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Wheat

Wheat
Scientific name: *Triticum aestivum*
Family: Cyperales: Poaceae
Local names: Ngano (Swahili)
Pests and Diseases: African armyworm African bollworm Anthracnose Aphids Barley fly Birds Chestnut weaver Damping-off diseases Rats Storage pests Thrips Barley fly (hylemia arambourgi) / Birds (red billed quelea, chestnut weaver) / Brown leaf rust (Puccinia recondita) / stem rust (Puccinia graminis) / striple yellow rust (puccinia striiformis) / septoria leaf spot / yellow blotch / take all (ophiobolus graminis) / loose smut

General Information and Agronomic Aspects

Geographical Distribution of Wheat in Africa

Of all the cereals, wheat is the most widely adapted, being grown from sea-level to altitudes of more than 4500 m, and from the equator to within the Arctic Circle.

Wheat has been grown in East Africa since early 1900s and currently occupies the second highest production figures after maize. Early development of this crop was confined to large scale farms, but this pattern is changing with small farmers taking up wheat farming on smaller plots.
The demand for wheat flour in Kenya at present cannot be sustained by local production, so the country relies on import to meet almost half its consumption.

Wheat provides almost 20% of all human food energy. It is made into various products including bread (leavened, flat and steamed), chapatties, pastries, crackers, biscuits, pretzels, noodles, farina, macaroni, spaghetti, bulgur, couscous, breakfast foods, baby foods, and food thickeners. It is also used as a brewing ingredient in certain beverages.

Climatic conditions, soil and water management

Wheat is essentially a temperate-climate crop. Optimum temperatures for development are 10 to 24°C. Relatively low temperatures result in the highest yields. Temperatures above 35°C stop photosynthesis and growth, and at 40°C the crop is killed by the heat. In tropical areas, wheat is best grown at higher elevations or in the cooler months of the year. The minimum amount of water required for an acceptable crop is 250 mm in the top 1.5 m of soil. Areas with 700 to 1000 mm rain per year will be able to grow rain fed wheat.
Wheat does not grow well under very warm conditions with high relative humidity, unless irradiation and nutrient availability are very favourable. In addition, wheat diseases are generally encouraged by such climatic conditions.
Soils best suited for production are well aerated, well drained, and deep, with 0.5% or more organic matter. Optimum soil pH ranges between 5.5 and 7.5. Wheat is sensitive to soil salinity.

Varieties

Successful wheat production depends on knowledge about suitable varieties for the area where wheat production is planned. The varieties which are recommended have good stem rust resistance, are medium to high yields and have acceptable baking quality. To reduce risks due to seasonal climatic variation, it is advisable to plant at least 3 of the recommended varieties.

Recommended wheat varieties:

Variety Name	Altitude (m)	Yield (90 Kg bags/ha)	Maturity
"Pasa"	all	37	late
"Kenya Chirika"	all	36	medium
"Mbuni"	all	37	late

"Kenya Kwale"	all	32	late
"Kenya Popo"	all	32	medium
"Kenya Fahari"	1800-2100	29	medium
"Kenya Kongoni"	2100-2400	32	medium
"Kenya Nyumbu"	1800-2400	32	medium
"Kenya Nyangumi"	1800-2100	25	early
"Kenya Paka"	1800-2100	24	early
"Kenya Kulungu"	1800-2400	30	late
"Kenya Nungu"	1800-2400	24	medium
"Kenya Mbeha"	1800-2100	28	medium
"Kenya Tembo"	1800-2100	32	medium
"Duma"	Below 1800	22	early
"Ngamia"	Below 1800	20	early
"Mbega"	Above 1800	36	medium

Bread wheat cultivars in Kenya are categorized into 4 classes depending on the baking characteristics:

- **Group I: Weak wheat not ideal for baking. Can be used for fodder or blended with superior wheat for baking. These include Kenya Bongo. Kenya Kudu, Kenya Kongoni, Kenya Tumbili Kenya Tausi, Kenya Chirika and Ngamia.**
- **Group II: Strong stable wheat. Fairly good baking qualities. These include Kenya Mamba, Nyangumi, African Mayo, Kenya Tembo, Nyumba, Popo, Ngiri, Nungu, Kifaro, Mbweha, Kwale and Duma.**
- **Group III: Strong dispensable wheat. Good baking quality. Also used for pasta. Varieties include: Kenya Zabadi, Kiboko, Swara, Paka, Fahari, Kuro, Nyati and Mbega.**

- **Group IV: White wheat used for confectionary and pasta. Good for home baking. Include following varieties: Kenya Kulungu, Nyoka, Leopard as well as Bounty, Mbuni, Pasa,Kenya Paa.**

Seed selection

Certified seed are recommended for the following reasons:

- **It does not contain weed seeds such as wild oats, *Setaria* spp., Rye, Browe, *Beckeropsis* and grasses.**
- **It has sound kernels - neither broken nor cracked and has good germination.**
- **Are of one variety to ensure even ripening. Farmers will be penalized if they deliver wheat that has 2 or more varieties mixed or immature kernels mixed with mature seed.**
- **Note: If certified seeds are dressed with insecticides to prevent damage from soil-borne insect pests, they are not suitable for organic farming.**

Home selection of seed

For organic farmers home selection of seeds is possible. Selection starts in the field which is closely watched for diseases and noxious weeds. Weeds such as wild oats and other troublesome weeds are removed by hand when observed. Diseases and pests are controlled as far as possible, and the harvested seed dried well to ensure no storage diseases or pests get a chance to multiply. Good healthy kernels are then suitable for seeding in another season.
Do not mix varieties.

Propagation and Planting

Wheat is propagated by seed. It requires a fine seed-bed that is free of weeds. Seed-bed preparation is usually done by tractor mounted equipment. Usually this can be rented in wheat growing areas.
Choose a suitable variety for the area and plant with the first rains. Advice on suitable varieties can be found at the KARI Njoro station. Sowing depth varies from 2-12 cm, with deeper planting required in dry conditions

to reach the soil moisture. However, care must be taken not to sow too deep as the seed will then die. Seeding rate is commonly 100-150 kg/ha, resulting in 250-300 plants/m², but depends on the tillering ability of the cultivar. The recommended seeding rates when using precision planters for some varieties are:

- **75 kg/ha: Kenya Nyangumi, Kenya Bongo, Kenya Tembo**
- **100kg/ha: Kenya Leopard, Bounty, Kenya Paka, K. Nungu, K. Kongoni, Zabadi,K. Popo, K. Nyumba, K. Kulungu, K. Tumbili, K. Kima. K. Chirika, Mbuni, Kwale, Tausi, Ngamia, Duma**
- **125 kg/ha: Kenya Fahari, K. Ngiri**

If hand sowing is decided on, it is advisable to increase seeding rates to be sure of a good stand especially when broadcasting the seed. The following practices can be used for hand seeding:

- **Broadcasting. Broadcast 1 ½ bag per acre of the chosen variety as evenly as possible. Cover seed with animal drawn surface harrow or some fairly solid branches tied together and dragged over the seeds. It is difficult to weed such a field by hand.**
- **Organic farmers are advised to prepare shallow planting furrows with enough distance between for a jembe (hoe) to pass through the spacing. If the wheat is for home consumption, it can be intercropped with such legumes as blue vetch: after the first weeding the legumes can be seeded in between the rows of wheat to help keep new weeds under control.**

Husbandry

Uniform crop stand and early vigour discourage weed growth. In this respect tillering allows the crop to compensate for poor stands and variable weather conditions. Yield losses due to weeds are caused by early competition in the first 4-5 weeks. The more common weeds are: Amaranth (*Amaranthus* spp.), Couch grass (*Cynodon dactylon*), purple nutsedge (*Cyperus rotundus*), East African couchgrass (*Digitaria abyssinica*), goose grass (*Eleusine indica*), purslane (*Portulaca oleracea*) and horse purslane (*Trianthema portulacastrum*).Weeds can be controlled by hand weeding and proper crop rotation.

Wheat is best rotated with non-graminaceous crops, particularly with pulses, potatoes or any other crop which is possible to keep free of weeds. Weeds effectively compete with wheat for nutrients, water and light and are the biggest constraint to good yields. Early seed bed preparation, allowing weeds to germinate with the first rains, followed by a very shallow harrowing will greatly reduce the amount of weeds in the wheat crop.

Irrigation has great potential to increase wheat production. It can be practised in basins, by furrow, or using overhead sprinklers. Care must be taken not to over-irrigate as wheat, which unlike rice, is very sensitive to early waterlogging. Critical water demanding periods is a) right after planting, b) at tillering stage and c) flowering stage.

Copper deficiency

Some areas in Kenya have been found to have soil deficient in copper. This results in poor growth and tipburn of all grasses and grains including wheat. Copper deficient areas include:

- **Nakuru district: Njoro, Rongai, Menengai, Lanet, areas bordering Elburgon and Mau Narok as well as Gilgil and Naivasha areas.**
- **The whole of Narok district.**

What to do: The seed must be dressed with copper oxychloride (1 kg/100 kg of seed). Also a foliar spray of 1 kg/ha should be applied at early tillering stage.

Fertilisation

Fertilization necessary for wheat depends on previous land use. As soils usually are deficient in particularly in phosphorous, an application of Mijingu rock phosphate or similar of about 150 - 200 kg/ha is usually needed. For Nitrogen supply, organic farmers can try the TwinN available from Lachlan Ltd, in Kenya. They report good results in wheat with this product which consist of free living nitrogen fixing bacteria. This product should not be mixed with copper sprays as copper will kill the bacteria.
The product is certified organic by the Soil Association. Contact: Lachlan@agriculture.co.ke, tel Kenya: +254 20 207 3912/3/4.

Harvesting

A crop harvested at physiological maturity must be dried thoroughly before threshing. Wheat matures in 4-7 months depending on variety and altitude. At higher altitudes it takes longer.
Small scale farmers usually cut the wheat using hand sickles. This should be done when the kernels have become hard. The wheat is then tied into bundles and stoked to be threshed when completely dry. Where birds are not a problem the cut wheat plants can be stacked or spread out to dry in the sun in a clean area - preferably on a cement slab or plastic sheet in order to reduce losses.

Threshing, which is more difficult with wheat than with rice, may be done by beating with flails, trampling by humans or animals, or by driving a small tractor over the straw. A wheat sheaf may also be beaten by hand against a low wall, an oil drum, or a wagon bed, so that the grains fall into a container or onto a mat. Grain losses can be considerable with these procedures. Pedal or motor-driven paddy rice threshers are also used.

Large scale farmers use combine harvesters and can sometimes be persuaded to harvest smaller plots for a fee.
The grain should be dried to a maximum moisture content of 13% before storing. Tooth test: Bite a grain. If it is possible to crush the grain with the teeth it is not dry enough. If the grain cracks under pressure it is probably dry. Also try the salt test method described in The Organic Farmer magazine Nr. 30, Nov 2007, page 3.

If the straw of wheat has had disease or pest problems it should be removed from the field and either sold or used as fuel or animal feed in order not to leave pests and diseases to survive in the field. If the straw is healthy, it is good to use as mulch for other crops (livestock does not much like wheat straw much) or to incorporate it into the soil. Burning straw is waste of a valuable resource and should only be practised if it is very diseased.

Some farmers (not organic) have successfully tried to treat wheat straw with urea. If packed airtight in plastic while undergoing treatment, this greatly improves the feeding quality of wheat straw.

Information on Pests

Pests

Field pests include various aphids (which being vectors of virus diseases can be serious pests in wheat), termites, grasshoppers, planthoppers, leafhoppers, bugs, thrips, beetles, grubs, worms, maggots, miners, midges, sawflies, nematodes (of the roots and the grain), and birds.
Storage pests include the rice weevil (*Sitophilus oryzae*), the lesser grain borer (*Rhyzopertha dominica*), the Angoumois grain moth (*Sitotroga cerealella*), and the khapra beetle (*Trogoderma granarium*). Rodents, mainly the black rat (*Bandicota bengalensis*), also damage stored seeds.

Birds: Wheat farmers have found that stringing aluminium or bright coloured plastic strips that move with the wind across the wheat fields can act as a deterrent to quelea and weaver birds. If this cannot be found others employ young boys with a long rope to patrol the field and snap the rope as a whip whenever the birds try to settle and eat in an area.

Aphids:
Cereal aphids various, being vectors of virus diseases, such as the Barley yellow dwarf virus, can be serious pests in wheat. The important cereal aphids that attack wheat in Kenya include Schizaphis graminum, Sitobion avenae, Rhopalosiphum padi, R. maidis, Metopolophium dirhodum and Diuraphis noxia (the Russian wheat aphid).

The Russian Wheat Aphid (*Diuraphis noxia*) is one of the most damaging pests of small grain cereals (e.g. wheat, barley, triticale, rye, and oats) in the world. This aphid is a relatively new pest of wheat in Kenya. It was first identified in farmers? fields in 1995. It then spread quickly to all the wheat growing areas of the country and it is nowadays the most important pest of wheat and barley. It is also a major pest in South Africa, but has

maintained minor pest status in Egypt, Sudan and Ethiopia.

The Russian wheat aphid is pale to light green in colour with an elongated, spindle shaped body and grows to up to two mm long. It has short antennae with rounded very short, nearly invisible cornicles. The feature that easily distinguishes it from other cereal aphids is the presence of an appendage above the cauda, which gives the aphid the appearance of having two tails. They prefer to live in the leaf whorls or in tightly rolled leaves, and thus are partially protected from natural enemies and from contact insecticides. They are hardy and can survive extremely low temperatures. Dry weather favours rapid increase of the aphid.

Unlike many important cereal aphids, the Russian wheat aphid is not a known transmitter of diseases, but causes damage by injecting a toxin into the plants during feeding. This toxin prevents the production of chlorophyll and causes, in susceptible cultivars, leaf chlorosis, longitudinal leaf rolling and white/yellow (warm weather) or purple reddish (cold weather) streaking on the leaves. Extensive chlorosis leads to death of plants while leaf rolling retards plant development causing stunted growth. The tight rolling of flag leaves delays ear emergence, leading to floret sterile heads resulting in reduction of seed set. Aphid infestation also reduces the quality of the seeds produced, as shown by low kernel weight, increased rate of seed deterioration under accelerated ageing conditions, and reduced seedling vigour. The effect of infestation on seed quality is more pronounced under dry conditions. Infestation also may result in reduced seedling vigour.

In Kenya, the damage usually appears when crops have attained the tillering stage. Yield losses ranging from 25 to 90% have been reported.

What to do:

- **Scout your crop regularly. Check for damage signs (first noticeable sign is slight to moderate yellowing of small areas of crop within the field; in addition the crop may appear to be under drought stress, even if there is no drought.)**

- **Use the correct seed rate to ensure good plant density, as low plant densities are susceptible to heavy attack by the aphid.**

- **Plant as early as possible for your area.**
- **Provide good growing conditions for the crop. A crop that is not stressed is more tolerant to aphid attack.**
- **Remove volunteer plants and grasses because they act as the aphid's hosts even before the main crop has been planted.**

Sources of information KARI and Kiplagat (2005).

Research in Kenya is focused on developing of resistant varieties, but as far as I know, there are no commercial resistant varieties in Kenya. KARI has been working on wheat for a long time. It would be good to check with them if they have any other recommendations, or if there is any promising variety available.

Information on Diseases

Diseases

On average, diseases and pests destroy 20% or more of potential grain harvest either in the field or in storage. The major diseases caused by obligate pathogens of wheat are stem rust (*Puccinia graminis* f.sp. *tritici*) and leaf rust (*Puccinia recondita* f.sp. *tritici*).

In cooler regions, stripe or yellow rust (*Puccinia striiformis*) may occur. The rusts infect the foliage and sometimes the spikes, resulting in maximum yield losses of 30-50%.

**The major diseases caused by non-obligate pathogens are spot blotch (*Cochliobolus sativus*), head scab and foot/root rot (*Fusarium* spp.), and sclerotium foot rot (*Corticium rolfsii*). Regionally important diseases are tan spot (*Pyrenophora tritici-repentis*), powdery mildew (*Erysiphe graminis*), speckled leaf blotch (*Mycosphaerella*

graminicola), glume blotch (_Phaeosphaeria nodorum_), alternaria leaf blight (_Alternaria_ spp.), rhizoctonia root rot (_Rhizoctonia_ spp.), bacterial leaf streak or black chaff (_Xanthomonas translucens pv. undulosa_) and Barley yellow dwarf virus. The most common fungi in stored wheat are various species of _Aspergillus_ and _Penicillium_.

The economic losses from diseases may range from slight to 100%. In order to reduce or minimize losses following practices are recommended:

- **Plant resistant or tolerant varieties. This is the most economical method.**
- **Early planting of susceptible cultivars can escape heavy infection from air boprne diseases**
- **Plant early maturing varieties - they stand a better chance of escaping serious attacks of air borne diseases**
- **Avoid monoculture of a given cultivar over a wide area**
- **Crop rotation with non cereal crops reduces the inoculum and level of soil borne diseases**
- **Good crop sanitation - reduces level of pathogen on trash left after harvest**
- **Use certified seeds**

Stem rust (Puccinia graminis f. sp. tritici)
It is characterised by pustules (a pimple-like or blister-like structure) that develop and break through the surface of the stems, leaves, sheaths, chaff and beards of the wheat plant. The kernels are badly shriveled, many of them being so light and chaffy that are blown out with chaff in threshing. The remaining grains may be shrunken to one-half or two-thirds normal size. Myriads of brick-red spores escape from the pustules and are carried by the wind to other wheat plants. Wheat stem rust also attacks barley, occasionally rye and many wild grasses (Hordeum spp., Agropyron spp., Elymus spp., Hystrix spp. and some bromegrasses). It does not attack oats.
What to do:
Plant resistant varieties, if available

Plant early
Control wild grasses
Avoid cropping of wheat in succession

Yellow rust (Puccinia striiformis)
The disease is also called stripe rust. Yellow or orange-yellow pustules develop on the glumes or chaff, on the leaves, and on the leaf sheaths. These lesions are arranged in parallel lines along the leaves. The disease may also attack the stems and the kernels. Infected leaves show distinct chlorosis. Damage to the disease is most serious, if plants are attack at milk stage or earlier. Under severe infection kernels may be shriveled. Rapid disease spread is favoured by warm weather with frequent rainfall. Yellow rust also attacks barley, rye, and over 60 species of grasses.
What to do:
Plant resistant varieties, if available
Control weeds
Avoid cropping of wheat in succession

Brown leaf rust (Puccinia recondita f. sp. tritici)
The lesions are brown at first and are most easily distinguished from those of stem rust by their size and shape: they are usually small and circular. They turn black as the crop matures. They occur on the leaf blades and the leaf sheaths and may appear at any stage of the crop's growth.
What to do:
Plant resistant varieties, if available
Control weeds
Avoid cropping of wheat in succession

Wheat bunt (Tilletia tritici)
Infected plants have reduced height. The smutted wheat heads are bluish green when thet emerge from the boot. The healthy heads are yellowish green. The disease also induces excessive tillering. The spores are blown by wind to developing ears which they invade. Bunt infected flowers have green ovaries while healthy

ones are white. The grain of wheat is replaced by a black mass of spores (spore ball) accompanied by a a smell like of rotting fish.
What to do:
Use certified diseased-free seeds
Plant resistant varieties, if available

Powdery mildew (Erysiphe graminis f. sp. tritici)
White powdery growth appears on all above ground parts of plants. The white growth consists of fungal mycelium and spores. The growth later turns buff in colour. The disease is wind-borne.
What to do:
Plant resistant varieties, if available
Remove crop debris after harvest
[Link to powdery mildew datasheet]

Take-all disease (Gaeumannomyces graminis)
It is soil-borne fungus. It invades and blackens the roots, frequently killing them in the process. Affected stems are black and shiny just above the soil level. This symptom can only been seen by peeling away the leaf sheaths. The disease occurs in slowly widening patches, and in these areas plants with poorly filled or empty ears (whiteheads) may be present. The pathogen survives between crops on cereal roots and stubble. It also attacks barley, oats and rye.
What to do:
Rotate with nonsusceptible crops such as alfalfa, sweet clover or maize
Remove stubble from the fields
Avoid continuous cropping with wheat, barley, oats or rye

Glume blotch [Phaeosphaeria (Leptosphaeria) nodorum]
It can cause considerable damage in wet years, especially where wheat has been grown for several years in succession. Symptoms consist of brown lesions on the glumes and around the nodes. At advanced stage of the disease black spots just like dots can been seen on the lesions. These are fungal spore bodies (pycnidia).

The affected leaves become shriveled with light brown patches on them. Glume blotch is spread by use of infected seeds, rain splash and infected crop residues.

What to do:

Use certified disease-free seeds

Burn stubble and crop debris after harvest

Rotate with nonsusceptible crops such fodder grasses or maize

Barley yellow dwarf virus (BYDV) (luteovirus)

Symptoms include leaf discolouration from tip to base and from margin to centre. The discolouration takes on different colours depending on the plant. In barley, the leaf turns bright yellow; in oat, an orange, red or purple discoloration is seen and in wheat, rye and triticale, the infected leaves are generally yellow and sometimes red. Plants are usually stunted, with a decrease in tiller number and biomass and a weak root system. Suppressed heading, sterility and failure of grains to fill occur in the most severe cases. In the field, symptoms appear usually as yellow or red patches of stunted plants. The disease is most damaging in terms of yield reduction, if it infects a crop at an early stage of growth. The virus is spread by cereal aphids (e.g. Rhopalosiphum padi, R. maidis, Sitobion avenae, etc.). It is neither seed-borne nor mechanically transmitted. It also attacks maize, rice and several grasses.

What to do:

Plant resistant varieties, if available

Control aphids

Control weeds

Information Source Links

- **Agriculture Information Centre (AIC) (2002). Field Crops Technical Handbook. Ministry of Agriculture, Nairobi Kenya**
- **CABI. (2005). Crop Protection Compendium, 2004 Edition. © CAB International Publishing. Wallingford, UK. www.cabi.org**
- **KARI. Keep Russian Wheat Aphid Off Your Crop. http://www.kari.org/Infobrochures/RussianWAphid.htm**
- **Kiplagat O.K. (2005). The Russian wheat aphid (Diuraphis noxia Mord.): Damage on Kenyan wheat**

(Triticum aestivum L.) varieties and possible control through resistance breeding . Thesis Wageningen University, The Netherlands. ISBN 90-8504-175-9

- **Lachlan Kenya Limited (2007). TwinN - 20 frequently asked questions. www.agriculture.co.ke**

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Amaranth

Amaranth
Scientific name: *Amaranthus* spp.
Family: Caryophyllales: Amaranthaceae
Local names: Mchicha (Swahili), terere (Kikuyu), lidodo (Luhya), ododo (Luo), kelichot (Kipsigis), w'oa (Kamba), emboga (Kisii), kichanya (Taita), doodo (Luganda)
Common names: Pig weed
Pests and Diseases: Aphids Bugs Choanephora fruit rot Cutworms Damping-off diseases Leafmining flies (leafminers) Spider mites Weeds Weevils Alternaria leaf spot, Flea beetles, Leafrollers

General Information and Agronomic Aspects

Geographical

While originating from tropical America Amaranth is now very widely distributed throughout the tropics.

