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Potato

Scientific name: *Solanum tuberosum*

Order/Family: Solanales: Solanaceae

Local names: Kiazi, egiasi, mbatata, potato, enkwashei (Kenya) / batata reno (Mozambique)

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General Information and Agronomic Aspects

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

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



Geographical
Distribution of
Potato in Africa

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.

| | |
|---------------------------------------|--|
| Teff | |
| Tomato | Propagation |
| Wheat | 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. |
| Yam | 'seed rate (tubers) ranges from 1.5 to 4.0 t/ha. The first problem facing growers in |
| Zucchini/Courgettes | developing countries is obtaining supplies of healthy planting material of a suitable <u>cultivar</u> 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. |
| Pests/diseases/weeds | |
| Medicinal plants | 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 <u>transplanting</u> them to the field. |
| Fruit and vegetable processing | |
| Natural pest control | Planting |
| Cultural practices | 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, OI Joro Orok and Tigoni Research Station (CIP).

Varieties in Kenya and their characteristics

| Variety | Yield | Storage | <u>Drought resistance</u> | Late blight | Viruses | Maturity | Eco-zone |
|----------------|-------------|-----------|---------------------------|------------------------|------------------------|----------|-------------|
| "Kenya Baraka" | High | Good | <u>Some resistance</u> | <u>Some resistance</u> | <u>Some resistance</u> | Medium | Medium High |
| "Roslin Eburu" | Medium High | Very good | Resistant | <u>Some resistance</u> | <u>Some resistance</u> | Medium | Medium High |

| | | | | | | | |
|----------------|--------|-------------|------------------------|------------------------|------------------------|-------------|-----------------------|
| "Feldelslohn" | High | Fairly good | Some <u>resistance</u> | Very susceptible | Some <u>resistance</u> | Medium late | High |
| "Annet" | High | Good | Some <u>resistance</u> | Some <u>resistance</u> | Some <u>resistance</u> | Early | High Medium Low |
| "Dutch Robjn" | High | Very good | Some <u>resistance</u> | Susceptible | Some <u>resistance</u> | Medium | High Medium |
| "Roslin Tana" | High | Fair | Some <u>tolerance</u> | - | - | Medium | High Medium |
| "Roslin Gucha" | Medium | Good | Tolerant | - | - | Medium | High Medium |
| "Desiree" | Medium | Fairly good | Some <u>tolerance</u> | - | - | Medium | High Medium |
| "Roslin Ruaka" | High | Good | Some <u>tolerance</u> | - | - | Medium | High Medium |
| "Cardinal" | Medium | Good | Some <u>tolerance</u> | - | - | Medium | High Medium |
| "Pimpernel" | Medium | Good | Some <u>tolerance</u> | - | - | 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 | Not good for mashing | Market |

| | | | tubers | | |
|-----------------|---|------------|---|---|------------------|
| "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 lose appeal and will start rotting.

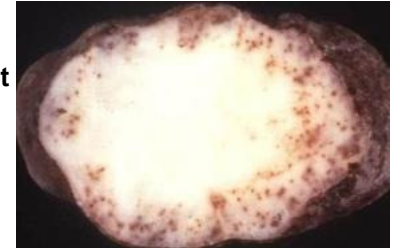
Information on Pests and Weeds

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



Root-knot nematodes
Root-knot nematodes
Meloidogyne incognita
damage on potato

© DAFF Archives,
www.insectimages.org.
Courtesy of
www.ecoport.org
[More Information on Root-knot nematodes](#)

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**

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



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

[More Information on Aphids](#)

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).

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)

[More Information on Cutworms](#)

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.

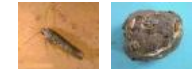
What to do:

- 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



Potato tuber moth
Potato tuber moth adult (*Phthorimaea operculella*) is about 12-16mm long.

© J. Kroschel, CIP



Potato tub... Potato tub...



Potato tub... Parasit ...

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.

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.



Epilachna beetle
Epilachna beetle (*Epilachna* spp.) and damage caused on water melon

© A. M. Varela, icipe

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).

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**



**Millipedes
Potato tubers damaged by
millipedes.**

© A. M. Varela, icipe

- **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.**

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**



Pigweed

Pigweed (*Chenopodium album*)

© Photography courtesy of Western Weeds CD-ROM.
Web version by R. Randall.
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[More Information on Weeds](#)

when tubers are enlarging.

