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Tomato
Scientific name: *Lycopersicon esculentum*
Order/Family: Solanales: Solanaceae
Local names: Nyanya (Swahili)
Pests and Diseases: African bollworm Anthracnose Aphids Bacterial canker Bacterial spot Bacterial wilt Blossom-end rot Cabbage looper Cutworms Damping-off diseases Early blight Fusarium wilt Late blight Leaf mould Leafmining flies (leafminers) Powdery mildew Root-knot nematodes Spider mites Thrips Tomato mirid bug Tomato mosaic virus Tomato russet mite Tomato spotted wilt virus Tomato Yellow Leaf Curl Virus Disease (TYLCV) Weeds Whiteflies Armyworm, Black speck

General Information and Agronomic Aspects

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

Geographical Distribution of Tomato in Africa

Tomatoes are native to South and Central America, and are now cultivated widely throughout the world.
Tomatoes are one of the most widely cultivated vegetable crops in Africa. They are grown for home consumption in the backyard of almost every homestead across sub-Saharan Africa. They are important source of vitamins and an important cash crop for both smallholders and medium-scale commercial farmers. Tomatoes acting as taste enhancers in food are always in high demand both for fresh consumption and processing.

Tomato yields in smallholder cropping systems in the region are generally far below the potential of the crop. Average yields as low as seven tonnes/ha have been reported from Tanzania and 10 tonnes/ha from Uganda, while yields as high as 100 tonnes / ha have been recorded from commercial farmers in Zimbabwe. There are several reasons for low yields. Among these are low quality seeds, non-availability of inputs, sub-optimum crop husbandry and a large number of pests and diseases.

Cherry Tomatoes are a fast expanding export crop in Kenya. These are miniature tomatoes with a preferred size of around 15g per fruit. Cherry tomatoes are easier to grow organically than most other tomatoes as many of them have a high tolerance to diseases and can be grown successfully both under green house and open field conditions.

Nutritive Value per 100 g of edible Portion

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

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

	(Calories)								(I.U)	
Tomato, Green	24	1.2	5.1	0.5	13	27	0.5	244	270	(
Tomato, Ripe	22	1.1	4.7	0.5	13	27	0.5	244	900	(

Climate conditions, soil and water management

Ideally, tomato requires a relatively cool, dry climate for high yield and premium quality. However, it is adapted to a wide range of climatic conditions. Tomatoes have been grown as far north as the Arctic Circle (under protection) and down to the hot and humid equator. The optimum temperature range for growth and development is 21 to 24°C. Prolonged exposure to temperatures below 12°C can cause chilling injury. Mean temperatures above 27°C severely impair growth and fruit set. Destruction of pollen and egg cells occurs when the maximum day-time temperature is 38°C or above for 5 to 10 days. Fruit set is also generally poor if the night temperatures are above 21°C just before and after flower formation. Hot dry winds can also cause flower abortion. Tomatoes are not sensitive to day length and set fruits in photoperiods ranging from 7 to 19 hours. Tomatoes can be grown in many soil types ranging from sandy loam to clay-loam soils that are rich in organic matter. The ideal soil pH range is 6 to 6.5; higher or lower pH can cause mineral deficiencies or toxicities. Long periods of flooding are detrimental to tomato growth and development.

Small-Holder Farmer Tomato Seed Production

For own seed production it is not recommended to use hybrid varieties. These varieties carry a label "F1". However, if a hybrid variety is preferred, it cannot be used for more than one generation (one crop cycle).

The conditions to be followed when producing seed:

- **The tomato seed should be multiplied once**
- **Buffer zone for tomato seed plot should be 25 m from any other tomato crop**
- **The plot should not have had tomatoes planted recently**
- **The tomato crop should be scouted for diseases**
- **The first step fruits should not be included for seed extraction**
- **After planting the seed the off types should be uprooted early**
- **Weeding and ploughing of plot should be done**
- **Proper crop management i.e. fertiliser application, pruning, staking etc**

Seed extraction process

- **Pick ripe fruit at second cluster from only robust, disease-free plants (plants not infected with diseases: bacterial canker / bacterial speck / bacterial spot / anthracnose fruit rot / early blight / late blight / tomato mosaic virus)**
- **Wash the fruit, preferably with a soap to decrease the chance of infection by diseases**
- **Cut the fruit in two pieces and remove the seeds with a spoon. Or the pieces can be squeezed out into a clean bucket, plastic, glass or ceramic bowl until only the seed-jelly and fruit sap is left**
- **Cover the bowl with cloth or paper to keep away dirt and other possible contaminants but do not make it airtight**
- **Let the seeds stand for 1 to 5 days (usually 2 to 3 days in warm areas)**

Tomato seed extraction by

smallholder farmers

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- **Stir the seeds daily to ensure uniform fermentation and to prevent seed discolouration**
- **Wash the fermented seeds in clean water. Any seeds that float during washing should be discarded because they are either not fully ripened or filled properly**
- **Dry the seeds in indirect light and in well-ventilated places. The seeds could be spread out over a clean manila sack to dry**

Locally produced tomato seed

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- **In case seeds cannot be sown immediately, they should be stored in a waterproof container (transparent plastic bag / non-coloured glass bottle). Transparent materials allow sunlight, which reduces mould development. Place a bit of ashes in the bottom of the container to absorb any moisture and to prevent the seeds from moulding. In case where pots or bottles are used for seed storage, the tops should be covered with plastic film to stop possible water seepage**
- **Store seed container in a cool place, as dry as possible**
- **Check the seeds regularly (at least weekly) for mould development. If mould is detected, dry the seeds again**

Seeds can be stored, if properly dried, up to 2 years.

One kg of tomatoes will produce between 1 and 4 grams of seeds.

(This information is based on a Biovision Project carried out in Taita Hills, Kenya, under Eastern Arc Mountains in conjunction with Wild Life Services)

Storage of locally produced tomato seeds in plastic bag

Propagation and planting

Tomatoes can be direct-seeded or transplanted in the field, but this method is expensive as large amounts of seed are required (about 500 to 1000 g of seeds/ ha) and adds about four weeks of weeding labour to growing costs. In contrast, raising the young transplants in a special nursery enables growers to achieve great seedling uniformity, requires smaller quantity of seed and saves on weeding costs.

Nursery bed preparation:

- **Construct raised seedbeds of max one m width in a place where no potatoes, tomatoes, eggplants or peppers have been grown for about 3 years.**
- **Incorporate about five kg of good compost/ m² into the seedbeds, which are finely cultivated on top.**
- **Drill shallow seeding furrows with a pointed stick. One ha of tomatoes requires 150 to 200 g of well germinating seed.**
- **Sow seeds in the furrows and cover them lightly with soil.**
- **Pat firmly with the flat side of a rake or similar tool, mulch and water liberally.**
- **Never use fresh manure on a seed bed as it will burn young seedlings.**
- **After emergence of seedlings push away the mulch from the rows to allow sunlight to get through to the young seedlings.**
- **Individual plant raising in banana leaf pots or plastic seedling trays will greatly improve eventual plant establishment, by reducing transplanting shock and root damage during**

transplanting.

- **The young seedlings require sufficient water to sustain good, healthy growth.A week before transplanting, reduce watering to harden the seedlings. Three- to four-week-old seedlings (15 to 25 cm high with 3 to 5 true leaves) are ready for transplanting. Seedlings must be thoroughly watered 12 to 14 hours before they are lifted out of the seedbed, to avoid excessive damage to the roots. Transplant seedlings in the afternoon or on a still, cloudy day to reduce the transplanting shock, and water them immediately. As little as a cup of water per plant immediately at planting will greatly speed up plant establishment.**
- **Spacing between plants and distance between rows depends on the cultivar's growth habit and whether the plants are to be supported by stakes or left to grow on the ground.**
- **Indeterminate varieties are generally staked while determinate varieties can be grown in the field without staking. Common configurations are plants spaced 30 to 60 cm apart in single or double rows on 1.0 to 1.4 m wide beds.**

Common Varieties available in Kenya and their yield potential (AIC 2003)

Varieties for processing	Yield potential (tonnes/ha)
"Roma VF"	83
"Sun Marzano"	100
"Rutgers 10x Hybrid"	100
"Heinz 1350"	60
"Roma Nova"	100
"Cal J"	73
"M-82"	57
Varieties for fresh Market	Yield potential (tonnes/ha)

"Money Maker"	20-50
"Early Beauty"	25
"Super Marmande"	85
"Ponderosa"	90
"Hot Set"	40
"Best of all"	100
"Marglobe"	90
"BWN 21"	90
"Kenton F"	32
"Zawadi"	30
"Fortune Maker"	30

Some varieties reported to be tolerant (T) or resistant (R) to pests and diseases available in east, central and southern Africa

Variety	Bacterial wilt	Early blight	*Fusarium* and *Verticilium* wilt	Late blight	Red spider mites	Root-knot nematodes	Tomato Mosaic Virus	Tomato Yellow Leaf Curl Virus
"Alboran"	-	-	-	T	-	-	-	-
"Fortune"	R	-	R	-	-	-	-	-
"Maker"	-	-	-	-	-	-	-	-
"Kentom"	R	-	-	-	-	R	R	-

"Meru"	-	-	-	R	-	-	R	-
"Rio Grande"	-	R	R	R	-	-	-	-
"Roma VF"	-	-	R	-	-	-	-	-
"Roma VFN"	-	-	R	-	R	R	-	-
"Shengena"	-	-	-	R	-	R	R	-
"Taiwan F1"	R	-	-	-	-	-	-	-
"Tengeru 97"	-	-	R	R	-	R	R	R

The breeding of new varieties of tropical cherry tomato varieties is continuing at the Asian Vegetable Research and Development Center (AVRDC) in Taiwan. All varieties available in Kenya so far are indeterminate and take 65 to 72 days to yield from date of transplanting. Cherry Tomatoes can typically produce for longer seasons than ordinary tomatoes due to their disease resistance or tolerance. The cultivars "Sugar Pearl" and "Girls Sweet" produce fruit that are prone to fruit cracking, so preferred varieties include "Tiny Tim", "Super Sweet 100F1", "Cherry King F1", "Cherry Sweet 100F1", "Sweetie" etc. Note that varieties with the added F1 on their name are hybrids, and seed collection from these may not produce as well as the bought seed. However "Tiny Tim" and "Sweetie" are open pollinated, and farmers could propagate seed from the best plants with good results.

Husbandry

Tomatoes respond very well to liberal amounts of well-rotted compost or manure. In addition a spoonful (or three teaspoons) rock phosphate should be added to each planting hole. If the soil is poor in organic matter it is advisable to grow a crop of good quality green manure such as cowpeas, mucuna, soybean, or crotalaria before transplanting tomato seedlings. Avoid commercial nitrogen fertilisers as excess nitrogen is associated with fruit puffiness and blossom-end rot, and generally causes excessive vegetative growth. Excess free nitrogen in the soil also causes softer leaves and makes the plants attractive to pests and diseases.
Competition with weeds, especially in the hot and humid tropics, can be very severe. To control weeds on open land crops, slash regularly emerging weeds as close to the ground as possible between rows of tomatoes is recommended. Leave slashed weeds on the soil as mulch to help prevent erosion, reduce soil temperature and conserve soil moisture. This should be supplemented by manual weeding in rows and mulching the beds with straw.

Staking: For tall growing indeterminate varieties, put a two m stake firmly in the ground for each tomato plant and tie the stems loosely as the plant grows. Alternatively put a stout pole in the ground at every four m and two wires run - one at two m and one at 0,15 m above the ground. Tye a fairly strong string between the two wires behind each tomato plant. The plants can then be carefully twisted around the strings as they grow.
Pruning of tomato plants is necessary for indeterminate varieties. One or two main stems should be allowed to grow and the side branches (laterals) pinched off as the crop grown on a weekly basis. When 6 to 8 flower clusters are formed, the growing top should be pinched off to encourage the growth of good size marketable fruit. Leaves close to the ground should be removed to help prevent entry of blight. No pruning and regulation of fruit number and clusters are normally practised on determinate cultivars. Semi-determinate cultivars may be grown either as a determinate or indeterminate crop. Smokers should wash their hands carefully with soap before handling tomato plants as they may otherwise transmit tobacco mosaic virus disease.
Tomatoes need adequate irrigation during the early plant growth, fruit set and fruit enlargement stages. Consistency of water supply to the plants plays a major role in attaining uniform maturity. It also reduces the incidence of blossom-end rot, a physiological disorder normally

attributed to calcium deficiency during fruit enlargement. In dry weather watering is essential at least twice a week. Drip irrigation is the most efficient and risk free method of irrigation, as it does not create water splashes onto the plants.

Cherry tomatoes although indeterminate can produce quite well even when not staked in the field, but must then be given adequate space as they spread quite extensively (one m² per plant is minimum. Higher production and easier field management are benefits of the expensive staking procedure.

Harvesting

Fresh-market tomatoes are often harvested at the mature-green stage and ripened in transit or in storage before they are marketed. Ethylene is sometimes used to rapidly and uniformly ripen mature-green tomatoes prior to shipping them to the market, but this adversely affects quality. This is not a common practice in Kenya. Generally, tomatoes harvested at pre-ripe stages tend to be of lower quality (lower soluble solids, ascorbic acid and reducing sugars) than vine-ripened tomatoes. The nature of the growth and ripening pattern of fresh-market tomato cultivars require frequent pickings for either mature-green or vine-ripe fruits. In contrast to the fresh-market or table tomatoes, processing tomatoes are picked fully ripe. In developed countries, harvesting is often by machine. Tomatoes used for pureed products such as soup, juice and sauces, are left on the vine until over 85% of the fruits are ripe. Those for whole tomatoes are picked while still firm, but often only 65% of the crop may be ready to pick all at once.

After picking, tomatoes should be stored in a shady place either in the field or at home to prepare them for the market. Properly sorted and graded fruits generally command a better market price than ungraded fruits. The marketable fruits are then packaged in suitable containers, often 20-kg wooden boxes, bamboo baskets, plastic boxes, or other locally available packaging materials. Proper packaging protects fruits from injury and reduces water loss. The

storage life of tomatoes depends on the maturity stage at which they were harvested and on the desired quality of fruits. Quality is highest when completely ripe, whether artificially or on the vine. Ideally mature-green tomatoes should be stored for 7 to 10 days at 13 to 18°C at 85 to 90% RH so that they will ripen properly. Colour is the single most important visual parameter of tomato quality. Lycopene development at temperatures above 30°C is generally poor. This is the main reason that tomatoes grown in the hot tropics tend to have a pale red or yellowish colour and are poorly flavoured.

Harvesting and packaging of cherry tomatoes depend on market requirements. For distant markets, the fruit clusters may be cut when the fruits start turning to a red or pink colour depending on the cultivar. Firm red ripe fruits are required for the domestic market. However for the export market, cherry tomatoes are graded and packaged into pre-packs before shipment direct to supermarkets in the export destinations. On the whole a marketable yield of 20 tons /ha and above is considered a good yield. Yield of up to 60 tons/ha have been obtained under experimental conditions at KARI,Thika Research Station.

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Information on Pests and Weeds

The main tomato pests in east and southern Africa are red spider mites and russet mites, fruitworms, whiteflies, leafminers and thrips.

Examples of Tomato Pests and Organic Control Methods

Cutworms (*Agrotis* spp)

Cutworms are the caterpillars of certain moths. They are serious pests of tomato seedlings. They cut stems of newly transplanted or emerged plants at the base. Cutworm damage is more critical after thinning or transplanting.

Cutworms
Cutworms *Agrotis* spp) on tomato. Note cut seedling. Early instars are about 7 to 12 mm long. Fully grown caterpillars are 35 to 50 mm long.

More Information on Cutworms

What to do:

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

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

Aphids such as cotton aphid (*Aphis gossypii*) and the green peach aphid (*Myzus persicae*) suck plant sap, which can reduce plant growth; they also secrete honeydew, on which sooty moulds growth. Sooty mould on fruits reduces their market value. These aphids may also transmit virus diseases during

feeding such as the cucumber mosaic virus. In Kenya, aphids are occasionally found on tomatoes, but they are not considered an important pest.

What to do:

- **Conserve natural enemies. Aphids are usually kept under control by a wide range of natural enemies. In particular, avoid use of wide spectrum pesticides since they kill natural enemies.**
- **Use reflective mulch. Reflective aluminium mulches deter aphids from landing on plants. The effect is lost once plants are large enough to cover the mulch.**

Green peach aphid
Green peach aphid (*Myzus persicae*). Adult wingless females are 1.2-2.1 mm in body length and very variable in colour.

© Whitney Cranshaw, Colorado State University, Bugwood.org
More Information on Aphids

Root-knot nematodes (*Meloidogyne* spp.)

Root-knot nematode are very destructive to tomatoes. Damage is most serious on light sandy soils in furrow-irrigated crops. The nematodes cause small lumps known as root knots or galls on the roots. Heavily infected roots are severely distorted and swollen. In time the roots rot. The affected plants are either stunted or have tendency to wilt or even die in hot weather. The affected plants, in most cases, just wilt with the foliage still green - without yellowing. The nematode problem is primarily due to improper crop rotation.

What to do:

Root-knot nematodes
Root-knot nematodes (*Meloidogyne incognita* / *M. javanica*) Roots of severely attacked (left) and healthy plant (right). Affected plants

- **Rotate with tomato, brassicas, cereals.**
- **Do not locate seedbeds where susceptible vegetables (e.g. okra - sweet pepper - eggplant - Irish potato - carrot - cucurbits) have been previously grown.**
- **Use tolerant / resistant tomato varieties (e.g. "Roma VNF", "Shengena","Tengeru-97", "Kentom", "Caracas", "Carmello", "Diego", "Piersol" and "Vegas"). Varieties with the "VFN" label exhibit some resistance - the "N" stands for Nematode-tolerant.**
- **Use mixed cropping or grow marigolds (Tagetes spp.) or sunnhemp (Crotalaria juncea).**
- **Maintain high levels of organic matter in the soil (manure and compost).**
- **Amend the soil with neem. Mixing neem cake (residue of neem seed after expression of neem oil) increases the organic content of the soil and kills nematodes due to the naturally-occurring nematicidal compounds in neem.**

are normally stunted and eventually wilt and die. The most characteristic symptom is formation of root galls (knots) and these can be seen with the naked eye. Affected roots rot.