Amaranth is an herbaceous annual belonging to the family Amaranthaceae with green or red leaves and branched flower stalks (heads) bearing small seeds, variable in colour from cream to gold and pink to shiny black. There are about 60 species of Amaranthus, however, only a limited number are of the cultivated types, while most are considered weedy species and hence rarely preserved. Many amaranth species are collected from the wild for subsistence, while only few are cultivated or occur as protected weeds in

Distribution of Amaranth in Africa

backyards and home gardens (Stallknecht and Schulz-Schaeffer, 1993; Ouma ; Keller, 2004).

Amaranth can be used as a high-protein grain or as a leafy vegetable. The seeds are eaten as a cereal grain. They are ground into flour, popped like popcorn or cooked into porridge. The seeds can be germinated into nutritious sprouts (GFU for Underutilized Species).
The leaves are cooked alone or combined with other local vegetables such as spider plant and pumpkins. The leaves are rich in calcium, iron and vitamins A, B and C, but fairly low in carbohydrates (Ouma M.A.). There is no distinct separation between the vegetable and grain type since the leaves of young grain type plants can be eaten as greens (Stallknecht and Schulz-Schaeffer, 1993).

Varieties
Of all the indigenous tropical leafy vegetables, amaranth has the largest number of species and varieties. The choice of variety varies widely among regions and is dictated largely by the species available. Regardless of species, the choice of variety is influenced by individual preference for leaf colour and taste. Some of the most common commercial amaranths are selections of *A. tricolor* which come in various leaf colours such as white (light green), dark green, red, purple and variegated. To identify which varieties are best adapted to your location, compare during different growing seasons the yield potential of currently grown varieties with that of other available varieties (AVRDC 2003).

Nutritive Value per 100 g of edible Portion

Raw or Cooked	Food Energy (Calories / % Daily Value*)	Carbohydrates (g / %DV)	Fat (g / %DV)	Protein (g / %DV)	Calcium (g / %DV)	Phosphorus (mg / %DV)	Iron (mg / %DV)	Potassium (mg / %DV)	Vitamin A (mg / %DV)	Vitamin C (mg / %DV)	Vitam B6 (mg / %DV)
Amaranth	102 / 5%	18.7 / 6%	1.6 /	3.8 /	47.0 /	148 / 15%	2.1 /	135 / 4%	-	-	0.1 /

grain cooked			2%	8%	5%		12%				6%

*** Percent Daily Values are based on a 2000 calorie diet. Your daily values may be higher or lower, depending on your calorie needs.**

Climatic conditions, soil and water management

Amaranth grows from sea level to 2400 m altitude. The different species may suit different altitudes. Normally the hotter it is the better it grows and it generally thrives within a temperature range of 22-30°C. A minimum temperature of 15 to17°C is needed for seed germination. Amaranth is grown during both wet and dry seasons, though irrigation is normally required for dry season crops since the rate of transpiration by the leaves is fairly high. Frequent applications of water are required, related to the stage of growth of the crop and the moisture-retaining capacity of the soil. It can however tolerate periods of drought after the plant has become established. It is adapted to low to medium humidity (Bruce French, EcoPort).

Amaranth grows best in loam or silty-loam soils with good water-holding capacity, but it can grow on a wide range of soil types and soil moisture levels. Amaranth can tolerate a soil pH from 4.5 to 8. (ACRDC 2003).

Propagation and planting

Amaranth requires thorough land preparation and a well-prepared bed for good growth. Form 20cm high beds during the dry season and 30 cm during the wet season using a plough. The distance between centres of adjacent furrows should be about 150 cm with a 90 cm bed top.
Amaranth is planted either by direct seeding or transplanting. The choice of planting method depends on availability of seed and labour and may also vary with the growing season. Direct seeding is appropriate when plenty of seed is available, labour is limited, and during the dry season when frequency of flooding is less. Transplanting is preferred when there is limited amount of seed, plenty of labor, and during the wet season when heavy rains and flooding are most likely to wash out seeds. Raising seedlings in a nursery and transplanting them to the field shorten the crop duration in the field, and secure a better and more uniform

stand especially during the wet season.

Direct seeding
When direct seeding is used, seeds are either broadcasted or sown in rows. Broadcast seeds uniformly at the rate of 0.5 to 1.0 g/m2 of bed; Since amaranth seeds are very small, mixing seeds with sand at a ratio of one g seed to 100 g sand makes it easier to sow the seed and to obtain a uniform stand. Cover seed lightly with a layer of compost or rice hulls immediately after broadcasting. When plants are to be grown in rows make furrows 0.5 to1.0 cm deep and space rows 10 cm apart on the bed. Sow seeds five cm apart within the row and cover with a layer of compost or rice hulls. (AVRDC 2003)

Transplanting
There are two steps to transplanting:

1. Seedling production
Seedlings are grown in a seedbed, pulled and bare-root transplanted. They can also be grown in divided trays, lifted with the root ball intact and transplanted. If seedlings are started in a raised soil bed, the soil should be partially sterilised by burning a 3-5 cm thick layer of rice straw or other dry organic matter on the bed. This also adds minor amounts of phosphorus (P) and potassium (K) to the soil, which helps in the establishment of the seedlings. Broadcast the seeds lightly in a seedbed and cover them with soil. The seeds should be one cm deep. Cover the seedbeds with an insect-proof net to protect seedlings from pests.

2. Setting plants into the field
Transplant in the late afternoon or on a cloudy day to minimise transplant shock. Dig holes 10 cm deep on the bed using recommended spacing for the chosen variety. Place each transplant in its hole and cover the roots with soil and lightly firm. Irrigate immediately after transplanting to establish good root-to-soil contact.

Husbandry
Amaranth is a low management crop and can grow in poor soils, but it will benefit from application of organic

fertiliser resulting in yield increases .
Although amaranth is relatively drought tolerant, yet insufficient water will reduce yield. Water should be applied especially just after sowing or transplanting to ensure a good stand. As a rule, the plants should be irrigated if wilting occurs at noontime. Another way to estimate soil moisture content is to take a handful of soil from the bottom of a 15-cm deephole. Squeeze the soil. If it holds together when you release your grip, there is sufficient soil moisture; if the soil crumbles, it is time to irrigate. Irrigate thoroughly to maintain vigorous plant growth. Avoid over-irrigation, which may enhance disease development and nutrient leaching. Drip irrigation or micro-sprinkler irrigation is recommended in areas with limited water supply (AVRDC 2003)

Harvesting

First harvest is at a plant height of 30 cm, about six weeks after transplanting. Plants may be harvested at once or leaves and tender shoots maybe harvested several times. One single harvesting is adapted for short maturing and quick growing varieties such as *A. tricolor*. Whole plants are pulled from soil with roots, washed and tied in bundles. With multiple harvests, young leaves and tender shoots are picked at 2 to 3 week intervals. Eventually, the plants begin to flower and develop fewer leaves. Frequent harvesting of leaves and shoots delays the onset of flowering and thus prolongs the harvest period.

Amaranth and other leafy vegetables have a large surface and loose water rapidly. To reduce water loss, harvest during the cooler time of day, such as early morning or late afternoon.

Information on Pests

Amaranth is susceptible to damage by foliar insects such as leafminers, leafroller caterpillars, cutworms, aphids, flea beetles, and mites.
An effective method of controlling insect pests is to cover the bed with a fine screen or nylon mesh netting (32-mesh or finer). (AVRDC 2003)

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 seed production. Damage may also reduce seed viability.

What to do:

- **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 vegetables (Maundu, 1997). For more information on biopesticides click here**
- **Conserve natural enemies. They are important in natural control of aphids. For more information on natural enemies click here**

Aphids
Adult wingless females are oval-bodied, 1-2mm in body length, of very variable colour.

Cutworms

Cutworms attack young seedlings. First instars are 7-12mm, later instars are 3.5-5cm long. The caterpillar emerges from the soil at night, encircles the plant with its body and cut through the stem of young plants just above ground level. They may also damage the plants underground. Cutworm damage causes plants to wilt and die. Cutworm damage is usually minor and does not normally warrant control. However, in severe outbreaks a young crop may be destroyed.

What to do:

- **Monitor damage by counting damaged and freshly cut young plants. Monitor cutworm at dawn**
- **Remove and destroy cutworms**
- **Prepare field and remove weeds well ahead (10-14 days) of planting the crop in the field. Ploughing exposes caterpillars to predators and to desiccation by the sun. If the field is planted soon after land preparation some cutworms may be alive and attack the new crop**

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

Leafminers (*Liriomyza* spp.)

Leafminers (*Liriomyza* spp.) are small flies, 1.3-1.6 mm in length. The maggot makes long, slender, white mines (tunnels) in leaves. Severely mined leaves may turn yellow and drop. Severely attacked seedlings are stunted and may eventually die. Control measures are necessary when attack is severe, especially on young plants.

What to do:

- **Conserve natural enemies. They are very important in natural control of leafminers. For more information on natural enemies click here**
- **Handpick and destroy mined leaves**
- **Whenever necessary spray the crop with neem products. Neem water extracts and neem oil give good control of leafminers. For more information on neem click here**

Leafminers
Damage on leaf by leafminers (*Liriomyza* spp.)
© A.M. Varela, icipe

Spider mites (*Tetranychus* spp., *Mononychellus* spp., *Oligonychus* spp.)

Spider mites feeding on plants may cause reduction in plant growth, flowering, number and number of seeds.

Damage is most severe when mites attack young plants. Mite damage may be particularly severe during the dry season.

What to do:

- **Avoid planting next to infested fields**
- **Avoid frequent 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 destroys their webs. Be sure to include the underneath of the leaves. However, this should be done early in the day to allow the foliage to dry. Wetness of the foliage for an extended period is conducive to development of fungal diseases**

Spider mites
Two-spotted spider mite (*Tetranychus urticae*). The adult female is 0.6 mm long. The male is smaller.
© Image supplied by Warwick HRI, University of Warwick

Weevils

Several species of weevils feed on amaranth. Adult weevils feed on leaves, but the larvae (grubs) are more damaging because they bore into roots and stems, causing rotting and potentially lodging and predisposition to diseases. Stem-boring weevils such as the pigweed weevil (*Hypolixus haerens*) are the most damaging

causing plants to wither and lodge. The adult weevil lays its eggs in branch crotches, and the larvae bore through stems to the root collar hollowing the stems. Feeding by larvae results in stems that are more susceptible to wind breakage, increasing crop losses. The larvae pupate in the stem.

In South Africa, attack by this weevil has been associated with extensive tissue discolouration, decay and cankers in branches, stems, and root collars of *Amaranthus hybridus*. This weevil has been found to be associated with fungi (mainly *Fusarium spp*) that cause tissue decay and a canker disease (Blodgett, J. T. et al., 2004).

What to do:

- **Uproot and destroy attacked plants to reduce number of weevils and prevent damage to healthy plants**

Adult weevil in amaranth stem

© A. M. Varela, icipe


Adult weev..


Weevil lar...


Amara p...


Canke and...

Bugs

Bugs can cause severe damage to flowering head and seeds, and may be particularly damaging to grain amaranth when present in large numbers during the critical seed fill stage. They are usually of minor importance in vegetable amaranth, and no control measures are needed.

What to do:

- **Bugs are usually of minor importance in vegetable amaranth, and no control measures are needed.**

Bugs
Bugs feeding on amaranth flowering head
© A. M. Varela

Information on Diseases

Damping-off caused by *Pythium* may occur when the seed-bed is too wet. Wet rot (also called Choanephora fruit rot or blight) caused by *Choanephora cucurbitarum* and some other fungal diseases (Albugo, Alternaria, Cercospora, Phoma, Rhizoctonia) may cause problems. The crop is more susceptible to these diseases under humid conditions, high plant density and high doses of nitrogen. Plant parasitic nematodes are reported to occur but are not a serious problem.
See detailled information below.

Damping-off diseases (*Pythium* spp.)

The disease is caused by *Pythium aphanidermatum*, *Rhizoctonia solani* and *Aphanomyces* sp. Seeds may rot in the soil before emergence (pre-emergence damping-off) or seedlings may exhibit stem canker above the soil line and/or root necrosis. Affected seedlings eventually wilt (post-emergence damping-off). The disease is favoured by high soil water content and low soil temperatures. Also dense planting without sufficient aeration enhances disease development.

What to do:

- **Use disease-free seeds**
- **Avoid over watering**
- **Avoid dense planting**

Damping-off
Damping-off disease *(Rhizoctonia solani)* (here on beans)
© Jürgen Kranz. Courtesy of Ecoport (www.ecoport.org)

Choanephora fruit rot

Choanephora blight (also called Choanephora fruit rot) is caused by fungus *Choanephora cucurbitarium*. It

causes wet rot of stems and leaves. Affected plant parts have hairy appearance (silk-like threads) consisting of fungal spores. Infection is predisposed by injuries. During rainy season it can cause heavy defoliation. The disease is spread by air currents and infected seeds. Warm, moist conditions favor disease development.

What to do:

- **Use resistant varieties where available**
- **Plant certified disease-free seeds**
- **Avoid dense planting to allow sufficient aeration**
- **Practise good field sanitation**
- **Spray copper when the disease is observed, see more under biopesticides: copper**

Choanephora fruit rot
Choanephora fruit rot (*Choanephora cucurbitarum*) on pumpkin (*Cucurbita maxima*)
© Clemson University - USDA Cooperative Extension Slide Series, www.insectimages.org

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Information on Weeds

Weeds

Weeds compete for light, water, and nutrients, thereby resulting in reduced yield. Thorough land preparation is the first key to effective weed control. Amaranth is small-seeded and slow to germinate, therefore, weed control is essential early in the season. A seedbed free of weed seeds allows amaranth seedlings to get a head

start on the weeds and establish a canopy that can shade out emerging weed seedlings.

What to do:

- **Mulching is recommended to reduce weed competition, soil compaction and erosion; mulching also conserves soil moisture. Be sure the organic mulching materials are free of weed seeds. Mulching is easier to apply if the amaranth crop is transplanted, but can also be used for row-seeded crops after the seedlings reach a height of 10 to 15 cm.**

Striga in maize field
Striga (*Striga hermonthica*) weeds in maize field.
© David C. Nowell, EcoPort

Fresh Quality Specifications for the Market in Kenya

The following specifications constitute raw material purchasing requirements.

PRODUCE:	Amaranthus (Terere, Mchicha)
IMAGE:	
VARIETY:	Various
General appearance criteria	
COLOUR:	Mid green to dark green.
VISUAL APPEARANCE:	Freshly cut non wilted healthy stems covered with medium sized green shiny leaves. Free from seedy brushes.
SENSORY:	Crisp stems and leaves, free from any signs of wilting
SHAPE:	Bunches of stems approximately two hands width
SIZE:	Approximately 35 cm long stem each 0.6 cm width . Weight approximately 500g
MATURITY:	Not tough or fibrous, young and succulent
INSECTS & PHYSICAL DAMAGE:	With no evidence of insect damage. Without unhealed cuts, holes or splits from physical or pest damage

Information Source Links

- **Amaranth (*Amaranthus* spp.) Global Facilitation Unit for Underutilized Species- Enabling deployment of underutilized species. www.underutilized-species.org**
- **Blodgett, J. T., Swart, W. J. and Louw, S. vdM. (2004). Identification of Fungi and Fungal Pathogens Associated with Hypolixus haerens and Decayed and Cankered Stems of *Amaranthus hybridus*. Plant Disease, Volume 88, Number 4: 333-337. http://apsjournals.apsnet.org**
- **EcoPort - The consilience Engine. www.ecoport.org**
- **FORMAT. Forum for Organic Resource Management and Agricultural Technologies. www.formatkenya.org**
- **Keller, G.B. (2004). African nightshade, eggplant, spiderflower et al. -production and consumption of traditional vegetables in Tanzania from the farmers point of view. Master thesis. Institut für Pflanzenbau in den Tropen und Subtropen. Georg-August Universität Göttingen, Fakultät für Agrarwissenschaften.**

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- Ouma, M.A. Indigenous vegetable production and utilization in Suba district, Kenya: Improving health, unlocking the wealth in Suba district. BioVision - T.T.U, ICIPE. Unpublished.
- Palada, M.C., Chang, L.C. (2003). AVRDC, International Cooperator's Guide Suggested Cultural Practices for Vegetable Amaranth. www.avrdc.org
- Stallknecht, G.F. and Schulz-Schaeffer, J.R. (1993). Amaranth rediscovered. p. 211-218. In: J. Janick and J.E. Simon (eds.), New crops. Wiley, New York.

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Peas

Peas
Scientific name: *Pisum sativum*
Family: Fabales: Fabaceae
Common names: Garden pea / English pea / green pea / snow pea / mangetout
Pests and Diseases: African bollworm Aphids Ascochyta blight Bacterial blight Cutworms Downy mildew Fusarium wilt Leafmining flies (leafminers) Pea blue butterfly Powdery mildew Root-knot nematodes Snails (Giant East African Snail) Spider mites Storage pests Thrips Virus diseases

General Information and Agronomic Aspects

***Pisum sativum* probably originated in South-West Asia; it is now cultivated in many temperate countries, as a cool-season crop in the subtropics and at higher altitudes in the tropics.**

Geographical Distribution of Peas in Africa

Peas are cultivated for the fresh green seeds, tender green pods, dried seeds and foliage. Dry seeds are used for food and feed. For food, they are cooked whole, split or ground into flour, and boiled or roasted. Large amounts are canned. Fresh peas are canned or frozen in the immature form. They are a major vegetable and commercial crop. Some cultivars are grown for their tender green pods such as snap peas (sugar snaps) and snow peas (sweet peas) mainly for export. The crop is also suitable as forage, hay, silage and green manure. Kenya export of garden peas in 2005 amounted to 2,206 tonnes at a value of KSh 729 million, and of snow peas 1,739 tonnes at a value of KSh 448 million. Total area of garden peas in 2005 was 5,313 hectares and for snow peas 1,550 hectares for both local and export market.

Nutritive Value per 100 g of edible Portion

Raw Vegetable	Food Energy (Calories)	Protein (g)	Carbohydrates (g)	Ash (g)	Calcium (g)	Phosphorus (mg)	Iron (mg)	Potassium (mg)	Vitamin A (I.U)	Thiamine (mg)	Ribof (mg)
Pea, Edible Podded	53	34	12.0	1.1	62	90	0.7	170	680	0.28	0.12
Pea, Green, Immature	84	6.3	14.4	0.9	26	116	1.9	316	640	0.35	0.14

Pea, Mature, Dry	**340**	**24.1**	**60.3**	**2.6**	**64**	**340**	**5.1**	**1005**	**120**	**0.74**	**0.29**

Climatic conditions, soil and water management

Peas produce best yields and quality in cool and moist growing conditions. They grow reasonably well between 10 and 30°C with an optimum of 20°C. Temperatures above 30°C will cause poor pollination, early maturity and lower yields. Good soil moisture content is a requirement of peas, particularly at flowering and pod development. A minimum of 400 to 500 mm rainfall per cropping season (about three months) is required for growing peas without supplementary irrigation In tropical regions, the crop has to be grown above an altitude of 750 m. Peas can grow on a wide range of soils but thrive best on a well-drained soil with an optimum pH of 6 to 7.7 and a high content of soil organic matter. Time of sowing and place in the crop rotation depend on regional climate, variety and purpose of growing, whether for export or for local use. Dry peas are primarily grown as a break or catch crop in cereal rotations.

Varieties

There are two types of pea varieties based on the texture of the seed coats: Wrinkled seed type - this is due to the sugar content and the varieties are used for fresh consumption or export. Smooth seed type - these are used for dry peas and the main variety is "Black Eyed Susan".

Peas grown for fresh consumption of their seeds (green or garden peas) are harvested as soon as the pods are well-filled but the seeds are still tender and sweet. Generally, the pod is discarded after the peas are removed; but some young tender varieties have an edible pod, which are often used in Chinese dishes. Green peas are highly perishable and the sugar to starch conversion begins the moment they are picked.

Some varieties of green peas:

- **Green feast**
- **Earlicrop - a short, early maturing variety that does not require staking**
- **Onward - a climbing variety suitable for wet season production**
- **Alderman - a late maturing variety that requires staking.**

Snow peas or sugar peas have edible flat pods and very small seeds. They are harvested when very young, just as the seeds start to form. If not picked at this stage, they can be shelled and eaten as garden peas, but are starchier and not as sweet.

Sugar snaps are also an edible pod pea but have larger and sweeter seeds and a thicker pod than snow peas, but more delicate than the green peas. They are grown to full size and then eaten like snap beans.
Both snow peas and sugar snap peas last much longer than the green pea.
The main varieties of snow peas grown in Kenya include: "Carouny", "Mammoth Melting Sugar", "Dwarf Grey Sugar", "Oregon Sugar Pod", "Sugar Snap" and "Toledo" (HCDA).

For export crops, the exporters normally provide the seed, choosing from many imported seed varieties (not all of which are well adapted to East African climate).

Propagation and planting

Peas are sown directly on well prepared moist soils. The seeds should be planted at a depth of 2.5 cm if the soils are deep. In dry, light soils the seeds should be planted about 4 cm deep. Peas need warm soil to grow and good spacing for adequate sunlight. The seeds should be sown in double rows of 10 x 50 to 60 cm. If staked, this is done between the double rows using twigs or short-staked wires and/or strings.

In soils with low organic matter, up to 20tons/ha of manure or compost should be applied before planting, as well as up to 200 kg/ha of rock phosphate. Being a legume, peas are not responsive to nitrogen fertilizer,

however it is recommended to inoculate the seeds with rhizobium (any of a genus (Rhizobium) of nitrogen-fixing bacteria found in nodules on the roots of certain leguminous plants) to encourage the plants to fix enough nitrogen from the atmosphere. Inoculating with rhizobium has been shown to increase yields by up to 100%. Mix crop residues and organic matter in the top 20cm of the soil prior to planting. This destroys current weed growth and provides a granular bed for seeding.

Husbandry

The first key need of peas is moisture. They have to be irrigated when conditions become dry. Also weed control is very essential at an early stage to reduce competition for nutrients. However, peas develop rapidly and the need for weeding is reduced when fully grown. Shallow cultivation is recommended to avoid root damage.
A suitable crop rotation program involving grains, potatoes and brassicas should be used. For good quality fresh market peas staking is recommended.

