pink spore masses become visible on the surface of the lesion.**
Berries often drop from the branch at an early stage of the disease. This is a characteristic feature of coffee berry disease. Lesions may also occur on young berry stalks, causing them to be shed before lesions are visible on the berry itself. The disease also affects ripening berries causing a 'brown blight' phase. This phase is characterised by typical dark, sunken lesions that envelop the red berry.
The coffee berry disease may also infect flowers under very wet conditions, and causes brown lesions on petals. This disease does not kill trees, but crop losses can be more than 80%. Spore dispersal within the tree is by rain splash. Disease spread from tree to tree and from farm to farm is by coffee pickers, birds or infected seedlings. Wet conditions and temperatures between 15 and 27.7° C favour disease development.

What to do:

- **Plant resistant variety where coffee berry disease is endemic (e.g. 'Ruiru 11').**
- **Prune coffee trees after harvest.**
- **Strip off diseased berries.**
- **Remove old stems and thin out branches**
- **Timely spray copper**

Coffee berry disease
Coffee berry disease (*Colletotrichum kahawae*)
© A.A. Seif, icipe

Armillaria root rot (*Armillaria heimii*)

Symptoms include wilting of leaves, death of verticals and subsequent death of affected trees. The root system of affected trees shows a white growth (mycelial) of the fungus beneath the bark. In advanced stage of the disease the wood of the affected tree is decomposed into a white, wet mass with characteristic black zone lines running through the wood tissue. Vertical cracks may occur at the base of the stem at this stage. Initial infection in coffee plantings usually can be traced to shade trees or woody debris (stumps or old roots of shade trees) left in the ground when land is cleared before coffee planting.

What to do:

- **Where coffee has to be planted in newly cleared forest land, it is recommended that ring-barking of the**

forest trees be done 2 to 3 years earlier, removal of forest trees stumps, removal as much as possible of forest trees roots, and drenching the root area with a copper fungicide. It is not possible to save a coffee tree once infected. The infected tree should be uprooted and replanting should be delayed for 2 years.

Coffee wilt (*Fusarium xylarioides*)

Indicative symptoms include wilting, chlorosis and defoliation of the aerial parts of the crop, and numerous vertical and spiral cracks in the bark of the trunk. Inspection under the bark, especially around the collar, will reveal characteristic blue-black streaks in the wood. Fungal fruiting bodies (stromata) producing spores can be observed in the bark. Infected berries turn red and appear to ripen early. Seed infection causes blue-black discoloration of the parchment and silver skin. Spores are spread by wind, rain and through human activities (harvesting, pruning etc.). The pathogen can penetrate through wounds so any agency causing wounds will aid the spread of the fungus. Insects may also spread the disease from tree to tree.

Seed from infected berries may contain the pathogen and seedborne infection is one way in which the disease is spread. Seedborne infection is responsible for seedling blight where the cotyledons fail to unfold, the stem becomes necrotic and the seedling dies. Infected seedlings often survive the nursery stage and later develop collar rot.

The fungus is an soil-inhabiting fungus, which can penetrate through wounds in the aerial parts or superficial roots. The incubation period from first symptoms to death of the tree varies from days in young plants to 8 months in trees more than 10 years old, although most affected trees die 2-3 months after initial symptoms are observed.

What to do:

- **The use of disease-free seed is advised (from areas where the disease is not present).**

- **Frequent inspection of the crop, along with burning infected material and spraying the soil surface with 2.5% copper sulphate has been advocated as an effective control measure.**
- **Replanting should not be done until 6 months after uprooting infected trees to allow the disease in the soil to decline.**

Coffee wilt symptoms on leaves
First symptoms of coffee wilt (*Fusarium xylarioides*) on leaves are generalized chlorosis of the leaves which became flaccid and curled. Leaves dry up, turn brown and very fragile, and absciss.


Coffee wil…


Coffee wil…

Damping-off diseases (*Rhizoctonia solani* and *Pythium*)

Damping-off affects coffee-seedlings in nurseries. It is caused by a complex of soil-inhabiting fungi such as *Rhizoctonia* spp. and *Pythium* spp. It should not be a problem in well-maintained coffee nurseries. Factors that predispose plants to attack include over watering, over shading and acid soil.

What to do:

- **Practice proper irrigation, avoid planting in wet, cold soils. Avoid over watering of seed beds**
- **Drench with 0.5% copper solution**
- **Use certified disease-free seeds. If using own seed, treat seeds with hot-water, if necessary. For more information on hot-water seed treatment click here**

Damping-off
Damping-off disease (here on okra seedlings)
© A.A. Seif & A.M. Varela, icipe

Bacterial blight of coffee (*Pseudomonas syringae* pv. *garcae*)

Bacterial blight of coffee (BBC) is confined to a few coffee growing areas in Kenya (Solai in Nakuru District and around Mt. Elgon). Recently a few cases have been reported in the East of Rift Valley.

This bacterium is favoured by cool wet weather. Lesions appear on leaves with water soaked margins at start of infection. Leaves eventually dry up and roll inwards turning brown. Dead and dried leaves do not shed but remain attached to the plant. Symptoms occur on secondary or tertiary branches and in severe cases the heads may be affected. On twigs the terminal bud is attacked. Infection then extends downwards, resulting in dieback. Flowers and pin-heads shrivel and turn black.

The initial symptom is the blackening of a node often accompanied by blackening of the petiole and basal part

of the leaf. This leads to death of the branch above the node and leaves on the branch turn brown and eventually necrotic (burnt). Severely affected trees appear scorched as if by fire. The bacterium persists on leaves, berries and on green and matured bark. During cool, wet weather, the bacterium multiplies and initiates an epidemic. The entire crop may be lost.

What to do:

- **Desucker or cut off infected twigs (at least 5 cm from the point of infection) and collecting them in buckets for burning.**
- **Observe field hygiene by disinfecting tools used for pruning infected trees with a suitable disinfectant such as spirits with 70% alcohol. Implements used must be sterilised after making each cut to avoid the risk of infecting the cut surfaces of the twig with a carry-over inoculum.**
- **Use of copper sprays especially during wet season. Spray at 2 week interval during the rains and 3 week interval after the rains.**
- **Plant shade trees and wind breaks on exposed sides of BBC areas.**
- **Avoid planting material from known BBC areas. In emergencies spray with copper just before, during and after flowering especially when this coincides with cool wet weather.**
- **Spray at 2 week intervals during the rains and 3 week intervals after the rains.**

Bacterial blight of coffee
Bacterial blight of coffee. Secondary branch of coffee killed by *Pseudomonas syringae* pv. *garcae*.

Wallingford, UK, 2006.

Fusarium Bark Disease (*Fusarium stilboides*)

Not widely spread in Kenya except in Taita Taveta District, Makuyu area. Occurs in three different forms and not necessarily present at the same time:

1. Storey's Bark Disease (most common). Suckers attacked at base causing depressed dark brown lesions with yellow margins at times. Pink spore masses are sometimes seen on lesions, which girdle the stem. Girdled older suckers at times continue growing with constriction of "bottle neck" at base. Weakened suckers may break from wind or picking.

2. Scaly bark (second most common). Bark of the tree rises up in flakes on mature stems. Cankerous regions may develop and die back can follow, though affected stems could also survive.

3. Collar rot. Infection spreads downwards from infected suckers, gradually girdling the tree base. Cankerous lesions develop round stem base at soil level. Constriction appearance may occur and die-back begin from top of tree. Mulching too close to the stem may cause similar rot. Soil borne fungi may cause seedlings in the nursery to die in the same manner.

What to do:

- **Report suspected infections to CRF or coffee extension officer. For Storey's bark disease affected suckers or heads should be cut off and burnt.**
- **Pruning scars should be treated with fungicidal paint or tar mixed with linseed oil.**
- **Desinfect pruning tools by dipping in spirits with 70% alcohol.**
- **Uproot and burn on the spot trees dying back from Collar rot and old stumps as well as severely diseased trees if no healthy suckers develop.**
- **Weed around the plants without damaging the bark.**

- **Pay attention to soil fertility and acidity, correcting where necessary.**
- **Eliminate wood boring insects.**

Fusarium Bark Disease
Symptoms of stem canker on coffee (*Fusarium stilboides*).

Fusarium Root Disease (*Fusarium solani*)

This fungus may stay in the stem and roots for years without symptoms until whole tree suddenly dies. The fungus enters through wounds on roots caused by ploughing, herbicides, die-back, frost, water logging etc. Symptoms appear when tree is subjected to water stress. If stem is cut near soil level, a purplish pink stain is seen. Dry rot will also show at centre of wood if infection has stayed long. This disease does not spread from tree to tree.

What to do:

- **Remove dead trees and leave hole unplanted for several months.**
- **Do not damage roots of new seedlings**
- **There is no cure for infected trees.**

Information on Pests

The coffee berry borer (*Hypothenemus hampei*)

It is the most serious pest of coffee in many of the major coffee-producing countries. Crop losses caused by this pest can be severe, ranging from 50 to 100% of berries attacked if the pest is not controlled. The adult is a tiny (about 1.5 to 2.5 mm long), cylindrical blackish beetle. The females (1.4 to 1.6 mm) penetrate into mature green or red berries, usually from the tip and lay eggs within the beans. Female beetles fly from tree to tree to lay eggs. Once the eggs hatch, the larvae feed on the beans, rendering them unsuitable for commerce or greatly lowering their quality. The white, legless grubs have a brown head. They feed by tunnelling in the tissues of the beans destroying them. Pupation takes place in the berry. Symptoms of attack are one or more small round holes near the apex of large green or ripe berries. The damaged beans, which have a distinct blue-green staining contain up to 20 grubs. Female beetles also attack young fruits.
Coffee Berry Borer damage predisposes the coffee bean to fungal infection and hence contamination with mycotoxins (food poison). Reasons for the infestation with coffee berry borer can be: the plantation is at a too low altitude, too much shade or that there are abandoned or infected plantations nearby. Infestations are carried over between peaks of fruiting by breeding in over-ripe berries left on the tree or fallen to the ground.

What to do:

- **Biological control methods include the introduction of parasitoids such as Heterospilus coffeicola, attacking grubs in Tanzania or Prorops nasuta, attacking grubs and pupae in Kenya and Tanzania.**
- **The fungus Beauveria bassiana is found naturally wherever the borer is present. In humid climates infection may reach more than 50%, and is probably the most significant natural control agent of the coffee berry borer. This fungus is used, alone or in combination with neem products, in several countries in South America for control of this pest. The fungus is easy to produce at a commercial scale, but it is difficult to apply (it must infect the adult borer before it bores into the berries), and its effectiveness is affected by the weather. For instance, in Colombia, where this fungus is widely used, much B.bassiana is**

being produced on farms and by small enterprises using simple technology. This fungus is also produced at industrial-scale by private companies (Smith and Bellotti, 1996; Depieri et al, 2005).

- **Proper and timely pruning accompanied by handling and desuckering.**
- **Field hygiene-strip: A complete harvest and collection of all affected coffee berries on trees as well as dropped berries on the ground; destroy infested berries by burning, deep burying or rapid drying on trays.**
- **Reduce shade on coffee. Heavy shade and/or inadequately pruned coffee cause unfavourable conditions for the natural enemies of the berry borer.**
- **Pick berries at least fortnightly during fruiting peaks and at least monthly during other times.**
- **Sacks or sheets should be spread on the ground to prevent berries from being lost in the mulch.**

Coffee berry borer
Coffee berry borer (*Hypothenemus hampei*). Adult female on a green coffee bean. Females are 1.4 to 1.6 mm long.
© Peggy Greb, USDA Agricultural Research Service, Bugwood.org

---

Soft green scale (*Coccus alpinus/viridis*)

Various species of scales attack coffee in East Africa. The soft green scales are common but minor pests of Arabica coffee. More serious on transplanted seedlings during the first two years in the field. The yellowish to greenish flat oval scales are about 5 mm in length. They prefer to attack green wood and leaves, and usually appear as rows of flat oval green scales along main leaf vein and near tips of green shoots. Soft green scales

produce large amounts of honeydew. This honeydew attracts ants, which while tending the scales protect them from their natural enemies. The sticky honeydew covers the leaves and sooty mould develops on it. As a result leaves appear black and sticky. Too dry microclimate favours infestation with soft green scale.

What to do:

- **Natural enemies of the soft green scale include predators such as ladybirds (Chilocorus melanophthalmus, Chilocorus nigrita), parasitic wasps (Coccophagus cowperi, Diversinervus stramineus, Metaphycus stanleyi). The parasitic fungus Cephalosporium (Verticillium) lecanii is particularly effective in the rainy season when it can kill large colonies of the green coffee scale in a short period of time.**
- **Control of soft green scale is possible indirectly by controlling ants by banding the tree stump. This keeps the attending ants away and allows natural enemies to clean up the infestation. The band should be at least 15 cm wide. Be careful not to leave any bridges.**
- **Improve shade on the plantation.**
- **Neem treatments have some effects on scales.**

Soft green scale
Soft green scale (*Coccus viridis*) are immobile and can usually be found settled at underside of leaf, close to central vein or near tips of green shoots. They are flat and oval (about 3 x 2 mm).
© United States National Collection of Scale Insects Photographs Archive, USDA ARS, Bugwood.org

---

Coffee thrips (*Diarthrothrips coffeae*)

The adult thrips are 1-1.5 mm in length and grey-brown in colour. The nymphs are wingless and yellow. Both adults and nymphs feed on the underside of leaves, but in severe infestations they also attack the upper side of leaves, berries and green shoots. Attacked plant parts show irregular grey or silvery patches covered by numerous tiny black spots, which are the excreta of the thrips. In case of severe infestation the leaves dry up and fall off. Heavy outbreaks occur during periods of drought and high temperatures.

What to do:

- **Mulching reduces thrips numbers considerably.**

Thrips
Thrips damage on lower leaf surface
© A.A. Seir

Thrips

Thrips

Lace bug (*Habrochila placida*)

This small bug (about 4 mm long) has wings with a lace-like pattern, hence its common name. The nymphs have knob-like projections on the head of the body. Both adults and nymphs suck on the leaves. Nymphs always feed in groups on the underside of the leaf. Their feeding causes yellow patches on the leaves. The

underside of affected leaves is covered with spots of black liquid excreta. In case of severe attack the leaves turn yellow and drop-off. This bug is a sporadically severe pest in Kenya and Tanzania, causing severe defoliation. The attack is often first confined to the lower leaves of a small group of coffee trees. They are most common in hot dry weather. Outbreaks have been associated with injudicious use of pesticides.

What to do:

- **A mirid bug, Stethoconus sp., is a voracious predator of the coffee lace bug.**
- **Avoid use of broad-spectrum pesticides to protect natural enemies.**

Coffee berry moth (*Prophantis smaragdina*)

The adult is a small golden brown moth with a wingspan of about 1.3 mm. The female moth lays scale-like eggs singly on or near green berries. The caterpillar is reddish to pink in colour with dark markings on the back, and measures 13 mm when fully grown. Caterpillars bore into green, half-grown berries, starting near the stalk and hollow them out. One caterpillar usually attacks several berries in one cluster. Attacked berries turn brown to black. When one bean has been eaten, it leaves the berries and wanders over the cluster of berries joining them with threads of silk before boring into a second berry. Flower buds and the tip of suckers may also be attacked. Caterpillars pupate on the ground between dry leaves. Occasionally severe attacks occur at low altitudes. Frequently slight damage by the berry moth is considered beneficial since it has the effect of thinning out overbearing branches.

What to do:

- **Conserve natural enemies. Parasitic wasps attack coffee berry moth caterpillars.**
- **Check the trees carefully for symptoms of infestation at and soon after the main flowering.**
- **Spraying should be done if buds or young berries are being eaten; this is before they bore into the**

berries, and if all berries are needed. Spraying when caterpillars are feeding inside large berries in webbed clusters is a waste, since the pesticide would not reach them.

- **Hand picking of attacked berries should be feasible in small plots.**
- **Experiments in Yemen showed that traditional methods (application of branches of Athab tree (Ficus salicifolius) inside coffee tree, smoking by burning cow manure at night during full moon and removing newly infested parts of trees attacked by the insect and burning them) decreased the population density of coffee berry moth and reduced damage by this pest. All treatments were effective but the combination of the tree treatment showed a long lasting effect and it was the most effective in reducing the rate of fruits infestation (H. S. Mahdi et al., 2006)**

Coffee berry moth
Coffee berry moth (*Prophanthis smaragdicola*)
© University of Minnesota. Dr. Jan Breithaupt. Courtesy of www.ecoport.org\n

---

White coffee borer (*Anthores leuconotus*)

Adult beetles of the white coffee borer (also called white stemborer) are about 3 cm long and has very long antenna. They are dark brown greyish in colour; the wing cases are greyish white with dark markings near the end. Adult beetles feed on the bark of branches, causing little damage. Female beetles lay eggs on the trunks of trees usually at the base near the ground level. The whitish, legless larva burrows into the bark and the wood of the trunk and main roots. The larva pupates in a large chamber within the trunk. The attack by larvae causes serious damage, particularly if the trunks are almost ring-barked. Young trees may be killed.

Older trees wilt, turn yellow and produce a poor crop. Symptoms of attack are round exit holes of the adult beetles in the trunk and wood shaving extruding from the bark or from the roots just below soil level. The white borer can become a serious pest especially below 1500 m (5000 ft) on shallow or eroded soil near shade trees.

What to do:

- **Stem banding is effective against this pest.**

White coffee borer
White coffe borer also called white stemborer, (*Monochamus leuconotus*). Adult is about 3cm long.
© Rory Hillocks, NRI

The red coffee mite (*Oligonychus coffeae*)

This red coffee mite may be a pest of unshaded coffee in localized attacks during the dry season. They attack the upper surface of mature leaves. As a result the upper surface of fully hardened leaves turn a rusty, purple or yellow brown colour. Under drought stress young leaves may also be attacked.

What to do:

- **Provide good growing conditions for the plants. In particular avoid drought stress.**

- **Conserve natural enemies. Predatory mites usually provide control of spider mites, provided no broad-spectrum pesticides are used.**

Spider mites
A related Spider mites species on cotton leaf. They are very tiny (they rarely exceed a size of 0.5 mm)
© O.P. Sharma, NCIPM, New Delhi. India, Bugwood.org

Root-knot nematodes (*Meloidogyne* spp.)

Important nematodes attacking both Arabica and Robusta coffee are *Meloidogyne arenaria*, *Meloidogyne decalineata* and *Meloidogyne incognita*, causing root knots and galls. Other nematode species include *Pratylenchus coffeae*, *Radopholus similis*, *Rotylenchus iperoiguensis* and *Rotylenchus pararobustus*.

What to do:

- **Ensure seedlings are nematode-free prior to transplanting**
- **Incorporate neem extracts into the seed beds where nematode problem is known to occur**

Root-knot nematode
Root-knot nematode (*Meloidogyne exigua*)damage on coffee
© Jonathan D. Eisenback, Virginia Polytechnic Institute and State University, Bugwood.org

Root-knot …

Root-knot …

Antestia bugs (*Antestiopsis* spp)

Antestia bugs are major pest of Arabica coffee in East African countries. The adult bug is shield-shaped, about 6 to 8 mm long and strikingly coloured dark brown with orange and white markings. They hide in berry or flower clusters. Females lay eggs in groups of about 12 on the underside of leaves. Newly hatched nymphs are about 1 mm long. Nymphs resemble the adults in colour but have a more rounded shape and lack functional wings.

Both adults and nymphs cause severe damage to green berries by feeding and indirectly by the transmission of a fungus (*Nematospora coryli*), which causes rotting of beans. The bug also attacks flower buds and shoots causing blackening of flower buds with no flower/fruit set. Attacked branches grow side shoots (fan branching). No visible surface marks/scars/wounds on berry are noticeable until seen on drying beds as

"zebra" beans. "Zebra" beans produce poor quality coffee and are possible avenues for fungal infection. Antestia bugs can live on shrubs belonging to the same family as coffee (*Rubiaceae* family).