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More Information on Root-knot nematodes

Weeds

Soil solarisation can provide control of many soil borne diseases, nematodes, and weeds. Preventing weeds from producing seed helps reduce weed populations in subsequent crops; this also applies to areas adjacent to the cropped fields. A soil cap (5 to 10 cm mound of soil) over the seedline at planting can reduce the first flush of weeds competing with the crop seedlings. The cap is removed just after tomato seedlings germinate, but before rapid elongation of the hypocotyls. This mound also reduces soil moisture loss and emergence problems

Weeds
Farmers do weeding in an irrigated rice field in Burkina

that result from soil crusting after periods of rainfall, and is formed by disks or other implements.

When tomato seedlings are about 10 cm tall, cultivation can create a dry layer of soil (dry mulch) on the seedline to prevent weed seeds from germinating and to smother small weeds that have already emerged. Flaming is also used for weed control in large-scale commercial tomato production.

What to do:

- **Crop rotation can effectively reduce difficult weed problems by altering the environmental conditions that favour a particular weed species or by permitting the use of alternative methods to control these weeds. Lucerne is a good choice for a rotational crop because its frequent cutting cycle reduces many weeds. Maize is also used in rotations with tomato as it is not a host to tomato diseases and weeds can be controlled in this crop.**

Faso.

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More Information on Weeds

The tobacco whitefly (*Bemisia tabaci*)

This whitefly is a serious pest of tomatoes. Whiteflies attack tomatoes from seedling to mature stage. They suck sap from the leaves, and may weaken the plants. Feeding of whiteflies cause yellowing of infested leaves. Immature stages (nymphs) produce honeydew on which sooty mould grows. Heavy honeydew or mould coating reduces plant growth and fruit quality.

Whiteflies
Whiteflies under leaf. Adult whiteflies are about 1mm long.

© Clemson University, Department of Entomology
More Information on Whiteflies

They attack tomatoes from seedling to mature stage. However, the main damage caused by whiteflies is indirect as vectors of virus diseases. *Bemisia tabaci* transmits several virus diseases in tomato. In particular it is an efficient vector of the Tomato Yellow Leaf Curl Virus (TYLCV), a major disease in Kenya.

Small numbers of whiteflies do not cause major direct plant damage. However, even small numbers of whiteflies may need to be controlled in areas where TYLCV is common.

What to do:

- **Time sowing and transplanting. If possible avoid the season when whiteflies are more likely to occur.**
- **Use cover crops (forage, peanut, weeds) and inert covers (silver, yellow, and white/black plastic mulches). They have been shown to reduce whitefly damage in tomatoes. Whiteflies are attracted by the colour of the plastic mulch. The heat of the plastic kills the whiteflies. However, this is effective as long as the plants are young and do not cover the mulch. The protection can last for 10 to 20 days after transplanting and about 30 days after direct seeding. Take care to avoid sunscald when using plastic covers.**
- **Prevent physical contact of the whiteflies with the plant; this can prevent the transmission of viral diseases. Cover tomato seedling nurseries with nylon nets or use tunnels for 3 to 5 weeks to protect seedlings from whiteflies infestation. These methods have been reported to reduce the transmission of**

the Tomato Yellow Leaf Curl Virus in several countries.

- **Conserve natural enemies. Whiteflies are mainly attacked by parasitic wasps and by predators such as phytoseiid mites, lacewings and ladybird beetles. For more information on natural enemies click here**
- **Check the crop regularly. Use yellow sticky traps to monitor the presence of whitefly adults. Yellow traps proved also to be useful as a control method for low infestations. For more information on traps click here**
- **Remove weeds in advance of planting tomatoes, and keep tomato fields weed-free. Weeds play an important role in harbouring whiteflies between crop plantings. They also often harbour whitefly-transmitted viruses.**
- **If necessary spray neem extracts. Neem-based insecticides are reported to substantially reduce egg laying by B. tabaci, inhibit the growth and development of nymphs, and significantly reduce the risk of TYLCV transmission.**
- **Spraying with soap and water solutions reportedly controls whiteflies. The amount of soap needed depends upon the soap type. For more information on soap spray click here**
- **Plant barrier crops. Fenugreek and coriander are reported to repel whiteflies**

Thrips (*Thrips tabaci, Frankliniella occidentalis, F. schultzeii* and *Ceratothripoides brunneus*)

Thrips may also be a problem in tomatoes in Kenya. Thrips are small (about 1 to 2 mm long). They usually feed on the lower

surface of leaves puncturing them and suck the exuding sap. They also attack buds, flowers and fruits. Attacked leaves have a silvery sheen and show small black spots (thrips excrements). Under heavy infestation attacked buds, and flowers usually fall off. Attacked fruits show speckling and small necrotic patches on the surface affecting fruit quality. Fruits may become deformed.

Thrips feed on tomatoes at all stages, but their feeding on seedlings is particularly damaging. Heavy infestation can reduce stands of young seedlings in hot weather. Thrips of the genus Thrips and Frankliniella are vectors of viruses such as the Tomato Spotted Wilt Virus (the most economically important virus in tomato production) and the Tomato Chlorotic Spot Virus.

What to do:

- **Conserve natural enemies. Predatory mites (eg. Amblyseius sp.), anthocorid bugs (e.g. Orius spp.), and other predators such as ladybird beetles, lacewings and spiders, and the fungus Entomophthora are important in natural control of thrips.**
- **Monitor the crop regularly. Check daily plants in the nursery, and crop borders in the field. Be particularly vigilant at flowering. Pay careful attention to flowers and flower buds.**
- **Destroy thrips pupae in the soil. This helps reducing subsequent thrips populations. Plough and harrow before transplanting to expose pupae in the soil from previously infested crops to natural enemies and desiccation. Soil**

Thrips
Thrips damage on tomato. Thrips are small (about 1 to 2 mm long)

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Thrips **Thrips** **Thrips**

More Information on Thrips

solarisation and flood irrigation (flooding previously infested fields prior to planting/transplanting) destroy a large proportion of thrips pupae present in the soil. For more information on solarisation click here

- **If necessary spray biopesticides. Neem and some other plant extracts are reported to control thrips. Spinosad, a bacterial derivative is effective in thrips control. However, timing of biopesticide application is important. Thrips are difficult to control with insecticides due to their secretive habits (eggs are laid in plant tissue, the larvae and adult shelter in the flowers and larvae pupate in the soil). Spraying early in the morning or in the evening and mixing the spray with a sugar solution (which attracts the thrips out of the flowers) are reported to increase efficacy of sprays.**

Leafminers (*Liriomyza* spp.)

Leafmining flies make tiny punctures on the side of tomato leaves when feeding and laying eggs. These punctures may serve as entry point for disease causing organisms such as bacteria and fungi.

The most destructive stages are the immature stages (maggots). Maggots measure up to 3 mm in length. The maggots feed on leaf tissue inside the leaf leaving a wandering track in the form of irregular mines. Heavy mining of leaves may reduce photosynthesis affecting development of flowers and fruits. Heavy attack may cause leaf drop. This is particular serious for tomato seedling which may die due to defoliation. Defoliation of

Leafminers
Damage by leafmining flies (*Liriomyza* spp.) on tomato leaf. Note maggot ready to pupate (yellow) and pupa (brown).

tomato plants may also expose fruits to sunburn and affect the market value. Leafminers attack a wide range of cultivated vegetables.

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More Information on Leafmining flies (leafminers)

What to do:

- **Conserve natural enemies. Parasitic wasps normally control Leafminers. However, the widespread indiscriminate use of persistent broad-spectrum insecticides, to control this and other pests, disrupt the natural control, leading to leafminer outbreaks.**
- **Rotate with non-host crops and plan the arrangement of fields so that old infested fields do not provide a reservoir of infestation for subsequent crops.**
- **Destroy leafminer pupae in the soil. This can be done by ploughing and tilling, by solarisation, and, on heavy soils, by flood irrigation.**
- **Monitor the crop by checking foliage for the presence of stipples caused by the adults while feeding and laying eggs, and for mines and larvae. Trap adult flies with yellow sticky or water traps. For more information on traps click here.**
- **If necessary spray with neem-based pesticides. For more information on neem-based pesticides click here.**

Fruit borers (*Helicoverpa armiguera, Spodoptera littoralis*)

Fruit borers such as the African bollworm (*Helicoverpa armigera*) and leaf-eating caterpillars such as the cotton leafworm

(*Spodoptera littoralis*) attack the developing and mature fruit of tomato. The African bollworm, also known as the tomato fruit worm, is one of the most destructive insect pests, causing yield losses as high as 70% due to fruit boring. They usually bore into the fruit from the stem end, and feed on the inner parts of the fruits, causing extensive fruit damage and promoting decay caused by secondary infections.

They prefer green fruit. Caterpillar of the cotton leaf worm feeds on the leaves of tomato and bores into the fruit, especially those growing down the plant near to the soil. They are olive-green, dark grey or brown in colour with large, black, triangular spots on their back. The fully-grown caterpillars are 3 to 5 cm long. The eggs are laid in batches in one or more layers, usually on the underside of the leaves and covered with hairs. Both caterpillars have many natural enemies such as predatory ants, spiders, damsel and robber flies, and parasitic wasps and flies

What to do:

- Avoid planting tomato near maize or cotton to prevent heavy pest infestations
- Monitor the crop regularly. Detection of eggs and small caterpillars before they enter into the fruit is very important. Once the caterpillars have entered the fruit they are protected from insecticidal sprays and will have caused damage. Check also for natural enemies and parasitised eggs. Healthy eggs are white with a reddish ring, but they turn black when parasitised. It has been recommended to randomly select 30

African bollworm
The african bollworm or tomato fruitworm (*Helicoverpa armiguera*) feeding on tomato fruit

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African bo...


African bo...


Cotton lea...

More Information on African bollworm

tomato plants and examine the leaves immediately below the topmost open flowers to look for eggs of African bollworm (AVRDC, 2000).

- **Conserve natural enemies. A very rich variety of natural enemies of fruit borers have been recorded. The most important are parasitic wasps (egg and larval parasitoids) and predators such as anthocorid bugs, ants, lacewings and ladybird beetles. Although these natural enemies cannot always prevent economic damage, they play a significant role in controlling the pest populations. For more information on natural enemies click here.**
- **Spray selective biopesticides such as Bt or neem extracts. Pyrethrin and rotenone are also used for control of this pest, but they are harmful to natural enemies and not allowed in organic agriculture. Control measures should start when more than five healthy eggs are found or when large numbers of small caterpillars are found on leaves. For more information on neem click here. For information on Bt click here**
- **Hand pick and destroy eggs and caterpillars. This helps when their numbers are low and in small fields.**

Spider mites (*Tetranychus* spp.)

Spider mites are important pests of tomatoes. They are more prevalent in dry areas. Infested leaves show a white to yellow speckling and then turn pale or bronzed. High spider mite

infestation causes defoliation, which leads to production of smaller fruits with lower content of ascorbic acid (vitamin C). Spider mite feeding on fruits causes speckling of the fruits.

The tobacco spider mite *Tetranychus evansi*, is one of the most damaging spider mites on tomato. This spider mite can kill plants very rapidly under hot and dry conditions. Plants with high numbers of this mite can be covered with webbing and an orange cloud of mites.

What to do:

- **Conserve natural enemies. Natural occurring predators are in many cases capable of controlling the two-spotted spider mite and the carmine red spider mite. However, this is not the case for the tobacco spider mite. There are few predators known to feed on this mite. In Kenya, ICIPE has released predatory mites for control of the tobacco spider mite in early 2007.**
- **Inspect the crop regularly to determine the presence and level of infestation of spider mites. A recommended monitoring method is to select randomly 20 tomato plants and access the level of mite damage of three leaflets per plant using a leaf index ranking from 1 to 5 (1 is few yellow spots, 5 is leaf totally covered with spots, dry patches occur). Once the average damage level excess the first rank, control measures should start.**
- **When detected early, initial infestations are usually concentrated on a few plants, in many cases in the borders of**

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

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


Spider mit…


Spider mit…


Spider mit…

More Information on Spider mites

the field. In this situation, remove and burn or bury infested plants to prevent the problem from spreading and becoming serious

- **Since mite populations are initially restricted to some plants, spot spraying (spraying only attacked plants) is usually effective**
- **Avoid the use of broad-spectrum insecticides. They may kill natural enemies. In addition some synthetic pyrethroids can actually enhance spider mite reproduction leading to mite outbreaks. Spraying neem extracts, soapy solutions and water are reported to help control red spider mites. For more information on spider mites click here**
- **Avoid water stress. If necessary, irrigate the crop regularly, and apply mulch to reduce water evaporation**
- **Practice good field sanitation to minimise the risk of infestation. Keep the field free from weeds, remove and burn or compost crop residues immediately after harvest**
- **Avoid planting new crops next to an already infested field (tomato or other crops).**

The tomato mirid bug (*Nesidiocoris tenuis*)

It is slender, greenish in colour with a dark brown tint on the forewings. Eggs are laid singly on the growing points, petioles and stems of the tomato plant. The young bugs (nymphs) resemble the adults, but initially have no wings. Older nymphs have wing pads. The tomato bug feed on stems, leaves and flowers of tomatoes, but prefer young leaves and growing

points. Sucking by nymphs and adults results in the formation of brownish rings on stems, petioles, growing points and leaf veins, which become brittle. Repeated feeding by the bugs cause crinkling (rolling, puckering and unevenness) of leaves.

Attacked stem bases become swollen with narrow brownish rings at the apices of the swollen areas. Shedding of flowers may be partly due to feeding by this bug. Other major crops attacked include eggplant, sesame and bottle gourds. The tomato bug also exhibit predatory habits, and has been reported preying on other insect pests, such as aphids, jassids (leafhoppers), caterpillars and whiteflies. It has been identified as an important predator of eggs and young caterpillars of the African bollworm and a potential control agent of whiteflies in Europe. This bug was found frequently and in large numbers on tomatoes, throughout NE and NW Somalia (Seif et al. 2003). It has also been reported as a tomato pest in Ghana (Youdeowei, 2002). In Kenya, large numbers of this bug have been observed in tomato fields under heavy and frequent spraying of synthetic pyrethroids.

What to do:

- **Inspect crops for nymphs and adults feeding on buds, developing flowers and leaves, and for signs of bug feeding, including discoloured spots, necrosis, stunting, and early fall of flowers and fruits.**
- **Avoid volunteer crops.**
- **Assure proper disposal of crop residues.**

Tomato mirid bug
Tomato bug adult (*Nesidiocoris tenuis*) on tomato plant, they are about 4mm long

© A. M. Varela, icipe


Tomato mir… **Tomato mir…**

More Information on Tomato mirid bug

- **Avoid indiscriminate use of broad-spectrum pesticides**

The tomato russet mite (*Aculops lycopersici*)

It is very tiny, approximately 0.2 mm long, and cannot be seen with the naked eye. They are yellowish, brown or pink. They have a ringed conical body with the head and two pair of legs at the large end. They complete the lifecycle in one week; this explains the rapid increase of this mite in tomato fields. They prefer high temperatures and low humidity. They feed on all above-ground parts of the tomato plant, causing spotting, twisting or folding of leaves and fine cracks on the fruits. Attacked leaves and stems develop a greasy appearance and turn bronzed. The plants can drop their leaves, especially in hot weather. Fruits are then exposed to sunburn. Damage to the plant typically begins near the ground and spreads upwards. Damage can develop very rapidly, and the mites can kill plants in a few days in dry hot weather. Since the mite cannot be seen, the symptoms are easily confused with diseases. The small size of the mites makes monitoring difficult. The first signs of mite presence are the curling and bronzing of the lower leaves of the stem.

Tomato russet mite Damage on tomato fruit and leaves caused by the Tomato russet mite, *Aculops lycopersici*

What to do:

- **Conserve natural enemies. Few natural enemies of the tomato russet mite are known. Predatory mites are considered to be the most important natural enemies. However, the effect of this natural enemies is hampered by extensive use of pesticides.**

- **Spray neem extracts. Neem oil and aqueous neem kernel have been reported to give good control of this mite in Costa Rica. For more information on neem extracts click here.**
- **Ensure proper irrigation during early stages of the crop. This can help prevent mite build-up later in the growing season since tomato russet mite infestation is higher on tomato plants under water stress.**
- **No resistant varieties are available. In Kenya, tolerance to leaf damage was observed in two varieties, namely "Early Stone" Improved' and "Beauty".**

The cabbage looper (*Trichoplusia ni*)

In addition to the cotton leaf worm (see fruit borers), other caterpillars such as the cabbage looper (*Trichoplusia ni*) feed on tomato leaves. However, generally they are not of economic importance.

The cabbage looper is a green caterpillar with faint white stripes along the body. Caterpillars are about 3.5 to 4 cm long when fully-grown. As they move, they arch their back in a looping fashion, hence the common name looper. Larvae (caterpillars) chew holes in the leaves, and larger caterpillars consume great amounts of plant material.

The adult is a moth, ca 2.5 cm in length and mottled, greyish-brown.

Cabbage looper caterpillar Cabbage looper (*Trichoplusia ni*) on cabbage. The first instar is white and almost clear with a black head capsule. Later instars are green with a thin white line on each side. Mature larvae reach 3 to 4

What to do:

- **Conserve natural enemies. These caterpillars are attacked by a large numbers of natural enemies, including parasitic wasps and flies. Birds and bats feed on the adults (moths).**
- **Pick caterpillars by hand and destroy them.**
- **When control is necessary use biopesticides such as neem-based products or Bt. Neem products control cabbage looper by interfering with the growth of the young caterpillar. Bt and neem should be applied when caterpillars (larvae) are still in the early growth stages.**
  For more information on neem click here.
  For more information on Bt click here.

cm in length.

© A.M. Varela, icipe


Cabbag lo... **Cabbag lo...**

More Information on Cabbage looper

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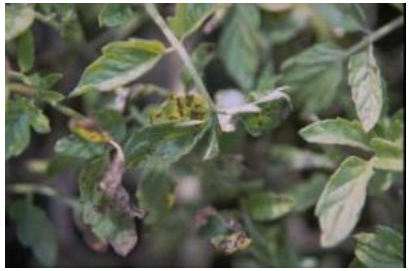
Information on Diseases

The main diseases affecting tomatoes in the region are early blight, late blight, bacterial wilt, Fusarium wilt, bacterial canker and nematodes.

Other bacterial diseases of tomato include bacterial speck (*Pseudomonas syringae* pv. *tomato*), bacterial stem and fruit rot (*Erwinia carotovora* subsp. *carotovora*), and pith necrosis (*Pseudomonas corrugata*).
Important fungal diseases of tomatoes are leaf mould (*Mycovellosiella fulva*) and powdery mildew (*Leveillula taurica*).