Harvesting

Green peas are ready for harvesting 8 to 12 weeks after planting. The time to harvest is determined by the appearance of the pods. For garden peas this means pods should be well filled but still smooth and green. Pod peas are harvested when pods have reached full size but before development of seeds. As the pods mature the sugar content decreases and market appeal is lost. The harvesting period may last 4 to 6 weeks. Yields vary from 1.5 tons to over 5 tons of shelled peas per hectare, with average yields of 2.5 to 3.5 tons per hectare. For the fresh market, yields of peas in pods vary from 3 tons to 10 tons per hectare, or an average of 5 or 6 tons of pods per hectare. Edible podded peas will normally yield 3 to 5 tons of pods per hectare. For fresh market whether locally or export, the harvested pods are sorted and packed. Washing is not desirable as it may bruise the pods; so soiled pods are discarded during sorting along with malformed or diseased pods. Rejected peas are excellent animal feed.
For dry peas the whole plant can be uprooted when about 80% of pods have turned brown and dry. The haulm is then either left in the field or carried to a threshing place to dry completely, after which the peas are threshed and winnowed. For storage of dry peas please see chapter on storage pests (click here).

Information on Pests

Cutworms

Cutworms are the caterpillars of some moths. They cut-off seedlings at ground level, usually at night. They also feed on roots and leaves. They hide in the soil during the day.

What to do:

- **Plough field and remove weeds well ahead of planting the crop in the field. Ploughing exposes caterpillars to predators and to desiccation by the sun. If the field is planted soon after land preparation some cutworms may be alive and attack the new crop.**
- **Inspect soil carefully for the presence of cutworms when preparing land for planting.**
- **Make barriers to protect seedlings. Barriers can be made by wrapping paper, aluminium foil, thin cardboard, or similar materials around the base of young plant stems. Toilet rolls are handy as cutworm collars since they are readily available and will biodegrade into the soil.**
- **Monitor damage by counting damaged and freshly cut young plants.**
- **Collect and destroy cutworms. Cutworms are found in the soil close to damaged plants at daytime. Check for cutworms at dawn.**

Black cutworm

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

Aphids

Aphids are serious pests of peas. The pea aphid (*Acyrthosiphon pisum*), the cowpea aphid (*Acyrthosiphon pisum*), and *Myzus* sp. (*Aphis carccivora*), are found on young leaves and growing points.
They suck sap from leaves, stems, blossoms and pods. Feeding by aphids causes leaf distortion and wilting. Heavily infested plants are stunted and produce fewer and smaller pods and seeds. The pea aphid may also transmit viruses such as pea enation mosaic virus, pea streak virus and pea leaf roll virus. Parasitic wasps and predators (hoverflies and ladybird beetles) are important for natural control of aphids.

What to do:

- **Parasitic wasps and predators (hoverflies and ladybird beetles) are important for natural control of aphids. Encourage natural enemies by interplanting peas with plants such as maize, which are host for aphids that do not attack peas, but allow predators to build up.**

Pea aphid
The pea aphid (*Acyrthosiphon pisum*) is a large, rather long-bodied aphid, with long slender appendages (legs and cornicles), which forms colonies on young growth and developing pods of many. Wingless forms

of females are usually 2.5-4.4mm long, winged females range from 2.3-4.3 mm.
© Whitney Cranshaw, Colorado State University, Bugwood.org


Pea aphid


Pea aphid

African bollworm (*Helicoverpa armiguera*) and other caterpillars

Various species of caterpillars feed on leaves and pods of peas. The most common are the African bollworm (*Helicoverpa armiguera*), the beet armyworm (*Spodotera exigua*) and hairy caterpillars (Arctiidae).

Caterpillars bore holes and feed on leaves, flower buds and maturing pods eating the seeds. They also attack young pods eating the pod wall and the developing seeds.

What to do:

- **Conserve natural enemies. Caterpillars have a wide range of natural enemies (parasitic wasps, predators and pathogens) that are important in their natural control.**
- **Inspect the crop regularly.**
- **Handpick and kill caterpillars or feed them to poultry. This helps when their numbers are low and in small fields.However, if possible wear gloves when handling hairy caterpillars. Some of them have urticating hairs, which may cause skin irritation.**
- **If necessary, spray Bt or neem products. For more information on neem click here. For information on Bt click here**

African bollworm
African bollworm (*Helicoverpa armiguera*) feeding on peas. Fully grown caterpillars are 3-4cm long.
© A.M. Varela, icipe


Africar bo…


Damag by …

The pea blue butterfly (*Lampides boeticus*)

It is a pest of peas during the flowering and podding stages. The adult is a butterfly bright blue (males) to brown (females) in colour. They have small tails at the edge of the hind wings, and two eye-like spots near each tail. The wing undersides are sandy-brown with creamy transverse bands. The moth lay eggs singly on the shoots, on or near the young flowers. Upon hatching the small caterpillars are yellow in colour, and are very active feeding first inside the flower and then inside the developing pod eating the young seeds. On small pods the caterpillar makes a hole in the pod wall in order to reach the seeds. Older caterpillars are grub-like green or pear white in colour and reach up to 15 mm when fully-grown. Pupation takes place amongst debris and leaves on the ground, under stones, or even in a curled-up, withered leaf on the plant.

What to do:

- **Conserve natural enemies. Parasitic wasps and flies attack caterpillars and are important for the natural**

control of this pest.

Pea blue butterfly
Caterpillar of the pea blue butterfly and damage to peas (*Lampides boeticus*)
© A.M. Varela, icipe

Thrips (*Sericothrips* spp, *Frankliniella occidentalis*, and *Thrips tabaci*

Thrips suck plant tissues causing withering of the plant. Infested parts show silvery white discolouration. Thrips feeding on pods cause tinny scars and blemishes. The damaged pods may not be noticed at harvest, but scars become more visible during post harvest transport to market. Thrips damage lowers the market value of snow peas and sugar snaps (which are eaten as pods) and may lead to rejection. Their feeding punctures may also be a point of entry for disease-causing fungi such as *Ascochyta*. Thrips are difficult to control since they often migrate into peas from surrounding vegetable crops and weeds.

What to do:

- **Conserve natural enemies. Anthocorid bugs and predatory mites are important natural enemies of thrips. Avoid use of pesticides that kill natural enemies**

Thrips
Thrips damage on snowpea
© A.M. Varela, icipe

Leafminers (*Liriomyza* spp. and *Chromatomyia horticola*)

Leafminers are major pests of peas. The maggots mine on leaves and pods. Mining of leaves affect the photosynthetic capacity of the plant. Mining of pods causes cosmetic damage leading to rejection of pods in varieties grown for their tender green pods such as a snowpeas and sugarsnap peas.

What to do:

- **Conserve natural enemies. Parasitic wasps usually keep leafminers under control. Avoid use of pesticides that kill these wasps and other natural enemies. For more information on natural enemies click here**
- **If necessary spray crop with neem products. For more information on neem click here**

Leafminer
Leafminer fly and damage caused by adult leafminer on peas.
© A.M. Varela, icipe

Spider mites (*Tetranychus* spp.)

Spider mites cause small white yellow specks on leaves. If spider mites are present in large numbers the leaf may be dry and fall off. Plants grow poorly when they are heavily infested. When infestations are heavy the spider mites will go up on the supports for the plants and accumulate on the tips so that the wind carry them to new crops.

What to do:

- **Monitor regularly the crop to determine the presence and level of infestations of spider mites.**
- **Conserve natural enemies. A number of predators are known to feed on spider mites. They usually keep spider mites under control provided broad-spectrum pesticides are applied and the crop is irrigated properly.**
- **Keep field free of weeds and destroy or compost crop residues immediately after harvesting. Crop residues from an infested field should be destroyed.**
- **Do not plant a new crop near an infested field.**

Spider mites
Two-spotted spider mite. The adult female is 0.6 mm long. The male is smaller.

Information on Diseases

Ascochyta blight (*Ascochyta pisi/ A. pinodella/Mycosphaerella pinodes*)

Ascochyta blight attacks all parts of the plant. The infected leaves have small to large, round to irregular, dark brown to purple spots. Some of the spots may have ashy grey centres. The spots usually have purple margins and may have rings. Spots may join up to form brownish purple blotches. Severely diseased leaves shrivel and dry, starting at the base of the plant and progressing upwards. Spots on pods are sunken but have no rings. Stem symptoms consist of brownish to purple streaks. Infection from infected seeds can cause a brown to black stem and foot rot just above the soil line. Such plants may die and result in a poor stand in the field. Blossoms may be infected and drop off during extended wet weather.

The disease is favoured by cool wet weather, heavy dews in the morning and relative humidity above 89%.

What to do:

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

- **Plough deeply pea stubble**
- **Remove crop residues from the field after harvest.**

Ascochyta blight
Ascochyta spots on snowpeas
© A.M. Varela, icipe


Ascocl **Ascocl**
… **…**

Powdery mildew (*Erysiphe polygoni*)

It is characterised by a white powdery growth on the leaves, stems and pods. The initial symptoms consist of tiny slightly discoloured spots on the upper surface of leaves. Theses spots enlarge and become covered with powdery fungal growth. The tissue beneath affected areas may turn purple and later brown. If infection is severe, affected plants turn brown and die. Affected seeds become brown. Water stress accelerates mildew development. Warm days and cool nights favour disease development. The fungus is seed-borne.

What to do:

- **Use certified disease-free seeds**

- **Treat own seeds by soaking for 30 minutes in 122° F / 500° C**
- **Plant resistant varieties, if available**
- **Practice crop rotation with non-legumes**
- **Plough under crop residues after harvest**
- **Spray with sulphur products, where local administration permits**

Powdery mildew
Powdery mildew of pea. Like all powdery mildews, *E. pisi* var. *pisi* produces a characteristic whitish, epigenous mycelium over the leaves, stems and fruits which is visible to the naked eye even from a distance.


Powde mi…


Powde mi…

Downy mildew (*Peronospora pisi*)

The fungal growth over leaf and pod is the most striking symptom. The fungal growth occurs on the lower leaf surface as well as on pods. Initially it is white but later it changes to a shade of violet and eventually to almost black. The disease may appear on pods even when it is not apparent on leaves. Affected pods show yellowish

brown areas. Inside of the affected pods a white fungal growth can be seen. Peas in such pods are small and have brown spots. The disease is favoured by cool and moist conditions.

What to do:

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

Downy mildew
Downy mildew (here on cabbage leaves)
© A.M. Varela, icipe

Fusarium near-wilt (*Fusarium oxysporum* f. sp. *pisi*)

The fungus can attack plants at any stage of development. Distinct symptoms consist of yellowing of foliage and wilting leading to death of affected plants. The disease appears in scattered areas of the field and eventually may cover bigger areas. If stem of diseased plant is split, the pith is brick-red in colour. The disease can be seed-borne.

What to do:

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

- **Use certified disease-free seeds**
- **Practice crop rotation**
- **Destroy crop residues.**

Fusarium wilt
Fusarium wilt on peas
© A.M. Varela, icipe

Bacterial blight (*Pseudomonas syringae* pv. *pisi*)

Blight symptoms can occur on all above-ground plant parts. Infected stems are olive-brown, while stipules and leaflets turn yellowish and/or water-soaked. Affected young pods shrivel or decay. Older pods may show water-soaked spots and may become scalded or cracked. In moist conditions, a white to cream-coloured slimy ooze forms on the spot surfaces.

If infection takes place at early growth stages, affected plants wither and die. The disease is seed-borne. High humidity and rains facilitate disease development. The optimum temperature for bacterial growth is about 27.8° C.

What to do:

- **Use resistant varieties, if available**

- **Use certified disease-free seeds**
- **Avoid dense planting**
- **Control weeds**
- **Use surface irrigation**

Bacterial blight
Bacterial blight on beans. Symptoms are similar on peas
© Sheppard JW (Courtesy of EcoPort, www.ecoport.org)

Virus diseases

Peas are susceptible to a large number of aphid- transmitted viruses, which can produce diseases individually or in combination. The main viruses infecting pea are pea enation mosaic, pea streak and bean yellow mosaic.

1) Pea enation mosaic virus (PEMV)
In addition to pea, PEMV also infects broad bean, sweet pea, and alfalfa. It probably overseasons in many common perennial legumes. The virus is spread in nature most efficiently by the pea aphid (*Acyrthosiphon pisum*) and to a lesser extent by the green peach aphid (*Myzus persicae*). The virus is transmitted in a persistent (circulative) manner. Infected pea plants develop mosaic and chlorotic vein flecking (appears as translucent windows) and veinal enations (blisterlike outgrowths), which are very characteristic for Pea enation mosaic virus. Plants are stunted, and proliferation of basal branches is common. Pods are distorted, split open, and may show prominent enations.

2) Bean yellow mosaic virus (BYMV)
Bean yellow mosaic virus is transmitted by at least 20 aphid species in a non-persistent manner. The symptoms depend upon the strain of virus involved. The pea strain, for example, causes a very bright yellow mosaic whereas the more typical isolates produce a dull light and dark green mosaic. Symptoms are masked or delayed at low temperatures (below 15.6°C), but develop normally at 18.3° to 23.9°C. Seed transmission is absent or very rare in pea and several other legumes.

What to do:

- **Control aphids**
- **Plant resistant varieties, if available**
- **Remove perennial legumes bordering the planting area to reduce the primary virus reservoir.**

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Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Sesame

Sesame
Scientific name: *Sesamum indicum*
Family: Scrophulariales: Pedaliaceae
Local names: Ufuta (Swahili), selit (Amharic)
Pests and Diseases: Aphids Bacterial blight Bacterial leaf spot Cutworms Fusarium wilt Leaf spot Powdery mildew Simsim gall midge Spider mites Stem rot or charcoal rot of bean Whiteflies Simsim webworm, Sesame seed bug, Stink bug or Cluster bug

General Information and Agronomic Aspects

Geographical Distribution of Sesame in Africa

Sesame is an excellent rotation crop of cotton, maize, groundnut, wheat, and sorghum. It reduces nematode populations that attack cotton and groundnut. It is also an excellent soil builder- it improves the soil texture and moisture retention and lessens soil erosion: the composted sesame leaves left on the soil binds the ground; retains soil moisture better for planting the next crop; increases the yield of the following crop. Sesame is resistant to drought, tolerant to insect pests and diseases, a low cost crop and therefore one of the best alternative specialty crops.

Sesame originates in East Africa and is the oldest of the commercial oil seeds. The oil is a clear edible oil with a pleasant taste and a very good long shelf life if properly refined. Sesame has an oil content of 48-55% which is the highest of any oil crop while the protein content ranges from 44 to 48%.

Sesame seeds are either consumed directly as a highly nutritious foodstuff or processed by the confectionery and bakery industries. The seed hulls, which are bitter due to their oxalic content, can be removed with the use of steam. Ragouts and soups are often prepared with crushed sesame seeds. Sesame hay, if carefully dried, can be used as fodder. A large proportion of the world's sesame production goes towards producing edible oil.
Purely white sesame seeds are in demand on conventional as on ecological markets, because of their higher oil content than pigmented varieties.

By-products of oil extraction are an excellent protein component to mix into animal feed.

Climatic conditions, soil and water management

Sesame needs a constant high temperature, the optimum range of growth, blossoms and fruit ripeness is 26 to 30°C.

Sesame only grows well in a warm climate and in East Africa it is only grown from sea level up to 1500 m. Most varieties of sesame are photoperiod sensitive .

In Kenya sesame is grown in the following areas:

- **Coast Province - Kwale, Kilifi and Lamu districts**
- **Western Province - Busia, Bungoma and Kakamega**
- **North Eastern Province - Mandera**
- **Eastern Province - Meru**

Good harvests can be expected when rainfall of 300-600 mm is equally distributed throughout the vegetation period. Optimum rainfall times: 35% before the first cusps are formed, 45% during the main blossoming period, 20% during the ripening period. Drought during harvesting is preferred. During each of its development stages, the plant is highly susceptible to water-logging, and can therefore only thrive during moderate rainfall, or when irrigation is carefully controlled in drier regions. Due to its tap roots, the plant is highly resistant to drought and can provide good harvests, when soil moisture is adequate.

A wide range of soils are suitable for sesame cultivation. Optimal are well-drained, loose, fertile and sandy alluvial soils that have a pH value between 5.4 and 6.75. When irrigated, or during summer rain spells, sesame grows better in sandy than in heavy soils because it is very sensitive to high soil moisture content. It is not recommended to plant sesame on sloping ground, because its need of weed-free seed beds and its slow rate of early development can lead to erosion.

Sesame tolerates temperatures of 24-33°C and the crop matures in 120-140 days.

Varieties
There are local varieties of sesame with black, white and brown seed colours. The black varieties are grown in the coastal region and the white in the western region.
Imported varieties have lower performance than local varieties. The best of the imported varieties is "Morada",

identified by its purple stems and leaves. It originated in Congo and further selected in Venezuela. It is higher yielding and more resistant to aphid attack. The local sesame varieties are branched and drought resistant but have a low yielding capacity and are susceptible to most diseases.

Propagation and planting

Sesame is often sown as an opening crop in a rotation, as it requires a fertile soil. In this case grasses must be eradicated as sesame is a poor competitor to weeds. Planting must be done as early in the rains as possible. A rough seed bed is required despite the small seed size of sesame. A smooth seedbed with a fine tilth is more likely to form a hard cap after heavy rains and prevent germination.
There are several cultivation methods:

- **Direct sowing in holes, with stick for support**
- **Sowing after narrow strips have been prepared**
- **Drilling in rows about 45 cm apart and later thinned (at a height of about 5-10 cm) to a distance of 15-20 cm within the row.**

The optimum depth to sow is around 1.5 to 2.5 cm. It is important to sow at an even depth to ensure simultaneous and uniform growth of the crop. Small-holder farmers will often sow by hand.. This method requires 5-10 kg/ha of seeds. Mixing seed with sand, dry soil, ash or dried, sieved manure or compost will help to make seed distribution more uniform. In order to achieve an optimum crop density, branching varieties should be singled out to 6-10 cm, or definitely less than 15 cm distance within the rows when they reach a height of 5-10 cm.

Intercropping. Sesame is often sown with other crops such as pigeon peas, maize or sorghum. It grows to a height of 1-2 m.

Husbandry

Young sesame plants grow very slowly during the first 25 days, due to the small seed size, and are not yet strong enough to compete against weeds. Natural weed resistance sets in when growth rapidly accelerates,

after the plants have attained a height of 10 cm. For this reason, the field should be kept as weed-free as possible during the first 20-25 days after seeding. This is usually achieved through 2-3 hand cultivations or by slashing weeds at soil surface as soon as practically possible, and hand weeding the rows of crops.
Additional measures in weed control include:

- **Early working in of the weeds and harvest residues from the previous crop**
- **The planting of rapidly-growing varieties**
- **Include plants in the crop rotation that cast strong shadows, or are good ground coverers (e.g. green manure plants).**
- **Bottom crops: Ground-covering legumes can be sown between the rows to suppress weed growth (e.g. groundnuts)**

Harvesting

Sesame matures between 3-4 months. It ripens very unevenly with the bottom seeds ripening first. Capsules shattering to shed their seeds is a problem in harvesting. If harvesting is delayed, most of the yield will be lost.

The plants are cut to a height of 10-15 cm, or uprooted before the capsules are fully ripened. The optimum time for harvesting is when:

- **The first, lowest capsules turn brown and begin to pop open**
- **The stem turns yellow**
- **The leaves begin to fall off**
- **Blossoming has finished**
- **The leaves have turned yellow**

Sesame is generally harvested by hand, and then left to dry for the first 2-3 days after cutting in a windrow. The leaves dry out quickly there, making it easier to bundle them into sheaves. The sheaves should be positioned so that the sun can shine down directly onto the capsules. The sheaves should be small (diameter

of 15 cm, bottom: 45-80 cm). During harvesting, the planting seeds should not be allowed to come into contact with the ground to avoid an infestation of soil borne diseases. The seed shells must remain intact to protect the seeds from infection, and to maintain their ability to germinate.
When the sheaves have dried out fully, they are tipped out onto sturdy cloths or canvases and threshed with sticks. To achieve maximum quality (and market price) the threshing cloths/canvases should be at least 2mx3m to avoid contamination with soil particles. Directly following the threshing, the sesame seeds are sieved of leaves, stems and capsule residues, and then dried out to a moisture content of 6% as rapidly as possible. This can be done on a clean, sun-drenched concrete base preferably covered by a clean plastic sheet to avoid contamination.

Yields. With good management, yield should be between 450-550 kg/ha. "Morada" variety can yield twice.

(Naturland e.V. 2002)

Information on Diseases

Stem rot / charcoal rot of bean (*Macrophomina phaseolina*)

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

What to do:

- **Use green manure**

- **Use resistant or less susceptible varieties (e.g. red shelled varieties)**

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

It is a fungal disease. Symptoms include partial or total wilting of plants at flowering and podding, a purple band of stems extending from the base upwards, browning of the stem tissue in the purple band area, and browning or blackening of internal tissue when the main stem or primary branches are split. Infected young plants may not show the purple band symptom but have conspicuous internal browning and blackening. Affected fields show patches of dead plants. The fungus survives on infected crop debris in the soil for about three years. Infection occurs from seeds or soil. Non-opening varieties are not as susceptible.

What to do:

- **If the soil is strongly infested, do not grow sesame for at least 5 years.**

Fusarium wilt
Fusarium wilt symptoms (here on tomato plant in field crop).

Leaf spot (*Alternaria* spp.)

The pathogen attacks all parts of the plant at all stages. Small, dark brown water soaked, round to irregular lesions, with concentric rings, 1-8 mm in diameter appear on the leaves and under excessive atmospheric and soil humidity the spot increases in size and number. The lesions may also appear on the midrib and veins of the leaves. Milder attacks cause only defoliation, in severe cases the plant may die. The pathogen is seed borne. Temperature of 20-30o C and high humid conditions favour the disease.

What to do:

- **Use certified disease-free seeds**
- **Use resistant varieties where available. Varieties totally covered with hair seem to be resistant**
- **Destruction of crop residues and weeds.**
- **Early planting i.e. immediately after onset of rains.**
- **Follow intercropping system of sesamum + sunflower.**
- **Copper based fungicides could be used as a preventive measure when conditions are conducive to disease development**

Leaf spot
Leaf spot (*Alternaria solani* (here on tomato)
© Clemson University, www.ecoport.org

Powdery mildew (*Sphaerotheca fuliginea, Leveillula taurica, Erysiphe cichoracearum*)

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

What to do:

- **Use resistant varieties, if available. Late ripening varieties are less susceptible.**
- **Use sulphur dust 20 kg/ha on the 45th and 65th day after sowing.**

Powdery mildew on sesame
Powdery mildew (*Erysiphe cichoracearum*) on sesame
© Jürgen Kranz (Courtesy of EcoPort, www.ecoport.org)

Bacterial Leaf Spot (*Pseudomonas syringae* pv. *sesami*)

Light brown angular spots with dark purple margin appear in the leaf veins. Defoliation and death of plant may occur in severe leave and stem infection. Sunken and shiny spots are appeared on the capsules. Early

capsule infection render them black and seedless. The pathogen is seed borne. High temperature, rainfall and persistent humidity favours the disease.