What to do:

- **Naturally occurring parasitic wasps attack antestia eggs. Attacked eggs are black while normal eggs are white.**
- **Undertake regular and timely pruning and desuckering. Antestia bugs prefer dense foliage.**
- **Spraying has been recommended when more than 3 bugs per tree are found in Tanzania, and two bugs are found per tree in drier areas and more than 1 bug per tree in wetter areas in Kenya.**

Capsid bug (*Lamprocapsidea (Lygus) coffeae*)

The capsid bug is a serious pest in all areas. The adult bug is green or brownish and about 0.7-0.8 mm long, and has a sharp downward bent in its wings, which is highly characteristic. Females insert eggs into flower buds, and thus eggs are not visible. Nymphs are pale green and pear shaped. Wing buds are visible on older nymphs. Both adults and nymphs feed on flower buds, but they are not present they would feed on any soft green part of the coffee bush. As a result of feeding flower buds blacken due to death of stamens and petals. The style however remains healthy and usually takes a club shaped appearance with pale green shaft and black head. Damaged flowers do not set fruit. This bug is frequently considered beneficial on unshaded coffee at lower altitudes since the pruning effect of the damage caused by this bug reduces the tendency to overbear.

What to do:

- **Control measures should only be applied when developing flower bugs are present, when most of the buds are required to set fruit, and when there is an average of more than 4 capsid bugs per tree.**

- **Spray with Pyrethrum (Flower DS or similar product) 10ml to 20 L of water or according to instructions. For more information on pyrethrum click here.**

Leafminers (*Leucoptera meyricki* and *Leucoptera caffeina*)

The adults of these pests are very small (3-4 mm long) white moths. They lay very small eggs (just visible to the naked eye) on the upper leaf surface scattered in small groups (*L. meyricki*) or touching each other in a neat row along a main vein (*L. caffeina*). Upon hatching, the caterpillars bore into the leaf and mine just below the upper leaf surface. The mines of each *L. meyricki* caterpillar are initially separated but after few days they join to form one large mine. The young caterpillars of *L. caffeine* produce one communal mine. These mines appear as irregular brown blotches on upper side of leaves, which when opened reveals many whitish caterpillars.

Caterpillars are flattened, white and very small (4-8 mm when fully grown). Mature caterpillars come out of the mine and pupate in a H- shaped cocoon (6 mm long) on dead leaves on the ground or on the underside of leaves on the tree.

The mining activity causes a reduction of the active leaf surface, reducing assimilation. Attacked leaves are usually shed prematurely. Leafminers can live on shrubs belonging to the same family as coffee (*Rubiaceae* family).

What to do:

- **The caterpillars and pupae are attacked by a large number of parasitic wasps, which occur naturally in the field, and eggs are sucked dry by a predacious mite**
- **Economic threshold level: If the tree is shaken vigorously and more than 35 moths are seen, the yield of coffee can be affected. The indiscriminate applications of insecticide usually kill the natural enemies**

faster than it kills the moths, resulting in more serious attacks.

- **When intercropping Artemisia with coffee in East Africa, the incidence of coffee leafminers is drastically reduced (Per Diemer, FAO consultant).**

Leafminers
Damage of leafmining caterpillars *(Leucoptera meyricki* and *Leucoptera caffeina)* on coffee leaf.
© A.M. Varela, icipe

Leaf skeletonizer (*Leucoplema dohertyi*)

The leaf skeletonizer is normally a minor pest but severe outbreaks could occur especially in nurseries.

The adult is a grey and brown moth with a wing-span of about 1.3 cm. It is often found on leaves during the day with the hind wings drawn back alongside of the body and the narrow forewings held at right angles to the body. They lay yellow-green eggs (0.5 mm in diameter) singly or in small groups mainly on the underside of leaves. The caterpillars are greyish white with many pimple-like projections on the body. They turn red the day before pupation. Fully-grown caterpillars are about 8 mm long. They feed on underside of the leaf, usually near the near mid-rib leaving many irregular lace-like patches.

What to do:

- **Eggs are attacked by parasitic wasps; parasitized eggs turn black.**

- **Caterpillars are attacked by an external parasitoid, which can be seen as shining, light brown objects stuck to the side of the caterpillars.**
- **Control is justified if over 35 moths are seen when a tree is shaken or when there are 20-30 caterpillars per tree.**

Giant looper (*Ascotis selenaria reciprocaria*)

The adult is a moth with a wingspan of up to 5 cm. They vary in colour from dark brown to light grey with numerous dark grey markings. They lay pale green eggs in crevices in the bark. The caterpillars are pale grey to dark brown resembling twigs, and move with a looping motion. They are about 5 cm when fully grown. Young caterpillars usually eat pits on the upper leaf surface and older caterpillars feed on the leaf margins leaving a jagged edge. All stages of caterpillar prefer tender and young leaves but berries and large flower buds may also be attacked. Alternate hosts include groundnuts, sweet potatoes, black jack weeds as well as some tree species like Datura and Eucalyptus.

What to do:

- **Control is justified when more than 10 caterpillars are present on seedlings and young suckers or 20 caterpillars on cropping coffee trees.**
- **Spray with Bacillus thuringensis products (Thuricide HP or similar product) at a rate of 4g in 20 L of water (200g/ha). For more information on Bt click here.**
- **Spray with Neem products. For information on neem click here.**
- **Similar control measures are recommended for the Green looper (Epigynopteryx stictigramma)**

Kenya mealybug (*Planococcus kenyae*)

This mealybug was a major pest of coffee in Kenya in the 20's and 30's in the East Rift area, but it was successfully controlled with introduction of natural enemies from Uganda. Sporadically severe attacks occur especially in the colder months of the year. The mealybugs appear as white masses between clusters of berries and flower buds or sucker top.They are often attended by ants, which feed on the sticky honeydew excreted by the mealybugs. Honeydew leads to growing of black sooty mould on the upper surfaces of leaves.

What to do:

- **Cut off unwanted suckers, and remove any branches touching the ground.**
- **Control attending ants by banding trees.**
- **Neem treatments have a good effect on mealybugs.**

Kenya mealybug
Adult females of Kenya mealybug (*Planococcus kenyae*) collected from coffee in Kenya. 1.4-2.7 mm long and 0.8-2.0 mm wide.

Root mealybug (*Planococcus citri*)

This mealybug is usually a minor pest of coffee, but it is potentially a serious pest. The mealybugs attack the roots where they usually live in association with a fungus (*Polyporus* sp.), which forms a crust over the mealybugs. Seedlings and very young trees are often free of the fungus. Attacked trees show wilting yellow leaves as if suffering from moisture stress. When affected trees are uprooted, the roots are stunted and encased in brown fungus. When the fungus is pealed off, the white mealybugs can be seen.

Damage is more prominent in dry conditions. The pest is associated with poorly established coffee. Severe infestation may lead to loss of quality, failure of berries to ripen and overbearing and die-back. Identical mealybugs have been reported on *Solanum* spp., *Combretum* spp. and *Indigofera* spp. The root mealybug is also known as the citrus mealybug; it also attacks citrus and cocoa, where it normally attacks the aerial part of the plants.

In the highlands of Java, the shade tree *Leucaena glauca* is main food plant of citrus mealybug at altitudes above 600m (2000 ft.). Measures that proved successful for the control of citrus mealybug were mainly directed against infestation of this tree and consisted of removing the flower clusters or, when necessary, pruning all foliage and flowers. It is also claimed that citrus mealybug can be controlled by increasing the shade in plantations and that this was undesirable for Robusta coffee but suitable for Arabica at high altitudes. Good results were obtained by providing three covers, one above the other, of Leucaena, Erythrina and Albizia, or with Leucaena and Albizia only. It is further suggested that because the insect infests mainly the flowers and pods of *L. glauca*, other shade trees that seldom flower, such as *L. pulverulenta (L. leucocephala),* or a sterile hybrid of *L. glauca* and *L. glabrosa* should be planted.

What to do:

- **Strictly observe the recommended nursery management and establishment procedures especially removal of all stem and root remnants. Destroy attacked suckers and do not use them as mulch.**
- **Uproot affected trees and burn on site.**
- **Allow "infill" holes to rest at least for 3 months before replanting in order for the remaining root mealybugs to die.**

- **Neem treatments have a good effect on mealybugs**

Root mealybug
Root or citrus mealybug (*Planococcus citri*). The adult female is oval in shape, 1.6-3.2 mm long and 1.2-2.0 mm wide.

Star scale (*Asterolecanium coffeae*)

The is yellowish to reddish brown, covered with numerous small spines. It attacks stems and branches, causing deformation of branches. The growth of trees severely attacked is retarded and the trees may be die. Symptoms include green branches bent at nodes with pits in green bark beneath the bend, drooping dead leaves on affected nodes and numerous small red or yellow objects are found in the bark crevices especially near the ground. Alternative hosts: Jacaranda and loquat trees.

What to do:

- **Ladybird beetles and their larvae are often found wandering about the bark eating crawlers.**
- **Parasitised scales turn into dark-brown or black colour and are easily distinguished from the reddish-brown healthy adults. The adult parasites emerge from the scales through a neat circular hole on the shield (carapace) of the scale.**
- **Prune the infested trees severely and strip off the crop. Cut off severely infested heads.**

- **Burn the infested pruned branches.**
- **Apply optimum organic matter such as compost and mulch to infested trees as well as foliar feed.**
- **Where road dust promotes infestation, plant live dust barrier such as key apple.**

Information Source Links

- **Bohlen, E. (1973). Crop pests in Tanzania and their control. Bfe. Federal Agency for Economic Cooperation.**
- **CAB International (2005). Crop Protection Compendium, 2005 edition. www.cabi.org Wallingford, UK**
- **Coffee Research Foundation. Document on Coffee Arabica. www.crf.co.ke**
- **Coffee Research Institute www.coffeeresearch.org**
- **Coffee Research Station (1989). An Atlas of Coffee Pests and Diseases. Published by the Coffee Research Foundation. Third Revision. Kenya.**
- **Depieri, R. A. , Martinez, S.S. and Menezes Jr, A.O. (2005). Compatibility of the fungus *Beauveria bassiana* (Bals.) Vuill. (Deuteromycetes) with extracts of neem seeds and leaves and the emulsible oil. Neotropical Entomology. vol.34 no.4. Print ISSN 1519-566X**
- **EcoPort www.ecoport.org**
- **Hill, D. (1983). Agricultural insect pests of the tropics and their control. 2nd edition. Cambridge University Press. ISBN: 0-521-24638-5.**
- **Mahdi, H.S., Al Hakimi, A., Mahyoub, M, Sayef, A., Al Sharjabi, S., and Pola, F. (2006). Traditional methods of integrated pest management are a promising strategy to reduce population density of coffee berry moth *prophantis smaragdina* (Butler) in the field. Ninth Arab Congress of Plant Protection, 19-23 November 2006, Damascus, Syria. www.asplantprotection.org**
- **Naturland e.V. www.naturland.de**
- **OISAT. Organisation for Non-Chemical Pest Management in the Tropics. www.oisat.org**
- **Republic of Kenya: Economic Review of Agriculture2006**
- **Smith, L. and Bellotti, A. C. (1996). Successful Biocontrol Projects with Emphasis on the Neotropics.**

Cornell University. Conference in Biological control. April 1-13, 1996.

Contacts

- **Coffee Research Foundation, P.O.Box 4, 00232 Ruiru, Kenya Tel: +254-67-25081/2, Fax: +254-067-54133/55282, E-mail: crf@kenyaweb.com**

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Tea

Tea
Scientific name: *Camellia sinensis*
Family: Theales: Theaceae
Local names: Chai (Swahili)
Pests and Diseases: Aphids Armillaria root rot Branch and collar canker Brown and Grey blight Cotton helopeltis or mosquito bug Crickets Cutworms Root-knot nematodes Scales Spider mites Tea weevils Termites Thrips Wood rot

General Information and Agronomic Aspects

The tea bush (*Camellia sinensis*) belongs to the Theaceae family. It originates from the high regions of South West China, Myanmar and North East India.
In Kenya tea ranks as the second most important cash crop in terms of foreign exchange earnings and is grown both in large estates (total hectares in 2005: 48,800) and by small holders (total hectares 2005: 88,000) with a total production in 2005 of 324,700 tonnes at a price of 12,696 KSh per 100 kg bag of black tea.

Tea is used worldwide as a beverage after infusion of the leaves in hot water. Primarily, tea is drunk as black tea. Recently, organic green tea and instant tea are manufactured

in increasing quantities.

Geographical Distribution of Tea in Africa

Climate conditions, soil and water management

The ideal growing conditions for tea are average annual temperatures of 18-20°C, an average daily amount of sunshine of 4 hours per day, as well as an optimum of 2000-2200 mm of rainfall distributed evenly throughout the year. Higher rainfall causes erosion through soil run off especially on steep slopes. A minimum of 1400 mm of rain is required but tea can grow adequately with less rainfall in areas with frequent mists and low clouds or under irrigation. Relative humidity should lie between 70 and 90%. Tea is grown in an altitude range of 1500-2200 m above sea level. Below 1500 m yields increase but the tea flavour decreases.

In regions with extensive dry seasons, shading trees play an important role in providing and maintaining sufficient humidity. Additionally, tea plantations in windy regions should also be protected by windbreaks (see below), to reduce the intensity of evapo-transpiration.

Tea performs best in soil of volcanic origin. Areas with bracken (ferns) are indicators of suitable ecology. The soil should be deep (1.8-2.0m), well-drained and aerated. Nutrient-rich and slightly acidic soils are best (optimum pH-value 4.0-6.0). Outside this range, basic nutrients are rendered immobile, i.e. above pH 6, calcium restricts the uptake of potassium and below pH 4, phosphorus is fixed (locked in).

Old hut, boma (homestead) and charcoal sites are not suitable for tea growing. Sufficient drainage and aeration of the soil can be lastingly and economically achieved with the combination of shading trees and deep-rooting green manure plants. China tea (*C. sinensis* var. *sinensis*) is especially suited to hilly regions. It is resistant to drought, and can tolerate short periods of frost (yet has a low tolerance of shade).

Contrastingly, Assam tea (*C. sinensis* var. *assamica*) is a purely tropical crop, and reacts sensitively to drought and cold (yet has a high tolerance of shade). With a slope of above 30°, expensive soil conservation measures will be necessary. If terraces are dug, they should be 1 m wide at 2 m vertical intervals and also have a 1:30 gradient for drainage.

Varieties

Assam type of tea is grown in Kenya. New plants are selected vegetatively from exceptionally good clones. Vegetatively propagated plants are identical to the mother plant and thus will flush at the same time with the yields and quality being similar to the mother plant. Use of seed produces seedlings that are genetically variable.

- **Old clones include: 6/8, 7/9, 12/12, 31/8, 100/5, 7/3, 11/4, 12/19, 31/11 and 108/82**
- **1986 releases include: 54/40, 303/178, 302/216**
- **1988 releases include: 31/27, 31/29, 55/56, 303/259, 55/55, 30/199**
- **others: clone 7, 15/11**

Propagation and Planting

There are several methods, which can be used in the propagation of tea plants i.e.

- **Tea seed production**
- **Tea breeding**
- **Tea seed nurseries**
- **Clonal selection**
- **Vegetative propagation**

Among these, only vegetative propagation is applied in Kenya for fast tea establishment and a uniform crop. The other four methods are long-term procedures, which are expensive and the crop may exhibit some variation. They are basically research oriented and the farmer may not have the required skills to carry out seed propagation.

Vegetative propagation:

1. Nursery site

- **Site should be well sheltered from prevailing winds**
- **Site should be exposed to sunlight for developing plants to benefit from the sun's warmth (i.e. in cold areas like Kericho and upper areas of Central Kenya.)**
- **In hot areas site needs some protection from the full heat of the sun. Suitable shading trees include *Crotalaria* spp. and, *Sesbania* spp. (both fast growing and able to fix nitrogen.)**
- **Avoid low lying areas which get very wet during rainy seasons or frost during dry months.**
- **Site should be near a reliable water source**

2. Nursery soil

- **Site should be near suitable source of soil**
- **Soil to be used in sleeves can be transported to the nursery**
- **Top soil should have a pH of 5.5 while subsoil should have a pH of 5. Cuttings will not root in soil with a pH higher than 5.5. Test both topsoil and subsoil for pH if it is being used the first time.**
- **Avoid subsoil with a high clay content as it will have poor drainage**
- **Rooting of cuttings is also hampered if the soil has a high organic matter content (humus)**
- **Cuttings should therefore be rooted in subsoil or in soil from below long established grass**
- **After establishment roots should eventually get access to a more fertile soil**

3. Nursery fertiliser guidelines

- **Cuttings should be planted in a layer of subsoil about 7.5 cm deep, containing 600g/m³ rock phosphate and 300-500 g/m³ wood ashes (containing potassium) or in polythene sleeves containing the same.**
- **Beneath this subsoil ("cap") or sleeve, enrich rooting medium by mixing with topsoil and additional fertiliser similar to above application. On grassland soil and exhausted soil, the site should be prepared with legumes 1 year ahead, e.g. with *Crotalaria* spp., *Tephrosia candida* that are afterwards mulched and worked into the subsoil and above "cap" added on top before planting.**

- **Do not compact the surface of the lower rooting medium to ensure transitional layer between it and the sub-soil "cap" or sleeve**
- **Soil used in the nursery may be heated to 60°C for killing the infective juveniles of root knot nematodes (see also "solarisation")**

4. Sleeve Nurseries

They are easier to transfer to planting holes than uprooted plants. Size of sleeves depends on size of plants required by the grower - larger plants need larger sleeves.

Cuttings in large sleeves are more widely spaced and have better lateral shoot growth. Large sleeves imply fewer plants raised in each bed which is expensive. Sleeves should be spot sealed or stapled once in the middle of the bottom edge to help hold the soil and allow for drainage. Excess water is drained by punching a few holes near the bottom edge. Fill sleeves with soil mix described above, from which all roots, hard soil lumps and stones are removed up to a height of 17.5-18 cm. Pack soil firmly (not too hard) and let it be damp all the time, otherwise it will pour out of the sleeve. If soil in the sleeve is allowed to dry, it becomes difficult to wet later.

5. Nursery construction

Size of nursery depends on number of plants required by the grower and can range from 1000 plants to hundreds of thousands of plants. There are two types of nurseries (i) low shade nursery and (ii) high shade nursery. For details of construction please contact nearest Agriculture Extension Office.

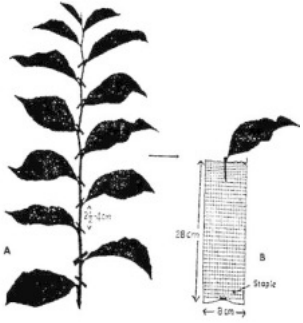
6. Mother bushes

These should be pruned twice a year even if cuttings are needed only once a year in order to get highest quality material. Time of pruning depends on the time cuttings are to be propagated: for propagation in September, mother bushes should be pruned the previous February to March.

New stems should never be allowed to remain on mother bushes for more than 7 months, as the material then gets too hard and produces poorly growing cuttings. Mother bushes should not be covered. If the mother bushes have aphids, these should be eliminated ahead of pruning for cuttings.

7. Preparation of cuttings

Prunings (cut branches) are wrapped in wet sacks and taken to a nearby shelter (shade) where they are watered immediately. They should be kept shaded at all stages thereafter. Cuttings are made from young shoots (5-7 months old), which are vigorously growing. Discard (trim off) the very soft tips (those that are smashed when pressed in between two open fingers and thumb) and the very hard lower parts of branch where bark is forming.



(A) Division of a tea shoot into internal cuttings
(B) Polythene sleeve with one cutting

Make cuttings consisting of a single leaf with 3-4 cm of stem below the leaf as shown on above diagram. Make one cut just above the bud and sloping away from bud with a sharp knife. Make second cut across the stem 3-4 cm below the bud and also a sloping cut.

Place cuttings immediately in a container full of water and let soak for about 30 minutes before planting. Place each cutting as in the drawing above making sure neither leaf nor bud is touching the soil. The bud should be just above the soil surface. Do not touch the top or buttom (ends) of the cutting as the sweat from the fingers may affect survival. Keep the cuttings moist during planting by regular light watering.
NB: Strong water jets displace cuttings. Shade the cuttings by spreading a clear polythene sheet over the nursery bed, forming a dome shape and tacking it into the soil.

After planting care: All beds should be inspected at least once a week. A heavy condensation should be found on the under surface of the polythene sheeting (enough to mar clear view). If there is only a little condensation, it means the soil in the sleeves is too dry or sheeting is torn or seal is poor. Such faults should be corrected immediately. Remove weeds by hand pulling and replace the shade. In hotter areas a more dense shade may be necessary.