Bacterial speck (*Pseudomonas syringae* pv. *tomato*) of tomato seedlings. Note the necrotic

Recent surveys have shown that viral diseases are a major constraint to tomato production in Eastern and Southern Africa. Important virus diseases are Tomato yellow leaf curl virus, and more recently also Tomato spotted wilt virus.

lesions and the widespread chlorosis.
© Laing M.D. (Courtesy of EcoPort, www.ecoport.org)

Bacterial wilt (*Ralstonia solanacearum*)

Bacterial wilt has often been reported as the most serious handicap for tomato in the tropics. The disease causes rapid wilting and death of the entire plant without any yellowing or spotting of leaves. Total collapse of the plant usually occurring when temperatures reach 32°C and above. Plant wilts while still green. When the stem of a wilting plant is cut across, the pith has a darkened water-soaked appearance, and on squeezing the cut stem, a white, yellow or greyish, slimy exudate may appear. In later stages of the disease, decay of the pith may cause extensive hollowing of the stem.

Bacterial wilt
A row of tomatoes with individual plants infected with bacterial wilt (*Ralstonia solanacearum*). Note that the wilt often starts next to a trellising pole because the pathogen can overwinter on the pole. Tomatoes in South Africa are typically cultivated with wire trellising to hold up

What to do:

- **If only a few wilted plants are found, immediately remove them from the field.**
- **Practice long-term crop rotation.**
- **A method called "bio-fumigation" is under development from the Australian Center for International Agricultural Research**

for the reduction and long-term elimination of bacterial diseases from the soil by incorporating especially mustard or radish plants in large amounts into the soil immediately before planting tomatoes or potatoes. This practice is reported to reduce incidence of bacterial wilt by 50-70% in the Philippines (ACIAR 2005/6). For more information on biofumigation click here

the plants.

Bacteri...

Bacteri...

More Information on Bacterial wilt

Powdery mildew (*Leveillula taurica*)

The spots of powdery mildew appear on older leaves and are light chlorotic to bright yellow. These spots later run together and become necrotic. Whole leaf blades may collapse and dry up. On the upper leaf surface of green leaves, a fine talcum-like powder is observed. This is fungal growth.

What to do:

- **Keep tomato fields free of weeds.**
- **Do not grow brinjals (eggplant) or tomatoes in succession.**

Powdery mildew
Powdery mildew (*Leveillula taurica*) on tomato. Irregular, yellow spots on lower leaves, at first yellow, later light brown.

© D. Persley and T. Cooke, www.ecoport.org


Powde mi... Powde mi...

More Information on Powdery mildew

Blossom-end rot

It is caused by calcium deficiency and irregular watering. The disease occurs at the blossom-end of the fruit. It starts as a water-soaked spot that enlarges to become dark brown and sunken. The surface of the spot becomes dark and leathery. The rot is dry.

Blossom-end rot
Stages of blossom-end rot

© A. M. Varela, icipe

What to do:

- **Avoid water stress during early stages of fruit development.**
- **Apply lime in calcium deficient soils.**
- **Apply foliar sprays of calcium chloride.**

Tomato yellow leaf curl virus

The virus is transmitted by whiteflies (*Bemisia tabaci*). It is not

seed-borne. Tomato plants infected early in the season are normally stunted and excessively branched. Affected leaves are chlorotic and are curled upward. Flower drop is common, and therefore, infected plants have a reduced number of flowers and fruits.

What to do:

- **Use resistant or tolerant varieties such as "Tengeru 97", "Amareto", "Peto 86", "Fiona F1", "Perlina", "Denise", "Cheyenne" ("E448"), "Rover", "Roma" and "Marglobe" are highly susceptible and should not be used in areas where the disease is common**
- **Protect seedbeds with a white nylon net (40 mesh), as the later the plants are infected with the virus the less impact the disease will have on yield reductions**
- **Eradicate weeds**
- **Rogue out diseased plants (in the seedbed and in the field) and destroy them**
- **Plant barrier crops**
- **Avoid continuous growing of tomato**
- **Control whiteflies. For more information on whitefly control click here**

Tomato yellow leaf curl Tomato yellow leaf curl virus. Note thickened shoots.

© A.A. Seif, icipe

More Information on Tomato Yellow Leaf Curl Virus Disease (TYLCV)

Tomato spotted wilt virus

The virus is transmitted by thrips (*Thrips tabaci* and *Frankliniella* spp.). The virus has a wide host range including many

ornamental plants, vegetable crops and weeds. Diseased leaves have purplish-brown spots. Diseased leaves later turn brown, die and droop. Brown streaks occur on leaf petioles and stems. Infected plant becomes dwarfed, and with its drooping leaves, it resembles a plant affected by wilt. Symptoms on fruits consist of circular zones with shades of yellow or brown alternating with green and later with pink or red. Fruit symptoms are very characteristic of the disease.

What to do:

- **Plant resistant cultivars, (e.g. "Star 9006", "Star 9008")**
- **Control the insect vectors early**
- **Practice general field sanitation**

Tomato spotted wilt
Tomato spotted wilt tospovirus: mottle in tomato fruit.

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

Tomato Mosaic Virus

Affected plants show light and dark green mottling and distortion of the youngest leaves. The latter may be stunted or elongated resembling fern leaves. Under high temperature and light intensity, mottling can be severe. Under low temperature and low light intensity, stunting and leaf distortion are severe. Internal browning of the fruit sometimes occurs; this symptom is most common when fruits become infected at mature green or pink stage.

The disease can be seed-borne but can also survive on plant

Tomaco mosaic virus
Tomaco mosaic virus. Note internal browing of the fruit.

debris in the soil and so re-infect newly planted crops. The virus is easily mechanically transmissible by contact between plants or through human activities (transplanting seedlings or pruning).

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What to do:

- **Use resistant varieties (e.g. "Alboran", "Kentom", "Meru", "Shengena", "Tengeru 97")**
- **Use certified disease-free seeds**
- **Avoid an overlap of tomato crops**
- **Do not use freshly harvested seeds**
- **Remove crop refuse and roots from fields**
- **Eradicate weeds**
- **Workers should not smoke or take snuff when working in tomato fields since the virus can be transmitted from tobacco**

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

It is another serious disease, occurring during the rainy season. It is most noticeable on fruits, but also causes damage to the foliage and stems. On green fruits, the initial spot is very small and water soaked. It eventually enlarges to about six mm. As the bacterial spot matures, it becomes brown and scabby without extending deep into the fruit. On foliage, irregular greasy, dark green spots, 2 to 3 mm wide, are observed. The spots eventually dry and the tissue often tears. The disease is transmitted through the seed.

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

What to do:

- **Use certified disease-free seed.**
- **Remove and destroy crop residues after harvest.**
- **Avoid working in the fields when plants are wet.**
- **Spray with copper fungicides; these can control this disease fairly well except under heavy infection.**
- **Grow resistant cultivars; this is the best control method for both bacterial diseases, but resistance is not universal owing to variable strains of the pathogens.**

leaf.

© Clemson University, www.insectimages.org



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

Bacterial canker (*Clavibacter michiganensis* subsp. *michiganensis*)

The first symptoms are yellowing, curling and wilting of the leaflets, often on one side of the leaf. The affected leaflets turn brown and dry but remain attached to the plant. The whole plant may also show a one-sided disease development. Long brown strips may appear on stems and shoots. These strips dry and crack open to form cankers from which the disease gets its name. When an affected stem is cut lengthwise, there is a creamy white, yellow or reddish-brown line inside the woody tissue. The pith is easily separated from the wood along this line.

The vascular bundles within the pith are destroyed and cavities are formed in the pith. Young affected fruits are small, deformed and seeds are aborted. Also spots may develop on older fruits. These spots are circular, up to three mm wide, with slightly raised brown centre surrounded by a pronounced white halo

Bacterial cancer
Birds eye symptoms on tomato caused by bacterial canker

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resembling a 'bird's eye. The halo is flat. The bacterium is seed-borne and can survive up to three years in soil in crop debris. Spread within a crop is by rain splash, sprinklers and pruning knives.

What to do:

- **Plant tolerant or resistant varieties, if available**
- **Use certified disease-free seeds.**
- **Rotate seedbeds and tomato fields with non-solanaceous crops.**
- **Eradicate solanaceous weeds.**
- **Avoid sprinkler irrigation where the disease is endemic.**
- **Avoid working in tomato fields when it is wet.**
- **Disinfect pruning knives with commercial detergents between plants .**

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

Damping-off can occur when seedlings die before they have pushed through the soil, resulting in patches that appear to have germinated poorly. Alternatively, seedlings may emerge but fall over and die some time afterwards. The base of stem of affected seedlings become wet and brown. These disease-causing fungi are common in moist soils. They can also be transmitted on seeds.

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

What to do:

- **Use certified disease-free seeds. If it is farmer-saved seed, it can be given hot water treatment. For more information on hot water treatment click here .**
- **Do not site seedbed on a field previously planted with brinjals (eggplants), pepper, potatoes or tomatoes.**
- **Solarisation of seedbed should be done where feasible. For more information on solarisation click here .**
- **Avoid excessive watering.**

© Jürgen Kranz. Courtesy of Ecoport (www.ecoport.org)
More Information on Damping-off diseases

Fusarium wilt (*Fusarium oxysporum* sp. *Lycopersici*)

The lower leaves of the plant usually turn yellow and die. One or more branches may exhibit such symptoms. Leaflets on one side may be affected while those on the other side are symptomless. Diseased leaves readily break away from the stem. When affected stems just above ground level and petioles are cut diagonally, a reddish-brown discolouration of the water conducting tissues will be observed. The fungus is both seed- and soil-borne. It causes most damage on light, sandy soils. It is most active at temperatures between 25 and 320 C. The fungus can survive in the soil indefinitely even when no tomatoes are grown. It can also survive in fibrous roots of weeds (e.g. *Amaranthus*, *Digitaria* and *Malva* species). Acidic soils (pH 5.0 to 5.6) and excessive nitrogen fertilisation promote disease development. Infestation by root-knot nematodes encourages the disease.

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

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

What to do:

Fusarium wilt

- **Use resistant tomato varieties (e.g. "Fortune Maker", "Rio Grande", "Tengeru 97", "Roma VFN").**
- **Use certified disease-free seeds.**
- **Do not locate seedbeds on land where Fusarium wilt is known to have occurred.**
- **Where soil is acidic, raise the pH by applying lime or farmyard manure.**
- **Avoid excessive nitrogen fertilisation and control root-knot nematodes.**

Early blight (*Alternaria solani*)

Leaf spots of early blight are circular, up to 12 mm in diameter, brown, and often show a circular pattern, which distinguishes this disease from other leaf spots on tomato.

What to do:

- **Use resistant varieties (e.g. "Rio Grande").**
- **Use certified disease-free seeds. If using own seeds, hot water treat the seeds. For more information on hot water treatment click here .**
- **Use disease-free plants.**
- **Do not plant plant consecutive tomato crops on the same land.**
- **Practice rotation with non-solanaceous crops (e.g. eggplant, peppers, potatoes etc).**
- **Stake and prune indeterminate varieties.**

Early blight
Early blight on tomato leaf. Note concentric rings in the spots.

© A. M. Varela, icipe

Early

Early

- **If disease is endemic, applied preventative sprays of copper compounds (e.g. copper hydroxide). For more information on copper click here.**

blig... **blig...**

More Information on Early blight

Late blight (*Phytophthora infestans*)

Symptoms of late blight are irregular, greenish-black, water soaked patches, which appear on the leaves. The spots soon turn brown and many of the affected leaves wither, yet frequently remain attached to the stem.

What to do:

- **Use resistant varieties (e.g. "Rio Grande", "Tengeru 97" etc).**
- **Use disease-free transplants.**
- **Stake and prune indeterminate varieties.**
- **Do not plant tomatoes after potatoes.**

Late blight
Late blight on tomatoes. Note scorched appearance of leaves, stems and fruits.

© B. Loehr, icipe


Late bligh... **Late bligh...**

More Information on Late blight

Leaf mould (*Mycovellosiella fulva*)

Symptoms of leaf mould are pale-green or yellowish areas with undefined margins that appear on the upper leaf surface. Under humid conditions the lower leaf surfaces of the spots become covered by an olive-green to greyish-purple velvety growth of the fungus.

What to do:

- **Prune and stake to remove humidity.**
- **Avoid excessive shading by providing adequate plant and row spacing.**
- **Avoid wetting leaves when watering.**

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Fresh Quality Specifications for the Market in Kenya

The following specifications constitute raw material purchasing requirements.

PRODUCE:	Tomato
IMAGE:	
VARIETY:	Various
	General appearance criteria
COLOUR:	Orange, pre red coluring
VISUAL APPEARANCE:	With bright bloom; calyx removed; seeds in clear reddish gel; no foreign matter.
SENSORY:	Thin, smooth skin; firm, juicy flesh with mild flavour; no foreign smells or taste.
SHAPE:	Uniformly round to round-slightly squat; nil kidney, egg or dumb-bell shaped, or with obvious raised ridges, grossly uneven segments or otherwise deformed.
SIZE:	In pre-ordered range per requirements in the following size ranges 5 – 6cm (small), 6 -6.4cm (small medium), and 6.5 – 7cm (medium), 7.1 – 7.6cm (large), in diameter.
MATURITY:	Firm fruit, not excessively green (immature) or soft and darkened (over mature).
INSECTS:	With no obvious live insects (e.g. insect larvae) With no holes, splits or insect damage that breaks the skin With no soft, dark areas due to severe bruising

PRODUCE:	Cherry Tomato
IMAGE:	
VARIETY:	Various
	General appearance criteria
COLOUR:	Orange, pre red colouring, yellow
VISUAL APPEARANCE:	With bright bloom; calyx removed; seeds in clear reddish gel; no foreign matter.
SENSORY:	Thin, smooth skin; firm, juicy flesh with m foreign smells or taste.
SHAPE:	Uniformly round to oval with no obvious r grossly uneven segments or otherwise de
SIZE:	Small: 1.1-1.5 cm diameter
MATURITY:	Firm fruit, not excessively green (immatu darkened (over mature).
INSECTS:	With no obvious live insects (e.g. insect l With no holes, splits or insect damage that b With no soft, dark areas due to severe br

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Crops/ fruits/ vegetables

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

more Images

Cassava
Scientific name: *Manihot esculenta*
Order/Family: Euphorbiales: Euphorbiaceae
Local names: Manioc, mandioca, tapioca; mhogo (Swahili- Kenya, Tanzania)
Pests and Diseases: African cassava mosaic virus (ACMV) Anthracnose Birds Brown leaf spot Cassava bacterial blight Cassava brown streak virus disease Cassava green spider mite Cassava scales Grasshoppers Larger grain borer Mealybugs Post harvest diseases Snails (Giant East African Snail) Spider mites Storage pests Stripped mealybug Termites Whiteflies

General Information and Agronomic Aspects Information on Diseases

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

Information on Pests
Information Source Links

General Information and Agronomic Aspects

Geographical Distribution of Cassava in Africa

Cassava typically grows as a shrub. Cassava is native of Latin America and was introduced to the African continent by Portuguese traders in the late 16th century.

Cassava is grown on an estimated 80 million hectares in 34 African countries. It is an important crop in subsistence farming, as it requires few production skills or inputs. It is drought tolerant and produces reasonable yields under adverse conditions. Most important is its ability to remain in the soil as a famine reserve. Other factors that make cassava popular with small-scale farmers, particularly in Africa, are that it requires little labour, there are no labour peaks because the necessary operations in its production can be spread throughout the year, and its yields fluctuate less than those of cereals.

The storage root (some people refer to it as "tuber") is a major source of energy and the leaves, which contain a high level of Vitamin A and up to 17 % protein, are often used as green vegetables. Its limitations are its poor nutritive value (mainly carbohydrates) and its cyanogenic glucoside content (HCN) that can lead to poisoning unless precautions (proper peeling/soaking in water/fermenting/drying/cooking) are taken during preparation of the tubers. The latter is only applicable to bitter cassava varieties. Sweet varieties can even be eaten raw and fresh as they have very low content of HCN.

The main diseases affecting cassava are cassava mosaic virus (CMV), cassava bacterial blight, cassava anthracnose, and root rot. Pests and diseases, in combination with poor agronomic practices, combine to cause high yield losses in Africa. While biological and chemical control

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

Pests/ diseases/ weeds

Medicinal plants

Fruit and vegetable processing

Natural pest control

Cultural practices

practices are available for other pests and diseases attacking cassava, CMV is difficult to control. In severe cases, plants become stunted. In fact, this disease can cause up to 60 percent yield loss, and no biological or chemical control is now available to farmers. Given the vegetative propagation method used for cassava, availability of clean planting material for propagation is a major constraint, since white flies and contaminated material transmit the disease.

While cassava production demands few external inputs, labor and planting material are main costs of production. As a root crop, cassava requires a lot of labor to harvest. The production of cassava is dependent on a supply of good quality stem cuttings. The multiplication rate of these vegetative planting materials is very low, compared to grain crops, which are propagated by true seeds. Postharvest deterioration of cassava is a major constraint. Cassava stem cuttings are bulky and highly perishable, drying up within a few days. Consequently, roots must be processed into a storable form soon after harvest. Farmers recognize postharvest loss as a major risk factor in cassava production. Nevertheless, the rapid postharvest perishability might lead to comparative advantages for small-scale producers linked to small-scale processing units.

Furthermore, many cassava varieties contain cyanogenic glucosides, and inadequate processing can lead to high toxicity. Various processing methods, such as grating, sun drying, and fermenting, are used to reduce the cyanide content.

Varieties

A number of both local and improved varieties exist in Kenya:

1. Coast region		
a.) Local types	**I**	**Kibanda meno - very sweet**
	II	**Katsunga - leaves taste like wild lettuce when cooked**

b) Improved types	I	Kaleso (46106/27) - high yielding, for human consumption
	II	Guso - Better yielder than Kaleso. Also for human consumption
	III	5543/156 - It is a high yielding variety for livestock. It is bitter.
2. Eastern Region Katumani	I	KME - Sweet, less fibrous and has low cyanide content
	II	KME 61 - Bitter and more fibrous than KME
3. Western Kenya	I	2200, Tereka, Serere, Adhiambo lera, CKI, TMS 60142, BAO

For more information on these varieties please contact the Kenya Agriculture Research Institute (KARI)

Propagation and planting

Propagation from storage roots is impossible, as the roots have no buds. Cassava is propagated through cuttings. The most suitable cuttings are 20-30 cm long and 20-25 mm in diameter (with 5-8 nodes), preferably from the middle browned-skinned portion of the stems of plants 8-14 months old. Cuttings from older, more mature parts of the stem give better yield than cuttings from younger parts, and long cuttings give higher yields than short cuttings. Select cuttings from healthy plants. Cuttings slightly infested with pests can be treated by immersion in heated water (mixing equal volumes of boiling and cold water) for 5-10 minutes just before planting.