What to do:

- **Dress seeds in hot water: 10 min. at 52°C. Transmission by seeds is possible for 11 months. For further information on hot-water treatment of seeds click here.**
- **Use white seeded varieties. They are reported to be more resistant than coloured varieties.**
- **Destroy crop residues**
- **Use resitant varieties, if available.**
- **Cultivate at low humidity and temperature (change sowing date).**

Bacterial blight (*Xanthomonas campestris* pv. *sesami*)

Water soaked, small and irregular spots are formed on the leaves which later increase in number and turn brown. Severely infected leaves defoliate. Later, the spots are formed on the twigs which bear poor capsules. Spots appear from 4 to 6 leaf stage of the crop and continue till maturity. Seed treatment with hot water at 52°C for 10 minutes is recommended.

What to do:

- **Dress seeds in hot water: 10 min. at 52°C. For more information on hot-water treatment of seeds click here.**
- **Identify resistance by infecting seedlings. Transmission occurs through the soil for up to 4-6 months. Via seeds it can be up to 16 months.**
- **Cultivate at low humidity and temperature (change sowing date).**
- **Destroy crop residues**

Information on Pests

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 seed production. Damage may also reduce seed viability.

What to do:

- **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 vegetables (Maundu, 1997). For more information on biopesticides click here**
- **Conserve natural enemies. They are important in natural control of aphids. For more information on natural enemies click here**

Aphids
Aphids (*Myzus persicae*). Adult wingless females are oval-bodied, 1.2-2.1 mm in body length, of very variable colour.
© Magnus Gammelgaard

Cutworms (*Agrotis* spp.)

Cutworms are caterpillars of *Agrotis* moth. The adult moth is grey to brown with a wingspan of about 4 cm and have lighter coloured hind wings. Whitish yellow eggs are laid at night on leaves. The eggs turn darker as hatching approaches. Young larvae may feed on leaves and cause tiny holes but they drop to the ground after a few days.

Mature larvae are about 4 cm long. They are easy to recognise by their smooth skin, greasy grey / black colour and C-shaped posture when disturbed. Cutworms emerge at night causing serious damage by cutting young plants at the base of the stem. Cutworm infestation is often associated with fields that are weedy, have high amounts of organic residue or are very wet due to poor drainage or heavily irrigated.

What to do:

- **Till weeds early, before harvest.**
- **Use light traps against moths, where feasible.**
- **Ploughing can help by exposing larvae to predators and can also bury others so that they cannot reach**

soil surface.

- **Flooding of the fields a few days before planting can kill larvae in the soil.**
- **Use preparations made of neem or pyrethrum.**

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

Simsim gall midge or gall fly (*Asphondylia sesami*)

The adult is a five mm long red-bodied midge (mosquito-like fly). Female midges lay eggs along the veins of terminal leaves. The larvae are typical maggots; they are whitish to orange in colour, legless and with body tapering exteriorly and grow up to 3 to 4 mm in length. Maggots feed inside the floral buds and young capsules leading to formation of galls of up to 6 mm in diameter. They pupate inside the galls. Attacked flower buds wither and drop, or become twisted and stunted and do not develop in to flower/capsules. The simsim gall midge is usually a minor pest, but occasionally high infestations occur resulting in considerable crop losses. Generally plants with green capsules appear to be more susceptible to attack than plants with black capsules.

What to do:

- **Monitor plants at the time of bud initiation**
- **Use resistant tolerant varieties where available (The following varieties are recommended in India: "RT-46", "Swetha Til", "RT-103", "RT-108", "RT-125" and "RT-127")**
- **Intercrop with mungbean, pearl millet and groundnut.**
- **Clip the galls, pick and burn the shed buds.**
- **Conserve natural enemies. Parasitic wasps, like species of Eurytoma, parasitise maggots of the gall fly.**
- **Use neem products when necessary. They help reducing capsule damage by gall flies, and providing higher seed yield. In trials in India the commercial products Neemgold and Neembicidine were found more effective than neem leaf extract, neem seed kernel extract, neem oil, NNG-4, Neemark and Neemax (AHUJA and KALYAN, 2001).**

Whiteflies (*Bemisia tabaci*)

Whiteflies are extremely polyphagous. They are a vector of many virus diseases. Whitefly feeding produces a honeydew, which is conducive to the development of sooty mould and also attracts ants. Whitefly incidence is favoured by dry conditions .

What to do:

- **Parasitoids can play an important role in reducing whitefly numbers. Flowering plants should be grown around the field to provide food source to the parasitoids and pesticide spraying should be discouraged.**
- **Neem seed extracts controls young nymphs, inhibits growth and development of older nymphs, and reduces egg laying capacity by adults. For further information on neem click here.**
- **Spraying with soapy water solutions can be effective in whitefly management**

Whiteflies
Whiteflies (*Bemisia tabaci*)under leaf. Adult whiteflies are about 1mm long.
© Clemson University, Department of Entomology

Spider mites (*Tetranychus* spp.)

Eggs of red spider mites are round, white/pink and of size about 0.1 mm. Eggs are usually laid on the under-surface of leaves. They hatch into six-legged larvae, light green in colour, which become reddish coloured adults. The adults are about 0.25 -0.6 mm long. They have eight legs, and produce a fine silk webbing that protects them predators and pesticide sprays. Infested leaves are spotted, yellowish or silvery as a result of feeding by red spider mites. Infested pods exhibit white speckling. The red spider mites are dispersed by wind and human activity on clothes while working in infested fields. Their development is favoured by warm weather and insufficient rains.

What to do:

- **Field hygiene is important as an old crop or weeds infested with mites can cause infestation of any new crop grown nearby, particularly, if it is downwind of the old crop.**
- **Interplanting with garlic, basil and onion is said to give some protection due to their strong smell.**
- **Encourage natural enemies. This can be achieved by planting flowering plants around the field**
- **Spray preparations made of garlic (click here), neem (click here) or soap (click here)**
- **Use a preparation of flour: 2 cups of fine, white flour, add 5-10 l water, mix well, spray infected plants**

early in the morning. The pests will drop off with the crust during the day. For more information on flour spray click here. For more information on natural enemies click here

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

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Information of www.infonet-biovision.org

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Spinach

Spinach
Scientific name: *Spinacia oleracea*
Family: Caryophyllales: Chenopodiaceae
Pests and Diseases: Anthracnose Aphids Bacterial soft rot Cucumber Mosaic Virus Downy mildew Fusarium wilt White rust Turnip mosaic virus

General Information and Agronomic Aspects

Spinach is cultivated worldwide in temperate areas and in the cooler parts of the tropics.

Spinach is an important green leafy vegetable in temperate climates. Leaves are eaten raw or cooked. Tender young leaves can be added to salads, older leaves are cooked and used in soups etc.

Geographical Distribution of Spinach in Africa

Nutritive Value per 100 g of edible Portion

Raw Vegetable	Food Energy (Calories)	Protein (g)	Carbohydrates (g)	Ash (g)	Calcium (g)	Phosphorus (mg)	Iron (mg)	Potassium (mg)	Vitamin A (I.U)	Thiamine (mg)	Ribof (mg)
Spinach	26	3.2	4.3	1.5	93	51	3.1	470	8100	0.10	0.20

Climatic conditions, soil and water management:

Optimum growing temperatures are 15-20°C. Vegetative growth is retarded by temperatures above 27°C. It does not suit the lowlands and grows best where the temperature varies between 10 and 20°C or above 2000 m altitude. It is frost resistant. Soils should be light in texture, well-drained, rich in organic matter and with a pH 6-7.5 (EcoPort).

Varieties

- **"Early Hybrid No. 7": It is an upright, compact and prolific plant. The leaves are dark green, semi-savoyed, and comparatively large with short petioles. It is early maturing and highly productive. It is tolerant to downy mildew and has a very good regeneration ability.**
- **"Bloomsdale Long Standing": It is an upright compact plant. It has thick fleshy leaves, which are dark green, savoyed, large and with very long petioles. It is vigorous and an exceptionally long standing variety.**
- **"Giant Noble": It is a dwarf plant, fast growing but produces moderate yields. The leaves are smoth, thick, mid-green with short petioles.**
- **"King of Denmark": It is a spreading plant, very prolific and vigorous. The leaves are smooth, thick, mid-green, medium sized with long petioles.**
- **"New Zealand Spinach": It is a hardy, low spreading, branching plant. It has numerous leaves, which are triangular, thick, fleshy, dark green and are smaller than other varieties. The seeds are large. Prickly, and germinate slowly. It does well in hot, dry climates. It produces large amounts of greens over a long period hence best suited for kitchen gardens.**

Propagation and planting

Transplants are not used commercially, but are good for home gardens. All commercial production is direct seeded with little or no thinning. The seed is either broadcast or sown in rows on wide beds. There should be 5-15cm in between plants in the row. The distance between rows should be 30- 90cm. Spinach seeds need consistent soil moisture for proper germination (University of Georgia).

Husbandry

In temperate areas two types of spinach are recognised, the round seeded type, usually sown in the spring and harvested in the summer, and the hardier prickly seeded type sown end of summer or beginning of fall for use in the winter and spring. Spinach needs high doses of N and K as well as a regular water supply throughout the season for optimum yield and quality. Summer crops may be intercropped with other vegetables to benefit from shade (CAB 2006).

Harvesting

Whole plants with 8-10 leaves are harvested, the roots are cut one cm below the plant base and the product is sold in bundles of 10-15 plants (CAB 2006).

Information on Pests

Green peach aphid (*Myzus persicae*)

It is a very detrimental insect to spinach. It can transmit diseases that can wipe out large portions of the crop. Aphids and leafminers cause the most serious damage on the crop (University of Georgia). The aphid is pale yellowish in color and small. It lives mainly on the underside of leaves and therefore hard to control.

What to do:

- **Conserve natural enemies. Parasitic wasps and predatory insects, including lady bird beetles, damsel**

bugs, lacewings, and hover fly larvae are important in natural control of aphids. For more information on natural enemies click here

Green peach 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

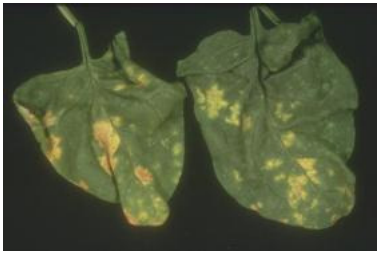
Information on Diseases

Downy mildew (*Peronospora spinaciae / Peronospora farinosa*)

This fungus is distributed worldwide. It causes leaf spotting that detracts from the quality and appearance. Leaf spots begin as indefinite yellowish areas on the upper leaf surface. A mat of grey to violet mould develops on the corresponding lower surface. With time under cool, wet conditions, the spots enlarge until the whole turns black and dies. The fungus increases profusely in high humidity. The spores can overseason in mild climatesin living spinach, in seeds and in the soil.

What to do:

- **Use resistant varieties (e.g. "Early Hybrid 7")**
- **Use certified disease-free seeds. If using own seeds, treat seeds with 500°C for 25 minutes.**
- **Practice at least a 3-year rotation and plant in well-drained soil.**



Downy mildew
Downy mildew *Peronospora spinaciae* spots on leaves of spinach.
© F. Rouxel, www.inra.fr \nSpinach downy mildew Spots of downy mildew on leaves of spinach.\n

Bacterial soft rot (*Erwinia carotovora*)

It is one of the most important diseases. Its symptoms include water soaked tissue and muddy-green or greasy appearance of leaves. Rapid decay occurs and the tissue becomes wet and mushy. This bacterium is found in the soil and in plant debris. It can enter into the plant through mechanical injury, insect injury, disease lesions and other skin punctures.

What to do:

- **Practice rotation with maize, beans, small grains and grasses.**
- **Care at harvesting and handling to avoid bruising.**
- **A storage temperature just above freezing (0°C) and a relative humidity below 90% does much to reduce soft rot losses.**
- **Storage rooms, dump tanks and boxes should be disinfected each season with copper sulfate.**

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

It is a wilt that is caused by a fungus. Plants can be affected anytime after the tree-leaf stage. Foliage loses its green luster, gradually wilts and turns yellow, beginning with the oldest leaves. The fungus is soil-borne and seed-borne. It commonly occurs where temperatures are fairly high. It can live in the soil indefinitely and there rotation is not effective in its control.

What to do:

- **Use resistant varieties where available.**
- **Use certified disease-free seeds.**

Fusarium wilt
Fusarium wilt (*Fusarium oxysporum* f. sp. *spinaciae*) on spinach seedling
© http://ipm.wsu.edu

White rust (*Albugo occidentalis*)

It is a fungus that causes white blister-like pustules on the underside of leaves. They are filled with white spores and the surrounding tissue turns brown and dies. The fungus favors clear, warm, and dry days with cool nights.

What to do:

- **Use resistant varieties where available.**
- **Use certified disease-free seeds.**
- **A 3-year rotation is recommended.**

White rust
White rust caused by *Albugo tragopogonis /Albugo ipomoeae-panduratae* on sunflower
© Martens and Ravagna, www.EcoPort.org \n

Cucumber Mosaic Virus (CMV)

It is transmitted by the green peach aphids. Symptoms begin as a mottling of the younger inner leaves, which later change to a yellow colour. The symptoms gradually appear on outer leaves, which also change to yellow. The affected leaves curl and wrinkles. Severely affected leaves die. If a plant is affected at the seedling stage, its growth is stunted. The dwarfing, yellowing, corrugation and leaf death are conspicuous symptoms of the disease different from other diseases attacking spinach.

Intensity of the virus increases under long days and intense light. This virus affects, in addition to spinach, a wider group of vegetables, flowers, weeds and ornamentals than any other virus. At least 34 plant families are included as hosts.

What to do:

- **Use resistant varieties (e.g. "Early Hybrid 7").**
- **Control aphid vectors throughout the growing season.**
- **Control weeds.**

Fresh Quality Specifications for the Market in Kenya

The following specifications constitute raw material purchasing requirements.

PRODUCE:	Spinach
IMAGE:	
VARIETY:	Various
GENERAL APPEARANCE CRITERIA	
COLOUR:	Mid green foliage with lighter green or white mid rib and stems.
VISUAL APPEARANCE:	Slender, erect leaf stems; smooth to slightly crinkled leaves;free from soil; no foreign matter.
SENSORY:	Crisp, fresh leaves and stems; mild to slightly bitter flavour; free from foreign odours and tastes.
SHAPE:	Long erect stems with oval leaves.
SIZE:	Bunch length 200 - 400 mm; bunch weight > 400g
MATURITY:	Fresh, erect leaves.
INSECTS:	With no obvious live insects (e.g. aphids, slugs,).

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Zucchini/Courgette

Zucchini/Courgette
Scientific name: *Cucurbita pepo*
Family: Violales: Cucurbitaceae
Common names: ornamental gourd, marrow, gourd, summer squash
Pests and Diseases: Anthracnose Aphids Downy mildew Epilachna beetles Fruit flies Powdery mildew Viruses Scab

General Information and Agronomic Aspects

Fruits, leaves and flowers of Zucchini and other Cucurbita species are used as vegetables, and their seeds are consumed roasted as a snack food (CAB 2006). Zucchini has a mild flavour and is very watery. It is often harvested when still very young. At this stage it is also called squash or courgette. Because the fruit has very little flavour of its own it is often used as a base for making savoury dishes. The seeds can be scooped out of and a replaced with a filling - this can then be baked (Plants for a Future 2003). Ornamental gourds are cultivars of *C. pepo* with small, bitter and inedible fruits in many shapes, sizes and colours (CAB 2006).

Geographical Distribution of Zucchini in Africa

Climatic conditions, soil and water management

Zucchini requires a rich, well-drained soil that is able to retain moisture. It grows best in a sunny and sheltered position. Plants are tolerant of light shade. It prefers a pH of 5.5 to 5.9, but tolerates up to 6.8 (Plants for a Future 2003). It responds very well to fairly heavy applications of good compost or well-decomposed manure in the planting hills or ridges. Drought stress quickly reduces fruit setting, so during dry spells irrigation is a must, preferably watering below the leaves or using drip irrigation.

Propagation and Planting

Zucchini and squashes are grown from seed. Seeds may be sown in containers and transplanted to the field

when they are 10 cm high or have 2 real leaves. Direct seeding of two to three per hill is also commonly practised. Trailing types are planted at distances of 2 to 3 m either way; the seed requirement is 2 to 3 kg/ha. The bushy types are planted closer, for example, plants spaced 60 to 120 cm in rows 1 to 1.5 m apart. The seed requirement for Zucchini is 7 kg/ha. Plant densities vary from 5,000 plants per ha for the long-running trailing forms to 20,000 plants per ha for the bushy types (CAB 2006).

Husbandry

Sole cropping is normally used for commercial production. Zucchini and squashes are also planted in home gardens as fresh vegetables. Cultural practices to improve growth and development include the removal of growing tips to check growth in case of trailing varieties.

Harvesting

Zucchini and other summer squashes, from which the immature fruit is used as a fresh vegetable, develop very rapidly. The first marketable fruits can be harvested 50 to 60 days after planting, or 3 to 6 days after appearance of the female flower. During the harvest season the fruits are harvested two to three times per week. (CAB 2006)

Crop yields for summer squash (immature fruits) are 7 to 12 t/ha. Unless grown for seed, mature fruits are not marketable, so plants are removed when yields become too low. Indicative figures for seed yield of Zucchini and other squashes are 400 to 1500 kg/ha. In seed production, isolation between fields of different Cucurbita species is recommended, not only for reason of purity but also for obtaining maximum yields (pollen of other species may cause reduced fruit set).

Summer squash of good quality (no attacks of fruit flies - little dots on fruits developing into sores full of white larvae) can be kept for up to 14 days when stored at 7 to 10°C and 85 to 95% RH (CAB 2006).

Information on Pests

General Information

Courgettes are affected by similar pests and diseases as other cucurbits; this is plants belonging to the family Cucurbitacea, including melons, squash, pumpkin, and cucumber.

The leaf-feeding Epilachna beetles are a serious problem for Cucurbita growers. Aphids and various leaf beetles can also cause problems on courgetes.

For more information on courgette pests refer to datasheet on cucumber (click here).

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

Fruit flies are the most serious insect pests on zucchini/squash with the ability to totally wipe out any marketable fruit.

Fruit flies are about 4-7mm long, they pierce the fruits and lay eggs in fruits. The fruit fly maggots feed inside the fruit causing sunken, discoloured patches, distortions and open cracks. These cracks serve as entry points for fungi and bacteria, causing fruit rot.

What to do:

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

laying eggs fruits. Wrapping or bagging should be started shortly after fruit set.

- **Spray with a pyrethrum solution in the evenings after the bees are mostly back in their hives (after 6 pm). There is a product commercially available called Flower-DS, made of natural pyrethrum and acceptable in Organic certified systems (see Hygrotech Company, contact-addresses below).**
  - Precautions: Be careful to spray late in the evening, follow the spraying instructions. Wear masks and skin protection.
  All insect poisons are also poisonous to humans even if coming from natural sources.
  - Frequency of spraying: start shortly after beginning of flowering, and repeat approx every 5 days or according to counts.

Fruit fly
External fruit fly damage symptoms on courgette
© M. K. Billah, icipe


Fruit fly


Fruit fly


Fruit fly …


Fruit fly …

Aphids (*Aphis gossypii*)

The cotton aphid (*Aphis gossypii*) is common on cucurbits, including cucumber. Colonies of green to blackish aphids are found on tender shoots, mainly on the lower leaf surface, where they suck sap. The growth of the

attacked shoots is stunted and the leaves are curled and twisted. Aphids excrete honeydew, which leads to growth of sooty mould, and may attract fruit flies. Aphids, in particular winged aphids, transmit virus diseases (e.g. cucumber mosaic virus) when moving from plant to plant.

What to do:

- **Plant barrier crops**
- **Apply sticky traps**
- **If necessary spray with botanicals (e.g. neem extracts). Spray only attacked plants (spot spraying).**
- **Use reflective mulch (e.g a polyethylene sheet covered with a thin layer of aluminium that is spread out on the growing bed at planting time). Covering the ground with a material like aluminium foil repel winged aphids, delay aphid colonisation and may delay virus infection**

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

The Epilachna beetle (*Epilachna chrysomelina*)

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

veins. Damaged leaves shrivel and dry up. They may also gnaw stems and eat holes in fruits.

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

What to do:

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

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

Information on Diseases

General Information

Courgettes are affected by similar pests and diseases as other cucurbits; this is plants belonging to the family Cucurbitacea, including melons, squash, pumpkin, and cucumber.

Anthracnose (*Colletotrichum orbiculare*) is the most destructive disease. It causes defoliation and lesions on the fruits.

Other fungal diseases, mainly affecting the leaves and stems are:

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

Many important virus diseases affect cucurbits. These include Cucumber mosaic cucumovirus (CMV), Watermelon mosaic 2 potyvirus (WMV-2), Watermelon mosaic 1 potyvirus, Zucchini yellow mosaic potyvirus (ZYMV), Squash leaf curl bigeminivirus (SLCV).

For more information on these diseases refer to datasheet on cucumber (click here).

Powdery mildew (*Sphaerotheca fuliginea* and *Erysiphe cichoracearum*)

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

Powdery mildew affects cucumber, gourd, muskmelon, pumpkin, squash and watermelon. Other hosts include African violets and pawpaws. The powdery mildew fungi are influenced by plant age, humidity and

temperature. Foliage is most susceptible 16 to 23 days after unfolding. The fungi reproduce under dry conditions. Infection increases as humidity increases, but does not occur when leaf surface is wet. Optimum temperature for infection is about 27.4º C. However, infection can take place at a temperature as high as 32º C and relative humidity as low as 46%.

What to do:

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

Powdery mildew
Severe powdery mildew attack (*Sphaerotheca fuligenea*) (here on cucumber)
© Jürgen Kranz (Courtesy of EcoPort, www.ecoport.org)

Downy mildew (*Pseudoperonospora cubensis*)

Symptoms on leaves appear as small, pale-yellow areas on upper leaf surface. Under humid conditions, a purplish, grey whitish growth may be seen on the underside of the yellowish spots. Affected leaves curl, shrivel and die.

Most downy mildew fungi require cool weather for reproduction and development. This is not true of the

cucurbit downy mildew fungus. Optimum temperature for infection is at 16 to 22º C. It can survive when temperatures are over 37.8º C. The most critical factor for infection is a film of moisture and / or long dew periods on leaves. Disease spread is primarily by wind and rain splash. The fungus attacks only members of the cucumber family, mostly those that are cultivated, although it can infect wild cucumber and a few other weed hosts.