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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).

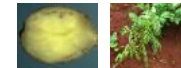
What to do:

- 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



Bacterial wilt
Bacterial wilt of potato tuber

© Courtesy of EcoPort,
www.ecoport.org



[Bacteri](#) [Bacteri](#)

...

[More Information on Bacterial wilt](#)

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 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)

© Oregon State University

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-solanaceous 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,



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

© Thorsten Kraska, University of Bonn, Germany. Reproduced from the Crop Protection Compendium, 2004 Edition.
© CAB International, Wallingford.



[Late bligh...](#) [Late bligh...](#) [Late bligh...](#)

[More Information on Late blight](#)

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*.

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:



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

- **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-solanaceous 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.**

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.

© Chad Behrendt.

Reproduced from University of Minnesota Extension.

[More Information on Early blight](#)

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 (russetting; 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



Scab

Scab symptoms (here on citrus leaf)

© www.ecoport.org

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.**
-

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 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.**

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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 splits. With no severely malformed or root constricted tubers, or tubers with advanced secondary growth. With no green areas on the skin or an overall green tinge (exposed to light, top of tubers may form) With no evidence of bacterial wilt (when cut and squeezed milky ring appears around potato edge) or black/brown sunken spots due to blight |

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vegetables](#)African
Nightshade
Amaranth**Coffee**Scientific name: *Coffea* spp. (*C. arabica* / *C. canephora*)

Order/Family: Gentianales: Rubiaceae

Pests and Diseases: [Antestia bugs](#) [Armillaria root rot](#)

Avocados [more Images](#) [Bacterial blight of coffee](#) [Capsid bug](#) [Coffee berry borer](#)
Bananas [Coffee berry disease](#) [Coffee berry moth](#) [Coffee leaf rust](#)
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Cowpea

Cucumber

Eggplant

Green gram

Groundnut

Maize

Mango

Millet

Okra

Onion

Papaya

Passion fruit

Peas



Geographical
Distribution of
Coffee in Africa

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.

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

| | |
|------------------------------|--|
| Peppers | content in a bean is dependant on the coffee type, variety, the site conditions and other factors, and can be more than 2.5%. |
| Pigeon pea | |
| Pineapple | |
| Potato | Economically, the most important coffee varieties are <i>Coffea arabica</i> called "Arabica" and <i>Coffea canephora</i> called "Robusta". The latter yields about 30% more than ?Arabica?, albeit its price is around 30% lower. |
| Pumpkin | |
| Rice | |
| Sesame | |
| Sorghum | Coffee is mainly grown as a beverage, though the plant residues can provide fuel (coffee charcoal or wood) and a good <u>mulch</u> . |
| Soybean | 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. |
| Spider plant | |
| Spinach | |
| Sugarcane | |
| Sweet potato | Climate conditions, soil and water management |
| Tea | The ideal temperature range for Arabica coffee plants lies between 18 and 24° C. Maximum day temperatures should not exceed 30°C 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 <u>distortion</u> , 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. |
| Teff | |
| Tomato | |
| Wheat | |
| Yam | |
| Zucchini/Courgette | |
| Pests/ diseases/ weeds | |
| Medicinal plants | 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, |
| Fruit and | |

vegetable
processing
Natural pest
control
Cultural
practices

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 34° 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 in 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 II' | All coffee growing areas | 2 x 2 m (6 x 6 ft) | <ul style="list-style-type: none"> • Resistant to coffee berry disease and leaf rust • Early maturing (18-24) |

| | | | |
|----------------|---|---|--|
| | | 2500 trees/ha | months) <ul style="list-style-type: none"> • 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 | <ul style="list-style-type: none"> • High yielding • High quality |
| 'SI 28' | Medium to high altitude coffee zones without serious leaf rust | 2.75 x 2.75 m (9 x 9 ft) 1330 trees/ha | <ul style="list-style-type: none"> • High yielding • High quality |
| 'K7' | Low altitude | 2.75 x 2.75 m (9 x 9 ft) | <ul style="list-style-type: none"> • 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 and 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, *Albizia* 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.

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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.



Coffea leaf rust
Coffee rust (*Hemileia vastatrix*)

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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.