The interval between cutting stems and planting should be as short as possible (not more than a couple of days). Cassava cuttings may be planted vertically, at an angle, or horizontally. The drier the soil the bigger the part of the stem placed in the soil. Under very dry conditions, plant cuttings at an angle and cover the larger part with soil. Vertical planting is best in sandy soils, as the roots develop deeper in the soil. Horizontal planting leads to a large number of thin

stems, which may cause lodging. Moreover, the roots develop more closely to the surface and are more likely to be exposed and attacked by rodents and birds. Do not plant cuttings upside down, as this drastically reduces yield.

The spacing between plants will depend on whether cassava is grown as a sole crop or with other crops (intercropping). If cassava is being grown alone, plants should be planted 1 meter apart from each other. This means that 10.000 cuttings are required for 1 ha (4000 cuttings per acre). If cassava is being grown as an intercrop, the branching habit of both the cassava and the other crops should be considered, making sure there is enough space for the plants.

The best land for planting cassava is flat or gently sloping land. Steep slopes are easily eroded. Valleys and depression areas that usually get waterlogged are not very suitable and cassava roots do not develop well. Before planting get to know the history of the land (previous crops, types of weeds, diseases and pests).

Soil preparation varies from practically zero under shifting cultivation to ploughing, harrowing and possible ridging in more intensive cropping systems. Planting on mounds and ridges is recommended, especially for areas with rainfall of more than 1200 mm per year or in areas where soils get waterlogged (e.g. valleys and depressions). Ridging may not give higher yield, but harvesting is easier and soil erosion may be reduced, especially by contoured ridges. In sandy soils, minimum tillage and planting cassava on the flat are appropriate. At sites, where the sandy soil get waterlogged, it is however better to plant on ridges or mounds. Plant at the beginning of the rainy season.

Husbandry

Weeding is necessary every 3-4 weeks until 2-3 months after planting. Afterwards the canopy may cover the soil and weeding is less necessary.

Although cassava grows rather well on poor soils, it requires large amount of nutrients to produce high yields. To maintain high yields, it is necessary to maintain the fertility of the soil. Phosphorous is important for root development. Symptoms of phosphorous deficiency are stunted growth and violet or purple discoloration of the leaves. In the absence of good compost, rock phosphate can be applied if needed. Potassium is also needed by cassava and can be applied in the form of compost or wood ashes. Potassium deficiency symptoms are: stunted growth, dark leaf colour which gradually becomes paler, dry brown spots on tips and margins of the leaves and "burnt" edges of leaves.

Fertilisers and manures are usually not used by small-scale cassava growers in most African countries because, in many cases, they cannot afford such additional inputs. However, it is important to provide good growing conditions for the plants, as healthy plants are able to withstand some damage by pests and diseases. In general, cassava responds well to farmyard manure. Manure can be applied at land preparation to increase soil nutrients, to improve the soil structure, and to improve the ability of the soil to hold water.

Mulching cassava, especially after planting, is helpful when growing cassava in dry areas or on slopes.

Crop rotation and Intercropping

There is a wide variety of cropping patterns and rotations with cassava. Though rotation with other crops is preferable, cassava is sometimes grown continuously on the same land, especially in dry areas not suitable for other crops. When grown in bush-fallow systems, cassava is usually planted at the end of the rotation cycle, as it still produces relatively well at lower fertility levels and also allows a smooth transition to the fallow.

Cassava when planted as an intercrop along with cowpea or groundnut in tree crops like

Leucaena **reduces soil run-off and soil-loss. Forage yield of** ***Leucaena*** **improves when grown with cassava and groundnut.** ***Canavalia*** **or** ***Crotalaria*** **(legume crops) when planted as intercrops with cassava improves soil productivity.**
Sow one row of ***Canavalia*** **or** ***Crotalaria*** **between rows of cassava immediately after planting cassava. Let these grow until harvest. Plough after harvest to incorporate crop residues into the soil.**

Harvesting

Harvesting is done either piece-meal or by uprooting whole plants. Young plants are usually harvested piece-meal, while old plants are more commonly uprooted to prevent the storage roots becoming very fibrous. As cassava roots do not keep fresh more than 2-3 days after harvesting, not all plants are harvested at once, but rather harvesting as the roots are consumed. When cassava is grown for urban markets they are harvested in bulk. Cassava is usually harvested 9-12 months after planting. It is sometimes harvested earlier if needed for food. Storage roots become too woody if harvesting is delayed. Early maturing varieties are ready for harvesting at 7 months while late maturing varieties are ready 12 months after planting.

Storage

Cassava does not store well when fresh and therefore has to be peeled, chopped and dried in the sun. It can then be stored in the form of chips or flour under dry conditions.

Average yields are between 3-4 tons of fresh tubers per acre (7.5-10 tons per ha) although with reasonable care and attention yields of up to 10 tons per acre (25 tons per ha) and more are possible. The ratio of fresh tubers to peeled and dried chips is about 3:1.

Marketing

Manual from ITTA 'Starting a cassava farm (pdf, 1.5mb)

Of the world production of cassava, 65% is used directly for human consumption, 20% for animal feed and the remaining 15% for starch and industrial uses (alcohol production). In Africa, stems are often used as firewood.

Climate conditions, soil and water management

In equatorial areas, cassava can be grown up to 1500 m altitude. The optimum temperature range is 20-30°. Specific cultivars are necessary for successful cultivation at an average temperature of 20°.
Cassava is grown in regions with 500-6000 mm of rainfall per year. Optimum annual rainfall is 1000-1500 mm, without distinct dry periods.
Once established, cassava can resist severe drought. With prolonged periods of drought, cassava plants shed their leaves but resume growth after the rains start, making it a suitable crop in areas with uncertain rainfall distribution. Because of its drought resistance, in many regions cassava is planted as a reserve crop against famine in dry years. Good drainage is essential for cassava; the crop does not tolerate water logging. High irradiance is preferred.

Best growth and yield are obtained on fertile sandy loams. Cassava is able to produce reasonable yields on severely depleted or even eroded soils where other crops fail. Gravelly or stony soils cause problems with root penetration and are unsuitable, as are heavy clay or other poorly drained soils.
Cassava growth and yield are reduced drastically on saline soils and on alkaline soils with a pH above 8.0. The optimum pH is between 5.5 and 7.5, but cultivars are available that tolerate a pH as low as 4.6 or as high as 8.0. Reasonably salt-tolerant cultivars have also been selected. Very

fertile soils encourage excessive foliage growth at the expense of storage roots.

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Information on Pests

Furthermore, many cassava varieties contain cyanogenic glucosides, and inadequate processing can lead to high toxicity. Various processing methods, such as grating, sun drying, and fermenting, are used to reduce the cyanide content.

The cassava mealybug (*Phenacoccus manihoti*)

The cassava mealybug is pinkish in colour. Its body is surrounded by very short filaments, and covered with a fine coating of wax. Adults are 0.5-1.4 mm long. This mealybug does not have males. Females live for about 20 days and lay 400 eggs in average. The lifecycle from egg to adult is completed in about one month at 27°C. It reproduces throughout the year and it reaches peak densities during the dry season. Mealybugs are dispersed by wind and through planting material.

The cassava mealybug strongly prefers cassava and other *Manihot* species; other host crops and wild hosts are only marginally infested. It sucks sap at cassava shoot tips, on the lower surface of leaves, and on stems. During feeding the mealybug injects a toxin into the cassava plant causing deformation of terminal shoots, which become stunted, resulting

Cassava mealybug
The cassava mealybug is pinkish in colour. Its body is surrounded by very short filaments, and covered with a fine coating of wax. Adults are 0.5 - 1.4mm long.

© G. Goergen (Courtesy of

in compression of terminal leaves into "bunchy tops". The length of internodes is reduced, and stems are distorted. When attack is severe plants die, starting at the plant tip, where most mealybugs are found.

Mealybug attack results in leaf loss and poor quality planting material (stem cuttings) due to dieback and weakening of stems used for crop propagation. Tuber losses have been estimated up to 80%. The pest-induced defoliation reduces availability of healthy leaves, which are consumed as leafy vegetables in most of West and Central Africa. After the pest cripples plant growth, weed and erosion sometimes lead to total destruction of the crops. In general, yield losses depend upon age of plant when attacked, length of dry season, severity of attack and general conditions of the plant. Mealybug damage is more severe in the dry than in the wet season.

The cassava mealybug was accidentally introduced to Africa from South America. After the first reports in the 1970s, the insect became the major cassava pest within a few years and spread rapidly through most of the African cassava belt. The outbreak led to famine in several countries where cassava is a staple crop and particularly important in times of drought. In an attempt to control this pest natural enemies, mainly parasitic wasps and ladybird beetles, were introduced from South America.

The most effective has been the parasitic wasp (*Apoanagyrus* (=*Epidinocarsis*) *lopezi*) (seeing on the image beside), which has

EcoPort, www.ecoport.org)


Cassav me… **Parasit …**

More Information on Mealybugs

kept this mealybug at low levels, resulting on significant reduction of yield losses in most areas in Africa (Neuenschwander, 2003).

What to do:

- **Plant early in the rainy season to allow the cassava plants a good growth before the dry season; Strong plants are more likely to withstand pest attacks**
- **Use soil amendments and mulch to avoid moisture stress in sandy or poor soils. Mealybug numbers are higher on cassava grown on poor, sandy soils, and may cause damage in spite of the presence of natural enemies**
- **Avoid using infested plant material. Before planting cutting can be treated with hot water [by immersing them in heated water (mixing equal volumes of boiling and cold water) for 5-10 minutes just before planting] to kill all insects/mites and to avoid transfer into the newly planted field. For more information on hot water treatment click here**
- **Avoid using pesticides on crops surrounding cassava fields. Although, no pesticides are used on cassava in Africa, insecticide drift from neighbouring fields may affect natural enemies that keep mealybugs and other pests under control**
- **Use of manure or other fertilizers can result in a reduction in the mealybug population because improved nutrition results in the production of larger parasitoid wasps with higher fertility levels. Mulch and fertilizer use also enhances the antibiotic properties of cassava against mealybug infestation.**

Larger grain borer (*Prostephanus truncatus*)

The larger grain borer has been found infesting cassava chips in storage particularly during the rainy season in West Africa. This beetle is currently the most serious pest of dried cassava in storage. Weight losses as high as 70% after four months of storage have been reported elsewhere.

What to do:

- **Use botanicals or plant parts to protect stored cassava. There are reports in Kenya, that the larger grain borer can be effectively repelled by storing cassava or grains with a fairly large amount of dried lantana or eucalyptus leaves (Personal communication, field officer of Meru herbs). Neem is also reported to be effective. For more information on neem click here**

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

More Information on Larger grain borer

Birds and other vertebrate pests

Birds, rodents, monkeys, pigs and domestic animals (cattle, goat and sheep) They are common vertebrate pests of cassava. Measures that help to manage damage by these pests include:

What to do:

- **Fence farms and set traps in the fence**
- **Cover exposed roots with soil**
- **Weed your cassava farm to discourage rodents pests**
- **Harvest roots as soon as they are mature (James et al., 2000).**

The stripped mealybug (*Ferrisia virgata*)

It is a whitish mealybug with two longitudinal dark stripes, long glassy wax threads and two long tails. It attains a length of 4 mm. The stripped mealybug occurs on the underside of leaves near the petioles and on the stems. It sucks sap but does not inject any toxin into plants. Severely attacked plants show general symptoms of weakening but do not show distortion.
It is a minor pest of cassava, and no control is usually required as is controlled naturally by natural enemies.

Stripped mealybug
Stripped mealybug (*Ferrisia virgata*)

What to do:

- **Select mealybug-free planting material.**

The cassava green spider mite (*Mononychellus tanajoa* (=*M. progresivus*))

This mite is green in colour at a young age turning yellowish as adult. Adult females attain a size of 0.8 mm. They appear as yellowish green specks to the naked eye. They occur on the

lower surface of young leaves, green stems and auxiliary buds of cassava. Damage initially appears as yellowish "pinpricks" on the surface of young leaves.

Symptoms vary from a few chlorotic spots to complete chlorosis. These symptoms are somehow similar to cassava mosaic disease, and should not be confused. Heavily attacked leaves are stunted and become deformed. Severe attacks cause the terminal leaves to die and drop, and the shoot tip looks like a "candle stick". Green spider mites are major pests in dry season. Severe mite attack results in 20-80 % loss in tuber yield.

Predatory mites (mainly *Typhlodromalus aripo* and *T. manihoti*) introduced from South America, the home of the cassava green mite, have given effective control of the cassava green mites in Africa (Yaninek and Hanna, 2003).

Cassava green mite
Cassava green mite (*Mononychellus tanajoa*) and egg. Real size 0.8 mm, egg 0.2 mm.

© G. Goergen (Courtesy of EcoPort)


Cassav gr... **Cassav gr...**

What to do:

- **Whenever possible, use varieties with good tolerance to green mites (Examples from West Africa: BEN 86052, MS6 and NR8082) (James et al, 2000).**
- **Use clean plant material for planting.**
- **Plant at the onset of the rains to encourage vigorous growth and thereby increase tolerance to mite attack. Cassava plants aged 2-9 months are the most vulnerable to infestation.**
- **Practice intercropping. Cassava intercropped with pigeon pea has been reported to suffer less damage from cassava green**

mite than that grown on a pure stand in Nigeria. Higher tuber yields were obtained when cassava was intercropped with pigeon pea in triple and double rows than when it was alternated in a single row or in a pure stand (Ezulike and Egwuatu, 1993).

Red spider mites (*Oligonychus gossypii* and *Tetranychus* spp.)

Several species of red spider mites also occur on cassava, mostly on the older leaves. Adults are about 0.6 mm long. Initial symptoms are yellowish pinpricks along the main vein of mature leaves. Spider mites produce protective webbing that can be readily seen on the plant. Attacked leaves turn reddish, brown or rusty in colour. Under severe mite attack, leaves die and drop beginning with older leaves. Most damage occurs at the beginning of the dry season.

Red spider mites (*Oligonychus gossypii* and *Tetranychus* spp.)
Red spider mites with eggs

More Information on Spider mites

What to do:

- **Conserve natural enemies. Local natural enemies usually control these spider mites and no further control measures are needed**
- **Avoid planting next to infested fields.**
- **Avoid use of broad-spectrum pesticides, in particular pyrethroids; this may lead to spider mite outbreaks.**

Cassava scales (Aonidomytilus albus)

It is a mussel-shaped scale with an elongated silvery-white cover and about 2-2.5 mm long. This scale may cover the stem with conspicuous white secretions, and eventually the leaves. This scale sucks from the stem and dehydrates it. The leaves of attacked plants turn pale, wilt and drop off. Severely attacked plants are stunted and yield poorly. Scale attack can kill cassava plants, in particular plants weakened by previous insect attack and drought. Stem cuttings derived from affected stem portions normally do not sprout.

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

© USDA ARS, Bugwood.org

What to do:

- **Apply of organic matter to improve soil fertility.**
- **Selection of clean (scale free) planting material).**
- **Destroy infested stems.**
- **Avoid use of pesticides in the cassava field or in neighbouring crops, which may kill natural enemies.**

Grasshoppers (*Zonocerus variegatus*)

Grasshoppers such as the variegated grasshopper (West to East Africa south of the Sahara), and the elegant grasshopper *Z. elegans* (Southern Africa and East Africa) are brightly coloured grasshoppers.

Grasshoppers
Variegated grasshopper

Adults are dark green with yellow, black and orange marking on their bodies. Nymphs are black with yellow markings on the body, legs and antenna and wing pads. Female grasshoppers lay many

eggs just below the surface of the soil in the shade under evergreen plants, usually outside cassava fields. Eggs are laid in masses of froth, which harden to form sponge-like packets, known as egg pods, which look like tiny groundnut pods. Eggs start to hatch at the beginning of the main dry season.

(*Zonocerus variegatus*)

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

Grasshoppers attack a wide range of crops mainly in the seedling stage. They feed on cassava plants, chewing leaves and stemsand may cause defoliation and debark stems. This is particularly severe in fields next to the bush when the dry season is prolonged.

What to do:

- **Hand pick grasshoppers. This is feasible in small plots.**
- **Locate and dig egg-laying sites to expose and destroy the eggs before they start to hatch early in the dry season. However, egg pod destruction has to be done over a wide area in the wet season in order to be effective. This will require participation of farmers on many neighbouring farms. If only one neighbour destroys the eggs in his/her farm, the grasshoppers will later invade the farm from the neighbouring farms and bushes.**
- **When available, use biopesticides. IITA researchers and partners have developed an environmental friendly biopesticide "Green Muscle®". It is based on a naturally occurring fungus strain indigenous to Africa (Metarhizium anisopliae) which is deadly to locusts and grasshoppers but reportedly does not damage other insects, plants, animals, or**

people. Typically 70 to 100 percent mortality rates were obtained after 8 to 28 days of application (www.iita.org). The bioinsecticide "Green Muscle®" is effective in grasshopper management in outbreak situations. However, it is costly and currently, it is only available in South Africa and West Africa.

- **Use neem extracts. Neem protects cassava from grasshopper damage. It acts as antifeedant (grasshoppers stop feeding when exposed to neem products) and affects development of the grasshoppers (Nicol et al, 1995; Olaoifa and Adenuga, 1988).**
  In Nigeria, the following neem products have given good control of Z. variegatus on cassava: 1- emulsifiable concentrate of neem oil at 0.5% to 2% applied at 8-day intervals or at 3-4% at 10-day intervals, 2- Aqueous neem kernel water extracts (NSKE) at 7-10% applied every 12 days and aqueous neem leaf water extracts (NLWE) 50% applied every 6 days. Aqueous extracts from neem leaves were less effective than neem seed extracts (Olaoifa and Adenuga, 1988). For more information on neem click here.

Whiteflies (*Bemisia tabaci*, *Aleurodicus dispersus*)

Several species of whiteflies are found on cassava in Africa. Feeding causes direct damage, which may cause considerable reduction in root yield if prolonged feeding occurs. Some whiteflies cause major damage to cassava as vectors of cassava viruses. The spiralling whitefly (*Aleurodicus dispersus*) was reported as a new pest of cassava in West Africa in the early

90s.
The adults and nymphs of this whitefly occur in large numbers on the lower surfaces of leaves covered with large amount of white waxy material. Females lay eggs on the lower leaf surface in spiral patterns (like fingerprints) of white material secreted by the female. This whitefly sucks sap from cassava leaves. It excretes large amounts of honeydew, which supports the growth of black sooty mould on the plant, causing premature fall of older leaves.