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

Anthracnose (*Colletotrichum orbiculare*)

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

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

Symptoms are most noticeable on fruits. Spots on fruits are circular, black, and sunken. When wet, the centres of the spots become salmon coloured due to a mass of fungal spores. Affected fruits can be

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

What to do:

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

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

Virus diseases

Many important virus diseases affect cucurbits. These include

- **Cucumber mosaic cucumovirus (CMV)**
- **Watermelon mosaic 2 potyvirus (WMV-2)**

- **Watermelon mosaic 1 potyvirus**
- **Zucchini yellow mosaic potyvirus (ZYMV)**
- **Squash leaf curl bigeminivirus (SLCV).**

What to do:

- **For more information on these diseases refer to datasheet on cucumber (click here).**

Zucchini yellow mosaic potyvirus on *Cucurbita pepo*. ZYMV provokes in cucurbit crops very severe symptoms of stunting, yellowing, necrosis (occasionally), mosaic, leaf deformations, fruit discolorations and deformations.
© Pone S. (Courtesy of EcoPort, www.ecoport.org)

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- **Plants for a Future (2003). Edible, medicinal and useful plants for a healthier world. http://www.pfaf.org/database/plants.php?Cucurbita+pepo**
- **Sherf, A.F., Macnab, A.A. (1986). Vegetable Diseases and Their Control. 2nd. Edition. John Wiley & Sons Inc. USA. ISBN: 0-471-05860-2**
- **University of Georgia: College of Agricultural and Environmental Sciences, Department of Horticulture Vegetable Crops: Pumpkin.**

Contact Links

- **For information on small scale farming techniques, seeds, equipment and insecticides (e.g. pyrethrum solution).**
  HYGROTECH EAST AFRICA, LTD
  Region :KENYA / TANZANIA - Location: NAIROBI

Address :P.O.Box 41446, Nairobi, Tigoni Centre, Limuru Road, KENYA
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Passion fruit

Passion fruit
Scientific name: *Passiflora edulis* (purple passion fruit) / *P. edulis* var. *flavicarpa* (yellow passion fruit)
Family: Violales: Passifloraceae
Common names: Maracuya
Pests and Diseases: Aphids Broad or yellow tea mite Brown spot Bugs Fruit flies Fusarium wilt Leafmining flies (leafminers) Mealybugs Phytophthora blight Root-knot nematodes Septoria spot Spider mites Thrips Woodiness potyvirus Brown spot, Septoria spot, Phytophthora blight, Woodiness potyvirus, Bugs, Broad or yellow tea mite

General Information and Agronomic Aspects

Passionfruit is a native of southern Brazil where it grows on the edges of rain forests. There are two distinct forms: forma edulis, the purple passionfruit, occurs in cool environments at higher altitudes, and forma flavicarpa, the yellow passionfruit, which is at home in the tropical lowlands. The two types were distributed throughout the tropics and subtropics via Europe and Australia during the 19th century.

The passion is a perennial climbing plant, which was introduced into Kenya in the 1920's. From 2001 to 2005 export from Kenya of passion fruit was around 1000 tons per

Geographical Distribution of Passion fruit in Africa

year, against a total production of around 30,000 tons yearly.

The fruit may be eaten fresh, but mostly the pulp is extracted and preserved by heating or cooling. The juice has a unique and intense flavour and high acidity, which makes it a natural concentrate. When sweetened and diluted it is very palatable and blends well with other fruit juices. Typical processed products are ice cream, sherbet, nectar, juices, concentrate, squash, jams and jellies. Passiflora plants are often cultivated as ornamentals for their showy flowers.

Passion flowers are widely employed by herbalists and natural health practitioners around the world today. They are mostly employed as a sedative, hypnotic (inducing sleep), nervine, anti-spasmodic and pain reliever.

Climatic conditions, soil and water management

The yellow passion fruit grows best at altitudes of 0-800 m and is used mainly for the fresh fruit market. It can also be used as a rootstock for grafting of the purple variety; the purple passion fruit forms virtually no flowers below 1000 m and should be grown at altitudes of 1200-2000 m.
The mature purple passion fruit tolerates light frosts and can be grown in the subtropics. Other varieties exist such as the so-called banana passion fruit growing in highland areas and often climb very tall trees. It is yellow at maturity but with soft velvety skin and pink flowers quite different from the commercial passion fruits. The banana passion fruit is mainly used in sweetened juices, as it is not usually very sweet on its own.

All varieties grow on a wide range of soils; but light to heavy sandy loams, of medium texture and at least 60 cm deep are most suitable. Heavy clay soils have to be drained and very sandy ones need heavy manuring. A pH of 5.5-7 is preferred. If the soil is too acidic, lime must be applied. Good drainage and aeration are essential to minimise the incidence of diseases such as collar rot.

Varieties

Purple passion fruit, especially, grows well on as little as 900 mm rainfall in Africa, provided the rainfall is well

distributed. The vines require sheltered locations without extreme temperatures: Optimum temperatures for the purple variety are between 18-25°C and for the yellow variety 25-30°C. Critical temperatures were established for hybrid cultivars in Australia as follows: below 20°C pollen does not germinate and at 18-15°C both growth and flowering are set back, whereas temperatures above 30-32°C stimulate growth at the expense of flowering and fruit set (CABI).

Propagation and planting

Passion fruit is generally propagated from seed, although cuttings and grafting can be used. Seed should be rubbed clean of pulp and dried in the shade. Germination takes 2-4 weeks. Fresh seeds are much easier to germinate than seeds older than one or two months. Older seeds can be soaked for at least one day to improve germination. Seedlings are often raised in polythene bags, 15 cm wide and 25 cm deep. Three seeds per bag are sown at a depth of 1 cm and thinned to leave one after two months. Cuttings are set in coarse sand and later transplanted into bags or a nursery bed. The seedlings grow slowly and require 3-4 months to reach the transplanting height of 15-25 cm. Seedlings must be hardened off by leaving them in an open, shaded area for a day or two.

Grafting is often used to control diseases. Yellow passion fruit is used as resistant rootstock although other *Passiflora* species, in particular *P. caerulea* L., show much greater resistance to *Phytophthora* root rot and *Fusarium* collar rot. Moreover, *P. caerulea* is tolerant of root-knot nematodes and to exposure to -1.5°C; it can be propagated from leaf and stem cuttings and is compatible with *P. edulis*. Wedge and whip grafts on seedling rootstocks - sometimes on rooted cuttings - are used.

Within 5-7 weeks after transplanting, each plant will have up to four healthy laterals. From then on the vine grows very rapidly; the first flowers are produced 5-7 months after transplanting when the vine can be 10-15 m long.

Light is the essential factor for flowering and in passionfruit this is particularly true for floral development and fruit set. That is why training and pruning are important to ensure adequate exposure of the shoots.

Depending on the climate there may be one to three harvest peaks (purple passionfruit) or a single, often very long harvest season (more common with the yellow passionfruit).

Land preparation

Deep ploughing and harrowing is necessary to remove hard pans in the soil. Passion fruit has a deep root system; therefore proper land cultivation is necessary. Commercial plantations adopt a row spacing of 1.2-1.8 m and a within-row spacing of 3 m. This gives around 1900-2700 plants/ha. Planting holes of 45 x 45 x 45 cm should be filled with topsoil mixed with up to 10 kg compost or manure. Transplanting is done at the start of the rainy season.
At planting the soil around the plants should be firmed down to establish good root/soil contact. In order to avoid fungal infection the grafting spot should not have any contact with the soil during and after planting. The seedling should then be irrigated to ensure quick rooting and establishment of the plant.

Husbandry

Early growth of passion fruit is slow and regular weeding is essential. Care should be taken when weeding in order to avoid any injury to the plant. Mulching along the rows or around the base of the plants greatly facilitates weed control and protects the roots. Elaborate trellises have been used in Australia and South Africa, but in East Africa, especially at closer spacing, a single wire trellis has been found to be as good. A 14-gauge galvanized wire is tightly stretched along the tops of hardwood posts 15 cm in diameter and 3 m long, dug in to a depth of 0.6 m; these posts are spaced 8 m apart. The trellis should be erected when the field is planted so that the main shoot and one vigorous lateral can be tied to the wire with a string. If laterals do not emerge in time, they can be forced to leaf out by pinching off the shoot tip. When the vines reach the wire they are trained in opposite directions along it. All laterals below the wire are pruned off. Laterals emerging along the wire are allowed to hang down freely; they are the secondary shoots branching into tertiary shoots. Secondary and higher-order shoots are the fruiting wood, which has to be thinned and rejuvenated by pruning.

Regular fertilization is necessary for optimum yields. Frequent sprays with compost tea or similar organic

foliar feed should be applied starting from 1 month after planting and at least every 3 months after that. Mixing EM or BM with foliar sprays may prevent fungus attacks.

Pruning

Old unproductive shoots and dead wood must be removed. Also secondary shoots reaching the ground must be cut off about 5 cm above the ground. The laterals which bear fruit should be left to hang down freely from the wire and the entangling tendrils removed to allow free air and light penetration and reduce incidences of disease and pest epidemics. Disinfect with commercial detergent all equipment used for pruning regularly to avoid spread of viral diseases.

Intercropping

A wide range of vegetables and other crops can be intercropped with passion fruit. Intercropping with annuals is recommended; especially vegetables like beans, cabbages and tomatoes are agronomically suitable. Other recommended crops include potatoes, beetroots, Swiss chard, carrots, spinach, strawberries, eggplants, peppers, onions, leeks and head lettuce. However, cucurbits (cucumbers, pumpkin, and squashes) are not recommended due to the woodiness virus and fruit flies. Other crops that should not be intercropped with passion fruits are maize, cowpea, sorghum, okra, sweet potatoes and other creepers (GTZ, 1978). Intercropping can help in erosion control particularly when fed with good compost.

Rotation

To avoid build up of soil borne diseases strict crop rotation should be practiced (see suitable crops under intercropping). Passion fruits should not be grown for more than 2-3 years on the same plot.

Yield

If a plantation is cropped for 3 years; of the total crop, roughly 50% is produced in the first year, 35% in the second, and 15% in the third year. The sharp decline in yield level, which is even more marked in areas with disease problems, is the main reason to replant fields after the second or third crop.

Average yields amount to 10-15 t/ha per year for the purple and 20-25 t/ha per year for the yellow passionfruit. Much higher yields are possible; yields as high as 50 t/ha per year for purple passionfruit have been reported from Kenya.

Harvesting

Fruit drops to the ground when fully mature. It is collected every second day; at this stage it looks shrivelled and unattractive, but for processing fruits should be picked at this stage. For fresh fruit markets, especially the export market, fruit is picked after full colour development when the whole fruit is purple or canary yellow, but before shrivelling and drying set in.

Information on Pests

Biological methods of plant protection

Nematodes, especially the root-knot nematodes (*Meloidogyne incognita, M. javanica* and *M. arenaria*), are the most serious pests on passion fruit. Practical control measures are crop rotation and the use of tolerant rootstocks.

Several species of sucking bugs feed on passion fruit. They suck and pierce leaves and young fruits; these are minor pests.

Fruit flies that feed on passionfruit include the melon fly (*B. cucurbitae*) and the Mediterranean fruit fly (*Ceratitis capitata*) and the Queensland fruit fly (*B. tryoni*). Pierced young fruit shrivels and falls; later injuries cause damage which lowers the grade. Spraying of biopesticides may be necessary if destruction of infested fruit and the use of baits do not adequately check the pest.

Mealybugs (*Planococcus citri* and *P. kenyae*) are usually controlled by their natural enemies.

The same to applies mites which incidentally do much damage: the red spider mites and the broad mites.

Examples of Passion Fruit Pests and Organic Control Methods

Mealybugs (*Planococcus citri* and *P. kenya*)

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.

They are 3-5 mm long, soft, elongate oval and somewhat flattened

What to do:

- **Conserve natural enemies. Mealybugs are usually controlled by a wide range of natural enemies. However, use of pesticides may kill these natural enemies leading to mealybug outbreaks.**

Mealybugs
Female mealybugs on passion fruit leaf. Female mealybugs are 3 to 5 mm long and their body is usually covered with a waxy secretion.
© A.M. Varela, icipe

Aphids (*Aphis gossypii* and *Myzus persicae*)

Aphids damage plants by sucking plant sap causing curling, wrinkling or cupping of infested leaves, giving plants a deformed shape. They spread viruses and excrete honeydew, which coat the plants and leads to growth of sooty mould, which can diminish the photosynthetic capacity of plants. Aphids are usually controlled by natural enemies if they have not been disturbed for instance by the use of broad-spectrum pesticides.

What to do:

- **Plant the crop in well prepared, fertile land, but do avoid applying nitrogenous fertilizer, as this will promote new growth, which is make the plants juicy and attractive to aphids.**

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

Leafmining flies (*Lyriomyza* spp)

Feeding and egg laying by leafmining flies cause stippling of leaves. This can kill seedlings and in older plants allows entry of disease-causing microorganisms. Feeding by maggots causes mining (tunnelling) of leaves reducing the productive leaf area. Heavily attacked leaves may drop off, and may lead to yield losses.

What to do:

- **Control by natural enemies is important**
- **Ploughing can help in exposing pupae to desiccation and natural enemies**
- **Neem products are effective for controlling leafminers**

Leafminer
Severe leafminer damage (*Lyriomyza* spp) on passion fruit
© A.M. Varela

Bugs

Several species of sucking bugs feed on passion fruit. The most important are:

- **The green stinkbug (*Nezara viridula*)**
- **The brown stinkbug (*Boerias maculata*)**
- **Coreid bugs such as the giant coreid bug or tip wilter (*Anoplocnemis curvipes*) and the leaf footed plant bug (*Leptoglossus membranaceus*).**

Bugs suck sap from the growing tips or developing fruits. The bugs pierce the terminal buds, which eventually wilt and die back. Young plants may be killed if the attack is severe. The punctured young fruits develop localised hardened spots that remain on the fruit reducing their market value.

What to do:

- **In small orchard bugs can be hand picked and destroyed.**
- **Watering and irrigation discourage bugs.**
- **Old crops or sprouting stumps left in the field provide refuges for bugs so they should be destroyed or dig into the soil.**
- **Growing strong smelling plants such as garlic and onion or near the crop is reported to reduce infestations.**
- **Spraying plants with a soapy solution helps to wash off young bugs.**

Tip wilter
Adult tip wilter (*Anoplocnemis curvipes*) is 2.5cm long.
© A.M.Varela, icipe


Tip wilter


Stinkb d…


Green stin…


Leaf foote..


Bug damag

Fruit flies (*Bactrocera cucurbitae* and *Ceratitis capitata*)

Fruit flies that feed on passion fruit in Africa include the melon fly (*Bactrocera cucurbitae*) and the Mediterranean fruit fly (*Ceratitis capitata*).

Pierced young fruit shrivels and falls; later injuries cause damage that lowers the market value of the fruit. However, the incidence of fruit flies on passion fruit is low, and usually of not economic importance. So control may not be necessary.

What to do:

- **Collect and destroy all fallen fruits at least twice a week during the fruit season.**
- **Do not put collected damaged fruits into compost heaps. Instead, burn them or bury them at least 50 cm deep, so that the fruit flies cannot reach the soil surface.**
- **Remove fruits with dimples and those that ooze clear sap. This method is more laborious than picking the rotten fruits from the ground, but it is also more effective.**
- **Whenever possible, wrap fruit in newspaper or paper bags to prevent fruit flies from laying eggs on the fruit. This has to be done well before the fruit matures.**
- **Pick overripe fruits, as they attract fruit flies.**
- **Physical methods include fruit fly traps and fruit bagging, see on fruit-fly datasheet**

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

Spider mites (*Tetranychus* spp.)

Their feeding causes tiny yellow or white speckles, eventually leaves become yellowish and may drop, and may led to complete defoliation. Heavily infested plants may become stunted. A heavy infestation might also cause vine dieback and shrivelling and dropping of immature fruit.

What to do:

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

Spider mites
Two-spotted spider mite. The adult female is 0.6 mm long. The male is smaller.

The broad mite or yellow tea mite (*Polyphagotarsonemus latus*)

It is the most important mite pest of passion fruit in Kenya. Broad mites are tiny (0.1-0.2 mm long) and cannot be seen with the naked eye, and are even difficult to detect with a hand lens. An attack by the broad mites can be detected by the symptoms of damage.

Their feeding produces discoloration, necrosis of tissues and deformation. Initial attack occurs on stems of terminal shoots and young terminal leaves. Attacked young leaves are stunted, deformed (slender, twisted or crumpled), fail to elongate and finally may wilt and dry. Stems of terminal shoots may become slightly swollen, roughened or russeted. As a result the growth of the plant is affected and flower production reduced causing considerably yield reduction. A bronzed dusty appearance may occur on affected plant parts. Attacked fruits become deformed and show white to tan or brown scars on the skin. This damage usually does not affect the internal quality of fruits but affect their market value. Severely attacked fruits may fall. Symptoms remain for a long period of time after control.

What to do:

- **Broad mites are attacked by predacious mites. Phytoseiulus persimilis is not very much attracted to broad mites. Amblyseius spp are better predators of broad mites, in particular A. californicus is used for control of broad mites in different parts of the world.**
- **Broad mites can be effectively controlled with sulphur sprays. However, sulphur is toxic to predatory mites and can have phytotoxic effects on young leaves and shoots at high sulphur dosages and when applied during hot weather.**

Broad mites
Broad mite damage on passionfruit
© A.M. Varela, icipe

Nematodes

Amongst nematodes infesting passion fruit the root-knot nematodes (*Meloidogyne incognita, M. javanica* and *M. arenaria*), are the most serious pests. Characteristic symptoms of infestation by root-knot nematodes are formation of galls or knots on roots, yellowing of leaves, stunting and eventual wilting of the affected plants.

What to do:

- **Rotate with cassava, cereals, maize, Baby corn, sweet corn, sweet potato, onions, cabbages / kale, garlic or fodder grasses (e.g. Sudan grass)**
- **Use of tolerant rootstocks (e.g. P. caerula)**
- **Maintain high organic matter (farmyard manure / compost) in the soil**
- **Incorporation of neem at transplanting**

Root-knot nematodes
Root-knot nematodes (*Meloidogyne incognita* / *M. javanica*) (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., EcoPort

Information on Diseases

Biological methods of plant protection

The most important disease on passion fruit is brown spot (*Alternaria passiflorae*) on leaves, vines and fruits. Phytophthora blight (*Phytophthora nicotianae*) causes the wilting of shoot tips and crown rot, particularly where water stagnates occasionally. Septoria spot, caused by the fungus *Septoria passiflorae*, causes extensive spotting of leaf and fruit, and occasionally of the stem. Yellow passionfruit and its hybrids are more tolerant of these diseases.

Fusarium wilt (also called collar rot) is caused by the soilborne fungus *Fusarium oxysporum* f.sp. *passiflorae*; the shoots wilt, followed by a complete collapse of the plant. Grafting to wilt-resistant yellow passionfruit rootstocks is the most practical way of control. Damping-off caused by *Rhizoctonia solani* and *Pythium* spp. can be a problem in nurseries and soils should be sterilized.

A number of virus diseases have been reported, notably passionfruit woodiness potyvirus (PWV). They are spread by aphids (*Aphis gossypii* and *Myzus persicae*) and pruning knives. Other virus diseases are ringspot from Côte d'Ivoire, which is similar to PWV. The most practical control is to use clean planting material, clean pruning tools and resistant hybrids, or rootstocks of yellow passionfruit.

Examples of Passion Fruit Pests and Organic Control Methods

Brown spot (*Alternaria passiflorae*)

The most important disease worldwide is brown spot on leaves, vines and fruits. Symptoms are brown spots, up to 10 mm diameter, on the leaves, often extending along the veins and drying out in the centre. On the stems, spots are up to 30 mm long, and when they occur at the leaf axils may kill the vine, resulting in dieback. On the fruit, the spots are light brown, round and sunken; they often merge, covering large areas, and produce red-brown spore masses. Spores, produced on the leaf, stem and fruit, are dispersed by wind-blown rain. Warm, moist weather favours disease development. (EcoPort)

What to do:

- **Yellow passion fruit and its hybrids are more tolerant of this disease.**
- **Field sanitation (collection and disposal of fallen diseased fruits, leaves and vines)**
- **Pruning vines to reduce density and thereby reducing humidity within the crop. It also facilitate better air circulation, light and spray penetration and cover.**
- **Timely sprays with copper based fungicides. During humid weather, when the vines are growing rapidly, reduce the intervals between spray applications to 2 or 3 weeks to ensure that new growth is adequately protected.**

Brown spot
Alternaria leaf spot on passion fruit
© A. A. Seif, icipe


Brown spot…


Brown spot

Septoria spot (*Septoria passiflorae*)

The disease attacks leaves, stems and fruits. Brown spots up to 2 mm with minute, black dots (fruiting bodies containing fungal spores) develop on leaf surface. Infected leaves fall readily leading to defoliation of vines.

Similar spots may form on the stems albeit elongated. On fruits light-brown spots studded with minute black dots may be formed. The spots often join up to cover large areas of the fruit. Affected fruits ripen unevenly. Spores produced by black dots (fruiting bodies) are blown to adjacent vines during wet, windy weather thus further spreading the disease. The disease is spread by rain, dew and overhead irrigation. Warm moist weather favours disease development.

What to do:

- **Disease management measures for brown spot disease (see above) are equally applicable for Septoria spot.**

Septoria spot
Septoria spot on passion fruit. Note fruiting bodies containing fungal spores seen as minute black dots within the spots.
© A. M. Varela, icipe.


Septor s… **Septor l…**

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

Fusarium wilt (also called collar rot) symptoms consist of yellowing of leaves, the collar region of affected plant at soil level turns brownish and vertically cracks and vines wilt followed by a complete collapse of the plant. On dissection of infected stem, vascular tissues show brown discolouration.

What to do:

- **Affected parts should be removed and burned. Snap off the affected parts or remove the affected plant manually.**
- **Do not cut tissue and then use the knife on healthy plants.**
- **Keep the base of the plant clear of grass and weeds, which favour fungal growth.**
- **Grafting to wilt-resistant yellow passion fruit rootstocks (e.g. P. caerula) is the most practical way of control.**

Fusarium wilt
Wilting of passion fruit vines due to Fusarium wilt
© A. M. Varela, icipe


Fusari w…


Fusari w…


Fusari w…

Phytophthora blight (*Phytophthora nicotianae* var. *parastica*)

Affected leaves are water-soaked and light-brown in colour. They fall readily, leading to defoliation of the vines. Affected areas of the stem are first purple and later brown above the graft union. They may completely girdle the stem causing wilting and collapse of the vine. Fruit symptoms comprise of large, water-soaked areas. Diseased fruits fall readily and in wet weather become covered with white, fungal growth.

Another strain of the fungus (*Phytophthora cinnamoni*) causes root rot. Yellow and purple varieties have different patterns of susceptibility. The yellow vine is susceptible to *P. cinnamoni*, and the purple vine is more susceptible to *P. nicotianae*. Both fungus strains attack both passion fruits and can cause root rot, wilt, damping off and leaf blight. Fungal spores are initially produced in wet soil beneath the vines and are splashed up to lower leaf canopy.

The disease is favoured by wet, windy weather.