Hardening off: Plants grown under polythene sheeting and shade are soft and will be scorched to death if sheeting is removed too quickly. Hardening off starts as soon as new shoots are 20 cm (8") tall. During the first 4 weeks, the polythene is gradually opened and raised on the side away from prevailing winds. First week open polythene a bit every 3 m and support by a stake. Second week the vents are doubled by making similar vents every 1.5 m.
Soil in the sleeves should not be allowed to dry, so watering is done through the vents with a hosepipe. Third week the whole sheeting is completely rolled upon the vent side, leaving only one side of the bed covered and at the fourth week polythene is removed completely, washed thoroughly and stored away from sun and rodents for later use.
Two weeks after removal of polythene the shade frame is raised 30 cm (1 ft) on one side only and supported by stakes. After this it is raised 30 cm every week for 3 weeks and then completely removed. Plants must be watered as necessary and foliar feed applied weekly until they are transplanted.
NB: If the weather changes and gets suddenly dry and plants start scorching, hardening off should be postponed or beds recovered.

Land preparation and mulching

When tea is to be cultivated on terraces, the soil should be protected against drying out by green manure plants (such as weeping love grass *Eragrostis curvula*). New tea plantations, especially those planted on slopes, are at the greatest risk of erosion taking place, which will lead to soil degradation and nutrient losses. Although trials in various regions have shown that there is no particular optimum spacing, the need for soil conservation has led to closer planting (60 cm) in the rows, with sufficient space (120 cm) between the rows to allow pluckers to walk and work. To further check erosion and provide some shade for the young plants, *Tephrosia candida*, *Crotalaria anagyroides* or *C. usaramoensis* are often sown between the rows of tea.

The cuttings of these leguminous plants or those of Guatemala grass (*Tripsacum laxum*) placed alongside the tea plants also serve to provide mulch for moisture conservation and to control erosion and weed growth. Other crops, which can be used in a young tea plantation, include oats, Napier grass or maize stalks. The mulch should not touch the stems of the tea, as this will encourage weevils and dusty brown beetles. Another advantage of mulching is the release of nutrients during decomposition of the mulch. The use of shade trees is restricted to low altitudes; the most important are *Falcataria moluccana* (syn. *Albizia falcata, A. falcataria, Paraserianthes falcataria*), *Leucaena leucocephala* and the December tree *Erythrina subumbrans*.

Mature tea is mulched with its own prunings.

Planting of wind breaks: Wind breaks should be put in place facing the prevailing wind. A row of tea could also be allowed to grow up as a wind break, or depending on the size of the field, tall or short trees can be planted about 3 m apart. Useful tall trees include pine, cypress and grevillea. Shorter windbreaks include bananas, and the willow-leaved Hakea (*Hakea salign*).

- **On level ground, the distance between adjacent belts should be ten times the effective height above the tea (e.g. the effective spacing of trees which are 10 m tall planted to protect tea plants which are 1,5 m tall will be 8.5 m (10-1.5) multiplied with 10 i.e. 85 m (8.5x10) or 85 m apart.**
- **On sloping ground the distance between adjacent belts should be less than this, but if the belts become too close the yields will be reduced by shading and also by competition with shelter trees**

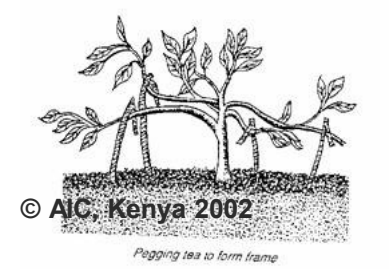
Husbandry and harvesting

In new plantings, weeding has to be done by hand until the canopy closes. It is recommended that a circle of at least 40 cm diameter around each tea plant must be kept weed free. The uprooted weeds are left between the rows as mulch. In mature tea weeds are slashed and left on the ground before they produce seed. Overhead irrigation during the dry season gives economic yield increases in many cases and is becoming increasingly popular with tea growers who have a nearby water supply.

Older plantations may have depleted the soil of certain nutrients. If a soil analysis shows very low calcium levels, an application of gypsum is recommended, as this will provide calcium without increasing the pH. Also rock phosphate is an allowed fertiliser in organic systems; apply about 30 g/bush per year (2 tablespoons) as well as light sprinkling of any wood ashes available.

Bringing tea into bearing: During establishment of tea in an estate or smallholding, there is a period when financial returns may depend on the speed and efficiency with which the young tea is brought into bearing. Any operation designed to form a permanent branch system, from the time the plants are in the nursery to the time they are "tipped in" to form a plucking table in the field is defined as 'bringing tea into bearing'.

Frame formation: The lower parts of the bush will form the "permanent frame" which remains unchanged throughout the life of the bush or until the bush is cut down or 'collar- pruned' to rejuvenate it. This frame must be low, strong and have a good spread. In tea, a wide frame of branches is needed for the "plucking table". The tea plant is cut back to 15 cm after being in the field for 12 months. When the new shoots reach height of 60-75 cm they are "pegged down" (when the reddish bark starts to develop near the main stem).



Pegging: The shoots that develop from a stump (explained above) or after the first light pruning of a sleeved plant are bent downwards and pegged so that they radiate outwards and upwards from the main stem. Pegged branches form the base of a permanent frame, which is an addition to the vertical shoots that develop from auxiliary buds among the branches. Development of these buds is encouraged by pegging the branches, so that they slope uniformly and slightly upwards. If pegging is done such that branches are horizontal or slope downwards, development of auxiliary buds is retarded or even stopped. Auxiliary bud development is further encouraged when two terminal leaves and buds are removed from the pegged branches during pegging. This activity removes growth inhibitors from the plant tip, which promote terminal growth and suppress or inhibit lateral or auxiliary bud growth. This phenomenon is known as "apical dominance".

Plucking table formation: After the frame is formed shoots are allowed to grow for 3 months, and then their growth is checked by "tipping" (removing 3 leaves and bud from each shoot above the desired height). Plucking table should be 50 cm from the ground and tipping should be done 4-5 times before plucking starts.

Plucking: This is done to maintain the established tea, starting usually after 2 years. Routine picking is done at intervals of 5-10 days depending on growth. There are four types of plucking:

- **Fine - plucking 1 or 2 leaves and a bud. A stick is placed on the tea table for guidance and shoots above it are picked (two leaves and a bud.**
- **Coarse - removal of 3 or more leaves and a bud.**
- **Light - pick leaving some new foliage above the previous plucking level.**

- **Hard - shoots are plucked right down to the previous plucking.**

Plucked leaves must NOT be compressed in a basket as this will cause fermentation. Plucked leaves should be kept in the shade and taken to the factory as soon as possible and in good condition the same day. Leaf containers should NOT be placed on the soil. Dormant shoots with unopened central leaf are called "Barijhi", they are hard and should be discarded. With correct plucking the plucking table rises some 10 cm every year. The finer the plucking, the better the quality of tea made. Under plucking causes the table to rise very quickly and may render the plucking physically impossible by third year.

Pruning: This is the removal of a shoot from a tea plant. When soft apical shoots are removed as at tipping in to form a table, auxiliary buds are stimulated to develop for a distance of 10-12 cm below the cut. This development also occurs during hard pruning and during preparation of stumps from the nursery.
Any auxiliary shoot that develops outwards contributes to the spread of the bush. After 3 years, yields begin to decline and the plucking table becomes too high. It is then necessary to prune back. At each pruning the height should be increased by 5 cm above the previous pruning to avoid callous tissues.
After several prunings the bush should be cut right back to 45 cm. Pruning should be done parallel to the slope on steep land to avoid a step effect. In dry weather, prunings should be left on top of the bushes to protect the plants from sun scorch. Otherwise the prunings should be left between the rows to return the organic material and nutrients to the soil and to prevent erosion. It is best to prune only a third of the garden when due so as to keep up production.

The pruning cycle varies from every 2 years in tropical lowlands to every 3-5 years at higher altitudes. Pruning should preferably be done during a dormant period if there is one, e.g. immediately following dry weather in East Africa.

Organic Tea Cultivation

At the start of the conversion to an organic tea garden, the tea garden needs to be developed sequentially and in stages from a monoculture towards a diversified crop system. Alongside the tea crop, plants should be

cultivated to improve soil fertility, provide a supply of nutrients (especially nitrogen), increase diversity (habitats for beneficial insects), supply wood (fuel and building material) and to provide feedstuff for on-farm animal husbandry. The main objective is to provide the soil with organic matter for the tea bushes. Spreading the organic matter over the site should be given preference to the more work-intensive practise of composting.

Organic fertilisation strategies

A. Litter fall and pruning material from shade trees
Litter is provided without any additional work. Additional working hours need to be calculated for pruning the shade trees (to create an ideal micro-climate, admit light and control the growth of the tea bushes). The pruning material should remain as mulch directly on the site, or, if applicable, be used as compost material. Yet if the pruning material is to be used as fuel, at least the ashes should be used as a compost supplement (e.g. to replace the potassium). Three aspects need to be heeded, in order to create the conditions necessary for the soil life to efficiently decompose the pruned material: The material needs to be sufficiently chopped (2-5 cm pieces). The material must then be evenly spread around the tea bushes (avoid creating heaps of material). The carbon-rich material needs to be mixed with additional nitrogen-rich material (e.g. neem-press cakes, castor cake or green manure from crotalaria) in order to achieve a better soil environment for successful decomposition.

B. Green Manure (mulch)
The foliage from green manure plants, as well as that from the other crops, should remain as mulch material on the site. In the cases of tea gardens where integrated animal husbandry is practised, care should be taken to choose green manure plants that can also be used as fodder crops.

C. Composting and animal husbandry
The basic source of fodder for the animals comes from green manure plants (e.g. Guatemala grass) and vegetation in the tea garden's edges, which are not planted with tea, or from plants neighbouring the tea garden. The space available to grow fodder must be taken into consideration when calculating the number of

cattle to acquire. If the nitrogen demand of the tea (on average around 60 kg) is to be met entirely from composted cattle manure, around 2 cattle per ha of cultivated tea are required. For this method, small ditches are dug between alternating plant rows every 3-4 years, and filled with pruning material, green manure plants, compost and cattle dung (the organic material must be well cut-up, and should not be buried too deep). Simultaneously, the tea bush roots are also cut to stimulate new growth. The disadvantage of this method is the high workload involved especially on older plantations with narrow gaps between the rows.

Yields

Annual yields of 1000 - 1300 kg/ha of processed tea or 5 times that amount of green leaf under good management are possible. An experienced plucker is able to pluck at least 30 kg of leaf per day in a good garden. For tea bushes over 50 years old, it is necessary to monitor the yield level and percentage of gaps in individual fields. If yields are less than 1000 kg/ha of made tea in such a field it is a sign of stagnant production and call for rehabilitation. This can be done by rejuvenation pruning or replanting.

Information on Pests

Nematodes (*Meloidogyne* spp., *Pratylenchus brachyurus* and *Radopholus similis*)

In some areas, nematodes reduce yields. Root-knot nematodes (*Meloidogyne* spp) can be a problem in nurseries. Infested roots develop knots or galls. They later die and devoid of lateral roots. Affected plants show chlorosis and stunted growth.

What to do:

- **Remove infested tea bushes, remove and replace large amounts of the soil.**
- **Use nematode-free planting material.**
- **To prevent infestation use plant-bags in the seedbed and use shade tree Indigoferra teismanii (Indigo tree) as a trap plant.**
- **Also sow Guatemala grass (Tripsacum laxum) before starting a new plantation to suppress weeds, which**

could harbour nematodes.

- **Another important non-chemical method of control is the use of resistant/tolerant clones, if available .**
- **Incorporation of neem cake into the soil is an effective management measure.**

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

Tea mites and spider mites

Mites are among the major pests of tea. Sporadic yield losses in the affected areas in Kenya are estimated to be about 50%. Growth of young tea is reduced by mites by about 30%.

1) The red crevice tea mite (*Brevipalpus phoenicis*)
They are also known as the false spider mites or the scarlet mites. They attack leaves of all ages, distorting them. They feed on the undersides of leaves, especially between the main veins at the petiole end. Corky areas are formed on the underside of leaves, especially between the main veins at the petiole end of leaves; attacked leaves may dry up and be prematurely shed; they may cause serious defoliation, resulting in reduced yield.
Numerous tiny red mites can be seen in the bark crevices of the new wood. A few bushes may be heavily

attacked, leaving the majority almost free from attack. This mite is a major pest of tea, causing heavy damage especially in prolonged drought. It occurs in all growing areas in Kenya, being serious around the Mount Kenya region (Sudoi et al., 1994).

2) The tea red spider mite (*Oligonychus coffeae*)
It is also called red coffee mite. It may cause considerable losses to tea production. Mite attacks are usually confined to few bushes. These mites are reddish brown and purple. They feed together on the upper surfaces of the leaves, the cast skins of the immature stages remain stuck on to the leaf and maybe seen with the unaided eye as irregular white spots. The upper surface of fully hardened leaves turns yellowish brown, rusty or purple colour. If the tea bush is under drought stress, flush leaves may also be attacked. They usually prefer older leaves but in heavy infestations younger leaves maybe attacked. This mite has been recorded in all tea growing areas in Kenya in low to moderate infestations (Sudoi, 1991).
For more information on spider mites click here.

3) Yellow tea mite (*Polyphagotarsonemus latus*)
It is also known as broad mite. It is a minute mite yellowish to whitish in colour and cannot be seen with the naked eye. This mite is a sporadically serious pest in tea nurseries, and has been reported as a common pest of tea in Tanzania (Bohlen, 1973).
Attacked leaves remain small, are crinkled, or otherwise distorted with corky brown areas between the main veins on the underside of the leaf. The plants are severely stunted in case of serious infestations.

What to do:

- **Use neem extracts in emergencies. Sudoi (1998) found that although neem seed oil at a rate of 0.03% was not satisfactory on contact against the tea red spider mite on tea, direct application on the pest at 2.5% significantly reduced its survival. Thus, he considered that neem products have potential against spider mites in tea nurseries and in the field. In India, neem oil and commercial neem products ('Neemguard', 'Repelin' and 'Biosol') significantly reduced broad mites on chilli (Ascher et al., 2002).**
- **Till weeds early enough before the main harvest begins.**

- **Use resistant clones, if available. It has been observed that certain clones suffer more attack by red spider mites than other during an outbreak of the mites. Thus, clone 7/9 is less suitable for red spider mite development. Certain clones, like SFS 150 and 6/8, exhibit resistance to the red crevice tea mite (Sudoi, 1992).**
- **Provide good growing conditions, healthy plants are more likely to withstand mite attack. Studies in the Eastern Highlands of Kenya showed that nitrogen fertilisation increased plant vigour and induced tolerance to attack by the red crevice mite (Sudoi et al., 2001).**

Spider mites
Predatory mites (*Phytoseiulus persimilis*) (orange-red individuals), in a colony of two-spotted spider mites (*Tetranychus urticae*). Two-spotted spider mite adult females are 0.6 mm long.
© Image supplied by Warwick HRI, University of Warwick.

Spider mit…

Spider mit…

Cutworms (*Agrotis segetum*)

Caterpillars of the common cutworm occasionally attack seedlings by feeding on the roots and cutting off the stems.

What to do:

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

Black cutworm
Black cutworm (*Agrotis ipsilon*). Early instars are about 7 to 12 mm long. Fully grown caterpillars are 35 to 50 mm long.
© Ooi P., Courtesy of Ecoport (www.ecoport.org)

Crickets

Crickets are fat, brown insects, two to five cm long. The front legs of the mole cricket are broad and curved adapted for digging. Many crickets live in burrows in the soil. Adults and nymphs of the tobacco cricket (*Brachytrupes membranaceus*) and the African mole cricket (*Gryllotalpa Africana*) are nursery pests. They cut seedlings and drag them into underground burrows, or left them on the surface wilting for a few days before taken them into the burrow.
The tobacco cricket may be a sporadic pest, particularly on light sandy soils where the adult crickets can easily burrow. The African mole cricket maybe a pest especially at low altitudes, and particularly in moist soil.

What to do:

- **When control is required, bran bait mixed with insecticide allowed in organic is generally effective.**

The cotton *Helopeltis* or mosquito bug (*Helopeltis schoutedeni*)

It is a slender, delicate bug is up to 10 mm long with very long antenna, nearly twice as long as the body. The nymphs are yellow with pale red markings. The adults have a red body with blackish antenna, head and wings. The eggs are white and about 1.7 mm long, and are laid into soft plant tissue.

Nymphs and adults feed on young plant tissues, injecting toxic saliva into the plant during sucking, causing necrotic patches, seen as dark brown spots, on leaves and stems. Spots exude moisture from a central puncture when squeezed. As a result the leaves are twisted and the shoots can be severely stunted. Die-back of young shoots is common under heavy attack. This bug is a common tea pest in all East African countries.

What to do:

- **In India neem products (e.g. 'Neemark') are recommended for control of the tea mosquito bug (Helopeltis antonii)**

Helopeltis bug
Body size 7-10 mm long
© F. Haas, icipe

Aphids (*Toxoptera aurantii*)

Aphids occur in groups on the buds and the undersides of young leaves. Large colonies of the aphid are mainly found feeding on seedlings causing leaf curl and defoliation They can be a major pest of tea in the nurseries. Additional damage is caused by production of honeydew, with subsequent growth of sooty moulds.

What to do:

- **Conserve natural enemies. Parasitic wasps and predators such as ladybird beetles, hoverfly and lacewing larvae are important in natural control of aphids**
- **Whenever necessary spray attacked plants only (spot spraying). Laboratory experiments suggested that a neem-based product (Codrej Achook) formulated as wettable soluble powder, containing azadirachtin 0.03% (300 ppm) could be used for control of the citrus black aphid when applied at concentrations of 10 and 20% (Sudoi, 1998)**

Aphids
The mango aphid (*Toxoptera odinae*)

The black tea thrips (*Heliothrips haemorrhoidales*)

The adult thrips are about 1.5 mm long and dark brown or black in colour with whitish legs, antenna and wings. The nymphs are whitish or greenish in colour. The feed on leaves of all ages.
Attacked buds are small, crisp and are brittle (easy to break). When the damaged bud unfolds, the leaves have a brown line of dry scars (like cork) along either side of the main rib. Yellow mites cause similar corky lesions, but thrips feeding usually does not cause the leaves to curl up like yellow mite. Even a few thrips feeding on a bud can lower the quality of the bud, making the dried buds brittle and the processed tea bitter.

Attacked leaves show silvering and a fine speckling of black spots, which are the excreta of the thrips. Damaged, leaves become thicker and harder than the normal ones, duller (not shining) and having darker green colour, and may be puckered or deformed. Thrips may also feed on the surface of stems, but only near the tip of a young shoot. This stem feeding causes rough, brown dots or patches on the surface of the stem. A tea bush with many thrips is often stunted and dry. Thrips can cause economic damage mainly in periods of drought.

What to do:

- **Provide favourable growing conditions for the crop. Thrips are often a bigger problem in old, stunted and dry tea fields. A strong tea crop can tolerate thrips Tea plants often grow out of the damage quite quickly if well tended. In particular adequate irrigation is a critical factor in minimising damage**
- **Use shade to increase humidity in regions with extensive dry seasons. Thrips are favoured by dry and hot weather conditions. Planting shade trees is one of the best ways to reduce thrips populations in dry conditions**
- **Pluck frequently to remove thrips and their eggs. Because thrips feed mostly on buds and the youngest leaves, plucking can greatly reduce the number of thrips. Frequent plucking reduces thrips more than plucking only once a month**
- **Conserve natural enemies. Predatory mites and pirate bugs are important for the natural control of thrips. For more information on natural enemies click here**

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

Tea weevils (*Aperitmetus brunneus*, *Entypotrachelus meyeri*)

Adult weevils feed on the foliage and chew the leaf edges and also bore irregular holes through the leaf surface. The larvae are the most destructive, feeding on the taproot and causing wilting, stunting, and eventual death of young plants. Stems of young plants may be bark-ringed at ground level by the larvae. In Kenya, the tea root weevil (*Aperitmetus brunneus*), which is about 7-9 mm long with pale grey scales on its body, is considered a serious pest in tea nurseries. Losses of 30 to 40% are common. The tea weevil or Kangaita weevils (*Entypotrachelus meyeri*) occasionally defoliate young tea newly transplanted to the field.