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



Coffee berry disease
Coffee berry disease
(*Colletotrichum kahawae*)

© A.A. Seif, icipe

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**

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



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.

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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.



Coffee Coffee
wil... wil...

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.

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



Damping-off
Damping-off disease (here on okra seedlings)

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- **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](#)**

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[More Information on Damping-off diseases](#)

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.



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

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Protection Compendium,
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UK, 2006.

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.**

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.



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

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

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.
-

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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



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

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.**

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).

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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

[More Information on 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.



Coffee berry moth
Coffee berry moth
(*Prophantis smaragdicola*)

© University of Minnesota. Dr. Jan Breithaupt.
Courtesy of
www.ecoport.org

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)

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.



White coffee borer
White coffe borer
also called white
stemborer,

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.

(*Monochamus leuconotus*). Adult is about 3cm long.

© Rory Hillocks, NRI

What to do:

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

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

[More Information on Spider](#)

mites**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 buds 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 coffeina*)

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. coffeina*). 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.

Leafminers
Damage of leafmining caterpillars (*Leucoptera meyricki* and *Leucoptera caffeinea*) on coffee leaf.

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).

© A.M. Varela, icipe

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).

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 thuringiensis* 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 stictigamma*)

Kenya mealybug (*Planococcus kenya*)

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.



Kenya mealybug
Adult females of Kenya mealybug (*Planococcus kenya*) collected from

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.

coffee in Kenya. 1.4-2.7 mm long and 0.8-2.0 mm wide.

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More Information on Mealybugs

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 peeled 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



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.

© United States National Collection of Scale Insects

mealybug is also known as the citrus mealybug; it also attacks citrus and cocoa, where it normally attacks the aerial part of the plants.

**Photographs Archive, USDA
ARS, Bugwood.org**

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**
-

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.
-

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Tea

Scientific name: *Camellia sinensis*

Order/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](#)

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



Geographical
 Distribution of Tea in
 Africa

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.

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

Spinach
Sugarcane
Sweet potato

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).

[Tea](#)

Teff
Tomato
Wheat
Yam
Zucchini/Courgette

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.

Pests/
diseases/
weeds

Medicinal
plants

Varieties

Fruit and
vegetable
processing

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.

Natural pest
control

- 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

Cultural
practices

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.



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 bottom (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 tea to form frame

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.

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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 *Indigofera 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.

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More Information on Root-knot nematodes

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 (Sudo et al., 1994).

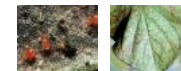
2) The tea red spider mite (*Oligonychus coffeae*)

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



**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...

More Information on Spider mites

infestations younger leaves maybe attacked. This mite has been recorded in all tea growing areas in Kenya in low to moderate infestations (Sudoj, 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. Sudoj (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 (Sudoj, 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 (Sudoj et al., 2001).

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.

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More Information on

Cutworms

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 (*Grylotalpa 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,



**Helopeltis bug
Body size 7-10 mm long**

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. © F. Haas, icipe

What to do:

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

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 Ahook) formulated as wettable soluble powder, containing azadirachtin 0.03% (300 ppm)



Aphids
The mango aphid (*Toxoptera odinae*)

[More Information on Aphids](#)

could be used for control of the citrus black aphid when applied at concentrations of 10 and 20% (Sudoj, 1998)

The black tea thrips (*Heliethrips 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. They 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:



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.

© A.M. Varela

[More Information on Thrips](#)

- **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](#)**
-

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% (Sudoj, 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**



Termites
Termites (*Coptotermes formosanus*)

© Scott Bauer, USDA
Agricultural Research
Service, Bugwood.org
[More Information on Termites](#)

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).**

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 (*Selanaspilus* 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.



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

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

- **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.**
-

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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 (*Pestalotiopsis 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.**
-

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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.