What to do:

- **Good field sanitation**
- **Pruning and keeping a grass sward under the vines to minimize spore splashed up to the lower leaves**
- **Graft to resistant rootstocks (e.g.)P. caerula**
- **The application of copper-based fungicides every 2-3 months during the wet season reduces disease incidence in areas where the disease is likely to be serious. Stem lesions may be painted with a copper fungicide. For more information on copper-based fungicides click here .**

Phytophthora blight
Phytophthora blight on passion fruit
© A. A. Seif, icipe


Phytop Phytop

Passion fruit woodiness potyvirus (PWV)

A number of virus diseases have been reported, notably the passion fruit woodiness potyvirus. Affected leaves show light and dark green mosaic pattern often with light yellow speckle. Sometimes small, yellow ring spots may develop on upper leaf surface. Infected fruits are small and misshapen with very hard rind and small pulp cavity. When affected fruit is cut, the inside rind tissue may have brown spots. Some strains of the virus cause cracking of affected fruits.
They are spread by aphids (*Aphis gossypii* and *Myzus persicae*) and pruning knives. The virus has a wide host range including bananas, cucurbits and many weeds.

What to do:

- **Use clean planting material**
- **Clean pruning tools**
- **Use resistant hybrids, or rootstocks of yellow passion fruit**
- **Remove diseased vines from the field**
- **Do proper weeding**
- **Avoid planting bananas and cucurbits near passion fruit fields**

Woodiness virus
Passionfruit woodiness virus - Fruit cracking
© A.A.Seif, icipe



Woodi … Woodi … Woodi …

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Information of www.infonet-biovision.org

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Coconut

Coconut
Scientific name: *Cocos nucifera*
Family: Arecales: Arecaceae
Local names: Mnazi (Swahili)
Pests and Diseases: African palm weevil African rhinoceros beetle Bud rot Coconut bug Coconut mite Lethal bole rot Lethal yellowing Mealybugs Rodents Scales Termites

General Information and Agronomic Aspects

Geographical Distribution of Coconut in Africa

Introduction

Coco palms *Cocos nucifera* L. (French.: cocotier; Spanish.: cocotero) originate from Melanesia. South east Asia is still an important cultivation region today. The coconut is a monocotyledon plant, and can therefore only proliferate via seeds. It can produce an inflorescence on each leaf axil, which can then have either male or female blossoms. These are formed on the side, so that generally, the coco palm is cross-fertilised by a variety of bee species, other insects and the wind. Coco palms live to an average age of 60 years old.

The coconut palm is an important tree in most tropical islands and along the coastal regions of tropical Africa. It is a multipurpose tree. Every part of the coconut palm can be used. The juice from the inflorescence, which can contain up to 15% sugar, is used to make palm-wine. Half-ripened nuts (6-7 months old) are often eaten fresh. The juice can be drunk, and milk is squeezed out of the meat (endosperm). Fully ripened nuts (after 11-12 months) provide the so-called copra, which is made from the firm meat of the nut.

Copra is high in oil and protein content (65% oil, 25% protein). Coconut oil is produced from drying and pressing the copra. Grated coconut is made from fresh copra. The hard coconut shells are used to make charcoal. When they have been finely grated, coconut shells are used as fillers for objects made of plastic, such as buttons, containers and other objects. Coconut fibres are used in the upholstery industry, to make ropes, as mulching material or as a substitute for peat. The leaves and wood are used as building material and to make household objects (e.g. baskets, brooms) and tools.

Climatic conditions, soil and water management

Site requirements

Coconut needs a continuous supply of water, which can be provided by regular rainfall of about 1250 mm per annum, or from ground water (at a depth of 1-3 m). It can not tolerate water logging though. The northern Kenya coast receives only a rainfall of 750-1000 mm and this restricts production. Coconut grows best at average temperatures of around 26-27°C. Because of its temperature requirements, the coconut palm cannot normally grow above 750 m. However, near to the equator and in areas where other conditions are favourable for coconut development, it is possible to grow the crop up to about 1300 m. Growth is stimulated by a

sufficient supply of chlorine in the soil. The coconut palm can withstand up to 1% salt in the soil.

These conditions are generally found in tropical and subtropical coastal regions with little rainfall. Coconut palms can also grow on deep, water-logging free, alluvial soil, away from the coast - yet low chlorine content in the soil could have negative effects. Consider these conditions when choosing a site.

Depending on the site, coconut palms can be cultivated on agroforestry systems. As a plant of the upper storey, with essential light requirements, the coconut palm towers above such crops as citrus plants, cacao and others.

Propagation and planting

Seeds

The quality of the seeds is important for the forthcoming yield from the palm. For this reason, the seeds should originate from a healthy, and productive stock plant. Usually, the seedlings are raised in state tree nurseries. If no tree nursery can be found which comply with the requirements of organic cultivation, then the seedlings will have to be raised on the site.

Two different main groups are cultivated in the commercial sector: the tall plants of the Typica group, which generally need to be cross-fertilised, and dwarf types of the Nana group, where self-pollination is the norm. Tall varieties should always be chosen for agroforestry systems, because these are the only sorts that can reach up to the upper levels intended for them, and thus fully develop. Dwarf palms grow very slowly, and are easily overshadowed in the system, hindering their full development. In addition, the Nana variety reacts more sensitively to drought and some diseases than Typica varieties.

Three distinct types grow in Kenya: the "East African tall", the "Pemba Dwarf" and hybrids. The following hybrids have been introduced to increase yields and quality of coconut in Kenya:

- **PB 121 ("Malayan Yellow Dwarf" x "West African Tall")**
- **A72 ("Green Dwarf" x "West African Tall")**
- **"Tahiti Tall" x "West African Dwarf"**
- **"Yellow Dwarf" x "Tahiti Tall"**
- **"Reussell Tall" x "West African Tall"**

The hybrid PB 121 has shown to be particularly high yielding (Griesbach, 1992).

Before sowing, the nuts are sorted; use only those nuts containing water. Cut away the shell on the germinating side of the nut to facilitate germination, and soak the nuts in water for 14 days, before sowing them in loose soil that can drain easily. Lay the nuts lengthways in the soil with the upper side visible. Sow nuts in nursery beds at a distance of 45 cm. Use coconut fibres as mulching material between the rows leaving the planting area uncovered.
On smallholdings, the nuts are often merely set out in shaded areas, lightly dug in, and then covered over with organic material.

Planting methods
Nuts usually begin to germinate after 12 weeks in the nursery beds. There, they require no additional fertiliser, as the endosperm provides them with sufficient nutrients. When the seedlings are planted in beds outside the rainy season, then the beds need to be irrigated twice a week with around 5 l water/m². Select the strongest seedlings after the 5th month and label them for transplanting. Around 20-40 % of the seedlings will be unusable. Suitable seedlings germinate earlier, and have thicker leaf bases. Early leaf-development is a sure sign of a strong plant. Transplant seedlings after 9-10 months, by that time they should have developed 4-5 fully opened leaves. Remove seedlings from the nursery beds, shorten their roots, and plant again as soon as possible.

The distances between the plants should be between 7.5 x 7.5 m and 6 x 9 m, depending on the cultivation method used and the other crops being grown, or similar distances resulting in an average density of 150-180

trees/ha. The recommended normal spacing for tall hybrids is 8 x 8 m or 9 x 9m, and for dwarf hybrids 7 x 7 m. The planting holes should be about 60 cm deep and 60 cm in diameter. The planting hole should be dug at least one month before planting and immediately filled with a mixture of topsoil, wood ash and well-rotted manure which is allowed to settle. Transplanting should be done at the beginning of the rains. Place the plant in the hole about 30 cm below the soil level. Fill the remaining space in the hole gradually as the palm becomes bigger. By using this planting method the palms are less susceptible to drought periods. This method should not be used when the ground water is relatively high. The nut should be earthed up only to the collar of the shoot to avoid soil entering the leaf axils.
The young seedlings need to be protected from bites when animals (cattle and other livestock) are being raised.

Diversification strategies

Organic coconut cultivation does not allow for monocropping. Existing plantations can be improved by sowing at least one bottom crop of plants that offer ground coverage. Legumes can be planted here as green fertilisers. In multi-level agroforestry systems, cacao, bananas, pineapples and many other crops can be used. Spices such as ginger and turmeric also thrive under palms. If animals are kept, fodder crops should be integrated in a crop rotation system underneath the coconut palms.

If possible large plants should be used from the nursery beds when setting up agroforestry systems including coconut palms. This applies not only to coconut palms, but also to all types of palms integrated within agroforestry systems. Coconut palms will grow on any sites that are suitable for cacao, bananas, citrus (oranges) or papaya. On citrus plantations, a slightly lower density should be used (120-150 plants/ha) than for e.g. cacao (150-180 plants/ha).

Three phases can be identified in the development (life cycle of the coco palm) of the crop:

Life cycle	Shade	Mixed crops

1st phase: up to 8th year	**A full frond will only have developed after 8 years; during this time, only partial shade is available**	**Cultivation of annual crops possible.**
2nd phase: from 8-25thyear	**Comparatively large amount of shade**	**Cultivation of shade-tolerant varieties**
3rd phase: older than 25years	**Shade reaching to the ground diminishes as trees attain full height**	**High amounts of sunlight allows cultivation of plants needing lots of light.**

Nutrient supply and organic fertilisation

The level of nutrient extraction on a coconut palms/mixed crop system can be balanced by encouraging the decomposition of organic material that is made available, e.g. through mulching material, green fertiliser and tree trimming. A dense crop of legumes or use of other plants providing ground coverage as bottom crops, and which are regularly supplied with mulching material, will provide a sufficient supply of nitrogen for the plants. It is important to take care that all harvest and processing residues, such as coco fibres and press-cakes from the oil-extraction process, are returned to the plantation. This also applies to the potassium-rich ash resulting from burning the coco husks. If insufficient organic material is produced on the plantation, the deficit can be balanced by regularly adding compost. The compost should be enriched with any wood ashes (or coco husk ashes) that are available.

The compost is spread out in a circle 3-5 m underneath the palms, and preferably covered over with coco shell mulching material. The latter may be especially necessary in systems lacking enough additional vegetation.

A deficiency in potash will result in a large reduction of yield for coco palms. The vast majority of the potassium is thereby contained in the fruit water of the coconuts. On cultivation systems which include cacao, returning the cacao shells to the site will supply sufficient potassium to balance out the extraction. The

continual pruning of crops on diversified agroforestry systems provides an important source of nutrients (e.g. of potassium).

When providing a nutrient supply to coco palms, it should be noted that it can take up to 36 months before inflorescence begins. This means that measures to supply nutrients, or to counteract deficits or other morphological disturbances, will take 3 years before they have an effect on production.

Due to their symbiosis with endomycorrhizae fungi (phosphate supply), and their tolerance of soil salts (which are often harmful to the other crops), coco palms, as well as other varieties of palm, have a beneficial effect on the growth of the other crops in an agroforestry system.

Keep area around the tree free of weeds. Coconut will suffer from too much competition from weeds and bush regrowth. Recommended weed control methods include slashing by hand or grazing by cattle. Avoid weeding with mechanical implements as these can damage the roots of the tree. The economic life of a coconut tree is about 25-30 years. After this period, the low producers, dead and diseased trees should be removed from the field and replaced with new seedlings.

Crop monitoring

The nuts ripen during the entire year. As a rule, a harvest is carried out every 1-2 months, when the ripened coconuts are harvested directly from the tree - farmers should not wait until the nuts fall from the tree. The nuts are fully ripened when the coconut water can be clearly heard sloshing against the inside when they are shaken. Harvesting too early can unfavourably affect the quality of the copra.

Harvesting

Stock plants that are suitable seed providers produce 100 nuts per year and up to 180 g copra per nut. In drier areas yields are usually 15-20 nuts/tree/year. Harvest fully-ripened nuts intended to provide seeds after 11-12 months. Cut down nuts and lower them carefully (e.g. by rope). Do not allow the nuts to fall down. Following the harvest, store nuts for a short break in a covered, well- ventilated place. (Naturland e.V. 2000)

Copra drying

- **Sun drying**

Remove the husk first. Dry nuts on a clean surface to reduce moisture from 45% to 6%. In fine weather this takes about 5 days. Turn the pieces occasionally and cover them at night and in rainy weather.

- **Kiln drying**

Make a fire in the pit of the kiln. Use the coconut shells as fuel as they heat well and smoke little. Put the copra on a wire mesh platform over the fire and protect it from the rain. This takes about 4 days.

Information on Diseases

Biological methods of plant protection

In a balanced cultivation system, which includes middle and bottom crops, as well as nitrogen-fixing green manuring plants (legumes), diseases and pests requiring some form of control measures will rarely occur, especially when enough birds are present on the plantation. These are often present in multi-level cultivation systems (see diversification strategies above).

Most of the problems concerning disease and pests have the following causes:

- **Cultivation in a monoculture, or with too few different varieties.**
- **Too little distance between species that grow to the same height; failure to trim agroforestry systems.**
- **Degenerated or poor soil, lack of organic material.**
- **Unsuitable sites (water-logging, too dry, soil not deep enough for roots).**

In most cases, the most effective cure is to alter the entire system of cultivation. If a system is not yet in a state of ecological equilibrium, bud rot or heart rot, caused by *Phytophthora palmivora*, can occur in all of the producing regions - where it is widely spread. In cases of heavy infestation by *Phytophtora palmivora*, harvest-losses can be lessened by using Bordeaux mixture, or any other copper-rich spraying preparations, which are permitted in organic farming systems. These measures should only be undertaken in cases of emergency. In less harmful cases, removing any infested plants from the plantation will result in the infection being limited. Amongst the young trees in tree nurseries, an attack of termites may occur. The termites can be effectively combated by pouring a thin layer of sand from the soil over the exposed parts of the buried nuts. Young coco palms are also susceptible to the rhinoceros beetle and coconut caterpillars. Pheromone traps have been successfully utilised in Sri Lanka against the rhinoceros beetle. In emergency cases, butterfly caterpillars can be regulated with *Bazillus thuringiensis*.

The trunks of young seedlings are often protected against pests by painting them with tar. This is not allowed on organic plantations, and the black covering also causes the plants to heat up unnecessarily. An alternative is to paint the trees with a mixture of sulphur, soil and lime, (1 : 2 : 1) added together with water to make a thick paste. If necessary, the paste may need to be renewed, as rain will wash it off.

Considerable damage can be caused in regions with large coco palm monocultures by the mycoplasmose, a fungi that grows in cuts in the fronds. The disease can be brought under control by removing infested plant parts or whole palms. Coconut red weevil and Rhinocerus beetle only usually damage young palms, yet may also, in exceptional cases, cause damage to mature crops. In acute cases, they can be combated by closing the larvae tunnels, and with pheromone traps.

In coco palm monocultures, rodents, and especially rats, can develop into a serious epidemic which is then difficult to bring under control again. Metal plates affixed to the trunks will effectively stop them from climbing up the trees, though.

Examples of Coconut Diseases and Organic Control Methods

Lethal bole rot (*Marasmiellus cocophilus*)

In East Africa, *Marasmiellus cocophilus* causes death of palms up to 8 years old, seedlings being highly susceptible on transplanting to the field. Root infections occur, leading to decay of basal tissues and finally a rot of the spear leaf. On older palms, the first symptoms are a general wilt of the fronds, which remain as a 'skirt' around the trunk. The spear leaf dies and a foul-smelling soft rot develops at the base of the leaves. A dry, reddish-brown rot with a yellow margin is typically present at the base of the bole. Cavities within these areas of rot are lined with mycelium (fungal growth) in young palms, 2-4 years old, but rare in 4-6-year-old palms, and absent in mature palms.
Fungal bodies (like small mushrooms) commonly occur on exposed roots, leaf bases of seedlings, exposed tops of seed nuts and on the soil surface around holes (growing from coconut debris) where diseased palms had been removed 2 years previously. On average, there is only about 8 weeks from the time of onset of symptoms till the death of the palm; this interval depends on the extent of fungal decay in the bole.
Spread occurs through soil, root contact between palms, infected coconut debris and probably by airborne basidiospores (fungal spores). Infection also occurs via wounds.

What to do:

- **Uproot and burn affected palms immediately after detection of the disease.**
- **Replant with healthy seedlings. This will be successful only if the infected soil is treated.**

Lethal bole rot
Lethal bole rot (*Marasmiellus cocophilus*)
© Grahame Jackson (EcoPort, www.ecoport.org)

Lethal yellowing (*Phytoplasma*)

Symptoms include necrosis of inflorescences, yellowing of leaves and premature shedding of all fruit (nut fall) regardless of their developmental stage. Aborted nuts often develop a brown-black calyx-end rot reducing seed viability. Premature nut fall is accompanied or followed by inflorescence necrosis. This symptom is most readily observed as newly mature inflorescences emerge from the ensheathing spathe. Normally light yellow to creamy white in colour; affected inflorescences are instead partially blackened (necrotic) usually at the tips of flower spikelets.
As disease progresses, additional emergent or unemerged inflorescences show more extensive necrosis and may be totally discoloured. Such symptom intensification results in the death of most male flowers and an associated lack of fruit set. Yellowing of the leaves usually starts once necrosis has developed on two or more inflorescences and discoloration is more rapid than that associated with normal leaf senescence. Yellowing begins with the older (lowermost) leaves and progresses upward to involve the entire crown. Yellowed leaves turn brown, desiccate and die. In some cases, the advent of this symptom is seen as a single yellow leaf (flag leaf) in the mid-crown. Affected leaves often hang down forming a skirt around the trunk for several days before falling.
A putrid basal soft rot of the newly emerged spear (youngest leaf) occurs once foliar yellowing is advanced.

Spear leaf collapse and rot of the apical meristem invariably precedes death of the palm at which point the crown topples away leaving a bare trunk. Infected palms usually die within 3 to 6 months after the appearance of the first symptoms.
Lethal yellowing symptomatology may be complicated by other factors. For example, non-bearing palms lack fruit and flower symptoms. Foliar discoloration also varies markedly among coconut ecotypes and hybrids. For most tall-type coconut palms, leaves turn a golden yellow before dying whereas on dwarf ecotypes leaves generally turn reddish to greyish-brown.
Phytoplasmas are transmitted in a persistent (circulative-propagative) manner primarily by insect vectors belonging to the families *Cicadelloidea* (leafhoppers) and *Fulgoroidea* (planthoppers).

What to do:

- **Use genetically resistant ecotypes (Malayan Yellow Dwarf) and hybrids (Malayan Yellow Dwarf x Panama Tall). This is the only practical long-term solution to Lethal yellowing.**

Lethal yellowing disease
Lethal yellowing disease of coconut palms. Note yellow leaves and a dead palm without leaves.
© B. Loehr, icipe


Lethal yel…


Lethal dis…

Bud rot (*Phytophthora palmivora*)

Bud rot (also called heart rot) caused by the fungus (*Phytophthora palmivora*) has an extensive host range of more than 200 plant species and it is widespread in the tropics including tropical Africa. The fungus enters into the plant by infecting tender host tissues (leaves, buds or young nuts). Affected leaves turn yellow and later brown.

The heart leaf becomes chlorotic, wilts and collapses. The disease may spread to older, adjacent leaves and spathes, producing a dead centre with a fringe of living leaves. Light brown to yellow, oily, sunken lesions may be found on leaf bases, stipules or pinnae. Internally, the tissues beneath the bud are discoloured pink to purple with a dark brown border. Affected leaves progressively drop. Infected nuts show brown to black necrotic areas with a yellow border developing on the surface; internally, they have a mottled appearance. Young nuts are highly susceptible and fail to mature, they then fall off the tree; older infected nuts ripen normally.

What to do:

- **Remove and destroy infected debris and infected coconut trees. This helps to reduce spread.**
- **Do not irrigate nurseries at dusk or at night to avoid prolonged periods of free moisture.**
- **Plant resistant varieties. Malaysian dwarf varieties, such as Malayan Yellow Dwarf, Bali Tall, Malayan Yellow Dwarf x Palu Tall hybrids, and other varieties originating in South-East Asia, show resistance.**

Bud rot (heart rot)
Seedling (right side) affected by dry bud rot
© Z. Seguni, MARI

Information on Pests

Biological methods of plant protection

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Examples of Coconut Pests and Organic Control Methods

Termites (*Coptotermes formosanus*)

Termites can be a serious problem for coconut palms, particularly for young trees in tree nurseries, or trees that have just been transplanted into the field. Termites live in the soil in hills, construct tunnel from the hills to the palms and feed on all parts of young coconut palms. Damage occurs mainly during the dry season.

Many plants have a repellent or even insecticidal effect on termites and can be applied as spray directly

against termites or as barrier around the trunk of coconut palms:

- **Neem: seeds and leaves (extracts or cake)**
- ***Quassia indica* or *Q. amara*: bark and leaves**
- **Sandalwood: wood**
- **Chinaberry, persian lilac (*Melia azedarach*): bark, branches, leaves, extracts**
- ***Euphorbia* sp.: "In Tanzania, especially in Dar es Salaam and coast regions, farmers plant with each seedling two or three sticks of Euphorbia sp. to protect the young palms from termite attack. On nurseries the Euphorbia plants can be planted around the seedbed to prevent access of termites to the palm seedlings and young palms. When the palms have grown big the euphorbia is simply cut down. The practice is widespread and farmers are convinced that it really does keep termites off the susceptible seedlings (personal communication Z. Seguni, MARI)".**

What to do:

- **Place nurseries in land without termites.**
- **Alternatively, raise palms in polyethylene bags and check them always for termites.**
- **Pour a thin layer of sand from the soil over the exposed parts of the buried nuts.**
- **Help termite enemies (birds, insect predators) to have close habitats by the above mentioned diversification strategies.**
- **Traditional methods for controlling termites include: Flooding mounds, Digging out mounds and removing the queens, Suffocating the colony by burning**

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


Termit Cocon se…

Adult coconut bug (*Pseudotheraptus wayi*)

The coconut bug (*Pseudotheraptus wayi*) is the most important pest of coconuts in East Africa. A related species of coconut bug, *Pseudotheraptus devastans*, causes similar damage to coconuts in West Africa.

Adult bugs are brown in colour and 1.2 to 1.4 cm long. They lay eggs singly on the flowers or young nuts. Nymphs are red brown to green brown in colour and have long antenna. Adults and nymphs suck on flowers and developing fruits causing flower abortion and early nutfall. The toxic saliva of the bugs causes necrotic sunken lesions (scars) and cracks on the nuts.
Attacked young nuts excrete gum. Many of the attacked young nuts fall off. Nuts older than three months at the time of attack may not be aborted but remain small and have scars. Yield losses are difficult to assess since many of the nuts (over 70%) fall naturally. Nuts which abort naturally, do not show scars or gummosis. Two bugs per palm can cause considerable damage. Damage is usually less serious in intercropped coconuts.

The bugs also feed on cashew, mango, cocoa and guava.

The predatory red weaver ant is an efficient natural enemy of the coconut bug. Weaver ants build nests on palms and other trees by joining leaves with silk produced by their larvae. They forage on the canopy chasing away or killing coconut bugs. Palms with weaver ants are usually free of damage by the coconut bug. Good control is achieved is more than 60% palms are occupied by thriving colonies of weaver ants. Unfortunately other ants present in coconut plantations fight weaver ants, and themselves do not protect (or not as effective as weaver ants) the palms against coconut bugs. These ants such as big headed ant (*Pheidole megacephala*), the crazy ant (*Anoplolepis custodiens*), and the long legged ant (*Anoplolepis longipes*) among others, kill or displace weaver ants, as a result palms are severely damaged. These competing or antagonistic ants need to be managed to allow weaver ants to do their beneficial work.