What to do:

- **Laboratory experiments suggested that a neem-based product Godrej Achook formulated as wettable soluble powder, containing 0.03% (300 ppm) azadirachtin has an antifeedant effect on the tea weevil (E. meyeri) (weevils stop feeding or eat less) when applied at concentrations of 10 and 20% (Sudoi, 1998).**

Termites (*Odontotermes* spp., *Microtermes natalensis*, *Pseudocanthotermes militaris*)

Termites feed on woody roots, branches and stems. The most damaging termites are those that attack living wood. They enter through the roots and work their way upward, finally destroying the heartwood. Stem beneath the soil is ring barked and the entire root system may be destroyed. Above-ground symptoms include wilting leaves and a poorly-growing plant. They occur most frequently on newly established plantations. Severely attacked plants wilt and die. Older plants may shed leaves. In most cases only a few plants are affected. Damage by termites to roots and stems of older plants can assume economic levels. A heavy infestation of termites that attack live wood can reduce yields by 10-15%. It may even kill large mature tea bushes. Termites that eat only dead wood do not cause direct damage, but they may make the plant more susceptible to fungus diseases.

What to do:

- **Remove stumps and dead trees (including their roots) when clearing land to plant a new tea field.**
- **Monitor crop regularly. Once a tea bush becomes infested, observe if the termites are eating living wood or only dead wood (wood already killed by sunscorch, die-back after pruning, or diseases).**
- **If the termites are eating living wood spray with an accepted insecticide. Neem products are reported to control termites. At pruning time, cut the branches back so that you expose at least two openings into the nest inside the trunk. Then, spray the insecticide into the nest. Spray immediately after pruning, because the termites will quickly block up the openings with mud.**
- **Dig up and burn infested bushes, and replant. Before replanting, check to make sure that neighbouring bushes are not infested.**
- **If the termites are eating only dead wood, prune off infested branches and clean away any sawdust or mud tunnels from the surface of the tree.**
- **If possible, find and destroy the nests (nests will be located in the soil or in a dead tree).**

Termites
Termites (*Coptotermes formosanus*)
© Scott Bauer, USDA Agricultural Research Service, Bugwood.org

Scales

Scales are small insects (1.0 to 7 mm long), usually green, yellowish or brown in colour and resemble shells glued to the plant. Female scales have neither wings nor legs. Females lay eggs under their scale. Some species give birth to young scales directly. Once hatched, the tiny scales, known as crawlers emerged from under the protective scale. They move in search of a feeding site and do not move afterwards. They suck sap on leaves and twigs. Their feeding may cause yellowing of leaves followed by leaf drop, poor growth, and dieback of branches. Two types of scales attack tea: soft and armoured scales.

Soft scales (*Coccus* spp; *Saissetia coffeae*) infest leaves and twigs. They cause damage by sucking sap from the plant and by excreting honeydew, causing growth of sooty mould. In heavy infestations leaves are heavily coated with sooty mould turning black. Heavy coating with sooty mould reduces photosynthesis and affects the quality of the leaves. 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 (*Selanaspidus* spp and *Aspidiotus destructor*) encrust foliage, the cause damage by sucking sap; they do not excrete honeydew.

What to do:

- **Conserve natural enemies. A large range of parasitic wasps and predators attacks scales. 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. If ants are protecting scales, try to control the ants by destroying their nests or spraying with soap mixed with water.**
- **Check infestation by scales. Peel off the hard shields and check whether there are living insects underneath. Dead empty shields can remain glued onto the plant for months, making it look like the scale population is much higher than it really is.**
- **If large numbers of living scales are present spray with light mineral oils. Sprays should target young stages of the scales. However, note that at high concentrations, mineral oils may be harmful to the plants. Oils should not be sprayed during periods of excessive heat or drought.**
- **At early stages of an outbreak cut and burn affected twigs and leaves.**

Soft brown scale (*Coccus hesperidum*). Scales are small, they attain a lenght of 1-7mm.
© Jeffrey W. Lotz, Florida Department of Agriculture and Consumer Services, Bugwood.org \n \n

Information on Diseases

A wide variety of diseases have been reported on tea, but many of them are not of economical importance. One of the most serious diseases in major tea producing countries is blister blight caused by the fungus

***Exobasidium vexans*, but this disease has not been reported in Africa. The major diseases in Africa are *Armillaria* root rot (*Armillaria heimii*) and wood rot (*Hypoxylon serpens*). Others like branch and collar canker (*Phomopsis theae*), brown blight (*Colletotrichum coccodes*) and grey blight (*Pestaliopsis theae*) are of variable importance. Root-knot nematodes (*Meloidogyne* spp.) could be a problem in the nurseries.**

Armillaria root rot (*Armillaria heimii*)

The fungus is confined to the soil and is normally a saprophyte living on dead stumps and roots of forest trees. However, if the root surface of the tea bush is damaged by cultivation or boring insects, the fungus can enter the roots and become parasitic. Leaves of affected bushes turn yellow and fall and sheets of white mycelium (fungal growth) can be found between the bark and the wood. The main root system rots away and the tea bush eventually dies.

What to do:

- **During land preparation stumps, pieces of wood and roots of forest trees must be removed from the soil.**
- **If Armillaria occurs in established tea, diseased trees must be thoroughly removed so that they do not become a source of infection for the neighbouring bushes.**

Wood rot (*Hypoxylon serpens*)

Wood rot in tea has been reported from several countries including India, Kenya, Malawi, Zimbabwe and Sri Lanka. The pathogen implicated is *Hypoxylon serpens*. Significantly, all affected areas lie at or above 1500 m. The characteristic symptoms normally appear when the bushes are about 15 to 20 years old. Suddenly, the foliage of a branch will show wilting followed by scorching. Such branches snap off easily near the base.

Sometimes intact lower branches with green foliage in these bushes could snap off similarly, especially when workers walk through during field operations. The bases of such branches have characteristic black encrustations (stroma - fungal fruiting bodies containing spores). The pathogen appears to be disseminated mainly through pruning knives and the infection progresses from pruning cuts during wet weather. Under natural field conditions, infection at 60-90% and over 90% could bring about 27 and 36% yield reductions, respectively, showing that the disease can cause significant damage.

What to do:

- **Plant resistant clones, if available.**
- **Avoid pruning of tea bushes and rejuvenation pruning during dry weather.**

Branch and collar canker (*Phomopsis theae*)

The first obvious symptom of attack is yellow or brown foliage on affected branches or bushes, contrasting with the green foliage of the surrounding healthy bushes. Closer examination reveals lesions or cankers at the base of branches or at the collar region of the bush. These lesions are less apparent in the early stages of infection but older cankers are easily recognisable by their raised margins due to the development of callus. The diseased areas may be regular or irregular in shape, often sunken, and grey to black in colour. The underlying dead wood can be seen by scraping back the bark using a knife. In instances where the branch or the collar is completely girdled (ring-barked), a thick ridge of callus forms at the upper margin of the canker. The fungus can also infect apparently uninjured succulent green shoots, causing small local lesions. This can lead to the death of the whole shoot. Tea plants are most susceptible when they are less than 8 years old. The disease is enhanced by drought conditions, deep planting, planting in gravelly soils, mulching close to the collar, wounds by weeding implements, low moisture status in the bark and surface watering during dry weather.

What to do:

- **Use resistant varieties, if available, particularly in areas with a history of the disease.**
- **Plant only healthy, vigorous plants with a well-developed root system.**
- **Avoid planting in poor soils and in areas where rainfall is marginal or inadequate.**
- **Mulch the soil towards the end of the rainy season to prevent it drying out too quickly.**
- **Plants should be treated lightly (light plucking) during propagation and nurturing.**

Brown and grey blight (*Colletotrichum coccodes* and *Pestalotiopsis theae*)

These fungi are considered weak pathogens and usually only affect plants that have been weakened by improper care or adverse environmental conditions. Often they occur together.
The diseases are favored by poor air circulation, high temperature, and high humidity or prolonged periods of leaf wetness. When young twigs of susceptible cultivars are cut and used to root new plants, latent mycelium (fungal growth) in the leaf tissue may start to invade nearby cells to form brown spots, and this may lead to death of leaves and twigs.
Symptoms consist of small, oval, pale yellow-green spots first appear on young leaves. Often the spots are surrounded by a narrow, yellow zone. As the spots grow and turn brown or grey, concentric rings with scattered, tiny black dots become visible and eventually the dried tissue falls, leading to defoliation. Leaves of any age can be affected. The tiny, black spots on the lesions contain the fungal spores. Rain splash transports the spores from one plant or site of infection to another. If the spores land on a leaf, they germinate to start a new leaf spot or a latent infection.

What to do:

- **Avoid plant stress.**
- **Grow tea with adequate spacing to permit air to circulate and reduce humidity and the duration of leaf**

wetness.

Information on Weeds

Weeds compete with tea for nutrients and moisture; grasses take away large quantities of potassium and deprive the tea plants of this major nutrient. Many of the weeds serve as alternate hosts of insect pests of tea. Weeds are problematic mainly in the new clearing and pruned fields and it is necessary to control them till the tea bushes cover the field. Certain cultural practices like mulching, raising cover crops, closer planting, higher pruning and tipping practices, infilling and manual weeding are important.

Information Source Links

- **AIC, Kenya (2002). Field Crops Technical Handbook.**
- **Acland J.D. (1980). East African Crops. An introduction to the production of field and plantation crops in Kenya, Tanzania and Uganda. FAO/Longman. ISBN: 0 582 60301 3**
- **Agricultural Information Center. Nairobi (2002). Field Crops Technical Handbook.**
- **Ascher, K. R. S., Manzor, M. and Mansour, F. A. (2002). Effect of neem of viruses and organisms.- Acarina: Mites. In The Neem Tree (*Azadirachta indica* A. Juss) and other Meliaceous Plants. Sources of Unique Natural Products for Integrated Pest Management, Medicine, Industry and Other Purposes. H. Schmutterer (ed.). Second edition**
- **CAB International (2005). Crop Protection Compendium, 2005 edition. Wallingford, UK www.cabi.org**
- **Naturland e.V. www.naturland.de**
- **Republic of Kenya, Ministry of Agriculture: Economic Review of Agriculture 2006**
- **Tea IPM Ecological Guide. Michael R. Zeiss, Koen den Braber. Published by CIDSE, April 2001. www.communityipm.org**
- **University of Hawaii, Cooperative Extension Service/CTAHR: Identification Guide for Diseases of Tea (*Camellia sinensis*) hawaiiteasociety.org**
- **Upasi Tea Research Foundation www.upasitearesearch.org Coimbatore District, India**

- **Virtual University of Agricultural Trade, Department of Agriculture, Government of Kerala vuatkerala.org**

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

African Nightshade

African Nightshade
Scientific name: *Solanum villosum*
Family: Solanales: Solanaceae
Local names: Mnavu (Swahili), managu (Kikuyu), namaska (Luhya), osuga (Luo), isoiyot (Kipsigis), kitulu (Kamba), ormomoi (Maa), ndunda (Taita), nsugga (Luganda)
Common names: Black nightshade / narrow-leaved nightshade
Pests and Diseases: Aphids Bacterial wilt Early blight Spider mites

General Information and Agronomic Aspects

Geographical Distribution of Nightshade in Africa

Introduction

Narrow-leaved African nightshades, also called mnavu in Swahili, is widely distributed throughout the tropics and can be found throughout East Africa. The plant is an erect, many-branched herb growing 0.5 to 1.0 m high. The plant bears thin, oval, slightly purplish leaves up to 15 cm in length, has numerous white flowers and usually purple to black, round berries about 0.75 cm in diameter containing many small, flattened, yellow seeds.

There are several species with black berries, but the most popular are those with orange berries belonging to *Solanum villosum*. This group of species is often erroneously referred to as *Solanum nigrum*, a poisonous plant from Europe that is not usually grown in Africa (AVRDC 2003).

The leaves are eaten as a cooked vegetable, often mixed with other vegetables and the fresh fruit is also consumed. Some *Solanum* varieties are prefered for their bitter taste while others are considered 'sweet', particularly after being boiled and the water discarded. The raw leaves contain 4% protein, 6% carbohydrates and are moderately high in vitamin C.

***Solanum* species that are found in Kenyan vegetable gardens include *S. macrocarpon*, *S. scabrun*, *S. villosum*.**

***Solanum* plays an important role in traditional medicine in Africa and elsewhere, but the leaves are considered poisonous in some areas of the world so one should be careful about obtaining seeds for planting.**

Climatic conditions, soil and water management

African nightshades can grow on a wide range of soil types but do not tolerate drought (AVRDC 2003). African nightshades do well in organic plots.

Propagation and planting

Plants are propagated from seeds. Seeds are marketed by Simlaw Seeds in Nairobi under the name Black Nightshade in 25 gram packets and another source with particularly large, tasty leaves is available from

SACRED Africa, Bugoma, Western Kenya.

The soil in the nursery should be loosened and enriched with decomposed manure. Seeds should be mixed with sand and/or ash for uniform sowing. Sow the mixture thinly, either by broadcasting or in rows, 15 - 20 cm apart and cover with a fine layer of soil. After sowing, the bed should be mulched with tall grass or a similar material to retain moisture. This mulch can be removed once the plants are 3 cm. Transplant when seedlings have six true leaves and are 10 - 15 cm tall. The spacing should be 20 cm in the row by 40 cm between the rows.

Husbandry

Nightshades require large amounts of nutrients, and therefore do well in soils that are rich in organic matter. They also grow well on land covered with ash from recently burned vegetation (AVRDC 2003). Apply organic manure where possible. Frequent irrigation is needed for good yields.

Harvesting

The crop is ready for harvest four weeks from transplanting. The stems are cut approximately 15 cm above the ground. This allows new side shoots to develop. Pickings are done at weekly intervals.

If complete harvesting is practiced, spacing can be as close as 10 x 10 cm and plants are uprooted. This method is mainly used when there is less than two months before the main staplefood crop will be planted. Roots of these crops can be kept in water to keep the plants fresh.

Picking should be done very early in the morning and the produce sold the same day. Alternatively, the crop can be harvested late in the afternoon and placed on plastic sheets or banana leaves. These should be tied in small bundles. The flowers should be removed before the crop is taken to market. Water these bundles sparingly to retain freshness.

Post-harvest

Preservation is done by sun-drying. The leaves may be dried and stored for up to one year though this practice greatly reduces the nutritive value and changes the texture.

Selected Recipes

a) Amaranth, spider plant and groundnut relish (contributed by Adija Baraza)

Ingredients:
1/4 kg amaranth (1 large bunch), 2 medium tomatoes, chopped, 1/4 kg spider plant (1 large bunch), 1/2 cup groundnut powder, 2 tbsp shortening or cow fat, 3 tbsp water, 1 medium onion, chopped and 1 tsp salt

Preparation. Clean and wash both the green vegetables, chop the vegetables, onion and tomatoes and set aside for later use. Heat the shortening or fat and fry the onion until soft and slightly brown. Add the tomatoes, stir and cook until soft. Add the green leafy vegetables, stir, cover and simmer for 20 minutes, stirring occasionally. Mix the groundnut powder into a smooth paste and add to the simmering vegetables, then salt to taste. Cook for an additional 5 minutes. Preparation yields four to six small portions and is best served while hot with ugali or mashed bananas.

b) Cream of nightshade spinach (contributed by Mathew K. Kwambai)

Ingredients:
1 kg nightshade leaves, 1 medium tomato, chopped, 1 cup water, 1 tbsp salt, 90 ml cream, 2 tbsp vegetable oil and 1 medium onion, chopped

Preparation. Pinch the leaves of nightshade from the main stalk while retaining a very small leaf stem. Wash the leaves in a basin and drain off the water. Bring the water to boil and put the leaves into the boiling water for 25 minutes, then remove from fire and drain excess water. Heat vegetable oil in a pan and add the chopped onions, stirring occasionally until the onions are soft. Add tomatoes and the boiled nightshade leaves and cook for two minutes, stirring occasionally. Add the cream and one litre of water, cover and simmer for five

minutes. This preparation makes four servings and is best served while hot with ugali. An alternative recipe involves the addition of 1 to 2 cups of other traditional green vegetables, particularly spider plant or amaranth, with the nightshades.

Information on Diseases

Diseases are similar to those of Solanaceae family (e.g. peppers, potatoes and tomatoes), therefore for more information see also under these crops.

Early blight

Leaf spots of early blight are circular, up to 1 cm in diameter, brown, and often show a circular pattern which distinguishes this disease from other leaf spots. Early blight thrives best under warm wet conditions. Leaf spots first appears on the oldest leaves and progress upward on the plant. Entire plant could be defoliated and killed.

Controlling early blight once it has established is very difficult. The most important way of controlling early blight is attempting to prevent its establishment and further spread.

What to do:

- **Rotating with other crops like amaranth is essential. Do not rotate with tomato, potato or peppers as these belong to the same family and attract the same diseases.**
- **In areas with a high humidity, wider plant spacing should be used.**
- **Practice good field hygiene. Remove infected leaves during the growing season discard all badly infected plant debris at the end of each season.**

- **Use certified disease-free seeds**
- **When using own seeds, hot water treat the seeds. For more information on hot water treatment click here**

Early blight
Early blight on tomato leaflet. Similar symptoms on African nightshade
© A.M. Varela, icipe

Information on Pests

Pests are similar to those of Solanaceae family (e.g. peppers, potatoes and tomatoes), therefore for more information see also under these crops.

Aphids (*Aphis* spp.)

Aphids are a major pest, causing leaves to curl and become unattractive to customers.

Aphids feed by sucking plant sap. Small aphid populations may be relatively harmless, but heavily infested plants usually have wrinkled leaves, stunted growth and deformed pods. Plants, in particular young plants, may dry out and die under heavy aphid attack. Heavy attack on older plants may cause crop loss by decreasing flower and pod production. Damage may also reduce seed viability.

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.**
- **Whenever necessary spray only affected plants (spot spraying).**
- **Use biopesticides that are not harmful to natural enemies (for instance neem, ashes, soapy water). In Kenya, foliar sprays with neem products such as Neemroc® (1-3%) and Neemros® water extract (50g/l) controlled the black bean aphid on French beans (Maundu, 1997). For more information on biopesticides click here**

Aphids
Adult wingless female aphids are oval-bodied, 1 to 2mm in body length, of very variable colour.
© Magnus Gammelgaard

Spider mites (*Tetranychus* spp.)

The plant's leaves and growth tips are susceptible to mites (very small, sucking arthropods) that result in twisted growth and low productivity (Formatkenya).

Generally, spider mites feeding may cause reduction in plant growth, flowering, number and length of pods, and number of seeds per pod. Damage is most severe when mites attack young plants. Mite damage may be

particularly severe during the dry season.

What to do:

- **Avoid planting next to infested fields.**
- **Avoid use of broad-spectrum pesticides, in particular pyrethroids; this may lead to spider mite outbreaks.**
- **Use overhead irrigation or wash plants with a strong jet of water to knock off mites and destroy their webs. Be sure to include the underneath of the leaves. However, this should be done early in the day to allow the foliage to dry. Wetness of the foliage for an extended period is conducive to development of fungal diseases.**

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

Information Source Links

- **AVRDC, 2003. International Cooperator's Guide. Narrow-leaved Nightshade. www.avrdc.org**
- **FORMAT, 2003. Forum for Organic Resource Management and Agricultural Technologies. Organic Resource Management, Chapter 17 www.formatkenya.org**
- **IPGRI, 1997. Traditional African Vegetables. Promoting the conservation and use of under-utilized and neglected crops. The proceedings of a conference held by the International Plant Genetic Resources Institute (IPGRI), August 1995, ICRAF, Nairobi, Kenya. 171 pp. www.bioversityinternational.org**

- **Maundu, P.M., Ngugi, G.W. and Kabuye, C.H.S. 1999. Traditional Food Plants in Kenya. Kenya Resource Centre for Indigenous Knowledge. National Museums of Kenya, Nairobi. 270 pp.**
- **Ministry of Agriculture and Rural Development, Kenya (2000). Local and export vegetables growing manual. Reprinted by Agricultural Information Resource Centre, Nairobi, Kenya.**
- **Ouma, M.A. Indigenous vegetable production and utilization in Suba district, Kenya: Improving health, unlocking the wealth in Suba district. BioVision - T.T.U, ICIPE. Unpublished.**
- **Woomer, P.L. 2002. The Traditional Green Vegetable Cookbook. Forum for Organic Resource Management and Agricultural Technologies. Nairobi. 46 pp.**

Reference addresses

- **Seeds are marketed by Simlaw Seeds in Nairobi under the name Black Nightshade in 25 gram packets and another source with particularly large, tasty leaves is available from SACRED Africa, Bugoma, Western Kenya.**

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Teff

Teff
Scientific name: *Eragrostis tef*
Family: Cyperales: Poaceae
Local names: Teff (Amharic); Taffi (Oromo); Taff (Tigrigna)
Common names: Lovegrass / Annual Bunch Grass (English) / Mil éthiopien (French).
Pests and Diseases: African armyworm Purple witchweed

General Information and Agronomic Aspects

Teff or Tef (*Eragrostis tef*) is a species of lovegrass native to northeastern Africa. It has an attractive nutrition profile, being high in dietary fiber and iron and providing some

Geographical Distribution of Teff in Africa

protein and calcium. It is similar to millet and quinoa in cooking, but the seed is much smaller. Teff is believed to have originated in Ethiopia between 4000 BCE and 1000 BCE. (Germer 1985).