The tobacco whitefly (*Bemisia tabaci*) transmits the cassava mosaic virus, one of the most important factors limiting production in Africa. The adults and nymphs of the tobacco whitefly occur on the lower surface of young leaves. They are not covered with white material. The nymphs appear as pale yellow oval specks to the naked eye.

What to do:

- **Conserve natural enemies. Parasitic wasps in particular are very important for natural control of whiteflies. For instance Encarsia formosa, natural enemy of the tobacco whitefly, and Encarsia haitiensis a natural enemy of the spiralling whitefly (Neuenschwander, 1998; James, et al, 2000).**

Whiteflies
Whiteflies under leaf. Adult whiteflies are about 1mm long.

© Clemson University, Department of Entomology
More Information on Whiteflies

Termites

Different species of termites damage cassava stems and roots.

Termites damage cassava planted late or in the dry season, in particular when the crop is still young at the peak of the dry season. They chew and eat stem cuttings; as a result, cuttings grow poorly, die and rot. The may destroy whole plantations. In older cassava plants termites chew and enter the stems. This weakens the stems and causes them to break easily.

What to do:

- **Plant early with the rains.**
- **Avoid planting on very dry land or on termite mounds.**

Termites
Termites (*Coptotermes formosanus*)

© Scott Bauer, USDA Agricultural Research Service, Bugwood.org
More Information on Termites

Storage pests

A number of beetles feed on dry cassava causing post harvest losses. In Benin Republic the most common are *Dinoderus* sp., *Carpophilus* sp., the coffee bean weevil (*Araecerus fasciculatus*), the lesser grain borer (*Rhizopertha dominica*), and more recently, the larger grain borer (*Prostephanus truncatus*). (see below)

Infestation by these insects is heavier in the rainy season than in

Lesser grain borer
Lesser grain borer

the dry season, is more prevalent in the humid zone than in the savannah, and is found more in large chips than in smaller ones. Maximum infestation was found after 6 to 8 months in storage, at which time chips would fall into dust when squeezed (Bokanga, IITA, FAO).

What to do:

- **Use botanicals or plant parts to protect stored cassava. There are reports in Kenya, that the larger grain borer can be effectively repelled by storing cassava or grains with a fairly large amount of dried lantana or eucalyptus leaves (Personal communication, field officer of Meru herbs). Neem is also reported to be effective. For more information on neem click here**

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

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More Information on Storage pests

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Information on Diseases

African Cassava Mosaic Disease (ACMD).

Cassava mosaic disease is one of the most serious and widespread diseases throughout cassava growing areas in Africa, causing yield reductions of up to 90%. It is spread through infected cuttings and by whiteflies (*Bemisia tabaci*).

Symptoms occur as characteristic leaf mosaic patterns that affect discrete areas and are determined at an early stage of leaf development. Symptoms vary from leaf to leaf, shoot to shoot and plant to plant, even of the same variety and virus strain in the same locality. Some leaves situated between affected ones may seem normal and give the appearance of recovery.

What to do:

- **Use disease-free cuttings. If it is not possible to find cassava plants that are completely free from the disease, select cuttings from stem branches instead of from the main stem. Stem cuttings from the branches are more likely to sprout into disease-free plants than stem cuttings from the main stems (James et al, 2000).**
- **Resistance to CMD has been successfully incorporated into high yielding cultivars of acceptable quality through breeding programmes at IITA. Use resistant/tolerant varieties (e.g. SS 4, TMS 60142, TMS 30337 and TMS 30572).**

African Cassava Mosaic Disease
Cassava plant showing severe symptoms of the African Cassava Mosaic Disease (ACMD).

More Information on African cassava mosaic virus (ACMV)

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

It is a major constraint to cassava cultivation in Africa. Infected leaves show localised, angular, water-soaked areas. Under severe disease attack heavy defoliation occurs, leaving bare stems, referred to as "candlesticks". Since the disease is systemic, infected stems and roots show brownish

discolouration. During periods of high humidity, bacterial exudation (appears as gum) can readily be observed on the lower leaf surfaces of infected leaves and on the petioles and stems. The disease is favoured by wet conditions.
This disease is primarily spread by infected cuttings. It can also be mechanically transmitted by raindrops, use of contaminated farm tools (e.g. knives), chewing insects (e.g. grasshoppers) and movement of man and animals through plantations, especially during or after rain. Yield loss due to the disease may range from 20 to 100% depending on variety, bacterial strain and environmental conditions.

Cassava bacterial blight
Cassava bacterial blight (*Xanthomonas campestris* pv. *manihotis*). Angular leaf spots, sometimes with yellow haloes, rapidly expanding, leading to necrosis and leaf fall.

What to do:

- **Use clean planting material. This can reduce disease incidence in areas where cassava bacterial blight is already widespread.**
- **In cases of sporadic occurrence of the disease, collect cuttings only from healthy plants and from the most lignified portion of the stem, up to 1 m from the base. Check visually the cuttings for vascular browning. Disinfect tools regularly**
- **Intercrop cassava with maize or melon. This been reported to reduce cassava bacterial blight significantly.**
- **Practise crop rotation and fallowing. These practices proved very successful when the new crop was planted with uninfected cuttings. Rotation or fallowing should last at least one rainy season.**
- **Remove and burn all infected plant debris and weeds. Alternatively plough them into the soil.**

Brown leaf spot (*Cercosporidium henningsii*)

Symptoms are restricted to older leaves. Brownish round spots with definite borders appear on the upper leaf surface. On the lower leaf surface, they are brownish-grey in colour. Infected leaves later become yellow and eventually drop. In wet areas the disease may yield reduction of up to 20%.

What to do:

- **Though the disease is widespread in most cassava growing countries, it is not an economically important disease problem and it does not warrant any intervention.**

Brown leaf spot
Cassava brown leaf spot (*Cercosporidium henningsii*)

Cassava brown streak virus disease (Potyvirus - Potyviridae)

It is particularly serious in coastal areas of Kenya, in Zanzibar, Mozambique and Tanzania and lakeshore region of Malawi and in Uganda and is a threat to the whole of sub-Saharan Africa. The virus is vectored by whiteflies (*Bemisia* spp.) and also transmitted through infected cuttings. Symptoms include yellowing (leaf chlorosis) and brown streaks in the stem bark (cortex). Infected tubers have brown streaks (root necrosis) (Field Crops Technical Handbook, MoA, Kenya). It's a stealth virus, which destroys everything in the field. The leaves may appear healthy even when the roots have rotted away.

Cassava brown streak virus disease (Potyvirus - Potyviridae)

What to do:

- **Use diseased-free cuttings.**
- **Use tolerant/resistant varieties (e.g. 5543/156, TMS 30572)**
- **Remove diseased plants from the field.**

Anthracnose (*Glomerella manihotis*)

Initial symptoms of the disease are oval lesions ("sores") on young stems. On older stems, raised fibrous lesions develop that eventually become sunken.

What to do:

- **It is not an economically important disease in most cassava growing countries and it does not warrant any intervention.**

Anthracnose on cassava Cancers of cassava anthracnose disease (*Glomerella manihotis*)on stem

More Information on Anthracnose

Post harvest diseases

Some fungi growth on cassava chips, usually when the moisture content of cassava chips

exceeds 14 percent, making them unfit for feed and food. A survey of cassava chips processing areas of West Africa has indicated that the most common fungi were *Rhizopus* sp. and *Aspergillus* sp. (IITA, 1996).

What to do:

- **For more information on storage pests click here**

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Information Source Links

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Okra

Scientific name: *Abelmoschus esculentus*

Nightshade
Amaranth
Avocados
Bananas
Beans
Cabbage/Kale, Brassicas
Carrot
Cashew
Cassava
Citrus plants
Cocoa
Coconut
Coffee
Cotton
Cowpea
Cucumber
Eggplant
Green gram
Groundnut
Maize
Mango
Millet
Okra
Onion
Papaya

more Images

Order/Family: Malvales: Malvaceae
Local names: Ghana: okro; Kenya / Tanzania: bamia, binda
Pests and Diseases: African bollworm Aphids Bacterial blight Black mould Cotton seed bugs Cotton stainers Cutworms Damping-off diseases Early blight Flea beetles Flower or blister beetles Fusarium wilt Grasshoppers Leafmining flies (leafminers) Powdery mildew Root-knot nematodes Semiloopers Spider mites Spiny bollworm Stink bugs Thrips Whiteflies Early blight

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

General Information and Agronomic Aspects

Okra is now widely cultivated in tropical and subtropical regions, but is particularly popular in India, West Africa and Brazil.

Okra, also called lady's fingers, is mainly grown for its young immature pods, which are consumed as a vegetable, raw, cooked or fried. It is a common ingredient of soups and sauces. The pods can be conserved by drying or pickling. The leaves are sometimes used as spinach or cattle feed, the fibres from the stem for cord, the plant mucilage (thick gluey substance) for medical and industrial purposes, and the seeds as a substitute for coffee. Okra seeds contain a considerable amount of good quality oil and protein.

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

Geographical Distribution of Okra in Africa

Nutritive Value per 100 g of edible Portion

Raw Vegetable	Food Energy (Calories)	Protein (g)	Carbohydrates (g)	Ash (g)	Calcium (g)	Phosphorus (mg)	Iron (mg)	Potassium (mg)	Vitamin A (I.U)	T (
Okra	36	2.4	7.6	0.8	92	51	0.6	249	520	(

Pests/ diseases/ weeds

Medicinal

Climate conditions, soil and water management

Okra is grown at elevations ranging from sea level to 1600m. The optimum temperatures for growth and production of high quality pods range between 24 and 30°C. The crop is sensitive to frost and temperatures below 12°C.

Okra will grow on a wide range of soils, but it prefers soils high in organic matter. When grown in sandy soils, it must be frequently fertilised, as soluble nutrients readily leach from the root zone. Its optimum range of soil pH is between 5.8 and 6.5. A soil test will indicate if lime is required to adjust the pH and the amount to apply. If lime is recommended, dolomite should be used, applied 3 to 4 months before the crop is seeded. Okra is sensitive to salinity.
Okra can grow in a wide range of rainfall regimes, but needs 400 mm of water for the growing period of about 3 months.

plants
Fruit and vegetable processing
Natural pest control
Cultural practices

Varieties available in Kenya (2002):

- **"Pusa sawani"**

High yielding variety tolerant to vein mosaic. It grows 2 to 2,5 m tall, has long pods. (18 to 20 cm), dark green, smooth and has 5 ridges. Mainly for export.

- **"Clemson spineless"**

1.2 to 1.5 m tall. Pods are about 15 cm long, green and moderately ridged.

- **"Green Emerald2**

This variety is about 1.5 m tall. Pods are 18 to 20 cm long slightly ridged (rounded) and green.

- **"White velvet"**

a medium tall variety of 1.5 to 1.8 m high. Pods are 15 to 18 cm long, slender, tapered, smooth and creamy white.

- **"Dwarf Green Long Pod"**

It grows up to 0.9 m high. It has several side branches. The pods are angular and green and about 18 to 20 cm long.

Propagation and planting

Land preparation
Thorough soil preparation 2 to 3 months before planting is recommended to allow crop residues and organic matter in the soil to decompose before okra is planted. Early land preparation also permits weed seeds to germinate and allows early cultivation to destroy young weeds before planting.

Planting

Okra plants may be established by direct seeding in the field, by growing seedlings in nursery seedbeds or by raising seedlings in plastic trays. To facilitate speedy germination, okra seed should be soaked in water overnight before planting. In Kenya, okra is sown directly in the field. About 8 to 10 kg of seed is required per hectare. Planting depth is about 1.5 cm. Spacing varies: 45x45 cm, 50x30 cm or 60x15 cm between the rows and within the rows, respectively. In some parts of Kenya, okra is planted in 2x2 m flood irrigation basis. The main export season in Kenya is October to May; hence planting should start from July so as to target this export season. However with irrigation okra can be grown all year round for the local and off-season export markets.

Fertilisation

It is recommended that soil be analysed before okra planting to determine fertility treatment needed. Without a soil test, the general recommendation in Kenya (issued by Horticultural Crops Development Authority) for conventional production (non-organic production) is as follows: well-composted manure should be applied at planting at the rate of 15 to 20 t/ha (17 to 20 gm/plant). It should be mixed thoroughly with the soil in the planting hole. Also, during planting, fertilizer (NPK 17:17:17) is recommended at the rate of 120 kg/ha (two gm/plant). The fertiliser should be applied in bands on the side of the furrow where the seeds will be planted and mixed well with the soil.

The plants should be top dressed using 140 kg of CAN (calcium ammonium nitrate) /ha spilt to two applications. The first application at the rate of 70 kg/ha (68 gm/plant) should be done 3-4 weeks after planting and the second application 3 to 4 weeks later. However, CAN should be applied only in soils with acid or neutral soil pH (pH smaller or equal to 7.0). In alkaline soils (ph greater or equal to 7.0) sulphate of ammonia should be used instead at the rate of 87 kg/ha (85 gm/plant). Urea is an alternative to CAN but it should be applied only in moist soils at the rate of 40 gm per plant. It should not be applied in soils with a pH 8 or higher as high volatilisation of ammonia would occur. Applying NPK (17:17:17) at flowering is recommended, at the same rate as at planting to boost flowering and pod production. Fertilisers containing chlorides should be

avoided, since okra is sensitive to salinity.

Sources of plant nutrients

In organic management we have to rely on the natural sources of plant nutrients such as compost, manure teas, plant teas such as tithonia for foliar feed. Well-composted manure should be applied at planting at the rate of 15 to 20 t/ha (17 to 20 gm/plant). Additional compost or manure is needed during the vegetation period. Manure and plant teas can be fed to the plants via a drip irrigation system to avoid excessive labour. However on acid soils agricultural lime is recommended and allowed. Also Mijingu (rock phosphate) is recommended on soils low in phosphorous (almost all soils in Kenya).

Irrigation

Okra is a heavily foliaged crop, so its water requirements are high. According to the Kenya Ministry of Agriculture okra needs 400 mm of water during the growing season of three months. A general guideline for semi-arid areas, where okra is mostly grown in Kenya, is to provide about 35 mm of water per week (this equals 35 litres of water per square metre). Critical times for irrigating okra are at emergence and from flowering to pod production. Saline or chlorinated water should not be used for irrigation.

Rotation

Okra should be rotated with baby corn, maize, peas, onions, potatoes, fodder grass or small grains. Being in the same family as cotton - with which it shares the same complex of pests and diseases - okra should not be grown before or after cotton.

Weed control

Okra is harvested over a long period and weed control is important throughout the cropping season. Smallholder growers in Kenya control weeds by hand hoeing.

Harvesting

Most varieties grown in Kenya are ready to pick 45 to 55 days after planting. Pods are ready for harvesting about 4 to 6 days after flowering. Pods are harvested when still tender and on attaining length of 7 to 15 cm, depending on variety and market requirements. The crop will bear pods for several months under ideal conditions, especially when mature pods are picked regularly. Under Kenyan conditions harvesting normally continue 45 days after the first harvest. Regular picking every 1 to 2 days is essential to ensure pods are within the size prescribed by the market. Okra should not be harvested when it is raining or excessively wet. Excess moisture can induce mould development on the pods and the cut petioles. Okra pods decay quickly; therefore they should be harvested within a day to marketing.

Harvesting is done by hand. The pods can be snapped off or cut off, leaving a small stalk not longer than one cm. The pods must be handled carefully otherwise they may be bruised and may discolour. It is best to pick pods into a waist bag to reduce skin damage and to avoid excessive bending of the pods. Wearing rubber gloves when harvesting and handling pods is recommended. This will protect the skin from irritating sap produced by okra plant.

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Information on Pests

Cutworms (*Agrotis* spp.)

Cutworms are the caterpillars of some moths. They destroy whole plants by girdling and cutting off young seedlings at the soil level during the night. 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.**

Cutworm
Okra seedling damaged by cutworm (*Agrotis* spp.) caterpillar (right). Note healthy seedling on the left. Close-up of cutworm (inset)

More Information on Cutworms

Cotton seed bugs (*Oxycarenus* sp.)

They feed on developing pods. These bugs are small (4 to 6 mm), and blackish in colour. Their wings are transparent. They attack open or damaged pods mainly at the end of the growing season. Nymphs and adults suck from immature seeds, preventing them from ripening. Groups of bugs are usually found between flower buds, flowers and pods. These bugs are minor pests of okra and usually no control measures are needed.

Cotton seed bugs

What to do:

- **No control is recommended since they are minor pests.**
- **Dislodge the bugs by shaking the plants.**
- **Control measures for cotton stainers are usually effective against cotton seed bugs.**

Cotton seed bugs (*Oxycarenus* sp.) on okra, these bugs are small (4 to 6 mm)

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African bollworm (*Helicoverpa armigera*)

The African bollworm feed on leaves, flowers and pods of okra. The main damage occurs on flowers and pods. Attack on flowers results in flower abortion. The caterpillar usually bore clean, circular holes in pods, causing extensive damage and promoting decay from secondary infection by diseases.

African bollworm
Young caterpillar of African bollworm (*Helicoverpa armigera*) feeding on okra leaf and a moth (inset). Fully-grown caterpillars are 35 - 40mm long.

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More Information on African bollworm

What to do:

- **Conserve natural enemies. The African bollworm has a wide variety of natural enemies. Parasitic wasps and predators such as ants, lacewings, and ladybird beetles are important in natural control of this pest.**
- **Inspect plants regularly; once or twice a week after plants begins to bloom. Early detection of eggs and/or caterpillars before they bore into the pods is important.**
- **Hand pick and destroy eggs and caterpillars. This helps when their numbers are low and in small fields.**
- **If necessary, spray with Bt or neem extracts. Good spray coverage and targeting small caterpillars before they bore**

into the pods is very important. For more information on neem click here. For information on Bt click here

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The spiny bollworm or spotted bollworm (*Earias* spp.)

It is a major pest of okra. The full grown larva is 13-18 mm long and 2.5 mm wide. It is stout and spindle shaped. The body colour is variable, ranging from greyish-brown, through grey to green, with a distinctly paler or white median line. The adult is a moth, about 12 mm long with a wingspan of about 20-22mm. The forewings (front wings) are white, peach, metallic green to straw yellow in colour according to the species.