What to do:

- **Keep bushes and trees that are hosts for weaver ants in the surrounding of coconut fields.**
- **Intercrop coconuts with plants favoured by weaver ants such as citrus, soursop, guava, mango, etc**
- **In areas where the bigheaded ant is dominant keep ground vegetation. If there were no ground vegetation this ant would be forced to search food on the trees and would displace weaver ants.**
- **Connect the canopy of neighbouring palms/trees with sticks, wire, or ropes. Weaver ants can easily walk among trees searching for food and set up new nests avoiding other ants active on the ground.**
- **Where weaver ants are not present transfer weaver ant nests into the field by collecting nests from bushes around and placing them onto coconut palms or other host plants in the field. Care should be taken not to mix ants from different colonies since they would fight. Do not place nests collected from different trees or trees far apart on the same trees since they are likely to belong to different colonies and will kill each other. The best time for collection of nests is during the rainy season, since in this period many new queens are present in the ant nests, and these may get established in the orchard and start new colonies. Ants in nests introduced without the queen will die out after some time (they may live up to 8 months) and new introductions are needed.**

Coconut bug
Adult coconut bug (*Pseudotheraptus wayi*) on coconut bunch
© B. Loehr, icipe


Cocon bu…


Cocon bu…

The African rhinoceros beetle (*Oryctes monoceros*)

It is a stout beetle, about 3.5 to 5 cm long, shiny dark brown to black in colour with a curved horn on the head, hence its common name. The adult flies at night to palms and bore into the hearth of the palms spear, chewing and cutting the youngest unopened leaves and the vegetative bud.
Attacked leaves continue to develop and unfold showing a characteristic V-shape damage. If the whole growing point is eaten, the palm usually dies, particularly young palms less than four years old. The boreholes are often marked with a bundle of fibres pushed out of the hole by the beetle. This beetle is a serious pest in plantations where field sanitation is neglected. Eggs are laid in rotting plant material, especially dead palm trunks, compost heaps and rubbish dumps. The larvae (grubs) and pupae develop in rotten coconut logs and other decaying material.

What to do:

- **Fell, chop and remove dead palms to eliminate breeding sites.**
- **If logs cannot be removed, check the decaying end. Collect and destroy grubs.**
- **Hook out beetles in young palms. Push a 30 cm long iron rod with a hook at one end is pushed into the tunnel bored by the beetle while feeding. If the beetle is still inside it will be hooked out.**

Rhinoceros beetle
Rhinoceros beetle adult, real size: 3.5 to 5 cm long
© KARI, National Horticultural Research Centre.





Rhinoc Rhinoc Rhinoc Rhinoc Iron rods

The coconut mite (*Aceria (=Eriophyes) guerreronis*)

This mite is tiny and difficult to see with the naked eye. When very many mites are together they appear as fine whitish dust. The coconut mite attacks and damages the upper part of the nutlets under the sepals of up to 6 months old nutlets. Attack is severe during the dry season. Attacked nuts may fall or have a scarred husk, which often splits. The nuts of coconuts showing light scarring on the husk are not seriously affected but in heavily scarred nuts there is significant damage to the nuts.

What to do:

- **Remove mature and prematurely fallen nuts. Although few mites are normally found on old bunches, they could rapid colonise young bunches.**
- **Provide balanced fertilisation to the palms. Mite damage seems to increase with increasing levels of nitrogen, and decrease with potassium. This suggests that the addition of N fertiliser could worsen the mite problem. However, the increased yield from fertiliser input could be greater offset than any increased loss due to worsened mite attack.**
- **Fertilization can play a role on mite damage. Damage seems to increase with increasing levels of nitrogen, and decrease with potassium. This suggests that the addition of N fertiliser could worsen the mite problem. However, the increased yield from fertiliser input could be greater offset than any increased loss due to worsened mite attack.**
- **Spray young bunches with Sulphur(wettable sulphur at high dosage of 0.5%)**
- **Spray neem kernel extracts. Reportedly neem extracts are effective against this mite. For more information on neem click here.**

Coconut mite damage
Nuts damaged by the coconut mite (*Aceria (=Eriophyes) guerreronis*)
© A. M. Varela, icipe

The coconut scale (*Aspidiotus destructor*)

A number of scales feed on leaves and fruits of coconut palms. The most damaging is the coconut scale (*Aspidiotus destructor*). This scale is bright yellow and round (females) or reddish and oval (males) covered

with a semitransparent greyish white flat scale. The scale diameter is 1.5 to 2.0 mm. Females are always wingless and remain under their scale their entire life. Adult males have one pair of membranous wings, move about actively in search of females and do not feed during the adult stage. Eggs are protected underneath the scale or shell of the mother insect until they hatch. Upon hatching the young scales leave the maternal scale, take up a position and start feeding. They do not move afterwards. They are found mainly on the undersides of the leaves, but frond stalks, flower clusters and young nuts can also be attacked.

A severe infestation of this armoured scale forms a continuous crust over flower spikes, young nuts and the lower surface of leaves. The leaves become yellow and eventually die. The crown dies leading to collapse of the infested plant. Attacks of young nuts cause shrivelling of nuts leading to premature nut falls. Mostly young coconut trees of up to 10-15 years are vulnerable to damage.

Scales may infest palms throughout the year, but damage is usually more severe during the dry season. Neglected plantations are particularly susceptible.

The coconut scale also attacks many species of fruit trees, such as avocado, breadfruit, mango, guava and papaya. Other major hosts are cocoa, cassava, cotton, oil palm, papaya, rubber, sugarcane and tea. It also attacks a range of ornamental plants including roses.

What to do:

- **Conserve natural enemies. They usually keep scales under control. Ladybird beetles and parasitic wasps are particularly effective in controlling the coconut scale**
- **Avoid or restrict movement of infested plants in areas where the coconut scale is a problem, to avoid spread of the scale.**
- **Destroy infested plants and plant parts. This may help to eradicated scales from new areas. However, this scale is is difficult to eradicate due to its wide host range.**
- **Provide good growing conditions for the palms. Healthy palms in well-drained soils are seldom seriously infested.**

Coconut scale
Coconut scale (*Aspidiotus destructor*) on coconut
© B. Loehr, icipe


Cocon sc…


Cocon sc…

African palm weevils (*Rhynchophorus phoenicis*)

Adults are large weevils (40-55 mm in long), with a long snout and reddish brown in colour, and generally with two reddish bands on the thorax. Females lay eggs on wounds of various origins, on the mature stem as well as in the crown. Upon hatching the larvae (grubs) penetrate into the living tissues of the palm, feeding on the shoot and young leaves, where the insect completes its development in about 3 months. The damaged tissues turn necrotic and decay. Sometimes the grubs feed on the growing point killing the palm. Grubs are whitish-yellow, legless, and oval in shape; their head is reddish brown, and is armed with strong mandibles. Fully-grown grubs are 50 to 60 mm long. The pupal stage is passed within a cocoon of vegetal debris made by the grub at the end of its development. The African palm weevil usually damages young palms, yet may also, in exceptional cases, cause damage to mature crops.

The primary means of control for African palm weevil is preventative, using cultural and sanitary methods.

What to do:

- **Avoid wounds during plantation management. Adults are attracted to the odour of feeding sites and to injured palms, in which they lay their eggs.**
- **Remove all heavily attacked and wounded palms, along with those showing distinct growth disorders.**
- **Trap weevils. Traps made from thinned or wild palms that have been felled and split into longitudinal sections divert weevils away from cultivated palms, because adults are attracted to the chemicals emitted from damaged wood. Trap- heaps are frequently burnt and replaced with fresh trap wood. Burn trap-heaps frequently and replace them with fresh trap wood. Older traps can be sprayed with palm sap to maintain their effectiveness.**

Palm weevil
African palm weevil adults (*Rhynchophorus phoenicis*).
© Reproduced from: Date Palm Cultivation: FAO Plant Production and Protection Paper. Food and Agricultural Organization of the United Nations. Rome, 2002. (www.fao.org)

Palm weevi.

Palm weevi.

Rodents

In coconut palm monocultures, rodents, and especially rats, can develop into a serious epidemic, which is then difficult to bring under control again.

What to do:

- **Affix metal plates to the trunks to stop rodents from climbing up the trees.**

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Cashew

Cashew
Scientific name: *Anacardium occidentale*
Family: Sapindales: Anacardiaceae
Local names: Mkorosho / mkanju (Swahili)
Pests and Diseases: Anthracnose Cashew stem girdler Cashew weevil Coconut bug Helopeltis bugs Mealybugs Powdery mildew Thrips Aphids

General Information and Agronomic Aspects

Geographical Distribution of Cashew in Africa

Cashew trees are grown along the coastal plains of Kenya and Tanzania. Cashews are evergreen trees with deep taproots, originating from the northern part of South America. The Portuguese introduced cashew to Mozambique in the 16th century where it flourished forming extensive forests; eventually it also became dispersed in East Africa. Cashew is grown along the coastal plains of Kenya and Tanzania

Cashew tree

© A. M.Varela

Uses

The kernels or nuts have a high nutritional as well as commercial value and are used for human consumption either raw or roasted. The cashew nut apple is rich in Vitamin C (about 5 times higher than the orange) and is used for the production of juice, wines, spirits, jam, pickles and chutneys.

The liquid of the shell is used for brake linings, heat proof and waterproof paints and protective varnishes. Cashew nut wood is of poor quality but can be used as firewood if mixed with other types of wood.

Cashew apples and nuts

© A. M. Varela

Climatic conditions, soil and water management

Cashew trees are usually grown at altitudes of between 0-500 m above sea level (asl), but can grow up to 1000 m asl. They can be very drought resistant provided their roots can penetrate deeply into the soil and draw water from the subsoil. For mature trees 500 mm of rainfall per year is adequate, but seedlings should be watered until properly established. If rainfall is below 900 mm per year plant at the widest spacing indicated. Cashew nut trees tolerate a wide range of soils provided they are deep and well drained. They can grow quite well on infertile soils but do not do well on coral outcrops at the coast.

Varieties

Improved varieties available at KARI - Mtwapa Research Centre (Kenya Agriculture Research Institute), Kenya include A41, A47A, A75-83, A81 and A100.

Planting material

Select seeds from healthy, high yielding trees. Before planting, sort out seeds by the water density method as follows:

- **Place the seeds in a bucket of sea water (100g salt per 5 litres of water) and select the seeds that sink for planting. Those that float have poor germination and growth potential.**
- **Sun dry seeds for planting for several weeks to prevent mould and rotting.**
- **Do not plant seeds that are more than one year old**
- **Good, selected seed may be purchased from the KARI - Mtwapa Research Centre, Kenya**

Land preparation and planting

Clean the field and dig holes 30cmx30cmx40cm deep and refill with topsoil mixed with 1 bucket of well-rotted manure or compost. Due to their extensive root system cashew nut trees compete for water and nutrients and therefore should be well spaced. Their canopies should not touch one another since this interferes with production of flowers and hence fruit setting.

Recommended spacing in good rainfall areas is 12mx 6m, giving 139 trees per ha. In low rainfall areas spacing of 12mx12 m (69 trees/ha) is recommended to give the trees a better chance for survival.

Only the healthiest trees are worthwhile keeping for long growing periods.

Planting methods include:

- **Direct planting of seeds: This method has the advantage that less labour is needed but there is higher risk of death during dry season and also a higher risk of early diseases. Plant 3 seeds per hole covered by 6-8 cm of soil**
- **Raising seedlings in polybags in the nursery: This method has the advantages that it is easier to water the seedlings properly, which is particularly important in the dry season, and that is possible to select the strongest and healthiest plants for transplanting. Disadvantages are that more labour is required and it is a bit more expensive. Seedlings in polybags should be transplanted 6 weeks after sowing in order to avoid damage to the taproot**

Intercropping

This can be done before the canopies close. Most annual crops can be used apart from cotton and sweet potatoes, which are host plants for *Helopeltis* bugs, major pests of cashew. Do not interplant young trees with pasture because of the high competition for water during the dry season.

Husbandry

No fertiliser is required, but well rotted manure at planting is beneficial. Keep the area around the tree (1 ½ times the size of the canopy) should be kept clean of weeds for the first 2 years to avoid competition. If planted on a slope the tree should have a U-shaped mound of soil below it to collect rainwater for improved growth. Seeds germinate within 2-4 weeks.

Thin after 3-4 months leaving only the strongest plant at each site. Protect seedlings from monkeys, rodents and bucks by placing wire cages or thorns around the seedlings. Support plants with a stick and trim off side shoots up to 60-90 cm from ground level. When trees are mature, prune dead wood or any borer damaged or intergrowing branchesto give the canopy air and light.

Harvesting

Trees normally bear fruit when they are 2 ½ - 3 years old. They reach maturity after 9-10 years and may have an economic life span of 30-40 years if well cared for. Harvesting starts at the beginning of October and continues till the end of December. Pick only the nuts that have dropped down and remove the attached apple by a twisting action. Pick on a weekly basis in the dry season and daily in wet weather to avoid fruit rotting or insect damage. Store only dry nuts. Average yield is about 6 kg/tree but with good husbandry 12 kg/tree can be obtained.

Grading

Cashew nuts are graded into 2 categories:

- **FAQ (Fair Average Quality) - normally about 75%. These are healthy nuts with pinkish to greyish colour with no shrinkage or distortion.**
- **UG (Under Grade) - normally about 25%. Nuts which may have some blackish colour, distortion or shrinkage but not rotten.**

Sun dried raw nuts for one to six days to reduce moisture content to 9% or less for safe storage and to mature the seed through the infra red and violet rays of the sun. Correctly dried nuts are pinkish in colour and produce a rattling sound when shaken. No mark can be made on a dry nut with a thumbnail. Dry raw nuts can

be stored under dry conditions for at least two years without losing their flavour, but they are generally processed within one year of harvesting.

The decortication of cashew nuts is hampered by the liquid contained in the cashew nut shell. This liquid is a viscous, oily liquid, pale yellow to dark brown in colour with a bitter taste and caustic properties; it causes blisters on human skin unless precautions are taken, and it will spoil kernels on contact. In traditional artisanal cashew processing the nuts are put in an open pan over an open fire and stirred continuously to avoid scorching until they start burning, then they are thrown on sand to extinguish the fire and to remove the remaining humidity on the outer skin.

In industrial processing the nuts are graded in different size classes and rehumidified at about 16% moisture by spreading water over them for about two days to make the kernel elastic and to fill the cells of the shell with water. Then, they are roasted in a hot oil bath heated to 192°C for about 90 seconds depending on the size of the nuts. Through the roasting process, the cells of the shell break and about 25 % of the shell liquid flows into the bath. The remaining liquid on the outer shell is removed with sawdust.
Both the artisanal and the industrial methods make the shell brittle so that they can be broken easily.

Another method to avoid contamination of the kernel with the shell liquid is to deep-freeze the nuts and split the shells while frozen.

There are different methods for manual cashew shelling. The simplest consist of placing the prepared nuts on a stone using a hardwood stick to crack the shell. A semi-mechanised process uses a pair of knives shaped in the contour of half a nut. The knife system is also used in industrial plants. In another industrial processing method centrifuges are used to crack the shells; shells and kernels are then separated in an air stream, heated shells are lighter and blow away.
After shelling the kernels have to be dried to about 6% moisture content, thereafter the testa can be peeled off easily. Kernels are then graded, rehumidified to 8% and packed in airtight containers filled with carbon dioxide (CO_2) and sealed. The CO_2 inhibits infestation by insects and is slowly absorbed by the nuts thus producing a vacuum that prevents shaking and breaking of the nuts during transportation.

Cashew apple processing:
Apples are steamed under pressure or cooked in a 2% salt solution to remove the astringency. Addition of gelatine, pectin or lime juice clears the cashew juice from remaining undesirable contents.

Information on Pests

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

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

Attacked leaves are deformed and show angular lesions, particularly along the veins, which may drop off, so that the leaves appear as if attacked by biting insects. Feeding on the stalks of the tender shoots causes elongated green lesions, sometimes accompanied by exudation of gum. Severely damaged shoots die back due to the effect of bug saliva in combination with fungi, which enter the plant tissue through the feeding lesions; the subsequent development of numerous auxiliary buds causes a bunched terminal growth known as 'witches broom'. In case of serious infestations the trees may appear as if scorched by fire. Bug feeding on developing apples and nuts causes brown sunken spots. The growth of trees is seriously retarded and fruit formation of attacking flowering shoots is reduced.

What to do:

- **Monitor the crop regularly. Helopeltis attack occurs very suddenly and great vigilance is very important to control this pest, particularly during the rainy season or when water is available leading to flushing**

(production of young shoots) when Helopeltis populations normally build up.

- **Conserve natural enemies. Weaver ants build nests on cashew trees providing good protection against this and other bug pests.**
- **Do not interplant cashew with crops that are host for Helopeltis bugs, such as cotton, tea, sweet potato, guava and mango.**

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




Helope Helope Helope Helope

Coconut bug (*Pseudotheraptus wayi*)

Adult bugs are reddish brown in colour and 12 to 14 mm long. Nymphs are red brown to green brown in colour and have long antennae. Bug feeding causes necrotic bruise-like depressions; a hard lump develops, which can be easily removed when the fruit is peeled. The bug sucks on the developing fruits causing pockmarks. The kernels are also affected showing spots, which lower their market value.

What to do:

- **Conserve natural enemies. Weaver ants nest on cashew trees deterring and feeding on coconut bugs.**

Coconut bug
Adult coconut bug
© A.M.Varela, icipe


Cocon bu…


Weave ant…

The cashew weevil (*Mecocorynus loripes*)

The cashew weevil is large weevil, about 20 mm long, and of a knobbed appearance. It is dark grey-brown in colour. The female weevil lays single eggs in small holes in the bark of the trunk or branches. The larvae are legless grubs, whitish in colour with a brown head. They bore through the bark and move downwards tunnelling under the bark while feeding on the sapwood.
Brown-black gummy frass is seen on the trunk and main branches. Heavily attacked trees become ringed by damaged sapwood and eventually die. Neglected plantations are likely to be severely attacked. Fully-grown larvae pupate in a chamber about 2 cm below the bark.

What to do:

- **Cut away bark from damaged areas of lightly infested trees and kill the larvae and pupae underneath. Repeat this every month for a further six months if required.**
- **Destroy severely infested trees. First collect and destroy all adult weevils; then fell the tree and remove the bark to expose all larval galleries; kill all larvae and pupa and burn the tree.**

Cashew weevil
Adult cashew weevil (*Mecocorynus loripes*). Real size:about 20 mm long.
© A. M. Varela

Red-bandet 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. Note a bright red band across the abdomen of immature thrips. Real size: about 1 mm long.

Mealybugs (*Pseudococcus longispinus*)

The long-tailed mealybug (*Pseudococcus longispinus*) attacks shoots, inflorescences, apples and nuts. Affected parts appear completely white. Trees infested during the flowering stage fail to produce fruits, whereas those infested at the nut swelling stage produce discoloured nuts, which result in a lower grade. However, cutting tests showed no difference in kernel outturn between clean and discoloured nuts. Mealybugs have been a problem for cashew growers in Tanzania.

The body of the adult female is 2.0-3.6 mm long, soft, elongate oval and somewhat flattened.

What to do:

- **Conserve natural enemies. Mealybugs are usually controlled by a wide range of natural enemies. However, use of pesticides may kill these natural enemies leading to mealybug outbreaks.**

Mealybugs
Mealybugs on leaf
© A.M. Varela, icipe

Cashew stem girdler (*Paranaleptes reticulata*)

Adults are a long horn beetles, with a body length of 25-35 mm and with antennae longer that the body. The head and the thorax are dark brown; the wing cases are orange with large black blotches giving them a reticulate appearance. Adult beetles girdle branches from 3-8 mm in diameter leaving a V-section cut; only a narrow, central pillar round the pith zone is left, which eventually breaks off. Female beetles lay elongated eggs in transverse slits made in the bark of the girdled branch at points above the girdle. Larvae are yellow, in colour and reaches a length of 45 mm when fully grown. They mine in dead wood of the girdled branches. Pupation takes place in the dead wood. The lifecycle takes one year. This beetle is a common but usually minor pest of cashew in the Coast Province of Kenya. However, neglected plantations may be severely damaged. It is also present in Tanzania.

What to do:

- **Once a year (in November or December) collect and burn all girdled branches should be collected and burned. Only the dead or dying part of the branch above the girdle needs to be collected.**

Cashew stem girdler (Paranaleptes reticulata)
Lamiinae/Ceroplesini. Paranaleptes reticulata Thomson, 1877 Distribution: Ethiopia, Somalia, Kenya, Tanzania, Uganda

Information on Diseases

Anthracnose (*Colletotrichum gloeosporioides*)

The disease attacks young plant tissues and can cause severe crop loss when it infects flowers, which turn black and die. Young leaves, cashew apples and nuts are similarly affected. Infected young terminal shoots die back. The disease is promoted by warm, damp conditions.

What to do:

- **Prune dead branches and twigs and remove from the field. They constitute the principal source of infection.**
- **Though pesticide application on cashews is not practised in East Africa, copper based fungicides are known to be effective against anthracnose.**

Anthracnose
Anthracnose blight on cashew
© J.M. Waller/CABI

Powdery mildew (*Oidium anacardii*)

This disease is particularly serious in coastal areas south of Dar es Salaam in Tanzania. Infected panicles and leaves are coated with white, powdery fungal growth. In severe attacks the entire panicle may be infected and the fruit and nuts fail to set.

What to do:

- **Pesticide application is not practised in cashew fields. However, sprays of powdered kelp, potassium / sodium bicarbonate and sulphur provide good control of powdery mildew.**

Powdery mildew
Powdery mildew on young cashew leaves
© A.A.Seif, icipe

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Avocados

Avocados

Scientific name: *Persea americana*
Family: Laurales: Lauraceae
Local names: Parachichi (Swahili)
Pests and Diseases: Anthracnose Avocado root rot Cercospora fruit spot Coconut bug False codling moth Fruit flies Scab Scales Spider mites Thrips

General Information and Agronomic Aspects

Geographical Distribution of Avocado in Africa

The avocado is native to the Americas but grows well in Kenya. It is very nutritious with a high protein and oil content and is becoming increasingly important as an export crop. The avocado oil is cholesterol free, of the monounsaturated type believed to protect against heart disease and certain kinds of cancers. The fruit is nearly sodium free, is rich in potassium and dietary fiber, vitamin B6, C, D and E. It is eaten as fresh fruit, in salads, soups, ice cream, also used to make avocado oil, perfume and avocado paste.