The word tef is thought to originate from the Amharic word teffa, which means "lost" (due to small size of the grain), or from the Arabic word tahf used by Semites in South Arabia.

Teff is an important food grain in Ethiopia and Eritrea, where it is used to make injera. Because of its small seeds (less than 1 mm diameter), one can hold enough to sow an entire field in one hand. This property makes teff particularly suited to a seminomadic lifestyle.

Climate conditions, soil and water management:

It is adapted to environments ranging from drought stress to water logged soil conditions. Maximum teff production occurs at altitudes of 1800 to 2100 m, with a temperature range of 10 to 27 °C. Average annual rainfall is about 750-1000 mm in the central Ethiopian highlands. Maximum rainfall in the area of cultivation is about 2500 mm. However, teff could produce good yields at much lower annual rainfalls: for most cultivars 300-500 mm of rainfall per growing season is adequate. Early maturing varieties (60-75 days) can do with less than 300 mm of seasonal rainfall. Teff is day length sensitive and flowers best during 12 hours of daylight.

Propagation and Planting:

Ethiopian farmers grow tef either as a staple or as a standby. As a staple, they plant it like other cereals, but they normally sow it late and harvest it well into the dry season. As a standby, they wait until their main crops maize, sorghum, or maybe wheat shows signs of failing. Then they sow a fast-maturing tef as a backup source of sustenance in case of disaster. (Lost Crops of Africa: Vol. I: Grains (1996))

Husbandry:

Teff requires little care once it is established. Its rapid growth stifles most weeds; few diseases and pests

attack it; and it is said to produce well without added nutrients. However, in most places tef will respond to fertilizers. In Ethiopia, large yield improvements can be achieved by applying techniques that are already known: careful land preparation, use of selected seeds, fertilization, sowing and weeding at the optimum time, and disease and pest control, for example. (Lost Crops of Africa: Vol. I: Grains (1996))

Harvesting:

Tef threshes well with standard methods and equipment. Very early-maturing types are ready to harvest in 45-60 days; early types in 60-120 days; and late types in 120-160 days.

Yields range from 300 to 3,000 kg per hectare, or even more. Although the national average in Ethiopia is 910 kg per hectare, yields of 2,000-2,200 kg per hectare are considered routinely attainable if good agronomic practices are carefully followed. Yields of 2,000 kg per hectare have been achieved on South African farms also, although storms have sometimes leveled the fields, resulting in large losses.

The grain is easy to store and will survive for many years in traditional storehouses without damage by insects. This makes it a valuable safeguard against famine. (Lost Crops of Africa: Vol. I: Grains (1996))

Information on Pests

Teffs rapid growth stifles most weeds and few diseases and pests attack it.

African armyworm

It is an occasional but seriously destructive pest on Teff in Ethiopia. It causes serious damage to young plants in years of armyworm outbreaks. The caterpillars feed on the leaves eating them down to the midrib. Outbreaks usually start during May in the southern provinces of Ethiopia. During the main growing season they move northwards.

What to do:

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

African armyworm
African armyworm (*Spodotera exempta*). Mature caterpillars measure up to 4 cm.
© University of Arkansas

Information Source Links

- **Germer, Renate (1985). Flora des pharaonischen Ägypten. Mainz: von Zabern. ISBN 3805306202.**
- **Insect pests of cereals in Ethiopia. http://ethiopia.ipm-info.org**
- **Lost Crops of Africa: Volume I: Grains (1996). NATIONAL RESEARCH COUNCIL Division on Policy and Global Affairs Development, Security, and Cooperation. Free online-version available: National Academies Press: http://www.nap.edu**
- **Wikipedia, the free encyclopedia http://en.wikipedia.org/wiki/Teff**

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Pineapple

Pineapple
Scientific name: *Ananas comosus*
Family: Bromeliales: Bromeliaceae
Local names: Nanasi (Swahili)
Pests and Diseases: Mealybug or pineapple wilt virus Mealybugs Pineapple top and root rot Root-knot nematodes Thrips White leaf spot Yellow spot virus

General Information and Agronomic Aspects

Geographical Distribution of Pineapple in Africa

The pineapple is native to South America, but it is now widely grown throughout the tropics and in warm locations in the subtropics, and it is also grown in heated greenhouses in temperate countries. Portuguese traders are said to have introduced pineapple into the east and west coasts of Africa. Pineapples in Kenya are mainly grown in Thika, Malindi and Kisii.

Pineapple is grown for its fruit that is eaten fresh, as dessert, in salads; processed into juice, jam, dried fruits and preserves (crystallised and glace fruit); cooked in pies, cakes, puddings; or used in sauces. Fruits are also canned as slices, spirals etc. Dried pineapple slices are becoming a popular snack in Kenya. The by-products of canning can be used as cattle feed or to produce pineapple wine or vinegar. In the Philippines and Taiwan the fibres from the leaves are woven into a fine cloth. The fruit has high sugar content and is rich in vitamins A and C.

Climate conditions, water and soil management

The pineapple is grown successfully in tropical lowlands and in the subtropics, in areas where the crop requires areas where the climate is warm, humid and free from extreme temperatures. A temperature range of 18 to 45°C is favourable, 25 °C being optimal, though the plant can tolerate cool nights for short periods. Prolonged cold retards growth, delays maturity and causes the fruit to be more acid. Temperatures under 20°C can lead to chlorotic discolouring, so, away from tropics, the right combination of heat and moisture are important factors to consider for successful pineapple production.

Very intensive solar radiation can damage the fruit. Under the full strength of the sun the fruits can develop sunburn, especially when they lodge and are no longer protected by the crown. One method of protection in these cases is the labour-intensive way of binding the leaves around the fruits in order to cover them. Alternatively, the crop can be dusted with lime or diatomite to leave a thin layer of reflecting substance on the fruits/plants.

Pineapple will produce fruit under annual precipitation ranging from 650 to 3,800 mm depending on cultivar, location and atmospheric humidity (it should range between 70 and 80 degrees). Ideal rainfall for pineapple production is about 1,100 mm. Reasonable yields can be obtained with as little as 750 mm of well-distributed rainfall per year or with supplementary irrigation (600mm and 2500mm being the outer limits). Irrigation is essential right after planting unless this is done during the rainy season. After establishment, irrigation is only necessary when long dry periods occur. Overhead or drip irrigation is recommended and flood irrigation should be avoided. Pineapples cannot stand waterlogging.

In Kenya pineapples grow well from sea level up to 2000 m or higher above sea level but above. . Altitude has an important effect on the flavour of the fruit; above 1800 m they become increasingly sour and acidic.

The best soil for pineapple culture is a well-drained, sandy loam with a high content of organic matter and it should be friable for a depth of at least 60 cm. The crop does well on optimum pH of 4,5. Soils with old anthills have a higher pH, and are not suitable for the production of good pineapples. Avoid black cotton soil, low lying areas and common red loams that are likely to flood.

Land preparation

The land should be well prepared before planting because the pineapple is shallow-rooted and easily damaged by post-planting cultivation. Proper land preparation is extremely important for the development of the roots. Poor land preparation result in poor yields. Perennial weeds should be cleared by repeated deep cultivations during the dry season. Uproot weeds (e.g. couch grass (*Digitaria* sp.), allow them to dry, harrow into strips and burn them.

In areas where the soils have high clay content, it is essential to plough also during the dry season to facilitate root penetration of pineapples. Plough to a depth of 45 cm, or if using hand digging, dig as deep as possible. After ploughing, use a disc harrow to produce a fine tilth.
Small-scale growers can uproot old pineapple plants by hand, while large growers can use a large harrow to uproot and chop the stumps and leaves.

Manures and fertilisers

Nitrogen is essential to the increase of fruit size and total yield. Five to 10 tons of manure per hectare applied to the field before mulching and planting will increase eventual yields. A general application of 180 to 200 kg/ ha of rock phosphate should be added at the same time. Each ratoon crop will again need a new supply of nutrients and will benefit from compost as well as rock phosphate at the same rate.

If legumes are used as green cover plants, it should be considered that they supply significant amounts of nitrogen to the soil when calculating the amounts of compost required. In this case, compost with a rather high C/N ratio should be used. If possible, the compost should be spread in two separate lots: one half (circa 2.5 tons) before planting, and circa 2.5 tons to induce flower formation. Organic foliar feed is also beneficial. However too much nitrogen will result in watery/ glassy fruit as well as in production of multiple crowns on fruits and too many slips. Deficits in the potassium supply can be balanced out by the use of wood ash (combined with compost). In exceptional cases, the certification bodies will allow the use of potassium magnesia in organic farming.
No fertilisation should take place after the first bud stage.

Crop rotation

Crop rotation should be followed allowing several years between pineapple crops on the same land. Some crops usually included in rotation with pineapples are groundnuts, beans, rice and vegetables. To prepare the land used for pineapple production, green manure plants like cowpea, can be grown and incorporated into the soil prior to planting pineapples.
Crop rotation is important to avoid build-up of root knot and other nematodes that contribute to large crop losses. To be effective, crops known to reduce or eliminate root knot nematode infestation should be planted between pineapple crops. (See also biofumigation). For more information on root-knot nematodes click here

Mulching

Use of black polythene 150 gauge is recommended as it helps maintain high soil temperature, retain moisture and controls weeds to some extent. In areas where temperatures are high, use of mulch may not be essential. Use of grass mulch has been found to reduce yields.

Varieties

The most important variety "Smooth Cayenne" is grown commercially in Kenya for both canning and the fresh market.

Propagation and planting

Commercial propagation of pineapple is not through seeds but by vegetative propagation. Three types of planting material are used for pineapple growing. These are crowns, slips and suckers.

- **Crowns are the leafy growth on top of the fruit. In Thika these take 25-28 months to come into bearing, but have uniform growth and are less susceptible to to premature fruiting.**
- **Slips are leafy shoot growth arising from the fruit stalks. They take 22-24 monts to come into bearing.**
- **Suckers are leafy shoot growth from the base of the plant where the roots grow. They give the highest yield, but have a long harvest duration. They are also more difficult to plant. Suckers take 18-22 months to**

come into bearing.

To achieve uniform plant growth, selection and sizing of planting material is of major importance.
All planting material can be stored upside down (to promote suberisation and avoid rotting) in the shade for up to three months and then planted in loose friable dry or preirrigated soil. Only totally healthy and if possible large shoots should be chosen (about 400 to 500 g in weight are best), in order to ensure a uniform crop.
Slips can also tolerate dryness, yet not as well as the suckers as they are generally lighter in weight. Slips vary much in size making grading in sizes necessary in order to have uniform plantings.

Rapid multiplication
If there is shortage of planting material, each type of planting material can be split vertically into two or four sections each with a bit of root section, suberised and planted into irrigated nurseries at very close spacing. They can then produce new plantlets in 3 to 4 months time.

To avoid infection by dry-rot fungus all of the shoots should be stored in a shady place for wounds to heal and suberise quickly. Take care that no mealybugs are present in the shoots or on the leaf blades.
No soil should remain on the shoots to prevent an infection by soil-borne fungus such as e.g. *Phytophtora* spp. and/or nematodes. Hot water treatment (50°C for 30 minutes to two hours) of planting material is efficient and can control both mealybugs, phytophtora and nematodes. After this treatment it is important to drip-dry the planting material to avoid fungus attack and deterioration.
Planting is normally done at the beginning of the long rains.

Spacing

Spacing depends on cropping pattern chosen. For monocropping where irrigation is available a plant population of 70,000 to 100,000 plants/ha is possible. This can be achieved by planting double rows 40cm apart, 60 cm between the double rows, and 20 cm between plants. This can give a yield of 100 to 120 t/ha plus about 40 t/ha for the ratoon crop. Under rainfed conditions spacing between double rows is increased to

double rows 60 cm apart and 90 cm between the double rows and 30 cm between plants. This spacing can yield about 75 t/ha plus 30 t/ha in the first ratoon.
In intercropping the same double rows can be used and interplanted with legumes and/or cereals. The intercropped area and the pineapple area can then switch location when pineapples need replanting. Intercropped legumes help provide nitrogen to the pineapple crop.
(From "Fruits and Vegetables Technical Handbook")

Flower induction

Pineapple flowering may be delayed or uneven, and it is highly desirable to attain uniform maturity and also to control the time of harvest in order to avoid overproduction in the peak periods. Synchronized flowering can be induced by smoke (due to ethylene produced). Ethylene and ethylene-releasing compounds (e.g. Calcium carbide) used in conventional production are very effective. Flower formation in agroforestry systems can be induced by selective tilling of the weeds and by cutting back trees two months before the blossoming is supposed to occur. The sudden increase of light will have a similar effect to using carbide. This enables the harvesting time to be controlled in response to market demand (e.g. before or after the usual regional harvesting season to gain a price advantage).

Harvesting

The fruits are ready to harvest when they snap off at the bending of the fruit. Fresh fruits destined for the local market are plucked when almost ripe. Fresh pineapples destined for export are harvested green-ripe (beginning to turn yellow-green at the base of the fruit). They are cut off with a sharp knife leaving a stem which is later trimmed to 3.4 cm.

Fruits can then be cool-stored for up to four weeks (storage temperature about 7°C). Because of their low sugar-content, pineapples harvested too early are unpopular amongst consumers (unripe pineapples do not ripen after harvest). The colour of the skin is an important criterion in determining the ripeness of the fruit. Fruits destined for the European market are often classified according to the extent to which an orange-yellow

colouring has spread up from the base of the fruit as follows:

- **Ripeness-colour 1: Only the base is orange-yellow.**
- **Ripeness-colour 2: The orange- yellow colour covers half of the fruit.**
- **Ripeness-colour 3: The orange- yellow colour reaches three quarter up.**
- **Ripeness-colour 4: Whole of the fruit yellow.**

Only ripeness-colour 1 can be exported.

Every care should be taken to prevent bruising. Pineapples should not be thrown into lorries as this will cause bruising.

For canning the sugar/acid ratio (°Brix) is measured and the fruit is graded according to sizes. 13 to 16° Brix is suitable for canning. This is only attainable when the fruits mature with plenty of sunshine.The graded sizes are measured on the diameter of the fruit as follows:

- **Grade I - 12.7 cm minimum diameter and 15.3 cm minimum length (about 3 ½ kg fruit)**
- **Grade II - 10.8cm min diameter and 13.3 cm minimum length (2 ½ - 3 kg fruit)**
- **Grade III: 8.9 cm min diameter and 11.4 cm min length (1 ½ - 2 kg fruit)**

Canneries accept only grade I and II.

Pruning

Once the fruit has been harvested, remove all slips and leave generally only one (maximum two) strong and healthy sucker arising from ground level. Leaving more suckers will reduce the size of harvested frutis. The rest of the slips and suckers can be used as additional planting material after sorting or can be chopped and used as mulch. The mother plant can be left in the field as mulch.

Ratoon crop. The yields of ratoon crops are much lower than of the planted crop, so generally only one ratoon crop is economical. A second and third ratoon crop are possible under small scale conditions infested where the crop is interplanted with other crops, and fertilized well, provided there is no mealybug infestation. Once

this has been harvested, all plants need to be dug up and the land prepared for rotation crops.

Planting methods and cultivation systems in organic farming:
In the majority of organic plantations, pineapples are planted together with other crops either in agroforestry or mixed crop systems. Examples exist where pineapples are planted as a rotation-fruit with green fallow land and other crops. The farm plan will depend upon which cultivation form is adopted (agroforestry system, mixed crops as a bottom culture, crop-rotation etc.).

Pineapples are an excellent choice to plant for a limited time on young agroforestry systems. Pineapples as well as papaya are well suited as so-called "nursery crops" to raise trees. Yet, they are less demanding regarding soil fertility. Pineapple plants require a lot of light; they will not produce saleable fruit if grown in the shade. Therefore, they should be planted away from the canopy of trees in an agroforestry system.
Pineapples planted in diverse agroforestry systems will usually have no need to be supplied with external, organic fertiliser. The less varieties an agroforestry systems contains (especially when leguminous trees are lacking), the more the soil will need to be fertilised with compost (or an undergrowth of soil-covering legumes).
Pineapples are easy to combine with other crops as a bottom crop. In particular: coffee, cocoa, coconut, cashew, coconut and date palms, avocado and mango. In diverse agroforestry systems, crop rotation is unnecessary. However, if pineapples are planted as bottom crops in a mixed system, e.g. with oil or date palms, then the crop rotation methods mentioned above must be adhered to in order to avoid a build up of pests and a decrease of the soil fertility.

As soon as the plantation begins to produce fruit, any harvested plants should be removed and cut up before being spread over the soil. The plantation will also need to be thinned out from time to time, because suckers, which continually develop, may limit the amount of room available for each individual plant.
Tilling weeds is neither possible nor desirable in agroforestry systems. When all possible niches are already occupied with plants, weeds will have little chance of gaining a foothold, and can also easily be uprooted by hand. Mature weeds can be cut down with a knife or pulled out and then cut up to be used for mulch material.
One preventative measure is to sow non-climbing legumes before the pineapples are planted (e.g. *Pueraria*

ssp, but *Purearia phaseoloides* develops strong tendrils, and is not suitable for pineapples, some *Vigna* ssp. among others). Usually, this bottom culture will suppress the growth of weeds. Depending upon the amount of water available, when enough weeds have accumulated, these can be cut down and used as mulching material.

Information on Pests

General Information

Pineapples rarely suffer from pests and diseases when good growth conditions are prevalent. The following diseases and pests occur especially in systems which lack diversification.

Examples of Pineapple Pests and Organic Control Methods

Nematodes (*Meloidogyne javanica* and *Pratylenchus brachyurus*)

Root-knot nematodes (*Meloidogyne javanica*) cause distinct swellings (galls/knots) on the roots. The root lesion nematodes (*Pratylenchus brachyurus*) develop brown lesions (spots) on the roots, which may girdle the roots and cause their premature death.

What to do:

- **Practice crop rotation**
- **Allow extended fallow if feasible**
- **Incorporate neem extracts in the soil**

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

The pineapple mealybug (*Dysmicoccus brevipes*)

The mealybugs are oval, pink in colour, up to 3 mm long, covered with a whitish waxy secretion, which develops into waxy filaments around the body. This mealybug is the most serious pest of pineapples, because it is a vector of the Mealybug or Pineapple Wilt Virus. The mealybug is common on the roots of pineapple and large colonies develop on the stems just above ground level.

The mealybugs may spread upwards to feed in the floral cavities, on both small and mature fruit, and on the crown leaves. Heavy infestations are conspicuous because of the white waxy adults, which often occur at the growing points, around the stem nodes, on the undersides of leaves, on the fruit and on the roots.

Feeding on leaves causes yellowing and drying up of the leaf-tips, which progresses towards the base of the leaves. Feeding in the blossom cavities causes wounds, which sometimes become contaminated by fungal spores resulting in a disorder called black spot. Feeding on roots is associated with the rotting of roots and subsequent wilting of the plant. Smooth Cayenne crowns used as planting material are frequently infested

with mealybugs, and therefore new plantations usually become infested from the time of planting.

The bigheaded ant, *Pheidole megacephala*, is commonly associated with mealybug colonies. They do not attack the mealybugs but feed on the honeydew excreted by the mealybugs, preventing the formation of thick honeydew coats where crawlers (young mealybugs) may get entangled. Moreover, while feeding on honeydew, the ants interfere with the mealybug natural enemies. Thus, mealybug colonies thrive in presence of ants. Mealybug infestations may also be spread in new plantings by ants carrying the young mealybugs from one plant to another in their jaws.

What to do:

- **Control ants to give a chance to natural enemies to keep mealybugs under control.**
- **See also what to do by pineapple wilt virus, specified above.**

Pineapple mealybug
Severe infestation of pineapple mealybug (*Dysmicoccus brevipes*) on the fruit
© Bedford ECG, de Villiers EA (Courtesy of EcoPort, www.ecoport.org)

Thrips (*Thrips tabaci* 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.