The larvae/caterpillars bore into terminal shoots of young plants, causing death of the tip and development of side shoots. When pod production starts, the caterpillars move to the flower buds, small pods and eventually mature pods. Damaged flower buds and young pods are shed, leading to yield reduction. Damaged pods ad pods contaminated with insect frass are not marketable. High doses of nitrogen fertilisers have been found to increase spiny bollworm infestation.

Spiny bollworm
Young okra pods damaged by caterpillar of the spiny bollworm (*Earias* spp.). The full grown larva is 13-18 mm long and 2.5mm wide. It is stout and spindle shaped. The body colour is variable, ranging from greyish-brown, through grey to green, with a distinctly paler or white median line.

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What to do:

- **Scout the crop regularly. Early detection of eggs and/or caterpillars before they bore into the pods is important.**
- **Conserve of natural enemies.**
- **Hand pick and destroy eggs and caterpillars, and damaged**

tips and pods (in small plots).

- **Regulate fertilisation. Avoid high doses of nitrogen.**
- **Destroy old crops and crop debris after harvesting**
- **Use biopesticides (e.g Bt, neem-based pesticides). Good spray coverage and targeting small caterpillars before they bore into the pods is very important.**
  For information on Bt click here.. For information on neem click here.

Spider mites (*Tetranychus* spp.)

Spider mites suck the sap of plant tissues. Infested leaves first show a white to yellow speckling and then turn pale or a reddish bronze colour as infestation becomes heavy. The leaves curl up under severe attack and finally wither and fall off, leading to plant defoliation. In severe infestation, spider mites will also attack pods, causing pod contamination. Major factors leading to spider mite outbreaks are very hot and dry conditions, destruction of natural enemies and the presence of other infested highly infested crops in the vicinity of the okra crop.

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.**

Spider mites
The predatory mite (*Phytoseiulus persimilis*) (orange-red individuals), in a colony of two-spotted spider mite (*Tetranychus urticae*). Two-spotted spider mite adult females are 0.6 mm long.

© Image supplied by Warwick HRI, University of

- **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.**

Warwick.

More Information on Spider mites

Thrips (*Frankliniella* spp.)

Thrips feed on the lower surface of leaves, flowers and fruits. Both larvae and adults puncture the leaves and suck the exuding sap. Heavily attacked leaves become curled, wrinkled and finally dry up. Any environmental stress that weakens the plants makes them more susceptible to thrips attack. Thrips attack on seedlings and young plants delays crop development. Feeding on the flowers may result in deformed pods. Attack on fruits may scar them. Affected fruits are not marketable.

Thrips
Thrips (*Frankliniella* spp.) on okra flower. Thrips are small (usually 1 to 2 mm), slender and usually winged.

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More Information on Thrips

What to do:

- **Conserve natural enemies. In particular predators (e.g. predatory bugs, mites and thrips) are important in natural control of thrips.**
- **Plough and harrow before planting. This exposes pupae in the soil to natural enemies and desiccation.**
- **If necessary, spray biopesticides. Spinosad, a bacterium metabolite, is effective in controlling thrips. Insecticides should only be used up to the early flowering stage. Spraying after flowering at a later stage may lead to pesticide residues on the pods. Observe preharvest intervals.**

The tobacco whitefly (*Bemisia tabaci*)

Adults and nymphs of the tobacco whitefly suck sap from leaves of okra plants. Attacked plants have low vigour and may wilt, turn yellow and die if whitefly infestations are severe or of long duration. Damage may be accentuated when plants suffer water stress. Whiteflies excrete honeydew on which sooty mould growth. These may cover the leaves during heavy infestation, and as a result the leaves may turn black, affecting photosynthesis.

Whiteflies
Whiteflies under leaf. Adult whiteflies are about 1mm long.

© Clemson University, Department of Entomology
More Information on Whiteflies

What to do:

- **Conserve natural enemies. Parasitic wasps, and predators (predatory mites, lacewings and ladybird beetles) are important in natural control of whiteflies.**
- **If necessary, spray neem extracts. Neem products inhibit growth and development of immature stages, repel whitefly adults and reduce egg laying. Other substances reported to be effective against whiteflies are soap an water solutions and mineral oils. The amount of soap needed depends on the soap type.**

Root-knot nematodes (*Meloidogyne* spp.)

The nematodes are soil inhabitants. They attack a wide range of crops, particularly vegetables. Their infestation is most serious

in light sandy soils and in furrow irrigated fields. Diseased plants are stunted, yellow and have a tendency to wilt in hot weather. Diseased plants appear in patches in the field. The roots of diseased plants have small lumps known as galls or root knots.

What to do:

- **Use tolerant/resistant varieties**
- **Rotate okra with onions, baby corn, maize, millet, sorghum, sesame or Sudan grass**
- **Maintain high levels of organic matter in the soil**
- **Mix crop with marigold (Tagetes spp.) or Indian mustard**
- **Remove crop debris**
- **Incorporate neem cake powder into the soil. Neem products are commercially available in Kenya and these products can be used for control of root-knot nematodes.**
- **Use biofumigation where possible. When growing okra in nematode infested fields intercrop with different mustards (e.g. Brassica juncea var. integrifolia or Brassica juncea var. juncea). As soon as mustards are flowering they are mulched and incorporated into the soil. While incorporated plant parts are decomposing in a moist soil, nematicidal compounds of this decomposing process do kill nematodes. Two weeks after incorporating plant material into the soil a new crop can be planted or sown (phytotoxic effects are usual if the crop is planted before two weeks). For more information on biofumigation click here.**

Root-knot nematodes
Okra roots damaged by root-knot nematodes. Note gall or root-knots (left) and healthy roots (right).

More Information on Root-knot nematodes

Aphids (*Aphis gossypii*)

The cotton aphid (*Aphis gossypii*), have been identified as one of the major pest problems of okra in Kenya. They cause damage by sucking plant sap weakening the plants, and by excreting a sticky substance (honeydew), which results in growth of sooty mould affecting photosynthesis. Contamination of pods with aphids, aphid skins, honeydew and/ or sooty mould may result in their rejection in the market.

The cotton aphid transmits the Yellow Vein Mosaic Virus in okra. Cotton aphid (*Aphis gossypii*) is a small aphid. Adults range from just under 1-1.5 mm in body length.

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. Link to natural enemies datasheet.**
- **Use reflective mulches. Reflective aluminium mulches deter aphids from landing on plants. The effect is lost once plants are large enough to cover the mulch.**
- **Monitor the crop regularly.**
- **If necessary, spray with botanicals (e.g. neem extracts). Experiments in Kenya showed that neem-based pesticides, namely Achook© (Azadirachtin 15% w/w) and a neem extractive (Azadirachtin 0.6 w/w) effectively controlled the cotton aphid giving protection to the crop for the whole**

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

© A.M. Varela, icipe
More Information on Aphids

season. Yield of plants treated with these two products was similar, but using Achook© was much economic that using the neem extractive (Malenge, 2005).

- **Spray only attacked plants (spot spraying).**

Flea beetles (*Nisostra* spp., *Podagrica* spp.)

Flea beetle
Flea beetle feeding on young okra pod

© A.M. Varela, icipe

These are common pests of okra. They are tiny to small beetles, with enlarged hind legs that enable them to jump long distances when disturbed. The colour of the adult beetles varies from black, brown, black and yellow striped or metallic blue-green depending on the species. The adults feed on cotyledons, stems and leaves. They make many small holes on okra leaves, known as "shot-holes". Larvae of flea beetles live in the soil and feed on okra roots, but the damage caused is not of economic importance. Flea beetles are particularly damaging to young plants. Seedlings may wilt and die under heavy flea beetle attack or may stunt if injury is not severe. Damage to cotyledons and young leaves is the major cause of crop loss, generally leading to uneven crop stand. When large numbers of flea beetles are present they will also feed on flower buds and pods, causing yield loss by injuring the pods. Damaged pods are not marketable. Some species of flea beetles are reported to transmit the Okra Mosaic Virus in West Africa.

What to do:

- **Rock powders and clay minerals have a repellent effect on**

adult flee beetles.

- **Treat plants with pyrethrum extracts. They kill adults and larvae. For more information on pyrethrum click here.**

Grasshoppers

Grasshoppers are long, slender, winged insects with powerful hind legs and strong mandibles, or mouthparts, adapted for chewing. They range from 1-10 cm in length. They have a front pair of rigid wings and a hind pair of larger, membranous wings, often brightly colored. When the wings are at rest, the hind pair folds and is covered by the front pair. The rear legs are well developed and usually have sharp spines. Grasshoppers are variable colour; but many are green or brown.

Many grasshoppers lay eggs in pods in the ground, preferably in bare soil; others lay eggs in plant tissue or in crevices. Immature stages are similar to adults but have shorts or no wings. Some grasshoppers have short antenna (short-horned) and other long antenna (long-horned). Grasshoppers can jump well and most of them can fly long distances.

Most grasshoppers are plant-eaters, but some long-horned grasshoppers are predatory with spiny front legs adapted for grasping prey. Grasshoppers feed on okra, eating chunks from the leaves, and stems of young shoots. They can be a problem at the seedling stage, but usually they do no cause damage to older plants.

Grasshoppers
Young grasshopper feeding on okra leaf

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What to do:

- **Catch grasshoppers by hand or with a butterfly net. Catching them in the early morning is easier, as they are less active in the mornings.**
- **Conserve natural enemies. Avoid destroying larvae of blister beetles, since they feed on eggs of grasshoppers. Other natural enemies include ants, parasitic flies, assassin bugs, predatory wasps, birds, lizards, snakes, frogs, and fungi. Robber flies are a major predator of grasshoppers. For more information on natural enemies click here**
- **Domesticated poultry (e.g. chickens, turkeys, guinea fowl, geese, and ducks) and wild birds are good for keeping grasshopper populations in check. They feed on them and dig up their eggs in patches of bare soil. However, birds may damage the plants too. To avoid this enclose the birds in wire fencing along the perimeter so that they can prey on visiting grasshoppers while staying out of the crop.**
- **Ensure the ground is covered with crops, grass or mulch. This is reported to reduce grasshopper numbers since they prefer laying eggs on bare soil.**
- **If necessary spray with neem extracts. Neem acts as antifeedant (grasshoppers stop feeding when exposed to neem products) and affects development of the grasshoppers. I For more information on neem click here**
- **Locate and dig egg-laying sites to expose and destroy the eggs before they start to hatch early in the dry season. However, egg pod destruction has to be done over a wide area in the wet season in order to be effective. This will**

require participation of farmers on many neighbouring farms. If only one neighbour destroys the eggs in his/her farm, the grasshoppers will later invade the farm from the neighbouring farms and bushes.

- **When available, use biopesticides. IITA researchers and partners have developed an environmental friendly biopesticide "Green Muscle®". It is based on a naturally occurring fungus strain indigenous to Africa (Metarhizium anisopliae) which is deadly to locusts and grasshoppers but reportedly does not damage other insects, plants, animals, or people. Typically 70 to 100 percent mortality rates were obtained after 8 to 28 days of application (www.iita.org). The bioinsecticide "Green Muscle®" is effective in grasshopper management in outbreak situations. However, it is costly and currently, it is only available in South Africa and West Africa.**

Leafmining flies (*Liriomyza* spp.)

Leafmining flies are common pests of okra in Kenya. Mining of leaves by larvae may reduce photosynthetic activity, affecting development of flowers and pods. In severe infestation, the leaves might be completely mined. As a result the leaves dry and fall off prematurely, causing loss of vigour and turgidity in the plant. This may eventually result in plant wilting.

Leafminers
Okra leaf severely damaged by leafminer (*Liriomyza* spp.) larvae

What to do:

- **Check the seedlings and older plants regularly**
- **Conserve natural enemies. Parasitic wasps, in particular,**

usually keep leafminers under control. However, the indiscriminate use of pesticides disrupts the natural control resulting in leafminer outbreaks

- **Spray neem extracts.**

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More Information on Leafmining flies (leafminers)

Semiloopers (*Anomis flava*) and Leafrollers (*Haritalodes derogata*)

Various species of caterpillars feed on okra leaves. Semiloopers chew irregular holes on leaves, giving them a ragged appearance. Other caterpillars feed on the lower leaf surface leaving the upper surface intact (this type of damage is known as windowing). Leafrollers spin or roll leaves together, and eat the leaf margins, causing the leaves to curl and droop. Leaf-eating caterpillars cause economic damage only when present in large numbers, especially in young or stressed plants. Well-established, healthy plants can tolerate considerable loss of leaves; however, seedlings may be killed by severe defoliation.

Leafroller
Caterpillar of the leafroller (*Haritalodes derogata*) on okra leaf. The size is from 3mm to 2.6cm.

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***H. derogata* larvae are creamy-white or pale yellow, but appear to be green, owing to ingested leaves in the gut. First-instar larvae are 2 mm long and grow 22-26 mm long, respectively, in later instars. The larvae have dark-brown heads. The adult is a moth with wingspan of 30-40 mm.**

What to do:

- **Check plants, in particularly seedlings, regularly and hand pick the caterpillars.**

- **Spray Bt products. In case of serious attack. Bt var.kurstaki and Bt var. aizawai effective when used against young caterpillars. For more information on Bt click here**

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

Flower beetles are also known as pollen beetles or blister beetles. Adult beetles feed on flowers reducing pod set. They also feed on foliage biting off irregular patches on leaves. Larvae of these beetles do not feed on plants but on eggs of grasshoppers and locusts. Therefore, they are beneficial and should not be destroyed.

The beetles lay eggs in the soil. Upon hatching, young larvae are very active and mobile searching for eggs of grasshoppers and locusts. The larvae then burrow underground and start feeding on the eggs. Older larvae become sluggish and change shape turning fat, and getting a large body and reduced legs. These beetles are difficult to control because of their mobility. The damage caused is usually not of economic importance.

Flower beetle
Flower beetle feeding on okra flower

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Flower bee...
Blister be...

What to do:

- **Monitor crop regularly.**
- **Hand pick adults regularly. This helps to maintain their numbers low in small plots. . However, do not destroy all of them, but keep numbers in check. Care should be taken when handling these beetles, since when disturbed they release a**

liquid that could burn the skin. To avoid this, wear thick gloves to protect your hands.

- **Provide alternative habitats by keeping flowering plants at the borders of the field.**
- **Spray repellents such as extracts of strong smelling plants (eucalyptus, lantana, onion, garlic etc.). Recommended mixes vary from 20 to100 g dried aromatic leaves per litre of water. Dried leaves are immersed in boiling water and left to steep till the tea is cold. Then sieved and sprayed onto affected plants. Repellents are reported to keep most beetles away (Elwell and Maas, 1995).**

Bugs: Cotton stainers (*Dysdercus* spp.)

Several species of bugs attack okra. Some of them occur from the early stages of the crop, but are more common during the mature stages, feeding on developing pods. Their feeding causes small, dark, raised blister-like spots on pods.

These bugs are very common on okra plants at the fruiting stage. They are conspicuously red with black bands. Both adults and nymphs feed on developing pods and seeds, piercing them to suck sap, thereby reducing yield. Attacked young fruits shrivel and then dry. Feeding on mature fruits results in damage to the seeds. Stainers also attack cotton and they live on baobab and silk cotton (kapok) trees.

Stainer bugs are between 14 and 24 mm long.

Cotton stainers
Cotton stainers (*Dysdercus* spp.). Nymphs (two to the left) and adult cotton stainer. Stainer bugs are 14-24 mm long.

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What to do:

- **Plough deeply or hoe to expose the eggs**
- **Uproot all plants after harvesting and destroy wild alternate hosts.**
- **Custard apple leaf extract is recommended for control of these bugs (PAN).**
- **Preventive control measures are sanitation; remove plants and all its debris as soon as harvesting is over. Keep stores clean. Hand pick and destroy the bugs, this is feasible in small plots and at the beginning of infestations, and will help to reduce population density.**
- **Caging chickens in cotton plots using chicken wire may control cotton stainers; about 15 birds will keep about 0.1 ha free of stainer bugs. This is a good option for small plots grown next to the homestead.**
- **Cotton stainers are attacked by a range of natural enemies; the most important are assassin bugs, ants, spiders, birds and parasitic flies.**
- **The baobab tree is one of the main host plants of stainer bugs. If cotton is grown where baobab occurs, the soil and trunk of the baobab tree should be sprayed with biopesticides to kill the nymphs hatching from eggs laid around the stem.**
- **Tanzania: Pyrethrum formulation is used with black wattle extract as UV light stabilisator**

Bugs: Stink bugs (*Nezara viridula*, *Atelocera* sp. and *Halydicoris* sp.)

Both adults and nymphs of the stink bugs feed on buds, blossoms, pods and seeds. They are 6-15mm long. Their feeding causes local necrosis resulting in small pimples on the pod, and occasionally pod shedding. On very young pods, it causes twisting and distortion of pods, rendering them unmarketable.

Stink bugs are a minor pest and normally do not justify any control. But they can be a problem at podding.

What to do:

- **If necessary, spray botanicals in the morning when nymphs and adults bask on the plant canopy. Neem based pesticides reportedly reduce feeding by sting bugs. For more information on neem click here. A number of other plants (lantana, garlic, oleander, African marigold, blackjack, goat weed, wormseed, among others) are reported as effective against various species of bugs (Elwell and Maas, 1995). Pyrethrins are recommended for control of bugs in organic production in USA (Layton, 2004).**

Brown stink bug
Brown stink bug (*Halydicoris* sp.) on okra.
Real size: 6 to 15 mm long.

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Information on Diseases

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

Damping-off diseases affect the initial establishment of a crop.

Their main features include poor emergence and death of seedlings leading to poor stands in seedbeds and fields. Seeds may rot before germination. Affected seedlings that have emerged from the soil show water-soaking, browning and shrivelling of the stem at the soil level. They eventually fall over and die. Damping-off diseases are favoured by excessive wetness of the soil and low soil temperatures.

What to do:

- **Use certified disease-free seeds**
- **Avoid over-irrigation and excessive fertilization with nitrogen fertilizers.**
- **Avoid fields previously planted with cotton or other related crops.**

Damping-off
Okra seedlings affected by damping-off (*Pythium* spp., *Rhizoctonia solani*)

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More Information on Damping-off diseases

Early blight

Early blight symptoms on

okra leaf.

More Information on Early blight

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

This fungus is seed- and soil-borne. Diseased plants are stunted. Leaves of diseased plants turn yellow, wilt and later are shed. Usually the lower leaves are first affected. When a stem or main root of diseased plant is cut crosswise, brown discolouration is usually found in the ring just beneath the bark. Wilting of plants is mostly gradual. Water stress, warm soil temperatures, acidic soils and high content of nitrogen in the soil favour the disease. Infestation by root-knot nematodes aggravates Fusarium wilt.