Climatic conditions, soil and water management

Depending on variety, avocado grows well from 0-2100 m above sea level (asl). The varieties 'Tonnage', 'Simmonds', 'Booth 7&8' are suited to lowland areas between 90 and 800 m asl. 'Hass' and 'Nabal' are suited to altitudes 800-2100 m asl. 'Fuerte' and 'Puebla' are suited to altitudes 1500-2100 m asl.

Avocado grows successfully on many types of soil provided they are deep, with good water holding capacity and free draining. Water logged or saline soils are unsuitable because avocado plants are sensitive to excessive soil moisture and high salinity. The optimum pH is 5.5-6.5. Temperatures between 16 and 24°C are good for growing avocados. Maximum temperature for avocado is 33°C. Above this temperature avocado

fruits and trees can be damaged. High temperatures and direct sunshine can cause sunburn damage to exposed fruit. Avocado will not grow where frost can occur. An annual rainfall 1200 mm is optimal for good production. Water requirements are not less than 1000 mm/year. If supplementary water is required not more than 50 mm at a time may be applied. Climatic conditions with alternating dry and rainy seasons are best for avocados.

Varieties

- **'Fuerte'. Hybrid of Guatemalan and Mexican races with thin skinned green-pebbled fruit of very good flavour. This variety has many lines with different shapes; the pear shaped fruit is preferred in the export market. Matures 6-8 months after flowering.**
- **'Haas'. Vigorous grower and bears medium-sized, rounded, rough-skinned, black fruits. Propagates well. Matures 8-9 months after flowering.**
- **'Nabal'. Bears fruit in alternate years. Its green fruits have a good flavor. Matures 8-9 months after flowering.**
- **'Puebla'. Spreading, dark green tree bearing deep purple to maroon round fruit. This variety is normally used as a rootstock. Matures 5-7 months after blossoming.**
- **Others: 'Reed', 'Simmonds', 'Booth 7&8', 'Pinkerton', 'Bacon', 'Lula' and 'Taylor'**

'Fuerte' is the main variety grown in Kenya. The variety 'Hass' is developing strongly, especially among small growers. These two varieties are grown for the export market. Other varieties ('Reed', 'Booth8', 'Puebla', 'Pinkerton', 'Simmond', etc.) are grown but not exported (Mugambi, 2002)

Propagation and planting

Select healthy, egg sized seeds and plant them in boxes or seedbeds. Immediately after germination transplant the seedlings into 4 liter pots, tins or polythene bags. Water them regularly until they are pencil thick. Grafting should be carried out when the seedling reaches pencil thickness. The wedge grafting method is most successful. Grafting should be done at the point where rootstock is soft. The scion should be dormant at the time of grafting and should match the size of the stock. Wrap the grafting point thoroughly to

exclude water from the union and prevent it from drying out.

Land preparation

The fields should be cleaned by removing tree stumps, bushes and perennial weeds. Then the land should be mowed or cultivated.

Planting out

Generally a spacing for pure stands of avocadoes of 9m x9m will be suitable. Dig holes of 60cmx60cm by 60cm deep keeping the top soil and the sub soil separate. Mix the top soil with one 20 litre bucket of well rotted manure or compost and 1-2 handfuls of Mijingu rock phosphate. Remove the plant from its pot keeping the root and soil structure intact (easiest if it has been properly wetted ahead of time) and plant out using only the topsoil mixture to fill the hole.
The subsoil may be used to make a basin around the tree. Water immediately after planting if it is not in the rainy season. Shade the young plants with banana leaves or similar material after planting and when they are putting up a new flush. If planted in a windy area, a windbreak will be necessary to protect the plants from leaning to one side and to help prevent leaf shedding and fruit drop and bruising.

Manuring

One avocado tree can yield 250-300 kg of fruit per harvest season. This causes a high demand on the soil to release nutrients. To determine the right amount of manures to apply the soil should be tested annually, otherwise the following table can be used as a guide for organic farmers for manuring individual trees:

Age of tree (years)	Nitrogen and potassium Liters animal urine mixed 1:4 with water in split applications	Mijingu rock phosphate	Additional potassium Ashes - handfuls	Manure or compost decomposed
1-3	8	500g	-	15 Kg

4-5	16	900g	-	15 Kg
6-7	30	1.4 Kg	1	30 Kg
8-9	46	1.4 Kg	2	30 Kg
10-14	60 (three 20 liter buckets/year, mixed with 12 buckets of water, divided into several applications)	2 Kg	4	30 Kg
15+	80 (four 20 liter buckets/year mixed with 16 buckets of water, divided into several applications	2.5 Kg	8	30 Kg

Adapted from AIC advice for conventional farmers replacing conventional fertilizers with natural products to get the same amount of nutrients.

If chicken manure is available, it can be used instead of animal urine as follows, but spread on top of the soil far enough from the tree stem to avoid burn it:

Age of tree (years)	Chicken manure Kg/tree/year	Additional Mijingu Rock phosphate	Additional potassium Ashes - handfuls	Compost decomposed
1-3	1.5	150g	-	15 Kg
4-5	3	300g	-	15 Kg
6-7	6	450g	1	30 Kg
8-9	9	450g	2	30 Kg
10-14	12	800g	4	30 Kg
15+	15	1 Kg	8	30 Kg

Trace elements: In spite of heavy applications of manures and compost, deficiencies may occur in avocado orchards. Usually these are seen as various degrees of discolouration. Accurate analysis can be made from plant analysis laboratories. The following list can be used as a guideline meanwhile:

Mineral	Symptom	Control
Zinc	Mottled leaves with light yellow areas between the veins and abnormal development of growing shoots	Apply 250 g zinc sulphate for each year of age to a maximum of 4.5 kg/tree. The application should be done in a 60 cm circle around the tree
Manganese	Progressive yellowing of the margins and interveinal parts of the leaves while the veins remain green	Spray the young leaves with foliar spray of manganese sulphate
Iron	Loss of green colour in leaves	Apply 360 g iron chelate per tree in acid soils. In normal soils 250 g of iron sulphate in 10 l of water/per tree correct iron deficiency
Chlorine	High concentration of chlorine in the soil may cause leaf burn, also damage the root system	Apply lime and compost to neutralize the chlorine.

Pruning

Initial pruning may be done to give the tree a good shape. Otherwise pruning is limited to the removal of dead wood and parasitic plants.

- **Remove all sucker and dead branches from main trunk branches**
- **Prune canopy to keep the tree to a height of 5-8 m and for ease of picking. The tree is very susceptible to**

sunburn, therefore pruning should be minimized.

- **Root pruning of the larger tree roots by cultivating to a depth of 50 cm around the edge of the tree canopy**

The area around the tree should be kept clean by weeding and removal of all dropped fruits.

Harvesting

Harvesting starts at 3-4 years from planting but a good yield is obtained from the 6th year onwards. It is not easy to tell when the fruits are ready for harvesting unless they are of the varieties that change colour at maturity. Harvest a sample and keep at room temperature. If they soften within 7-10 days without shrivelling then the fruit of that age are ready for harvesting.

Information on Pests

Insect pests are not serious constraints to avocado production at present.
The most common insect pests attacking avocados are:

False codling moth (*Cryptophlebia leucotreta*)

The false codling moth is small (wingspan of 16-20 mm), dark brown to grey in colour. The moths are active at night. Female moths lay single eggs mostly on the fruit. After emerging from the egg, the young caterpillar tunnels into the fruit and the fruit sap thus liberated forms a typical white crystalline excrescence on the surface of the fruit. When moths lay eggs on young fruits the caterpillars usually die and thus large caterpillars are seldom found.

However, the caterpillars are able to develop if fruits are approaching maturity when infested. The young

caterpillar is creamy-white with a dark brownish head. With age the body turn pinkish red. The fully-grown caterpillar is 15 to 20 mm in length. When mature the caterpillar leaves the fruit and pupates in the soil or beneath surface debris.

What to do:

- **Proper orchard sanitation in combination with natural enemies normally keep this pest under control.**
- **Infested fruits (both on the tree and fallen fruits) should be removed regularly (twice a week), and buried at least 50 cm deep, or dump in a drum filled with water mixed with a little used oil. The fruits should be left in the drum for one week.**
- **This moth also attacks citrus, cotton, maize, castor, tea, guava and carambola fruits. Other host plants include wild guava plants, oak trees and wild castor . These other host plants should be included in the sanitation programme.**
- **If possible, remove wild host plants from around the orchard.**

False codling moth
Caterpillar of the false codling moth (*Cryptophlebia leucotreta*). The fully-grown caterpillar is 15 to 20 mm in length.
© A. M. Varela, icipe

Fruit flies

Avocados, especially thin-skinned varieties might be attacked by various species of fruit flies. Some fruit flies lay eggs under the skin of the fruit that is just beginning to ripen, but others attack young and old fruit. When the fruit reaches about the size of a golf ball a sting lesion appears as a slight puncture mark surrounded by a white exudate. As the fruit develops the lesion becomes dry and turn into distinct star-shaped crack on the skin surface.

What to do:

- **Practise orchard sanitation**
- **Practise monitoring**
- **Apply baits (see more under fruit fly site)**

Fruit fly
Mediterranean fruit fly (*Ceratitis capitata*). Adult mediterrenean fruit flies are 4-7 mm long, brightly coloured, usually in brown-yellow patterns. The wings are spotted or banded with yellow and brown margins.
© Scott Bauer, USDA Agricultural Research Service, www.insectimages.org

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Scales

Scales are small, stationary brown greenish insects occasionally found sucking sap from avocado leaves. Soft scales such as *Coccus* spp. excrete large amount of honeydew, which lead to the development of sooty mould on leaves, branches and fruit. Honeydew attracts ants, which while feeding on the honeydew protect scales

from natural enemies.

Armoured scales such as the coconut scale (*Aspidiotus destructor*) may encrust young twigs, leaves and fruit. They do not produce honeydew. Scales are usually not a problem in avocado orchards; however, damage can be serious on young tress and small twigs may be killed. Although the presence of scales on the skin of fruit does not cause internal damage, it may lead to rejection of fruit, especially if grown for export.

What to do:

- **Conserve natural enemies. Scales are usually kept under control by parasitic wasps, ladybird beetles and lacewings, provided no broad spectrum pesticides are used and no ants are present.**

Armoured scales
Armoured scales on avocado fruit. The scale cover of the adult female is oval to circular, 1.5-2.0 mm across, fairly flat, very thin and translucent
© A. M. Varela, icipe

Armou s...

Armou s...

Thrips (e.g. the black tea thrips *Heliothrips haemorrhoidalis* and the red banded thrips *Selenothrips*

***rubrocinctus*)**

Thrips are small, slender insects (1-2 mm long) with two pairs of fringed wings. Adult thrips attacking avocado are dark brown or black, and the immature stages are yellow in colour. The red-banded thrips can be distinguished by a bright red band across the abdomen of immature thrips.

Thrips are sometimes troublesome pests in avocado. They may cause damage to the leaves and fruit. Affected parts become whitish or silvery and are usually covered by dark-coloured droppings.

On fruit, feeding begins near the calyx, gradually producing a scar that can cover the whole fruit. Attacked fruits develop a leathery brown skin. Feeding is most common on young fruit; economic damage generally occurs on fruit up to 2 cm in length (2-3 weeks after fruit set). Older fruit with thicker skin is less susceptible to attack.

What to do:

- **Conserve natural enemies. Thrips are attacked by predatory thrips, lacewings and predatory bugs. Control measures are rarely needed.**

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.

Bugs (Coconut bugs, *Helopeltis* bugs, stink bugs)

Adult coconut bugs (*Pseudotheraptus wayi*) are brown in colour and 10 to 15 mm long. Nymphs are red brown to green brown in colour and have long antenna. The adults and nymphs of the coconut bug feed on young and mature avocado fruit. Bug feeding causes necrotic bruise-like depressions. A hard lump develops, which can be easily removed when the fruit is peeled.

***Helopeltis* bugs also known as tea mosquito or mired bug are slender, delicate bugs, about 7- 10 mm long and have long legs and antenna. The females are red and the males brown to yellowish red. The bugs prefer to feed on young plant tissue piercing the shoots, stems, leaves peduncles, petioles and fruits; their feeding cause brown necrotic patches. Attacked leaves present angular lesion, which often drop out leaving holes as it attacked by biting insects. Feeding on young shoots causes dieback of the shoots. Feeding on fruits cause first a dark water-soaked mark around the feeding puncture, turning into a lesion with a light brown center and black edge. The fruit may exude sap that forms a whitish deposit as it dries.**

Stink bugs are shield-shaped bugs variable in size (6 to 15 mm long) and colour (green to brown or reddish brown). They emit a characteristic unpleasant odour when disturbed. They usually feed on the developing fruit; the feeding punctures cause local necrosis resulting in fruit spotting, and deformation.

What to do:

- **Conserve natural enemies. Weaver ants in particular, are efficient predators of bugs in the coastal areas of East Africa.**

Coconut bug
Adult coconut bug (*Pseudotheraptus wayi*. Real size 10 to 15 mm long.
© A.M.Varela, icipe



Cocon bu… **Helope** **Brown stin…**

Spider mites (*Oligonychus* spp.)

Attack by spider mites (*Oligonychus* spp.) produce circular necrotic spots covered by dense webbing. As mite populations increase feeding causes leaf drop. These mites are more damaging to 'Haas' variety; 'Fuerte' variety is less affected.

Feeding by broad mites (*Polyphagotarsonemus latus*) causes leaf distortion. These tiny mites (0.1-0.2 mm long) cannot be seen with the naked eye, and are even difficult to detect with a hand lens. An attack by the broad mites can be detected by the symptoms of damage. Their feeding produces discoloration, necrosis and deformation of tissues.

What to do:

- **Conserve natural enemies. Mites are attacked by a range of natural enemies which can keep the pest**

under control provided that the natural enemies are not killed by application of pesticides.

- **Wash the leaves with water using high-pressure hoses. This helps to reduce mite populations.**
- **Irrigate and fertilise adequately heavily infested trees to maintain the flush of new growth that occurs after leaf shed due to mite attack. However, care should be taken not to overfertilise trees to avoid promoting mite populations.**

Spider mites
Two-spotted spider mite (*Tetranychus urticae*) (related species). The adult female is 0.6 mm long. The male is smaller.
© Image supplied by Warwick HRI, University of Warwick


Spider mit…


Broad mite

Information on Diseases

Scab (*Sphaceloma perseae*)

The fungus readily infects young, succulent tissues of leaves, twigs and fruits. Lesions appear as small dark spots, slightly raised, oval to elongated. These spots join up, giving a corky appearance to the surface of the fruits, impairing the appearance but not the internal quality of the fruit. Fruits are only susceptible when

young until about half size development. The fungus requires moist conditions for sporulation and infection.

What to do:

- **Remove dead branches and twigs since they harbour the fungus.**
- **Remove fallen rotten fruits from the field.**
- **Apply copper-based fungicides pre-flowering, at fruit formation, and after harvest.**

Scab
Scab (*Sphaceloma perseae*) on avocado fruit
© A.A. Seif, icipe

Avocado root rot (*Phytophthora cinnamomi*)

This disease can attack trees of any size and age. Leaves of infected trees are small, usually pale or yellow green, are often wilted and fall prematurely giving the tree sparse appearance. In advanced stages of the disease, branches die-back and fruit remains small and crop yield drastically reduced. Feeder roots get blackened, decayed and died. Infected trees die prematurely. The disease is prone in areas subject to flooding and in poorly drained soils. The fungus can be spread or introduced to new areas by use of infected seeds, infested soil, irrigation water containing spores of the fungus and infected seedlings. The host range of the fungus includes Acacia, Camellia, Casuarina, Cypress, Eucalyptus and Grevillea.

What to do:

- **Use diseased-free seed.**
- **Treat seed for planting in a hot-water bath at 48 to 500C for 20 minutes. After the hot-water treatment, rinse the seed immediately with clean, cold running water and spread out to dry thoroughly on a clean surface not in contact with the soil.**
- **Use clean nursery soil for container-grown plants. The soil should be well drained and carefully irrigated to prevent excessive moisture. Use tolerant/resistant rootstocks (e.g. Duke No. 6 and 7; G 6).**
- **Remove diseased trees from the field.**
- **Avoid movement of soil or water from diseased to noninfested areas.**
- **Use cultivation equipment first in healthy portion of the orchard before use in diseased areas. Washed and dry cultivation equipment after use in diseased areas.**

Anthracnose (*Colletotrichum gloeosporioides*)

This fungal disease is primarily a post-harvest problem when fruit is at maturity stage. Infection takes place when fruit is still very young and the fungus stays dormant till the fruit ripens. The disease appears as depressed spots on the fruit and the spots are manifested as a rot, which can penetrate deep into the flesh. In wet weather, the spots may be covered with mass of slimy, salmony pink fungal spore mass. The disease may develop very rapidly in storage if conditions in storage are humid and warm.

The anthracnose fungus lives saprophytically on twigs, rotten fallen fruits and dead or dying infected leaves. The fungus is spread by water splash.

What to do:

- **Remove dead branches and twigs since they harbour the fungus.**

- **Remove fallen rotten fruits from the field.**
- **Apply copper-based fungicides pre-flowering, at fruit formation, and after harvest.**

Anthracnose
Anthracnose *(Colletotrichum gloeosporioides)* on avocado fruit.
© A. A. Seif, icipe

Cercospora fruit spot (*Pseudocercospora purpurea*)

The disease is primarily a problem to quality of fruits. The severity of infection varies from season to season and can cause losses of up to 60%. The lesions appear as small light-yellow spots on fruits and leaves. They later become reddish brown and eventually become hard and crack. Mature fruits are resistant. The disease development is favoured by humid conditions and high temperatures. The fungus is essentially spread by water splash and its spores are also wind-borne.

What to do:

- **Remove dead branches and twigs since they harbour the fungus.**
- **Remove fallen rotten fruits from the field.**
- **Apply copper-based fungicides pre-flowering, at fruit formation, and after harvest.**

Cercospora fruit spot
Avocado fruit showing a lesion caused by Cercospora (*Pseudocercospora purpurea*).

Fresh Quality Specifications for the market in Kenya

The following specifications constitute raw material purchasing requirements.

PRODUCE:	AVOCADO
IMAGE:	
VARIETY:	Various
GENERAL APPEARANCE CRITERIA	
INTERNAL COLOUR	Creamy pale yellow flesh grading to bright green at skin;
EXERNAL VISUAL APPEARANCE	Glossy skin with slightly bumpy texture; stem buttons attached.
SENSORY	With firm flesh slightly softening at stem end; medium thin skin which peels easily; no off odours.
SHAPE	Typical [illegible] shape
SIZE	In pre-ordered size range only per requirements.
MATURITY	Fruit firm, yielding to slight pressure at stem end.
INSECTS	With no evidence of live insects. With no [illegible] in flesh under skin (fruit fly/fruit spotting bug damage).
PHYSICAL DAMAGE:	With no cuts, holes, punctures or cracks (that break the skin). With no damaged stem button holes. With no deep skin scarring due to insect chewing. With no soft, depressed [illegible] nodule bruising damage).

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Information of www.infonet-biovision.org

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Tomato

Images

Simone Hunziker

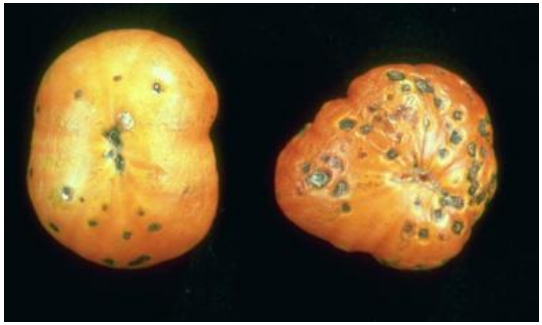
Fruit on plant. Although tomatoes generally rank low in comparative nutritional value, they outrank all other vegetables in total contribution to human nutrition because so much is consumed in so many different ways.

Anthracnose (*Colletotrichum coccodes*) on tomato

Clemson University - USDA Cooperative Extension Slide Series, www.insectimages.org (www.ecoport.org)

Spider mites on tomato. Note the mites and their webbing visible beetween the leaves.

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



Bacterial spot (*Xanthomonas vesicatoria*) on tomato fruit: Typical sunken, black spots on the fruit and malformation due to the bacterial infection.

Plant Protection Service Archives,

Wageningen, NL, www.insectimages.org (Courtesy of EcoPort, www.ecoport.org)

Clemson University, www.insectimages.org

Damage of Bacterial spot (*Xanthomonas campestris* pv. *vesicatoria*) on tomato leaf.

Bacterial speck (*Pseudomonas syringae* pv. *tomato*) of tomato seedlings. Note the necrotic lesions and the widespread chlorosis.

Laing M.D. (Courtesy of EcoPort, www.ecoport.org)

Mike Pearson (Courtesy of EcoPort, www.ecoport.org)

Tomato spotted wilt tospovirus: mottle in tomato fruit.

Damage on tomato fruit and leaves caused by the Tomato russet

mite, *Aculops lycopersici*

Steynberg L. (Courtesy of EcoPort, www.ecoport.org)

Damage of bacterial wilt on tomato.

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

Blossom-end rot on tomato. Blackened or rotten appearance on the blossom end of the fruit caused by calcium deficiency and affects all fruiting vegetables. Secondary fungal infections may occur on the affected areas.

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

A. A. Seif, icipe

Powdery mildew on tomato

Tomato mosaic virus

A.A. Seif, icipe

A.A. Seif, icipe

Early blight symptoms on tomato fruit

'Birds eye' symptoms on tomato caused by bacterial canker

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Mites on tomato leaf.

A. M. Varela, icipe

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Cassava

Images

Cassava

IITA Annual Report 1998, Courtesy of EcoPort, (www.ecoport.org)

Cassava roots

CIAT, UAGRM Courtesy of EcoPort, (www.ecoport.org)

Cassava (*Manihot esculenta*)

Purdue University, USA

Cassava (*Manihot esculenta*)

Purdue University, USA

Cassava brown leaf spot

A.A.Seif, icipe

Cassava bacterial blight (*Xanthomonas campestris* pv. *manihotis*).

Angular leaf spots, sometimes with yellow haloes, rapidly expanding, leading to necrosis and leaf fall.

Grahame Jackson (Courtesy of EcoPort)

Variegated grasshopper (*Zonocerus variegatus*)

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

Stripped mealybug (*Ferrisia virgata*)

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

error

A. M. Varela, icipe

Parasitic wasp of mealybugs

A.M. Varela, icipe

Scale insect. This is not the cassava scale, but an armored scale (related species)

USDA ARS, Bugwood.org

Cassava brown streak virus disease

Anne Sweetmore. Reproduced from CABI 2006

Eggs and larva of the cassava green mite *(Mononychellus tanajoa)*, real size 0.2 mm.

F. Haas, icipe

Female of the cassava green mite *(Mononychellus tanajoa)*, real size 0.8 mm.

F. Haas, icipe

Male of the cassava green mite. *(Mononychellus tanajoa)*, real size 0.8 mm.

F. Haas, icipe

Information of www.infonet-biovision.org