The onion thrips (*Thrips tabaci*) and the blossom or cotton bud thrips (*Frankliniella schultzei*) are considered important pests of pineapples because they are vectors of the yellow spot virus, which have been shown to be identical to the tomato spotted wilt virus. The blossom thrips feeds mainly on flowers and its feeding results in the development of "dead-eye" in the fruit. Thrips feeding on the crown of fruits results in concentric ring patterns developing on crown leaves.

What to do:

- **Control weeds in and around pineapple as certain weeds leads to increased number of thrips.**
- **Control thrips in the early stages, in particular immature thrips; adult thrips are unable to pick the virus from infected plants. Once the immature thrips are infected with the virus they remain vectors for the rest of their lives.**
- **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. Liquid herbal manure and pyrethrum (in extreme situations) has also been recommended (Naturland, 2001). See also upper section on yellow spot virus.**

Thrips

Adult and immature thrips (*Thrips tabaci*). Immatures (on top) are wingless and generally are light colored. Immatures are generally light colored without wings. The adult has four wings lined with long hairs, it is about 1-1.5mm small.

Information on Diseases

General Information

Pineapples rarely suffer from pests and diseases when good growth conditions are prevalent. The following diseases and pests occur especially in systems which lack diversification.

Examples of Pineapple Diseases and Organic Control Methods

Pineapple top and root rot (*Phytophtora cinnamomi* and *P. nicotianae* var. *parasitica*)

Top rot initially manifests in a colour change of heart leaves from green to yellow or light-brown with a red tinge. The leaf edges curve back and leaves are easily pulled out from the plant. Internally, the stem and leaf bases become soft, rotten and have an unpleasant smell. The growing point of the stem has a cheese-like appearance. Root rot causes similar symptoms like top rot. However, the outer leaves become limp and dieback from the tips. By this stage, the root system has rotten and plants can be easily pulled from the ground. Rot rot often extends through the stem to cause top rot. Fruits from diseased plants are normally small and are not marketable. Both *P. cinnamomi* and *P. nicotianae* var. *parasitica* are soil inhabitants and require water for spore production and infection. These fungi prefer wet soil conditions.

What to do:

- **Do not plant pineapples in soils prone to waterlogging.**

- **Improve soil by selective fruit rotations and application of organic compost material.**

White leaf spot (*Ceratocystis paradoxa*/ *Thielaviopsis paradoxa*)

The fungus *Ceratocystis paradoxa* causes white leaf spot, black rot, base or but rot and soft rot or water blisters. White leaf spots are yellow to brown and several centimetres long. Later they dry to become papery and straw coloured.

Base or but rot of pineapple is a common disease of crowns, slips and suckers used for establishing new plantings. Rot of planting material occurs when they are not dried and are packed with little aeration. The fungus also destroys older plants by entering through wounds caused in the collar region while weeding or other field operations. In severe conditions the entire plant may turn dark and rot within two or three days.

Black rot is a post-harvest disease occurring only on injured pineapple fruit. Only freshly cut or injured tissue is infected, and a soft black rot with dark coloured mycelium develops. Water blisters consist of a soft, watery rot of the fruit flesh with overlying skin glassy, water-soaked and brittle. Eventually, the skin, flesh and core disintegrate and the fruit dries out, leaving an empty fruit carcass containing a few, black vascular fibres. The fungus enters the fruit through wounds and the crevices between individual fruits.

What to do:

- **Use healthy sets of an appropriate physiological age to ensure rapid germination.**
- **Choose sets with at least three nodes to increase the likelihood that the buds towards the centre will germinate before the fungus invades all the tissues.**
- **Use crop management practices that promote germination and rooting. In disease prone areas, if possible, plant varieties that are quick to germinate. Varieties that are slow to germinate should be treated in hot water (50°C for two hours).**

- **Avoid extremely wet or dry soil conditions.**
- **Do not plant freshly cut pineapples unless dried out.**
- **To prevent the spread of the pathogen, avoid wounds to tissue and remove infected pineapple plants.**
- **Improve soil drainage and avoid planting during wet weather.**

Black rot
Black rot (*Ceratocystis paradoxa*) of pineapple

Mealybug or pineapple wilt virus

Infected plants become yellowish-red to bright red at the leaf tips, this colouration spreading down the leaf with time. Soon other leaves turn colour and also show signs of wilting. However, the inner heartleaves remain normal. Severely infected plants become stunted and produce small, undergrade and immature fruits. The first effect of the disease usually appears in the roots, which stop growing, collapse and then rot; this results in leaves symptoms similar to the effect of drought. The root system collapses and rots before the first leaf symptoms appear.
The disease is probably introduced in planting material, which may not show obvious disease symptoms. Once established, it is spread by mealybugs, sedentary insects, which are moved from plant to plant by attendant ants. The mealybugs are found at the base of leaves, moving on to healthy plants once their host starts to wilt. Mealybugs are also moved from plant to plant by attendant ants.

Warm weather favours the build-up of mealybugs and this is when most serious outbreaks of the disease occur. Plants growing vigorously as on virgin land and well-fertilised soil (especially with nitrogen fertiliser) appear to be more resistant to wilt. Adverse growing conditions increase the susceptibility of plants to wilt. Plants may recover from wilt to different degrees, depending on the extent of the wilt and the age of the plant at the time of wilting; younger plants stand a better chance of recovery. Older plants are less susceptible than younger plants, and slips and suckers less susceptible than the mother plant on which they are borne.

What to do:

- **Use planting material from wilt-free areas.**
- **Control mealybugs. For more information on mealybugs click here**
- **In Hawaii, heating pineapple crowns in a large water bath at 50°C for 30 minutes permitted 100% plant survival and rendered 100% of the plants free of pineapple wilt-associated-virus. Growth of the heat-treated plants is more rapid than in non-heat-treated plants. The heat-treated plants are not readily colonised by mealybugs, nor do they show mealybug wilt even after more than two years from being planted in a commercial crop with severe mealybug wilt (Ullman et al., 1993).**
- **Plant resistant varieties if available. Some varieties of pineapple are more resistant to the virus than others, the variety Cayenne (and 'Masmerah') being highly susceptible. 'Singapore Spanish' shows some resistance.**

Yellow spot virus

The yellow spot virus has been shown to be identical to the tomato spotted wilt virus. It infects over a 100 species of plants including peppers, tomato, tobacco, eggplant, potato, broad bean, spinach, chicory and peas. A number of wild plants, including some common weeds such as the black jack (*Bidens pilosa*), *Emilia sonchifolia* and *Datura stramonium*, are also host of this virus.
Thrips are vectors of this virus. When host plants of the virus are grown near to pineapple plants, the

incidence of the yellow spot virus is considerable enhanced due to thrips migrating into the pineapple field. Wind carries thrips long distances and thus also plays an important role in the transmission of the virus. One of the symptoms in the fruit is a blackened, dry cavity in the side of the fruit due to one or more "eyes" having died. This is known as "dead eye". Infection of very young fruit results in an irregular arrangement of fruitlets as some fail to develop. Attacked fruits may also fail to develop a crown. Thrips feeding on the crown of fruits results in concentric ring patterns developing on crown leaves. These spots enlarge and the infection spreads into the fruit itself, by which time the crown will often have dried out. The flesh of fruits thus infected will be discoloured and necrotic below the butt of the crown. The whole fruit may eventually become affected.

What to do:

- **Control weeds in and around pineapple fields. This is very important for disease control because the presence of certain weeds leads to increased number of thrips.**
- **Field management offers potential effective control. Cut off the fruits showing early symptoms of infection. This will prevent the spread of infections into the fruits.**
- **Where this disease is a problem avoid planting near host plants of the thrips and the virus. Even if thrips are not strongly inclined to migrate from their favoured host plants, they will do so if disturbed, for instance by human passing, animals or machinery.**
- **Control thrips. For more information on thrips click here**

Information Source Links

- **ARC-Institute for Tropical and Subtropical Crops (2000). Cultivation of pineapples. www.nda.agric.za. Also available from the National Department of Agriculture at: www.nda.agric.za/publications ISBN 1-86871-072-6**
- **Acland, J.D. (1980). East African Crops. An introduction to the production of field and plantation crops in Kenya, Tanzania and Uganda. FAO/Longman. ISBN: 0 582 60301 3**
- **Agricultural Information Centre, Nairobi (2003). Fruits and Vegetables Technical Handbook**
- **CAB International (2005). Crop Protection Compendium, 2005 edition. Wallingford, UK www.cabi.org**

- **Common Names of Diseases, The American Phytopathological Society.Retrieved from "en.wikipedia.org/wiki/List_of_pineapple_diseases"**
- **FICCI Agribusiness Information Centre India**
- **Food Market Exchange (2002-2003). foodmarketexchange.com**
- **Morton, J. (1987). Pineapple. p. 18?28. In: Fruits of warm climates. Julia F. Morton, Miami, FL. www.hort.purdue.edu**
- **Naturland e.V. www.naturland.de (2001). Organic farming in the Tropics and Subtropics. Pineapples. 209.85.135.104/search?q=cache:NCsncqmaumAJ:www.naturland.de/fileadmin/MDB/documents/Publication/English/pineapple.pdf**
- **Personal interview with Dr. S. Nganga, former Head Superintendent, Founder of Research and Development at DelMonte, Kenya.**
- **Petty, G. J. (1994). The pineapple mealybug. Institute for Tropical and Subtropical Crops, Nelspruit. H. 15/1994.**
- **Ullman, D. E., Williams, D. F., Fleisch, H., Hu, J. S., Sether, D., Gonsalves, A. (1993). Heat treatment of pineapple: subsequent growth and occurrence of mealybug wilt of pineapple. Acta Horticulturae, 334:407-410.**

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Cocoa

Cocoa
Scientific name: *Theobroma cacao*
Family: Malvales: Sterculiaceae
Pests and Diseases: Aphids Cocoa bud or black rot Fruit flies Helopeltis bugs Leafhoppers Mealybugs Pod borers Pod rot Snails (Giant East African Snail) Spiny bollworm Thrips Ants, Anthracnose

General Information and Agronomic Aspects

Geographical Distribution of Cocoa in Africa

The crop was known to the Aztecs, who relished it as a "drink of the Gods". The cocoa seeds are highly rich in fat content, and therefore provide an energy-rich and delicious foodstuff.
Today, cocoa is cultivated in all of the humid, tropical countries.

The main products made from cocoa beans are chocolate, cocoa powder and butterfat, which are all used for human consumption. Butterfat is also used in cosmetics and pharmaceutical products but the amount used for these purposes is insignificant in relation to that used in chocolate manufacture. On the international market, raw cocoa (dried cocoa seeds) is most seeked after for product, which is used for production of cocoa butter, chocolate, and cocoa powder.

Climate conditions, soil and water management

Cocoa grows in the primary forests in the so-called under-storey and is associated with a variety of palm species, as well as a number of other different tree varieties. For example, with tree varieties stemming from the upper storey in rain forests, among them mainly single trees overtopping the forest canopy which lose their foliage during the months of shorter daylight hours. The resulting increase in light encourages the development of the cocoa blossoms, and the falling leaves an enrichment of organic material.

With an even annual distribution of rainfall (100 mm per month), the plantations can survive on 1250 mm per year. Short drought periods can be compensated for by heavy clouds and high humidity. The average annual temperature should be around 25°C. In regions with extensive wet periods or large seasonal temperature fluctuations, the harvesting periods are reduced to only a few months per year. In regions with a balanced climate, and only slight temperature and rainfall fluctuations, cocoa produces fruit practically throughout the year. Cocoa is thus a typical crop of the tropical lowlands. It can also be grown at higher altitudes if other conditions are favourable. Especially in areas without a dry season, cocoa has shown to develop more quickly than in the major production areas of West Africa, where growth is stopped by drought during certain months

of the year.

The soil on cocoa plantations should be deep, well-drained, and have sufficient water-retaining capacity. Soils with a high available moisture-storage capacity can compensate for periodic lack of rain, while excessive rainfall will cause fewer problems on well-drained soils. The pH-value should lie between 4.0 and 7.5. Care must be taken that sufficient organic material is available.
Cocoa trees can live for over one hundred years. Naturally occurring cocoa crops propagate themselves through lateral shoots, which can occur at any height on the trunk. The natural vegetative proliferation occurs when the seeds are spread by small rodents and apes.

Propagation and Planting

When choosing the site for a new plantation, the natural site requirements of cocoa should be adhered to. Ideal sites are those with alluvial soils, which are not susceptible to water-logging. Other suitable sites are sites irrigated form wells, and in hollows. Unsuitable sites are steep and convex slopes. When you create a new plantation, take care to reproduce as closely as possible the natural structure of forests. This means that all of the varieties that are to be cultivated along with cocoa in the agro eco-system should be planted at the same time (or even beforehand) as the cocoa. The best method is to leave an area free for natural growth, and to plant tall-growing trees which will rapidly provide cover, such as bananas and manioc, and to plant the cocoa in-between them at a later date. This way, the biological activity of the soil is maintained, and the mycorhiza of the cocoa can begin to develop immediately.

Cocoa is usually planted as seedlings, which are easy and cheap to produce. Vegetative propagation by rooted cuttings or budding is used to establish seed gardens. Seedlings are usually raised in polythene bags in a shaded nursery. Young plants are planted in the field 3 - 4 m apart or about 1100 trees/ha at an age of 4 - 6 months. Young trees need shade to reduce irradiance, to buffer the microenvironment and to promote the right shape and habit of the trees. When a closed canopy has been formed, the need for shade is reduced. Only under most favourable conditions of soil and nutrient supply can cocoa be grown without shade. It is

normally necessary to retain some shade to reduce moisture stress and incidence of insect damage in order to prolong the economic life of plantations.

Shade can be provided either by thinning forest or by planting shade trees. Shade trees are common in South-East Asia, where mainly seedless *Leucaena leucocephala* and Mother of cocoa (*Gliricidia sepium*) are used. Often, hedges of leguminous shrubs are used for temporary side-protection between rows and as a source of mulch. Cocoa is also grown as an intercrop under coconuts.

Budding of cocoa plants

© Putter CA (Courtesy of EcoPort, www.ecoport.org)

Organic fertilisation strategies

It is not advisable to use fertiliser that has not originated from the site's production, also of organic origin, because the costs are simply too high. Creating organic material through mulching and pruning activities is sufficient for an economically viable production, provided a stratified (multi-phase), diverse and densely planted system is in place.

Any shells that are left over after the harvest must remain on the plantation. This means that the fruits should be broken open on site, if possible. The resulting shell material should be spread as evenly as possible. The

cocoa pods harvested on a plot are first plied into a heap, and then broken open to provide around 50 kg of fresh cocoa. The cocoa pods should then be plied onto a different heap during the next harvest stage, and broken open there.

Many varieties of palms are capable of actively breaking down phosphorus, as well as binding heavy metals in the soil, which thereby reduces the amounts absorbed by the cocoa plants. This can be useful, because the amount of heavy metals in the cocoa seeds can be problematic. It is therefore recommended to integrate suitable palm varieties into the plantation.

Husbandry

During the first three years, selective weeding is required, whereby grasses are removed, and flowering weeds cut down to be used as mulching material. Trees which do not loose their leaves need to be radically trimmed during the blossoming period of the cocoa (ca. 6 months before the main harvest begins), in order to increase the amount of light. The resulting organic material should then be chopped and spread out over the soil. Diseased plant parts and pods should be removed. The cocoa trees should also be lightly trimmed, and diseased or poorly developed trees removed (in cases of direct sowing), during these shading regulation tasks.
Once the canopy has closed, lack of light will prevent weed growth. Young trees need no pruning during the first 2 - 3 years. Later, low-hanging branches should be pruned to facilitate harvesting. Vertical growth is usually restricted to the first jorquette (fan of branches). If the first jorquette is formed too low (below a height of 1.5 m), the tree is allowed to make a second one. To retain trees at the desired height, cocoa seedlings (chupons) should be removed at regular intervals.

Diversification strategies for cocoa

Diversification strategies for Cocoa 1

1. Year	2. Year	3. Year	5. - 10. Year	from 11. Year
Maize/dry rice	Sweet potato (Ipomoea batata)			
Papaya	Papaya	Papaya		
Bananas	Bananas	Bananas	Bananas	
Cocoa	Cocoa	Cocoa	Cocoa	Cocoa
Forest trees	Forest trees	Forest trees	Forest trees	Forest trees

Diversification strategies for Cocoa 2

1. Year	2. Year	3. Year	5. - 10. Year	from 11. Year
Maize-beans-Okra	Cocojam, Taro (Xanthosoma sagittifolium or Colocasia esculenta sp.)			
Bananas	Bananas	Bananas	Bananas	
Cocoa	Cocoa	Cocoa	Cocoa	Cocoa
Forest trees	Forest trees	Forest trees	Forest trees	Forest trees

Diversification strategies for Cocoa 3

1. Year	2. Year	3. Year	5. Year	6. to 10. Year	from 11 Year
Manioc	Okra (Hibiscus esculentus)				
Pineapple	Pineapple	Pineapple	Pineapple		
Bananas	Bananas	Bananas	Bananas	Bananas	
Cocoa	Cocoa	Cocoa	Cocoa	Cocoa	Cocoa
Forest trees	Forest trees	Forest trees	Forest trees	Forest trees	Forest trees

Diversification strategies for Cocoa 4

1. Year	2. Year	3. Year	5. Year	6. to 10. Year	from 11. Year
Maize					
Papaya	Papaya	Papaya			
Bananas	Bananas	Bananas	Bananas	Bananas	
Rubber	Rubber	Rubber	Rubber	Rubber	Rubber
Cocoa	Cocoa	Cocoa	Cocoa	Cocoa	Cocoa
Forest-/	Forest-/	Forest-/	Forest-/	Forest-/	Forest-/
Fruit trees	Fruit trees	Fruit trees	Fruit trees	Fruit trees	Fruit trees

Rice as well as maize can be sown as a pioneer crop, depending on the starting conditions (soil fertility, market access, consumer habits, etc.), simultaneously with manioc (*Manihot esculentum*), new coco-jam (*Xanthosoma sagittifolium*) in Nigeria and Cameroon and pigeon peas (*Cajanus cajan*).
Before a pioneer crop is sown, bananas should be planted. The distance between each plant depends on the distances between the individual cocoa plants and the variety of banana. Along with standard commercial varieties of banana from the Cavendish group, other tall-growing local varieties which can tolerate shade should also be integrated into the plantation. The number of cocoa trees should lie between 600 and 1100 trees per ha.

During the first few years, on fertile soils, papaya (*Carica papaya*) can also be cultivated in addition to bananas within the system (2 x 2 m). Together with the papaya seeds or bananas, trees growing up to the middle storey (such as *Inga* ssp., *Erytrina* ssp., *Gliricida sepium*) as well as growing up to the upper storey must also be planted. This can be in seed form. Only in the cases of certain varieties (such as e.g. palm varieties that are old, or difficult to germinate), should the trees be first sown in a tree nursery. The choice of tree depends on which varieties are available in the region. In addition to the varieties listed above, it is recommended to integrate palm species at a density of 100-150 trees per ha in organic cultivation systems. Many combinations are possible, in which other fruit trees such as avocado, jackfruit and many more can be integrated.

Monoculture plantations that already exist, and which have only very few shading trees can be improved. The

best method is to re-forest wrongly cultivated spots, and also spaces that become available after unproductive single plants have been removed.

Harvesting

The most essential quality characteristics of cocoa depend on the correct processing, which begins with the harvesting process and ends with the storage method. Pod development from setting to maturity takes about 6 months. The harvest can begin when the pods are completely ripe. In many Trinitario types, with their red and dark violet pods, this can be recognised by an orange discolouring of the shell. Yet other varieties take on a yellow colouration when ripe.
Depending on the region and weather conditions, there are usually one or two harvesting phases, which are spread out over several months. In order to achieve a uniform ripeness of the pods harvested, it is wise to harvest all of the ripened pods every 2-3 weeks. During peak production, pods are harvested each week. The best way to avoid harming the bark is to cut off the pods at the base of the blossom with a sharp knife or other suitable instrument.

Storage

Cocoa can be stored for years in temperate climates without fear. In the moist tropics on the other hand, the high temperatures and humidity cause a rapid infestation of storage pests and mould fungi. Because cocoa is strongly hygroscopic, even a product that has been well dried can rise in moisture content up to 10% in regions with 80-90% humidity, and thereby lose its capacity to be stored, the critical value for which is 8%.