Fusarium wilt
Wilting of okra plant due to Fusarium wilt (*Fusarium oxysporum* f.sp.*vasinfectum*)

More Information on Fusarium wilt

What to do:

- Use certified disease-free seeds
- Treat seeds with a biopesticide preparation of Trichoderma viride (commercially available in Kenya)
- Control root-knot nematodes

- **Practice regular irrigation**
- **Control weeds**

Powdery mildew (*Leveillula taurica* / *Oidiopsis taurica*)

The disease is characterised by a white coating resembling a fine talcum powder on lower and upper leaf surfaces. The white coating is the fungal growth. Severe infection causes the affected leaves to roll upward and eventually scorching. The disease also attacks stems, flower buds and okra pods. Infection occurs when humidity is in the range of 52 to 75% and air temperatures are around 26 to 27°C.

What to do:

- **Practice field sanitation**
- **Do not grow okra or related crops like cotton in succession**
- **Use sulphur based fungicides (in conventional production) or sulphur (in organic production).**

Powdery mildew
Powdery mildew on upper surface of an okra leaf.

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Powde mi… **Powde mi…**

More Information on Powdery mildew

Bacterial blight (*Xanthomonas campestris* p.v. *malvacearum*)

The bacterium is transmitted through seed and water splash. Symptoms consist of spots on leaves and pods. Leaf spots are

initially soaked with water and are more obvious on the underside of leaves. They are restricted to the veins and are angular in shape. Spots on petioles are elongated, sometimes slightly sunken and blackish. Spots on pods are initially water-soaked and round. Later, they join together and turn oily black. All spots appear waxy and shiny.

What to do:

- **Use certified disease-free seeds**
- **Avoid overhead irrigation**
- **Avoid working in the field when wet**
- **Remove crop debris after harvest**
- **Spray with copper-based fungicides. For more information on copper-based fungicides click here.**

Bacterial blight
Bacterial blight (*Xanthomonas campestris* p.v. *malvacearum*) on young okra pod

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Bacteri ... **Bacteri ...**

Black mould (*Cercospora abelmoschi*)

Black mould can be serious in humid warm areas. It causes leaf spots of various shapes. It grows as a sooty to dark oily (olivaceous) mould on the underside of leaves, but when infection is severe and conditions are very humid it also appears

on upper surface of infected leaves. Seriously infected foliage rolls, wilts and falls to the ground.

What to do:

- **Avoid overlap of okra in the same field**
- **Rotate with baby corn, maize, small grains or pulses**
- **Avoid overhead irrigation**
- **Use copper prays. For more information on copper sprays, click here.**

Black mould
Black mould (*Cercospora abelmoschi*) leaf spots on the top side of an okra leaf

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Avocados
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Cabbage/Kale, Brassicas
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Okra

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Eggplant
Scientific name: *Solanum melongena*
Order/Family: Solanales: Solanaceae
Local names: Aubergine, brinjal, birigiyani (Swahili)
Pests and Diseases: Anthracnose Aphids Bacterial wilt Budworm Cotton leafhoppers or jassids Cutworms Early blight Eggplant lace bug Epilachna beetles Fusarium wilt Late blight Mole crickets Phytothphora fruit rot Powdery mildew Root-knot nematodes Shoot and fruit borer Spider mites Thrips Weeds Whiteflies

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General Information and Agronomic Aspects

Geographical Distribution of

The young and almost mature fruits are used as a vegetable. The fruit is a good source of vitamin A and C, potassium phosphorous and calcium. They may be roasted, fried, stuffed, cooked as curry or pickled. Cooking for prolonged periods will destroy most of the vitamins. In Kenya production is done throughout the year and the bulk of the crop is exported. The fruits of the white varieties have medicinal value for diabetics. Eggplant has a cropping period of 4-7 months. In Kenya they are normally planted from beginning of June to end of December to correspond with the export season from October to May.

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

Pests/ diseases/ weeds

Eggplant in Africa

Nutritive Value per 100 g of edible Portion

Raw Vegetable	Food Energy (Calories)	Protein (g)	Carbohydrates (g)	Ash (g)	Calcium (g)	Phosphorus (mg)	Iron (mg)	Potassium (mg)	Vitamin A (I.U)	T (
Eggplant	25	1.2	5.6	0.6	12	26	0.7	214	10	(

Climate conditions, soil and water management

Optimum day temperatures for eggplant are in the range of 25-35°C and night temperatures from 20-27°C. Eggplant is more susceptible to low temperatures than tomato and capsicum and it does not tolerate frost. It is tolerant of drought and excessive rainfall, but struggles to grow when temperatures exceed 30°C, and where water logging occurs. When temperature and humidity are high, eggplant becomes more vegetative. Eggplant does best in well-drained, sandy loam soils. The best environmental conditions are normally found in lowland areas with

Medicinal plants
Fruit and vegetable processing
Natural pest control
Cultural practices

relatively little temperature variation. When grown at altitudes above 800 m, growth is retarded and yields reduced. The pH requirements range from 6-7 with the optimum being pH 6.4.

Propagation and planting

Eggplant is normally propagated by seed. Propagation by rooting of healthy shoots is also possible. Soaking the seeds in water for 24 hours speeds up germination. No treatment is needed when sowing fresh, vigorous seed in sterilized soil. Otherwise, soak seeds in warm water (50 °C) for 30 minutes, rinse them in cold water, and dry them before sowing. For information on hot-water treatment for seeds click here

Nursery preparation. The seeds are sown in a well-prepared raised seedbed with friable soil (soil that breaks or crumbles easily when handled) in rows 10 cm apart. Space the seeds well to make transplanting easier. Before sowing an application of 3 to 5 kg of good compost per m² is incorporated into the nursery seedbed.

In tropical areas, seeds are sown in a shaded seedbed and watered regularly. The seedlings emerge after 8-10 days. Before planting, fertilise the field with compost or farmyard manure. The ideal transplant is a seedling with three to four true leaves, stocky and disease-free, and without flower buds. Begin hardening plants six to nine days before transplanting to reduce transplanting shock. Slightly withhold water. Thoroughly water seedlings 12 to14 hours before transplanting to the field. Transplanting should be done in the late afternoon or on a cloudy day in order to minimize transplanting shock. Before transplanting, place a basal dose of 15 to 30 tons/ha compost or well-rotted farmyard manure in the planting furrows or planting holes and mixed with the soil.
Transplant seedlings by digging a hole deep enough to bury a plant so that its first true leaf is just above the soil surface. Press the soil firmly around the root. Irrigate furrows immediately after transplanting.

Watering newly transplanted plants well with compost tea or EM (effective microorganisms) will give the seedlings a good start. To prepare your own compost tea, mix 1 part of compost with 6 parts of water. Leave the mixture for one week. Strain and spray on seedlings to control fungal pathogens and prevent infection.

Varieties

- **"Black Beauty"**
- **"Florida High Bush"**
- **"Ravaya"**

Crop rotation

Eggplants should not be planted after tomato, pepper, potato, or other solanaceous crops to prevent a recurrence of the same pests and disease pathogens. Rotate eggplants with other crops. Planting eggplant after rice reduces the incidence of bacterial wilt and nematodes.

Husbandry

Side dressing with groundnut cake is recommended forty days after transplanting. Also at this period, remove three nodes at the tips of the plants to improve branching and to increase the number of fruits. Weed control should be shallow, to avoid damage to the roots. Tall-growing cultivars will also require support. Supplementary irrigation is required during dry periods. Mulching with dried plant materials reduces moisture loss and weed problems. Apply well-decomposed farm yard manure and neem cake as basal fertilisers.

Harvesting

The first harvestable fruits appear 60-90 days after planting. Harvest fruits when they are about two-thirds of their maximum size. Harvesting is done once or twice a week by cutting the fruit

from the stem and leaving a short piece of stem on the fruit. For seed production, harvest only fully mature fruits from healthy and productive plants. Yields of 20 to 25 tons/ha of immature fruits can be expected.

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Information on Diseases

Bacterial wilt (*Ralstonia solanacearum*)

This disease occurs with bad drainage, especially in the hot, wet season and is often combined with symptoms of root-knot nematodes. Plants wilt and die suddenly. When newly infected stems are cut crosswise and placed in water, a greyish or yellowish ooze appears from the cut stem. The pathogen is soil-borne with a wide host range. Root-knot nematode infestation aggravates the disease development.

Bacterial wilt
Bacterial wilt symptoms (here on potato plants).

What to do:

- **Use resistant varieties, if available**
- **Use certified disease-free seeds**
- **Remove infected plants from fields and destroy affected plants.**
- **Rotate with non-solanaceous crops (e.g. maize or beans)**
- **Use raised beds for improved drainage**
- **Graft plants onto resistant rootstocks**

More Information on Bacterial wilt

Powdery mildew (*Leveillula taurica*)

Powdery mildew
Powdery mildew (here on tomato)

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More Information on Powdery mildew

Symptoms appear as yellowish spots on the leaves. On the lower surface of affected leaves the spots are covered by a whitish growth constituting spores of the fungus. Affected leaves eventually dry up but do not fall off. The fungus is endophytic (grows within the leaf contrary to other powdery mildew fungi that are grow on surface of the leaves). It has a wide host range. It is not seed-borne but it survives on herbaceous weeds and other susceptible hosts. Temperatures slightly above 20° C, dry conditions and fairly high relative humidity favour disease infection. However, fungal dispersal takes place mainly at low humidity.

What to do:

- **Use of resistant varieties, if available**
- **Use overhead irrigation**
- **Use sulphur sprays.**

Anthracnose (*Colletotrichum melongenae*)

Spots of fruits are sunken. When weather is moist, the spots get tan-coloured (growth of fungal spores). There may be several spots on affected fruit and they may join up and cover the whole

fruit. Severely affected fruits drop. Eventually, affected fruits dry and become black. Most often, soft-rot bacteria invade affected fruits and cause a soft watery decay. The fungus usually attacks fruits on plants that are weakened or over-ripe. Infection is favoured by relative humidity close to 100% and temperatures between 21 and 30° C.

What to do:

- **Use resistant varieties, if available**
- **Use certified disease-free seeds**
- **Practice crop rotation**
- **Destroy infected crop residues**

Anthracnose
Anthracnose (*Colletotrichum melongenae*) symptoms on eggplant, following artificial inoculation via needle puncture of fruit.

More Information on Anthracnose

Phytophthora fruit rot (*Phythophthora parasitica*)

Phytophthora fruit rot fungus can cause damping-off in seedbeds, leaf spotting and collar rot on the main stem final resulting in plant death. The fungus may attack fruit at any growth

stage and any part of the fruit. Spots on the fruit are dark brown, water-soaked and may have a light-coloured border. A whitish mould develops on the spots when wet conditions prevail. The spots are neither sunken nor exhibit concentric rings (zonation). Infected fruits drop prematurely.

The fungus is soil-borne. It is spread in the field by run-off water and farm implements. The disease is favoured by prolonged periods of high moisture and temperatures near 30° C.

What to do:

- **Avoid dense planting**
- **Remove and destroy diseased fruit and plants**
- **Plough deep because Phytophthora would not survive**
- **Practice crop rotation with non-solanaceous crops such as tomato, potato and peppers**
- **Where practical, add copper sulphate to irrigation water**

Late blight (*Phytophthora infestans*)

The late blight fungus affects tomatos, potatoes and eggplants but not pepper. Its symptoms consist of brown spots with purplish tinge can develop on leaves, stems, branches and both green and ripe fruits. In moist weather it can cause complete defoliation and rotting of fruits.

Late blight
Late blight (*Phytophthora infestans*) sporulation symptoms on potato leaf in

What to do:

- **Use resistant varieties, if available**
- **Practice rotation with non-solanaceous crops (solanaceous crops are e.g. tomato, potato, peppers etc) away from for 3 to**

4 years. However, this will only be effective if it is done in cooperation with neighbouring farmers since the fungal spores can travel quite large distances on the wind.

- **In wet weather, copper fungicides, could be applied as soon as the disease is observed or as soon as local experience suggests that the weather conditions are favourable for disease development.**

the field

More Information on Late blight

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

Affected plants show yellowing of leaves that progressively wilt and die from bottom upwards. Woody stem and root tissue of diseased plants turn brown. This fungus does not affect tomatoes. Optimum temperature for its growth on eggplants is 27.8° C.

What to do:

- **Use resistant varieties, if available**
- **Amend soils with organic matter (e.g. compost)**
- **Practice crop rotation**
- **In some countries susceptible eggplant varieties are grafted onto resistant rootstocks (e.g. Solanum gilo and S. integrefolium).**

Fusarium wilt
Wilting of okra plant due to fusarium wilt

More Information on Fusarium wilt

Early blight or Alternaria leaf and fruit spots (*Alternaria* spp.)

Several *Alternaria* spp. are involved. These include *A. melongenae, A. solani* and *A. tenuis*. They cause leaf spotting and fruit rots. They produce leaf spots with concentric rings. The spots are mostly irregular, 4 to 8 mm in diameter and may enlarge and cover a large area of the leaf blade. Severely infected leaves drop off prematurely resulting in the reduction of yield. Fruit spots are circular, brown, dry and hard.

What to do:

- **Observe proper field sanitation**
- **Use certified disease-free seed**
- **Own seed should be water heat treated. For more information on hot water treatment click here**

Early blight
Early blight (here on tomato leaf). Leaf spots of early blight are circular, up to 1 cm in diameter, brown, and often show a circular pattern, which distinguishes this disease from other leaf spots on tomato.

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More Information on Early blight

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Information on Pests

Cutworms (*Agrotis* spp.)

These caterpillars are serious pests particularly in nurseries and of newly transplanted plants. They attack eggplants and many other plants at night. They cut seedlings and usually drag them down into the soil leaving the clean-cut stem. They cannot cut older plants. Large ground beetles, frogs, and birds prey mole crickets.

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)
More Information on Cutworms

What to do:

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

Budworm (*Scrobipalpa blapsigona*)

It is reported as one of the major pests of eggplants in Ghana. The small brown caterpillars of the budworm bore into flower buds and feed inside the flowers. This causes the flowers to drop off. Budworm damage is often overlooked, but it can be serious, leading to very low fruit

set (Youdeowi, 2002).

What to do:

- **Conserve natural enemies. Caterpillars are usually parasitised by wasps.**
- **Practice crop rotation.**
- **Avoid growing eggplant two years in succession.**

Whiteflies (*Bemisia tabaci*)

Whiteflies feed on leaves of eggplant sucking plant sap. Whiteflies are vectors of the mosaic virus reported to occasionally affect eggplant in West Africa.

What to do:

- **Apply neem products. Neem products have given control of the tobacco whitefly on eggplant. In the Caribbean, weekly sprays of neem seed powder (50g/l), and 2% neem oil gave good protection against this pest (Ostermann and Dreyer, 1995).**
  In Sudan, commercial neem products and home-made products (neem seed water extract 50g/l) reduced the populations of Bemisia tabaci on eggplant and potato (El Shafie, 2001).

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

© Clemson University, Department of Entomology
More Information on Whiteflies

Root-knot nematodes (*Meloidogyne* spp.)

Eggplant is highly susceptible to root-knot nematodes, especially on sandy soils. Symptoms of infestation by root-knot nematodes are similar in all crops: wilting of plants and if infested plants are pulled from the soil the roots can be seen to be distorted, swollen and bearing knots. The infested roots eventually rot and affected plants die.

What to do:

- **Use resistant varieties, if available**
- **Practice crop rotation**
- **Practice mixed cropping. Mixed cropping with African marigold (Tagetes spp.) minimise root-knot nematode damage. Intercrop with different mustards (e.g. Brassica juncea var. integrifolia or Brassica juncea var. juncea) on infested fields. As soon as mustards are flowering they are mulched and incorporated into the soil. While incorporated plant parts are decomposing in a moist soil, nematicidal compounds of this decomposing process do kill nematodes. Two weeks after incorporating plant material into the soil a new crop can be planted or sown (phytotoxic effects are usual if the crop is planted before two weeks).**
- **Use bioproducts (e.g. neem extracts). For more information on neem click here.**
- **Use biofumigation where possible.**
- **Maintain high levels of organic matter in the soil (manure or compost).**

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

More Information on Root-knot nematodes

Weeds

Eggplant is slow to become established and cannot compete with aggressive weeds. Weeds also harbour damaging insects and diseases.

What to do:

- **Remove weeds by hand regularly.**
- **Cultivate the land. Only shallow cultivation is necessary.**
- **Mulch plants. Black plastic mulch effectively controls weeds and reduces labour needs. Natural organic mulches such as rice straw help conserving moisture and add organic matter to the soil.**

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

More Information on Weeds

Mole crickets (*Brachytrupes* spp.)

Mole crickets have been reported as major pests of eggplants in Ghana. They live in the soil, feeding on the roots of many vegetables. They cut seedlings and drag them down into the soil leaving the clean-cut stem.

What to do:

- **Hand pick adults from their burrows**
- **Sprinkle wood ash in nursery**
- **Plough deep to destroy burrows**
- **Expose insects to predators. Large ground beetles, frogs and birds prey mole crickets**

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

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

Thrips attack eggplant mostly during the dry season. They cause browning of leaves, especially on the lower leaf surface. In severe cases, the entire leaf dries. Thrips feeding on fruits causesscarring, irregular discoloration and deformation, which reduce the market value of fruits.

What to do:

- **Monitor the crop regularly for early detection of the pest and signs of infestation**
- **Conserve natural enemies. Anthocorid bugs and predatory mites are important natural enemies of thrips. Avoid use of pesticides that kill natural enemies**
- **Whenever necessary spray the crop with botanicals or other biopesticides. Some plant extracts (e.g. garlic, rotenone, neem, pyrethrum, and a mixture of garlic and pepper) are reported to control thrips. Spinosad, a bacterial derivative, is effective in controlling thrips**

Thrips
Thrips damage on eggplant

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Thrips

Thrips

More Information on Thrips

Cotton leafhoppers or jassids

They are small insects (1-3 mm long), green in colour with slender tapered bodies. Leafhoppers are very mobile. The adults hop away when disturbed. Nymphs resemble adults, but have no wings, and run sideways when disturbed. The eggs are inserted in the leaf tissue on the underside of leaflets. They feed mainly on the underside of eggplant leaves, causing small yellow patches on leaves. Infested leaves curl upwards along the margin. Under heavy attack, leaves turn yellow and then brown and dry, giving a burned appearance. Fruit setting may be very low. Leafhoppers multiply rapid during dry spells and can cause extensive damage.