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Search[Publications](#) [About us](#) [TC](#) [TOF](#)[Home](#) [Help](#) [Contact](#)You are here: [Home](#) > [Plant Health](#) > [Crops/ fruits/ vegetables](#) > [African Nightshade](#)[← Back](#)[Print](#) [Crops/ fruits/
vegetables](#)[African
Nightshade](#)[Amaranth](#)[Avocados](#)[Bananas](#)[Beans](#)[Cabbage/Kale,](#)[Brassicas](#)[Carrot](#)[Cashew](#)[Cassava](#)[Citrus](#)[plants](#)[Cocoa](#)[more Images](#)**African Nightshade****Scientific name:** *Solanum villosum***Order/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](#)[Selected Recipes](#)[Information on Diseases](#)[General Information and Agronomic Aspects](#)[Information on Pests](#)[Information Source Links](#)[Reference addresses](#)

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



**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 preferred 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.

| | |
|--------------------------------|---|
| Spinach | |
| Sugarcane | <i>Solanum</i> species that are found in Kenyan vegetable gardens include <i>S. macrocarpon</i>, <i>S. scabrun</i>, <i>S. villosum</i>. |
| Sweet potato | |
| Tea | <i>Solanum</i> 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. |
| Teff | |
| Tomato | |
| Wheat | |
| Yam | Climatic conditions, soil and water management |
| Zucchini/Courgette | 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. |
| Pests/ diseases/ weeds | Propagation and planting |
| Medicinal plants | 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. |
| Fruit and vegetable processing | 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 <u>mulch</u> 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. |
| Natural pest control | |
| Cultural practices | 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.

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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



Early blight
Early blight on tomato leaflet. Similar symptoms on African nightshade

© A.M. Varela, icipe
[More Information on Early blight](#)

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](#)**
-

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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



Aphids
Adult wingless female aphids are oval-bodied, 1 to 2mm in

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](#)

body length, of very variable colour.

© Magnus Gammelgaard
More Information on Aphids

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.



Spider mites
Two-spotted spider mite
(*Tetranychus urticae*). The

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.**

adult female is 0.6 mm long.
The male is smaller.

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Warwick

[More Information on Spider mites](#)

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Teff

Scientific name: *Eragrostis tef*

Order/Family: Cyperales: Poaceae

Local names: Teff (Amharic); Taffi (Oromo); Taff (Tigrigna)

Common names: Lovegrass / Annual Bunch Grass (English) / Mil éthiopien (French).

Beans

Pests and Diseases: African armyworm

Purple witchweed

Cabbage/Kale,

Brassicas

Carrot

Cashew

Cassava

Citrus

plants

Cocoa

Coconut

Coffee

Cotton

Cowpea

Cucumber

Eggplant

Green gram

Groundnut

Maize

Mango

Millet

Okra

Onion

Papaya

Passion fruit

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General Information and Agronomic Aspects



Geographical
Distribution of Teff
in Africa

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 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

| | |
|--------------------------------|---|
| Pineapple | seasonal rainfall. Tef is day length sensitive and flowers best during 12 hours of daylight. |
| Potato | |
| Pumpkin | Propagation and Planting: |
| Rice | 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)) |
| Sesame | |
| Sorghum | |
| Soybean | |
| Spider plant | |
| Spinach | |
| Sugarcane | Husbandry: |
| Sweet potato | Tef 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)) |
| Tea | |
| Teff | |
| Tomato | |
| Wheat | |
| Yam | |
| Zucchini/Courgette | Harvesting: |
| Pests/diseases/weeds | 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. |
| Medicinal plants | 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. |
| Fruit and vegetable processing | |

Natural pest control
Cultural practices

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))

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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**



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

© University of Arkansas
[More Information on African armyworm](#)

damage and it may no longer be economical to treat the crop. For more information on ([neem click here](#), for [pyrethrum click here](#) and for [Bt click here](#))

- Conserve and encourage natural enemies. For more information on [natural enemies click here](#)
- Practise field sanitation. For more information on [field sanitation click here](#)

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Cucumber

Eggplant

Green gram

Groundnut

Maize

Mango



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Pineapple

Scientific name: *Ananas comosus*

Order/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](#)

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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.

Millet**Okra****Climate conditions, water and soil management****Onion****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.****Papaya****Passion fruit****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,****Peas****Peppers****so, away from tropics, the right combination of heat and moisture are important factors to consider for successful pineapple production.****Pigeon pea****[Pineapple](#)****Potato****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.****Pumpkin****Rice****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.****Sesame****Sorghum****Soybean****Spider plant****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).****Spinach****Sugarcane****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****Sweet****potato****(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.****Tea****Teff****Tomato****Wheat****Yam****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.****Zucchini/Courgette**

**Pests/
diseases/
weeds**

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.

**Medicinal
plants****Fruit and
vegetable
processing****Land preparation****Natural pest
control**

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.