The cocoa should be stored in air-permeable sacks on the production site for only a short time, whereby the sacks should be stacked on wooden planks or boards. The use of sacks made of organic material (jute) should be avoided, if these have been treated with pesticides. The cocoa butter part in the cocoa shell is an excellent solvent for chlorinated hydrocarbons which can diffuse through the outer shell when they come into contact with it, and into the cocoa seed. In such cases, tests have then shown limits for certain agricultural

poisons being exceeded - although no pesticides had ever been used on the site.

The storage area should always be well-ventilated - the inside temperature should remain below the outside temperature.

On conventional plantations, it is quite usual to gas the cocoa with methyl bromide in order to protect them against storage pests. In addition, tetraline soap, hydrogen phosphide and prussic acid are also used. On organic cocoa plantations, it is not permitted to use either insecticides against storage pests, or to gas the beans.

Cocoa beans should be stored in dark, dry and well-ventilated rooms at low temperatures.
Short-term: ca. 16°C; relative humidity: 55%
Long-term: ca. 11°C; relative humidity: 55

Information on Diseases

Biological methods of plant protection

Most diseases are caused by the following:

- **Cultivation in monocropping systems with no or only very few varieties and number of shading trees (on conventional plantations, 25-40 trees of mostly one variety per ha recommended)**
- **Ignoring the natural rotation of the forest system. For example, cocoa plantations which grow beneath old shading trees from the secondary forest system (mostly *Inga* ssp., *Gliricidia sepium* etc.), are highly susceptible to diseases and pests. Cocoa, as a plant from the primary forest, can tolerate old primary forest trees above it, yet not trees from the secondary forest system.**
- **Too little distance between the different varieties in a system which have the same status; failure to thin out the agroforestry system**
- **Degraded and poor soils, lack of organic material**
- **Unsuitable site (water-logging, too dry, no possibility for deep root development)**

Effective measures are often only possible in the form of improvements to the whole system. One possibility lies in radically cutting back the trees and subsequently replacing them with the correct varieties, or, with a complete renewal measure, whereby the trees are sawn down to a stump of around 40 cm. One to three of the resulting shoots which develop out of the stumps are left to develop. Opening up the plantation allows many new varieties to be included.

A tolerable loss at harvest time, which is also heavily dependant on weather conditions, is often caused by the fungus (*Phytophtora palmivora*). In addition to the measures described here, regular harvesting, which should then include diseased fruit, can reduce the infestation (many farmers only harvest the healthy fruits). In the case of a heavy infestation by *Phytophtora palmivora*, harvest losses can be alleviated with Bordeaux mixture, or other spray preparations containing copper, that are permitted on organic plantations. These methods should only be used in emergencies.

Examples of Cocoa Diseases and Organic Control Methods

Fungal diseases are of major importance both to the trees and the pods, although cocoa types show a wide range of susceptibility.

Fungal infections are caused by *Botryodiplodia theobromae, Colletotrichum* sp. (Anthracnose) and *Trachysphaera fructigena*. On cocoa, infection by *T. fructigena* is an insignificant component of pod diseases.

More information on these diseases will follow.

Cocoa bud rot or Cocoa black rot (*Phytophthora palmivora*)

It is a foot rot disease caused by the fungus (*Phytophthora* sp.) which results in large pod losses in West

Africa and stem canker in Trinitario populations.

Cocoa bud rot attacks the whole plant. On pods, the disease begins with a circular brown lesion that enlarges to cover the whole pod. It eventually becomes black and mummified, and sometimes covered in a white mass of fungal growth (sporangia). Stem cankers are characterised by oval to round, rusty-brown discolouration of the external bark that looks purple when scraped. Attack of young shoots results in die-back.

Regular harvesting plays the greatest role, as it reduces spread to other pods and bark where stem canker and flower cushion infections may develop.

What to do:

- **Harvest pods regularly and remove diseased pods.**
- **Thin canopy to improve airflow and reduce humidity.**
- **Space planting in well drained sites.**
- **Avoid infested soil.**

Cocoa black rot / bud rot
Cocoa black rot (*Phytophthora palmivora*)
© Jürgen Kranz (Courtesy of EcoPort, www.ecoport.org)

Pod rot of cocoa (*Lasiodiplodia theobromae*)

In cocoa pod rot the infected tissue shows brown necrosis with dark brown powdery spore masses. Such infected tissues show greyish-black mycelia.

The fungus is most important as a cause of postharvest food decay. It also causes damage in cocoa in the form of dieback disease.

Information on Pests

Biological methods of plant protection

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

A variety of insect pests are important during establishment, because they destroy the apical bud and delay or prevent canopy formation. In mature cocoa, mirids (Helopeltis and other regionally specific genera) are the major widely represented insect pest, causing severe damage to twigs, branches and young pods.

An infestation of pests in a cocoa plantation has the same causes as diseases which affect a system. The causes are listed under 'diseases'.

The losses caused by these pests world-wide is enormous. They result from the cocoa fruits being sucked dry in all stages of growth, after which, the plant dies off, according to the amount of damage done.

Without losing sight of the need to combat the root causes, a solution which can be immediately utilised to save a harvest is by spraying with a 3% alkaline soap solution (potassium soap), which has proven itself in Bolivia in regulating different bug varieties. In addition, other preparations being permitted on organic farms

can also be used.

Some common pests of cocoa are:

- **Mealybugs (Planococcus, Stictococcus in Africa)**
- **Bollworms and various other psyllids**
- **Leafhoppers**
- **Thrips (*Selenothrips rubrocinctus, Heliothrips rubrocinctus*)**
- **Leaf cutter ants (*Atta* ssp.)**

More information on these pests will follow.

Examples of Cocoa Pests and Organic Control Methods

Helopeltis bugs (*Helopeltis schoutedeni*)

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

Typical feeding damage of Helopeltis species appears as a discoloured, necrotic (blackened) area or lesion around the affected plant tissue.

Heavy infestations of Helopeltis species can result in pod malformations and premature drop, thus providing a venue for secondary infection by microorganisms and serving to attract other pests to cacao.

What to do:

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

Helopeltis bug
Helopeltis bug (*Helopeltis schoutedeni*). Real size: 6 to 10 mm long.
© F. Haas, icipe


Helope Helope

Pod-borers (*Characoma stictigrapta*)

Pod-borers are serious pests of cocoa. The pod husk borer (*Characoma stictigrapta*) for example, occurs in West Africa.

The damage is done by the larva which bores holes into pods of all sizes. It produces a mass of frass held together by silk at the entrance of the holes. If the pod is very young and soft (cherelle) then it wilts. The insect is usually not controlled.

What to do:

- **Simple cultural methods, such as adjustment of shading level or improved soil drainage, will contain many of the most troublesome diseases.**

Pod-borer damage on cocoa
Pod-borer *Characoma stictigrapha* damage on cocoa
© www.dropdata.net

Pod-borer …

Pod-borer …

The spiny bollworm (*Earias biplaga*)

It feeds on a wide range of plants and also attacks cocoa. It may prefer wild hosts to crops. If crops are grown while wild hosts are available nearby, the crops may not be badly affected. Wild hosts will also maintain a

supply of natural enemies.

The larva eats the growing tips of the stems and young soft leaves. It?s feeding activity prevents the plant from growing properly to form canopy.

The attack is more where there is no shade over the cocoa. It?s attack therefore may be prevented if fast growing shade trees are provided over cocoa that has been freshly planted.

What to do:

- **Adjust shading level**
- **Improve soil drainage**

Spiny bollworm
Caterpillar of the spiny bollworm (*Earias biplaga*)(here on okra plant)
© A.M. Varela, icipe

Spiny boll…

Spiny boll…

Mealybugs

Mealybugs infest fruits and foliage. They can be serious pests in the warm season, if natural enemies, which usually control them, are destroyed by spraying with pesticides.

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

Leafhoppers (*Empoasca* spp)

Adult leafhoppers are small (2 to 3 mm long), long and thin. The wings are held roof like over the abdomen. They are pale green to yellowish green in colour, shiny and more or less transparent. The legs are slender with bristles. The nymphs resemble the adults but are smaller and do not have fully developed wings. Adults and nymphs suck sap from the leaves, remaining on the underside during the day, but also moving to the upper surface during the evening; when disturbed they run sideways rapidly to reach a shady part of the host plant.

Feeding by leafhoppers causes discolouration, and leaf curl, the outer zone of the leaf turn yellow to reddish and whiter later. Heavy leafhopper infestation may retard plant growth and cause severe yield losses. In Africa, leafhopper damage is usually minor and does not warrant control.

Leafhoppers
Leafhopper. Adults are small, about 2.5 mm long. Picture shows *Empoasca fabae*

Red-banded thrips (*Selenothrips rubrocinctus*)

Adults of the red banded thrips are dark brown or blackish. Nymphs are pale yellow with a broad transverse red band on the dorsal side of the abdomen. Thrips attack older leaves, flowers and shoots. Attacked leaves drop off leaving bare shoots with few young leaves at the tip. Infestation of flowers causes poor fruit formation. Locally limited infestations may cause considerable damage.

What to do:

- **Conserve natural enemies. Anthocorid bugs are important in natural control of thrips.**

Red-banded thrips

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

Information Source Links

- **CAB International (2005). Crop Protection Compendium, 2005 edition. Wallingford, UK www.cabi.org**
- **Naturland e.V. (2000). Organic Farming in the Tropics and Subtropics. Exemplary description of 20 crops. Cocoa. www.naturland.de**

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Yam

Yam
Scientific name: *Dioscorea alata*
Family: Violales: Dioscoreaceae
Common names: White yam / water yam / greater yam
Pests and Diseases: Anthracnose Fusarium wilt Greater yam beetle Mealybugs Pigs Scale insects Rodents, Snails, Larger grain borer, Scales, Mealybugs, Nematodes, Termites

General Information and Agronomic Aspects

White Yam is native to Southeast Asia and is grown in practically all parts of the tropics where, except in parts of Africa, it is the predominant kind of yam.
West Africa is the most important area for yam production in the world. Over 90% of global yam production comes from this region. Nigeria alone produces about 68% of the world's yams, flowed by Cote d'Ivoire, Benin, Ghana and Togo. Within West Africa,

Geographical Distribution of Yam in Africa

production occurs in the northern forest and southern savanna zones. Further north, the rainy season is too short, and further south the soils are waterlogged and there is too much cloud cover for economical yam production.

Elsewhere in Africa and in the rest of the tropics, the white yam (water yam) is the dominant yam species. Significant quantities are produced in Democratic Republic of Congo, Ethiopia, the Central African Republic and Sudan.

Yam is a preferred food security crop in the drier areas of Kenya. One plant is reported to be able to produce one full 90 kg bag of tubers, which can be harvested a few at the time for home consumption or sold in the market for a good price. Many families in Kenya plant yam near the trees in the shamba, so they can get support for climbing vines.

The tubers and larger bulbils of white yam are consumed as a starchy staple, after cooking in various ways. They can be processed into yam flakes or yam flour. Their use as a source of starch is minor.

Climate conditions, soil and water management

White yam is a plant of the subhumid to humid tropics but also does well in semiarid regions, in fairly light soils. Reported temperature range for growth is 14-40°C with the optimum between 20-32°C or 25-30°C. The growth is considerably retarded at temperatures below 20°C.

Since it requires 7-10 months to mature in the field, it is essential that the rainy season lasts at least as long, unless supplementary irrigation can be provided. A well-distributed rainfall (or water supply) of 1500 mm per annum is adequate for yam production. However, dry spells of up to a month during the growing season need not severely reduce yields. It is occasionally grown in high rainfall areas in East Africa. Reported annual rainfall range for growth is 700-8000 mm with the optimum between 1200-4000 mm.

It is mostly a crop of the lowlands, though it occurs at elevations of up to 2500 m (in India). It tolerates poorer soils than most other cultivated yams. White yam is sensitive to aluminium toxicity in the soil.

It thrives in deep, fertile, well drained, loose, loams and sandy-loam soils with low levels of salinity. It can tolerate poorer soils than most other edible yams but responds well to manuring. However compared with other tropical tuber crops, yams require soil of high fertility. Heavy clays tend to be waterlogged and result in tuber rots and difficult harvesting. Gravel or rocky soils tend to hinder tuber penetration. Reported soil pH range for growth is 4.8-8.5 with the optimum between 5.5-6.5.

Propagation and Planting

Tuber dormancy lasts for 2-4 months after harvest. Small intact tubers ("seed tubers") or tuber pieces weighing 50-500 g are used for planting on mounds, ridges, or on the flat. Intercropping is the most common practice, with the distance between Yam plants determined by the number and types of the other crops in the field. Where sole cropping is done, rows are 1 m apart, with intra-row spacing of 50-100 cm.

Husbandry

Plants are usually staked soon after emergence. Unstaked cultivation, which suppresses weeds better but gives lower yields, also occurs. Weeding is done 3-4 times during the season, using hand tools. In general, yam is the first crop in the rotation after fallow.

Harvesting

Harvesting occurs 7-10 months after planting. Hand tools are used to dig up the tubers. Although the tubers can be kept quite well, they are easily damaged during and after harvest, and are handled carefully to avoid bruises. They are stored in cool shady conditions. Tubers can be processed into yam flakes or yam flour, or marketed fresh.

Information on Diseases

Anthracnose (*Glomerella cingulata*)

It is a serious disease which results in blackening and dieback of the leaves. The disease is more severe on white yam than in other edible yams.

What to do:

- **The best control measure is the use of resistant cultivars such as 'TDA 291' or 'TDA 297' (International Institute for Tropical Agriculture (IITA).**

Anthracnose on yam
Anthracnose (*Glomerella cingulata*) on yam (*Dioscorea alata*)
© Grahame Jackson (Courtesy of EcoPort, www.ecoport.org)

Fusarium wilt (*Fusarium* spp.)

Fusarium wilt and other tuber rots afflict white yam tubers, especially in storage.

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

Information on Pests

The greater yam beetle (*Heteroligus meles*) attacks the tubers. Adult beetles eat the planting setts and plants may wilt and die. The holes in tubers reduce market value.Scale insects and mealybugs may infest the tubers, especially during storage.

Nematodes attack the plant, resulting in warty appearance of the tuber.

Wild animals such as pigs and rodents may destroy the crop in some locations.

The greater yam beetle (*Heteroligus meles*)

***Heteroligus meles* is widespread in tropical Africa. It attacks the tubers. Adult beetles eat the planting setts and plants may wilt and die. The holes in tubers reduce market value.**

Adult beetles are 23-33 mm long, dark brown to black, with two prominent knobs on the head. The beetles lay

eggs in the soil close to river banks and these hatch to produce creamy-white to grey larvae, which feed on grass roots and other organic matter. From egg to adult takes 22-24 weeks and emergence coincides with the beginning of the rains and the planting of yams. Further attack occurs just before harvest when the beetles again feed voraciously and then migrate to the breeding sites.

What to do:

- **Yam beetles can be controlled by planting as late as possible in the season.**

Yam scale (*Aspidiella hartii*)

Infestations of tubers and sometimes foliage cause poor growth. Stored tubers are particularly susceptible to attack and large numbers cause shrivelling.

Adult female scales are pinkish-brown, roughly oyster-shaped, conical, with a white patch at the tip of the cone. Younger scales with relatively more white. Crawlers are yellow.

Information Source Links

- **A.A. Brunt, G.V.H. Jackson and E.A. Frison, FAO/IBPGR Technical guidelines for the safe movement of yam germplasm. http://www.cabicompendium.org/cpc/library/ipgri/yam.pdf**
- **CAB International (2005). Crop Protection Compendium, 2005 edition. Wallingford, UK www.cabi.org**
- **OISAT: Organisation for Non-Chemical Pest Management in the Tropics. www.oisat.org**

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Carrot

Carrot
Scientific name: *Daucus carota*
Family: Araliales: Apiaceae
Pests and Diseases: African armyworm Bacterial soft rot Cottony soft rot Cutworms Damping-off diseases Leaf blight Powdery mildew Root-knot nematodes

General Information and Agronomic Aspects

Geographical Distribution of Carrots in Africa

Carrot is a popular vegetable with a high vitamin A content, grown in East Africa mostly in the cooler highlands. The roots are consumed raw or cooked, alone or in combination with other vegetables (for example, peas), as an ingredient of soups, sauces and in dietary compositions. Young leaves are sometimes eaten raw or used as fodder. Carrots are an important source of vitamin A in human diets. Vitamin A deficiency can lead to blindness and especially for children to a greater risk of dying from ailments such as measles, diarrhoea or malaria.

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)	Thiamine (mg)	Riboflavin (mg)
Carrot	42	1.1	9.7	0.8	37	36	0.7	341	11000	0.06	0.05

Climatic conditions, soil and water management

Carrots can grow under a range of climatic conditions, but they perform best under moderate temperatures. They are mostly cultivated as a cool season crop. Seed germination occurs between 7°C and 30°C. Optimum air temperatures are 16-24°C. Soil temperatures above 25°C may reduce root quality, including root colour. High temperatures can cause burning of young seedlings. For economic yields, carrots should be grown in tropical regions at altitudes above 700 m. Early-maturing carrot cultivars may grow in the lowlands, but yields will be low and roots will have a poor colour.

Carrots grow best in a well-drained friable loam free of stones and hard soil clods. It is a short season crop of 2-3 months with the potential of high yields for family food security and fresh market sales. It does well in the cooler areas of Kenya under both rainfed and irrigated conditions.

Propagation and planting

Carrots are propagated by seeds. Seeds are sown, often mixed with sand, 1/2 - 1 cm deep in drills 10-15 cm apart in finely prepared soils previously cultivated to a depth of at least 30 cm. Lightly aerate the soil by shallow digging before sowing carrots or sow them in ridge culture (small dams of 10 to 20cm height) to facilitate mechanical weeding, thinning, and to limit soil borne diseases. In addition, this will allow easier penetration by the carrot root and will also improve water holding capacity.
Seedlings are thinned to 5-8 cm in the rows. Seed requirements (200 plants/m² and 70% germination) for the dominant half-long carrot cultivars used in Asia, are 4-5 kg/ha. For bigger carrots, the density may be reduced

to about 100 plants/m².

Examples of Varieties

Chantenay	**Fresh market and canning**
Nantes	**Fresh market**
Amsterdam forcing	**Fresh market variety**
Little finger	**Suitable for canning**
Touchon	**Fresh market**

Carrots that bolt (produce seed) in between normal carrots should be pulled out and fed to livestock. Seed produced this way will not produce good quality carrots. Seed production under tropical highland (above 1200m) conditions is possible by selecting and harvesting the best quality mature carrot roots and replanting them separately in a corner of the field. Bolting and seed setting soon follows.

Husbandry

Crop rotation is essential to reduce soil borne diseases and pests. Mulching (rice straw or dried grass) after sowing is recommended to encourage germination. Seedlings may be earthed-up when roots start swelling to keep them cool and prevent green tops. Temperature of 15 to 20°C is optimal for seed development. In hot weather, light overhead shade is beneficial. Under such conditions carrots grow well under the canopy of fruit trees. Irrigation during dry spells is necessary to prevent irregular root development. Nutrient requirements of carrots are particularly high for potassium (200-300 kg/ha), low to medium for nitrogen (0-90 kg/ha), normal for phosphorus, calcium, magnesium and other elements. Carrots are sensitive to high Cl concentrations and more susceptible to diseases at very high soil pH. Liming is recommended when pH is below 5.5. Well-decomposed organic manures are beneficial when applied moderately (10-20 t/ha). Fresh organic matter such as farmyard manure or from a leguminous crop, can result in forked roots, which are difficult to clean and to

market.

Young carrot seedlings are weak and grow slowly. Therefore, it is essential to keep weeds under control for the first few weeks after germination. Cultivate shallowly with a hoe.

Deep cultivation may injure the roots. Weeding and thinning of young plants can be very labour intensive, for which reason most families grow fairly small beds at any one time.

Intercropping

Because of their limited space requirements and early growing habits, carrots are ideal for intercropping between other crops such as tomatoes, lettuce or capsicums and because of their fragrant leaves can help keep pest levels low. Other crops good for intercropping with carrots include garlic, dwarf bean, onion, parsnip, leek, small peas, pea mange-tout (snow peas), and radish. The most profitable example of an association is that of carrots and leeks. Carrots have very deep roots that extract nutrients deep in the soil, whereas leeks have extremely superficial roots, which help the crop to extract nutrients near the soil surface. Moreover, carrots can drive away worms from leeks, while leeks can drive away flies from the carrots (TOF Nr. 8, page 8).