**Cultural
practices**

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 premature fruiting.**
- **Slips are leafy shoot growth arising from the fruit stalks. They take 22-24 months 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. *Phytophthora* 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, phytophthora 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 fruit. 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 *Pueraria 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.

© Bridge J., IIP. Courtesy of
Ecoport (www.ecoport.org)
**More Information on Root-
knot nematodes**

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



Pineapple mealybug
Severe infestation of
pineapple mealybug
(*Dysmicoccus brevipes*) on
the fruit

© Bedford ECG, de Villiers
EA (Courtesy of EcoPort,
www.ecoport.org)
**More Information on
Mealybugs**

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.

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



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.

© Alton N. Sparks, Jr., The University of Georgia, www.insectimages.org, Courtesy of Ecoport (www.ecoport.org)

More Information on Thrips

manure and pyrethrum (in extreme situations) has also been recommended (Naturland, 2001). See also upper section on yellow spot virus.

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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 (*Phytophthora 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 butt 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 butt 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:

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

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the Crop Protection
Compendium, 2005
Edition. © CAB
International,
Wallingford, UK,
2005)

- **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.**
-

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 considerably 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](#)

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vegetables](#)[African
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plants](#)
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Order/Family: Malvales: Sterculiaceae

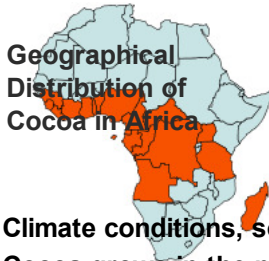
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[Anthracnose](#)[General Information and Agronomic Aspects](#)[Information on Pests](#)[Information on Diseases](#)[Information Source Links](#)**General Information and Agronomic Aspects**

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

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



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 sought 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

| | |
|---|---|
| Tea | should lie between 4.0 and 7.5. Care must be taken that sufficient organic material is available. |
| Teff | 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. |
| Tomato | |
| Wheat | |
| Yam | |
| Zucchini/Courgette | |
| Pests/ diseases/ weeds | 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. |
| Medicinal plants | |
| Fruit and vegetable processing | |
| Natural pest control | |
| Cultural practices | 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 lose 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 |

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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 |

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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 |

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Diversification strategies for Cocoa 4

| 1. Year | 2. Year | 3. Year | 5. Year | 5. 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 |

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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., *Erythrina* 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

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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 (*Phytophthora 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 *Phytophthora 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



Cocoa black rot / bud rot
Cocoa black rot
(*Phytophthora palmivora*)

© Jürgen Kranz
(Courtesy of

develop.

**EcoPort,
www.ecoport.org)**

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.**
-

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.

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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*, *Heliiothrips 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



Helopeltis bug
Helopeltis bug (*Helopeltis schoutedeni*). Real size: 6 to 10 mm long.

© F. Haas, icipe



Helope Helope

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.

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 stictigrapta* damage on cocoa

© www.dropdata.net



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.

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[More Information on Mealybugs](#)

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



Leafhoppers

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.

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

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

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.

© A. M. Varela
More Information on Thrips

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vegetables](#)

African
Nightshade
Amaranth
Avocados
Bananas
Beans

[more Images](#)**Yam**Scientific name: *Dioscorea alata*

Order/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

[Cabbage/Kale, General Information and Agronomic Aspects](#)[Brassicac Information on Diseases](#)[Information on Pests](#)[Information Source Links](#)

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

General Information and Agronomic Aspects



Geographical
Distribution of Yam
in Africa

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, followed by Cote d'Ivoire, Benin, Ghana and Togo. Within West 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

| | |
|--------------------------------------|---|
| Rice | 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. |
| Sesame | |
| Sorghum | 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. |
| Soybean | |
| Spider plant | |
| Spinach | |
| Sugarcane | |
| Sweet potato | |
| Tea | 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. |
| Teff | |
| Tomato | |
| Wheat | |
| Yam | 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. |
| Zucchini/Courgette | |
| Pests/ diseases/ weeds | |
| Medicinal plants | Propagation and Planting |
| Fruit and vegetable processing | 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. <u>Intercropping</u> 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. |
| Natural pest control | |
| Cultural | |

practices**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.

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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)
**More Information on
Anthracnose**

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.

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

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.

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