Harvesting

Carrots are mostly harvested manually by pulling up the roots at the leaves as long as the soil is moist and soft. If the soil has dried, it will be necessary to use either a spade or similar tool to loosen the soil and harvest the roots. Carrots are usually ready for harvesting 60-85 days after sowing. Mature roots should be orange-coloured internally down to the blunt tip.

A good market price can be fetched from young carrots with a fresh top, but leaving the top on dries out the root quickly and reduces the marketing period of the crop. An alternative is to trim the top back to about 2 cm and package attractively.

For mature carrots the tops are trimmed down completely to avoid storage rots before marketing. Carrots can remain in good condition for 100-150 days when the foliage is removed and they are stored at 1-4° C with 95-100% relative humidity. Carrots should be stored separately from other vegetables to prevent a bitter flavour induced by ethylene (a colourless gas with a sweet odour that is produced by many fruits and vegetables that accelerates the ripening process). Generally carrots store better when they are mature and harvested under moist conditions, and undamaged and free of diseases and pests.

Information on Diseases

Cottony soft rot

The disease is caused by the fungus *Sclerotinia sclerotiorum* and is characterized by development of soft, watery rot of leaves, crowns and roots. Affected areas become covered with white, cottony fungal growth in which black, irregular, fungal resting bodies (sclerotia) form. The sclerotia enable the fungus to survive for long periods in the soil. This disease is a serious field and storage problem. If diseased roots are packed, extensive breakdown may occur during transit and storage.

What to do:

- **Practice 3-year rotation using cereals and forage grasses**
- **Soil flooding is helpful where feasible**
- **Do not pack and store damaged and or diseased roots**
- **Use clean containers in storage**
- **Maintain temperature near 0°C and a relative humidity no higher than 95% during storage**

Cottony soft rot (*Sclerotinia sclerotiorum*) on carrot
Greyish, white mold forms at the base of stem. Black round structures appear as disease progresses. Can extend underground to the root.
© David B. Langston, University of Georgia, Bugwood.org

Leaf blight

The disease is caused by the fungus *Alternaria dauci*. Dark-grey to brown, angular spots form on leaves. Surrounding tissue yellows and affected leaves eventually die. Older leaves are attacked first and only in very severe cases are younger leaves affected. Large spots can girdle leaf petioles and kill leaves without spots developing on individual leaflets. During warm moist weather, dying of affected leaves may occur so rapidly that plants appear scorched. This fungus can also cause seedling damping-off. The fungus is seed-borne and survives in the soil crop debris.

What to do:

- **Use resistant hybrids where available.**
- **Use certified disease-free seeds. In case of using own seeds hot water treat seeds. For information hot water treatment of seeds click here**
- **Avoid parsley in crop rotation and practice good field hygiene.**
- **Enhance aeration of crop field by less dense crops and ridge cultivation.**
- **No or little N-fertilisation.**

- **Monitor fields regularly to be able to react properly.**
- **Copper treatments can reduce infection. For more information on copper click here**

Leaf blight (*Alternaria dauci*)
Small, irregular, black to purplish coloured spots. Spots may coalesce to cover the entire leaf.
© David B. Langston, University of Georgia, Bugwood.org

Powdery mildew

The disease is caused by the fungus *Erysiphe polygoni (E. heraclei)*. It is characterised by the development of white, powdery fungal growth on leaves. Affected leaves become chlorotic and eventually die. The fungus is seed-borne.

What to do:

- **Use certified disease-free seeds if using own seeds hot water treat the seeds.**
- **Practice good field hygiene**
- **Practice over-head irrigation where feasible**
- **Spray with sulphur based products where acceptable**

Powdery mildew on carrot
Powdery mildew on carrot caused by Erysiphe heraclei

Damping-off on carrot (*Phytium* sp.)

Damping-off diseases are caused by a complex of plant pathogens (disease inciting agents) including *Alternaria* spp., *Fusarium* spp., *Pythium* spp. and *Rhizoctonia* spp. These pathogenic fungi may cause rotting of seeds before emergence or death of seedlings after emergence. The most disposing factors are use of non-certified disease-free seeds and excessive watering of seed-beds or field plots.

What to do:

- **Always use certified disease-free seeds. If using own seeds hot water the seeds. For more information on hot water treatment of seeds click here**
- **Avoid overwatering of seed-beds or field plots where direct sowing is done**

Damping-off
Damping-off on carrot (*Phytium* sp.)
© David B. Langston, University of Georgia, Bugwood.org

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

***Erwinia carotovora* subsp. *carotovora* is a bacterium. Bacteria survive in decaying refuse and enter the root principally through cultivation wounds, harvest bruises, freezing injury, and insect openings. After infection, high humidity is essential for progress of the disease. When soft rot occurs in the field, it usually follows a period of water logging in low areas following excessive rain or irrigation. Carrots, potatoes, onions, crucifers, and celery are only a few of the many plants attacked.**

The disease causes a soft, watery, slimy rot. The rotted tissues are grey to brown and may have a foul odour. It decays the core of the root. Also prolonged wet weather favours disease development. It is a serious transit and storage problem if affected carrots are not discarded. In the field, tops of rotted carrots turn yellow and wilt as roots break down.

What to do:

- **Follow a crop rotation of cereals and fodder grasses**
- **Destroy by burning of infected plants**
- **Carefully handle carrots at harvesting to minimize bruising**

- **Discard affected carrots before transport and storage**
- **Store carrots in well ventilated places**

Soft rot on carrot (Daucus carota)
Bacterial soft rot caused by (Erwinia carotovora var. carotovora) on carrot

Information on Pests

Root-knot nematodes *(Meloidogyne* spp.)

Various species of *Meloidogyne* cause galls or swellings on the fleshy tap-root. In warm climates *M. incognita, M. javanica* and *M. hapla* are the main species causing problem. The disease is a problem in carrots grown in sandy soils.

What to do:

- **Plant resistant hybrids where available**
- **Practice crop rotation with cereals and fodder grasses**
- **A 3-year stop for all Apiaceae and Chenopodiaceae crops and a 4 to 5 year stop for Legumisosae is needed to interrupt the life-cycle of these nematodes**
- **Soil amendments with neem cake or extracts are recommended**
- **Where feasible, practice at least one year fallow cultivation**

Root-knot nematodes of carrot
Root knot (nematodes, Meloidogyne spp.): | galling and deformation of carrot roots

Cutworms (*Agrotis* spp)

Cutworms such as the black cutworm (*Agrotis ipsilon*) and the common cutworm, also known as the turnip moth (*Agrotis segetum*), attack carrot roots. Feeding on roots causes holes ranging from small and superficial to very large deep holes[link. /]

What to do:

- **Conserve and encourage natural enemies. For more information on natural enemies click here.**
- **Plough fields to expose caterpillars to predators and dessication by the sun**
- **Destroy weeds and vegetation before planting**
- **Flood fields for a few days before planting**
- **Spread ash thickly in the seedbeds, around seedlings or mixed with the soil in the planting holes**

Cutworms
Black cutworm (*Agrotis ipsilon*). Early instars are about 7 to 1.2 cm long. Fully grown caterpillars are 3.5 to 5 cm long.
© Ooi P., Courtesy of Ecoport (www.ecoport.org)

The African armyworm (*Spodoptera exempta*)

The African armyworm can cause serious crop losses. Armyworms may cause indirect injury to the taproot by cutting stems and/or consuming foliage above ground.

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**

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

Fresh Quality Specifications for the Market in Kenya

The following specifications constitute raw material purchasing requirements

PRODUCE:	CARROT
IMAGE:	
VARIETY:	Various
	GENERAL APPEARANCE
COLOUR	Mid to bright orange skin and flesh.
VISUAL APPEARANCE	Fresh, bright colour; tops removed; minimal remaining stalk (<1cm); no secondary roots; no excess forking; matter (slight scuffing in skin/abrasions allowable)
SENSORY	Firm with relatively smooth skin; crisp and juicy, not fibrous or dry and woody; slightly sweet taste (not bitter). No off-odours or tastes.
SHAPE	Straight, conical, with even taper, rounded to slightly [illegible] according to variety. Uniform within box.
SIZE	Bulk Loose Produce graded by length: small < 100mm, medium 100-150mm, medium-large 150-200mm, large >200mm. A 10% size overlap between size grades is allowable. (as per pre-ordered size)
MATERIAL	[illegible]
INSECTS	[illegible]

© S. Kahumbu, Kenya

Information Source Links

- **Agricultural Information and Resource Centre 2003: Fruits and Vegetables Technical Handbook.**
- **CABI. (2004). Crop Protection Compendium, 2004 Edition. © CAB International Publishing. Wallingford, UK. www.cabi.org**
- **Herold, W. (1919). A Contribution to the knowledge of Agrotis segetum, Schiff. Zeitschrift für angewandte Entomologie. 1: 47-59.**
- **Madge, D., Jaeger, C., Clarke, S. (2003). Agriculture notes. Organic farming: Carrot production and marketing. State of Victoria, Department of Primary Industries. http://www.dpi.vic.gov.au/link]**
- **Ministry of Agriculture and Rural Development (Kenya) and Japan International Cooperation Agency (2000). Growing Manual for Local and Export Vegetables. Reprinted by Agricultural Information Resource Centre (Nairobi, Kenya). 274 pp.**
- **Neergaard P. (1945). Danish Species of Alternaria and Stemphylium. London, UK: Oxford University Press.**
- **Pests of carrots. http://ipm.ncsu.edu**
- **Sherf, A. F., Macnab, A. A. (1986). Vegetable Diseases and Their Control. 2nd. Edition. A Wiley-Interscience Publication. ISBN: 0 471 05860 2**
- **University of Illinois Extension. http://www.urbanext.uiuc.edu**
- **East African Seed Co. Ltd. Africa's Best Grower's Guide www.easeed.com**

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Spider plant

Spider plant
Scientific name: *Cleome gynandra*
Family: Capparidales: Capparaceae
Local names: Mwangani (Swahili), thageti (Kikuyu), tsisaka (Luhya), alot-dek (Luo), saget (Kalenjin), chinsaga (Kisii), mwianzo (Kamba), jjobyu (Luganda), yobyu (Lusoga)
Common names: African cabbage, spider flower, spider wisp, cat's whiskers
Pests and Diseases: Aphids Beetles

General Information and Agronomic Aspects

Geographical Distribution of Spider Plant in Africa

Spider plant is an erect herbaceous annual herb with hairy, often purple stems and many branches growing to a height of about one meter. The plant has edible leaves; each leaf has up to 7 leaflets spreading like fingers, which are usually 2-10 cm long and 2-4 cm wide. The flowers are rather showy, long and bearing many small white or pink flowers. The elongate fruit resembles a pod, but is referred to as a capsule, containing many small, dark seeds. Spider plant originated in Africa and Tropical Asia but now has a worldwide distribution. The plant is either cultivated or harvested from the wild. It is a fast-growing plant that is read for harvest in as few as three weeks. The leaves are eaten as a cooked green vegetable, have a mildly bitter taste and contain 5% protein, 6% carbohydrates and are high in vitamins A and C, calcium, phosphorus and iron. Spider plant is used as a vegetable, and as such adds important nutrients to the diet in rural areas of East and Southern Africa. The leaves are usually cooked when fresh but may also be dried and stored for up to two years although this practice greatly reduces the crop?s nutrition value. In East Africa, fresh leaves are used as ingredients in other mashed foods, and the dried leaves are ground and incorporated in weaning foods. Spider plant is believed to replenish blood and therefore referred to as a "traditional meat" by some Kenyan communities (Chweya and Mnzava, 1997; Woomer and Imbumi, 2003).

Climatic conditions, soil and water management

Spider plant is commonly found throughout East and Southern Africa during the rainy season. (AVRDC). In Kenya, it grows from sea level to 2400 metres (FORMAT). The crop grows well during the warm season under irrigation. Spider plant is sensitive to cold and does not grow well when temperatures drop below 15 °C. It thrives on sandy loam soils but does not perform well on wet, marshy and heavy clay soils. It requires exposure to sunlight and does not do well in the shade.Although the plants are able to tolerate short-term drought, periods of drought will hasten development of flowers and lower the yields (AVRDC). Seeds should be sown at the onset of rainfall. This ensures availability of adequate soil moisture throughout the growth period. When rainfall is inadequate, frequent watering is necessary during the vegetative growth period (Chweya and Mnzava,1997; Woomer and Imbumi, 2003).

Propagation and planting

Propagation is done by seed. Seeds are sown directly in a well prepared seedbed. Transplanting has proved unsuccessful. (EcoPort)

Seeds can be extracted when the pods are fully ripe (yellow or black), but before they open naturally. Seeds should be kept in a dry, closed container for at least three months to reduce dormancy (ACRDC).

It requires a well-prepared seedbed without weeds and dug to a depth of about 15 cm followed by a light harrowing. It may be planted on traditional raised or flat beds. After digging, the soil is harrowed to a fine tilth. Organic manure is applied and worked into the soil. The seedbed is then levelled before planting. Plants can be grown on flat beds or on traditional raised beds, which are normally one m wide. The appropriate bed length depends on the amount of the crop to be grown, but may not exceed three m. There are usually narrow pathways between the beds to facilitate weeding and harvesting. These pathways also act as drainage channels during the very wet season, as plants do not withstand waterlogging. When raised beds are used, application of organic manure is delayed until the beds have been dug (Chweya and Mnzava,1997).

Shallow planting at one cm depth and with 30 cm between rows or broadcasting followed by raking on prepared seedbeds is recommended. Some farmers mix the seeds with sand when broadcasting them. About four g of seed per m2 or 40 kg per ha are required. Emergence is normally from 6 to 8 days after sowing. Thinning is done three weeks after emergence to leave 10 to 15 cm between plants. (EcoPort)

Husbandry

Plants do not have dense foliage, and as such are unable to compete with weeds. It is therefore essential that seedbeds are kept weed-free at all times, but especially during the first six weeks. Shallow cultivation or hand-pulling of weeds should be practised (Chweya and Mnzava, 1997)
Spider plant responds well to well-decomposed manure. Flowering is delayed when adequate manure is available, allowing more, larger leaves to be harvested. Optimum yields could be obtained with an application of 20 to 30 tons of manure per hectare. Topping and removing inflorescences as soon as they appear are other practices that increase leaf production for harvesting. This crop grows rapidly and requires weeding only in the open space between the rows. Plants require water two or three times a week. Periods of drought will hasten development of flowers and lower the yields. Pests and diseases are not usually serious and spraying with insecticides is not recommended even when aphids appear to become problematic. (AVRDC; Chweya and Mnzava, 1997)

Harvesting

The first harvests consist of thinned plants. Plants are brought to the market with their roots attached; roots are removed just before selling to maintain freshness. Where possible, roots should be placed in water overnight to absorb moisture. In case of a mixed cultivation with amaranths or nightshades, spider plants are uprooted to make more space for the companion crop. In case of monocropping, which is more common, the tops are removed 10 cm from the ground. This encourages the development of side shoots. Harvesting is repeated several times, depending on the soil fertility and moisture conditions. The harvested shoots are kept in a bag without water during the night. In the following morning, the shoots are dipped in water for 30 minutes. Sprinkle water on heaps of produce sparingly. After several successive leaf harvestings, the plants are left to flower and produce seeds. Growers harvest the ripe capsules at the end of rainy season, to save seed for the next crop (AVRDC).

Recipes

Recipe: Spider plant with coconut milk

Ingredients

- **1 kg spider plant leaves**
- **1 medium onion**
- **0.250 liter water**
- **3 medium tomatoes**
- **1 tsp salt**
- **0.25 liter coconut milk**

Preparation

Harvest the young spider plant leaves including the stem tips then remove the leaf stalks. Wash the leaves with clean water and cut into small pieces. Place into a pot containing 0.25 liter of water, add 1 teaspoon of salt then vegetables and boil over a medium fire for 10 minutes. Next add 0.25 liter of dilute coconut milk and boil for 10 minutes. When leaves are cooked, mash in pot and add oil (or cow fat). Using a separate sufuria fry onions till brown, add tomatoes then vegetables and 0.25 liter of thick coconut milk (or fresh cow's milk), then cook for 5 minutes, stirring occasionally. Provides 4 to 6 medium portions. Best served with chapati, rice or ugali. To mix with other vegetables, boil Amaranth leaves and spider plant separately. When cooked, mix both then mash in one pot.

(FORMAT, http://www.formatkenya.org/ormbook/Chapters/chapter17.htm) (FORMAT, contributed by Maryam Imbumi).

Information on Pests, Diseases and Weeds

Information on Diseases

There are no records of plant diseases, possibly as a result of natural plant selection (EcoPort: Wilfried Baudoin).

Information on Weeds

Spider plant is a poor competitor with weeds. Control at early growth stages is critical.

Information on Pests

Beetles

Pure stands in Nairobi were observed to be attacked by flea beetles *Phyllotreta mashonana*. (EcoPort: Wilfried Baudoin).

Flea beetles are tiny to small with enlarged hindlegs that enable them to jump long distance when disturbed. The adults vary in colour from shiny black or metallic grey to black with yellow stripes on the wing cases. Eggs are laid in the soil near the host plant. The larvae generally feed on the plant roots, but usually do not cause economic damage. The characteristic symptom of flea beetle attack is small, round holes all over the leaf surface. Damage may be of importance when flea beetles are present in large numbers, especially during the seedling stage.

What to do:

- **Weeding in and around fields may help to eliminate flea beetle shelters and breeding sites, reducing crop damage.**
- **Covering the seedbed with a fine-mesh material is useful to protect seedlings and older plants.**

Flea beetle

A related species of flea beetles, *Phyllotreta cruciferae* feeding damage to a young oilseed canola leaf. Adults are about 2-3mm long.

Aphids

Aphids can be serious pests during dry weather. Aphids are a major pest, causing leaves to curl and become unattractive to customers.

Aphids feed by sucking plant sap. Small aphid populations may be relatively harmless, but heavily infested plants usually have wrinkled leaves, stunted growth and deformed pods. Plants, in particular young plants, may dry out and die under heavy aphid attack. Heavy attack on older plants may cause crop loss by decreasing flower and pod production. Damage may also reduce seed viability.

What to do:

- **Check the plants regularly. Aphids tend to be more common along upwind field borders and next to other leafy vegetable crops or weeds; so initial sampling should be focused in these areas. Because aphid populations are generally clumped within fields, each field should be uniformly sampled.**
- **Destroy aphids by rubbing them off, or by gently pressing the infested stems or leaves between your fingers. This helps controlling low, initial infestations.**
- **Apply a strong jet of water to dislodge aphids from attacked plants. When repeated at regular intervals, this method knocks aphid populations down to acceptable levels.**
- **Prune or remove and destroy infested leaves. This helps reduce further infestations.**
- **Conserve natural enemies. Ladybird beetles, lacewings, hover fly larvae, parasitic wasps and naturally occurring aphid diseases are common and effective natural enemies of aphids.**

Aphids
Green peach aphids (*Myzus persicae*) on pepper leaf. Adult wingless females are oval-bodied, 1.2-2.1 mm in body length, of very variable colour.

Information Source Links

- **AVRDC Learning Center. Publication and Fact Sheets on Indigenous Vegetables: Spider plant. http://www.avrdc.org/LC/indigenous/cleome.pdf**
- **Chweya J.A., Mnzava N.A. (1997). Cat's whiskers. Cleome gynandra L. Promoting the conservation of underutilized and neglected crops. 11. Gatersleben: IPK/Rome: IPGRI. ISBN 92-9043-303-5 www.bioversityinternational.org**
- **EcoPort: The consilience engine: www.ecoport.org Page on Spider plant**
- **FORMAT: Forum for Organic Resource Management and Agricultural Technologies. www.formatkenya.org/ormbook/Chapters/chapter17.htm**
- **Ouma, M.A. Indigenous vegetable production and utilization in Suba district, Kenya: Improving health, unlocking the wealth in Suba district. BioVision - T.T.U, ICIPE. Unpublished.**
- **SANBI: South African National Biodiversity Institute, South Africa. www.plantzafrica.com/plantcd/cleomegyn.htm**
- **The Australian New Crops Newsletter, Issue No. 11, January 1999. www.newcrops.uq.edu.au/newslett/ncn11165.htm**
- **Woomer, P. L. and Imbumi, M. (2003).Traditional Green Vegetables in Kenya. In Organic Resource**

Management in Kenya -Perspectives and Guidelines. Chapter 17. www.formatkenya.org Published by Forum for Organic Resource Management and Agricultural Technologies (FORMAT).

Information of www.infonet-biovision.org