Leafhopper
Adults are small, about 2.5 mm long. Picture shows the leafhopper *Empoasca fabae* (related species).

What to do:

- **Spray neem products. Commercial and simple (home-made) neem products give control of leafhoppers on eggplants. Thus, an aqueous neem seed extract (10g/l) sprayed at 10 days interval showed repellent effects against leafhoppers (Empoasca) in India. Weekly applications of aqueous neem kernel extracts (6 to 50g/l) and of neem oil (5 to 10 l/ha) controlled the leafhopper, Jacobiasca facialis, in Togo (Osterman and Dreyer, 1995). In Sudan, the commercial products (Neem-Azal-T/S and neem oil-Rimulgan), and home-made neem products (50g/l) controlled leafhoppers on potatoes and eggplants.Control was improved when the neem extract was applied with a pre-pressurised knap sap sprayer**

instead of a palm leaf brush (El Shafie, 2001).

Aphids (*Aphis gossypii*)

Aphids are found in groups on the under surface of young leaves. When numbers increase they can move to upper leaf surfaces, stems and flowers. Aphids, in particular the cotton aphid, can become important pests in the cool dry season.

What to do:

- **Spray neem products. They have a repellent effect and have been effective in reducing numbers of the cotton aphid on eggplants. Effective treatments included foliar sprays with aqueous extracts of neem seeds, kernel and neem cake at concentrations of 10 to 50 g/l, and 3% neem oil applied at 10 days intervals. Bare root dipping with 50g/l aqueous neem kernel seed extract, 3% neem oil and a 10 g/l aqueous neem cake extract have also been effective (Ostermann & Dreyer,1995).**

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

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More Information on Aphids

Spider mites (*Tetranychus* spp.)

Spider mites may become serious pests of eggplant during the dry season. Attacked leaves show a stippled appearance (white specks), and their surface covered with a fine web. Continuous infestation causes the leaves to dry-up. The plants are stunted

and yields reduced.

What to do:

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

Spider mites
Spider mites on cotton leaf. They are very tiny (they rarely exceed a size of 0.5 mm)

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More Information on Spider mites

Epilachna beetles (*Epilachna* spp.)

The adult beetle is oval in shape, about 6 mm in length and reddish brown in colour with black spots on their backs. They look very similar to the beneficial ladybird beetles (predators), but the body of this pest ladybird beetle is covered with short, light coloured hairs, which give them a non-glossy or matt appearance. The larvae are pale yellow and covered with branched spines.

Epilachna beetles

They feed on the leaves of eggplants by scraping the surface and eaten the leaf tissue between the veins reducing the leaves. Attacked leaves may be completely stripped to the mid-veins to skeletons. They may also feed on fruits causing small shallow hollows on the fruit surface. High numbers of these beetles can cause considerable damage.

What to do:

- **Hand pick and destroy adults and larvae. This is feasible in small plots.**
- **Spray neem products. Neem extracts have repellent effects on these beetles. For instance, sprays with an aqueous neem seed extract (10g/l) at 10 days intervals showed repellent effect on Epilachna beetles in India (Ostermann and Dreyer, 1995).**

Epilachna beetles (*Epilachna* spp.) larvae and pupae on eggplant. Larvae are about 6 mm long.

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Eggplant lace bug (*Urentius hystricellus*)

It is a small bug (about 3 mm in length), brownish in colour. Its body is covered with spines and the wings show a distinct lace-like appearance. Nymphs resemble adults, but are initially wingless, developing wings as they grow. Both adults and nymphs are usually found in groups on the underside of leaves. They suck sap from the leaves causing whitish to yellowish mottled patches on the leaves. In case of serious infestations the leaves turn entirely yellow and drop off. Attacked leaves are speckled with small black shiny spots, which are the faeces of

Lace bug
Close-up of an adult of the eggplant lace bug (*Urentius*

the bugs.

What to do:

- **Spray neem products. They have given effective control of lace bugs on eggplants. The lace bug (Urenthius sp.) was repelled from eggplant plots treated with neem oil (5, 10 and 20%). However, concentrations of 10 and 20% showed phytotoxic effects.**
  Weekly sprays of an aqueous neem seed extract (50 g/l) and 2% neem oil gave good results against another species of lace bug (Corythaica cyathicollis) attacking eggplant in the Caribbean (Ostermann and Dreyer, 1995).

***hystricellus*). Real size: 3 mm in length.**

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Shoot and fruit borer (*Leucinodes orbonalis*)

It is a major pest of eggplant. The adult is a small moth, with a wingspan of 18-24 mm, white in colour with a pink and bluish tinge, and a few brown spots on its wings. Moths lay creamy white single eggs on leaf undersides, stems, flower buds, or the basefruits. Upon hatching the caterpillars (white in colour) bore into the top section of fruits and tender shoots. Caterpillars develop inside fruits and stems reaching a length of 15-18 mm. When fully-grown, caterpillars make a small hole in the fruit or shoot and drop to the soil and pupate among fallen debris.

When plants start bearing fruits, most caterpillars prefer to feed on the tender fruits. The damage to the shoots is not seen until they droop as a result of the caterpillar feeding inside them. Recently damaged fruits are not easy to detect. The first indication of damage to the fruit is a small hole just below the calyx where the insect has entered. Fruits are filled with frass. They change colour and taste; they drop off and are unmarketable. Caterpillars are

difficult to control with pesticides. Within hours of hatching from eggs, caterpillars enter the shoots or fruits, and are not reached by contact pesticides.

What to do:

- **Conserve natural enemies. Predatory ants are the main natural enemies of the shoot and fruit borer. Other natural enemies include: ladybird beetles, praying mantis, earwigs, predatory bugs and spiders**
- **Destroy eggplant old plants and stubble (burn or bury them) immediately after harvest. Pupae can survive in the stubble for several weeks, infesting the new crop.**
- **Use healthy, pest-free seedlings. Raise seedlings far away from sources of infestation (old eggplant fields, eggplant stubble)**
- **Grow seedlings under nylon netting to prevent moths from laying eggs on the plants.**
- **Remove and destroy infested shoots (readily visible as dry tip of branches). Burn, shred into tiny pieces or bury attacked shoots at least 20 cm in the soil. If this is done by all farmers in a community, especially before fruiting, pest infestation and damage can be drastically reduced. Continue cutting attacked shoots at least once a week until the final harvest.**
- **Destroy infested fruits found during harvest.**

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Fresh Quality Specifications for the Market in Kenya

The following specifications constitute raw material purchasing requirements.

PRODUCE:	Aubergine
IMAGE:	
VARIETY:	Various
General appearance criteria	
COLOUR	Dark purple skin, darker in the centre and white at the ends; green stem and calyx; cream to white flesh; white seeds.
VISUAL APPEARANCE	Smooth, glossy skin; small, soft flattened seeds embedded in flesh; short, clean-cut stem retained; coarse, bristly calyx; free from foreign matter.
SENSORY	Firm to slightly spongy texture; mild flavour with little aroma before cooking; free from foreign and 'off ' smells or tastes.
SHAPE	Approximately cylindrical, may be slightly curved or bent, tapering to a blunt point at the blossom end.
SIZE	170 - 250 mm long; as per requirements.
MATURITY	Not with strong, bitter flavour or dark brown seeds (over mature).
INSECTS	With no evidence of live insects or insect infestation.

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Cabbage/Kale, Brassicas
Scientific name: *Brassica spp.*
Order/Family: Capparales: Cruciferae/Brassicaceae
Local names: Kenya: Sukuma wiki (kale)
Common names and related Brassicas: Cabbage, kale, choumolea, Chinese cabbage, cauliflower, rape, broccoli, Brussels sprouts, kohlrabi, savoy, turnip.
Pests and Diseases: Alternaria leaf spot Aphids Bacterial soft rot Bagrada bug Black rot Cabbage looper Cabbage moth Cabbage webworm Cauliflower Mosaic Virus Cercospora leafspots Clubroot Cutworms Damping-off diseases Diamondback moth (DBM) Downy mildew Leafmining flies (leafminers) Powdery mildew Sawflies Snails (Giant East African Snail) Thrips Turnip Mosaic Virus (TuMV) White rust Whiteflies

General Information and Agronomic Aspects

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

Geographical Distribution of Cabbage/Kale and Brassicas in Africa

Brassicas constitute the majority of cultivated Cruciferae in eastern and southern Africa. The main brassicas grown in the region include:

- **Cabbage (*Brassica oleracea* L. var. *capitata*)**
- **Kale (sukumawiki) or choumolea (*B.o. acephala*)**
- **Chinese cabbage(*B. campestris chinensis/pekinensis*)**
- **Cauliflower (*B.o botrytis*)**
- **Rape *B.carinata* (indigenous), and *B.napus*, (exotic type).**

Other brassicas grown in the region are broccoli, Brussels sprouts, kohlrabi, savoy and turnip.
Also grown in the region are radish (*Raphanus sativus* L. var. *hortensis*) and horseradish (*Armoracia rusicana* Gaertn.)

These vegetables are grown mainly for the local market. They are valuable as sources of vitamins and minerals, as well as a source of cash for smallscale farmers in rural and peri-urban areas. However, production is often constrained by damage caused by a range of pests (insects, diseases, nematodes and weeds).
The range of pests attacking the different brassicas is similar, but the relative importance of individual pest species varies between the different crops.

Cabbage is mainly sold fresh or as processed canned product. Processed products include those that are treated in vinegar, or fermented such as sauerkraut or kimchi. Fresh cut or lightly processed products include coleslaw and ready-to-eat salad mixes that contain shredded cabbage. Consumers generally prefer fresh green cabbage, when available, to stored cabbage. Much of the storage cabbage is grown for processing.

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)
Broccoli	32	3.6	5.9	1.1	103	78	1.1	382	2500
Brussel Sprouts	45	4.9	8.3	1.2	36	80	1.5	390	550
Cabbage White	24	1.3	5.4	0.7	49	29	0.4	233	130
Cabbage Red	31	2.0	6.9	0.7	42	35	0.8	268	40
Cabbage, Savoy	24	2.4	4.6	0.8	67	54	0.9	269	200
Cabbage, Chinese	14	1.2	3.0	0.7	43	40	0.6	253	150
Cauliflower	27	2.7	5.2	0.9	25	56	1.1	295	60
Kale (Sukuma wiku)	53	6.0	9.0	1.5	249	93	2.7	378	10000
Kohlrabi	29	2.0	6.6	1.0	41	51	0.5	372	20
Radish	17	1.0	3.6	0.8	30	31	1.0	322	10
Turnip, Greens	28	3.0	5.0	1.4	246	58	1.8	-	7600
Turnip, Roots	30	1.0	6.6	0.7	39	30	0.5	268	Trace

Climate conditions, soil and water management

Cabbage is a biennial plant that grows best under full sunlight. The optimum mean temperature for growth and quality head development is 15-18°C, with a minimum temperature of 4°C and a maximum 24°C. Generally, young plants are more tolerant to heat and cold than plants nearing maturity. For seed production cabbage plants need to pass through vernalisation: continous days with temperatures at 1.7-10 °C before they start bolting. Broccoli and cauliflower produce seed without vernalisation.

Cabbage grows well on a wide range of soils with adequate moisture and fertility. Soil pH in the range of 6.0-6.5 is preferred, but cabbage will tolerate a soil pH range of 5.5 to 6.8. Cabbage is a heavy feeder, so to get good yields, proper fertilisation is necessary.

To maintain growth, cabbage requires a consistent supply of moisture, and should as a general rule receive a minimum of 2.5 cm of water per week. Larger quantities may be required when cabbage is grown on sandy soils or when evapotranspiration is high.

Nutrient deficiencies

Growing healthy plants is the best way of avoiding problems. Healthy plants grow on a healthy and well nourished soil with a good texture. Good compost is the best and most balanced soil and plant feed available to farmers. Regardless of soil type, excessive N (nitrogen) can promote second growth and split heads. A high level of nitrogen will also shorten storage life of cabbage and promote pungent odour (strong smells) during cooking.

Combined with high temperatures, excess N (nitrogen) can promote such rapid growth that plants show symptoms of tip burn in susceptible cultivars. Depressed yields, delayed maturity, reduced keeping quality and strong or objectionable flavours are indicative of N deficiency. Like

most cruciferous crops, cabbage has a high requirement for *boron* and *molybdenum*. Boron deficiency causes yellowing or chlorosis of the youngest leaves and stems, which often starts from the base and extends to the tip, hollow and discoloured inside stems of broccoli and cauliflower, and hollow and/or shrunken roots of turnips.

Rosetting or even death of terminal shoots or buds occurs in extreme cases. The common symptoms of *molybdenum deficiency* in cabbage include a general yellowing, marginal and interveinal chlorosis, marginal necrosis, rolling, scorching and downward curling of margins usually on older leaves. Compost and well rotted animal manures are good sources of most micronutrients including *boron* and *molybdenum*.

Land preparation and management

- **Prepare land well before transplanting**
- **Avoid field operations when it is wet. This will help to prevent inadvertent spread of diseases from plant to plant and movement of infested soil within and outside the field**
- **Keep fields free of weeds. Especially weeds of the brassica family are potential alternative hosts of insect pests and diseases and are nutrient competitors**
- **Ensure optimal fertilisation. Cabbage has a very shallow root system and is particularly responsive to phosphorus. Where the soil has a low phosphorus content the application of 'Mijingu Rock Phosphate' is recommended**

Propagation and planting

Seedlings:

- **Practice crop rotation: site seedbeds on land not previously under crucifers, and preferably away from old crucifer fields**
- **Use clean wooden trays to raise seedlings, use mixture of compost and top soil or forest**

soil for raising seedlings

- **Heat soil in the seedbed: place plenty of crop trash or straw and burn for at least 30 min, and after cooling, mix the soil with compost in equal proportions**
- **Use certified disease free seed of resistant/tolerant cultivars**
- **Mulch seedlings in the seedbed, if possible**
- **Do not over water seedlings in the seedbed: water seedlings early in the morning and thin out seedlings to avoid plant congestion in the seedbed. Excessive watering is conducive to damping-off diseases, and extended wetness of seedlings favours development of foliar diseases**

Seeds:

Treat own seed in hot water to prevent seed borne diseases such as black rot, black leg, black spot and ring spot is recommended where these diseases have appeared before (pls see further below the symptoms of the diseases). Hot water treatment of seeds helps reduce the seedborne pathogens. However, the specified temperature and time interval should be strictly followed in order to maintain seed viability. Use a good thermometer or better ask for assistance from qualified personnel from your local agriculturist office.

Recommended temperature and time for hot water treatment for broccoli, cabbage, cauliflower, kale kohlrabi and turnip is 50°C (122 F) for 30 minutes.

For more details on hot water treatment click here

Husbandry

Raised beds and conservation tillage

- **Cabbage is often planted on raised beds that are shaped from bare soil after ploughing and disking. This technique is popular on level soils where furrow irrigation is also used. Bed culture is also used in other areas to improve soil drainage or when plastic mulch is used. The**

trend has been toward increased use of conservation tillage, particularly on steeply-sloping soils prone to erosion. Producing cabbage using conservation tillage reduces the number of field passes by farm equipment, thus reducing compaction, preserving equipment and conserving fuel.

- **Conservation tillage systems cause minimum disturbance to the soil after the previous crop has been harvested. Crop residues are left in the field to reduce soil erosion, conserve moisture, inhibit weed growth, and act as green manure. There are several types of conservation tillage in use, as well as combinations of conservation and conventional tillage. However, in disease management, crop residues must be either removed from the field and destroyed or deeply ploughed to reduce sources of disease infection and spread.**
- **Advantages of conservation tillage for cabbage production include less machinery, labour and fuel, as well as reduced soil erosion and compaction. Disadvantages of conservation tillage include lower soil temperatures, slower germination and emergence when direct sowing is used, slower early growth, delayed competition with weeds, higher incidence of root diseases, heavier crop residue, the possibility of more difficult planter operation, weed spectrum changes, and potential increase of soil insect pests or insects that spend part of their life cycle in the soil (e.g. cutworms, thrips, leafmining flies, grubs). Cultivation exposes these pests to desiccation by the sun heat and to predation by natural enemies**

Intercropping

- **Intercrop brassica crops with trap crops or repellent plants, to reduce pest infestation. Tomato reportedly repels diamondback moth and Indian mustard acts as a trap crop. Intercropping brassicas with spinach, beans or dill reportedly reduces aphid infestation.**
- **Cabbage when planted 14 days after tomatoes reduces the incidence of and damage by diamondback moth. Cabbage intercropped with tomato, coriander or garlic, combined with the application of neem seed kernel extract protects plants from diamondback moth in the field. Indian mustard, Chinese cabbage, and radish are good trap crops for controlling cabbage**

webworm, flea hopper, and mustard aphid when planted in every 15 rows of cabbage. The mustard row is either in the outermost or in the middle row to avoid caterpillars being blown by wind into the cabbage plants. To control cabbage head caterpillar, Indian mustard should be planted 12 days before transplanting cabbage. Do not plant cabbage where members of the cabbage family have been grown for 3 consecutive years to avoid serious problems of pests and diseases (especially soil borne diseases). Intercropping with certain combinations will have a beneficial effect on reducing pest damage in crucifer areas.

Monitoring

It entails regular field observation during the crop production cycle for pests, diseases, weeds and general aspects of crop health like nutrition and water requirements. Field monitoring methods are virtually the same, but most importantly, in the process is problem recognition. Thus it is very important to be able to identify pests and diseases and to differentiate a pest from a beneficial insect, a pest damage from disease damage, and a pest or disease damage from nutritional problems or physiological disorders.

- **Monitor fields regularly for pest and disease occurrence. Early detection of pests and diseases is important as outbreaks are easier controlled in the initial stages. Cutworms and other insects can do a lot of damage in just one or two days.**
- **Scout for caterpillar presence: feeding damage and caterpillar excrement give an indication of their activity. Scouting can be done by walking in a zigzag pattern through the field.**
- **Check for aphids and whether parasitised aphids (mummies) and natural enemies such as ladybird beetles and lacewings are present. Since aphid populations are often clustered, all portions of the field should be checked. For more information on natural enemies click here.**
- **Scout for the major brassica diseases**

Harvesting

Cabbage is often hand-harvested when heads are firm to the touch but before cracking begins. With hand harvesting, a given field is harvested two to four times to obtain heads of uniform size and maturity. Only one to three harvests of hybrid cultivars are required because of their greater uniformity. Use of uniform transplants and consistent growing conditions also helps reduce the number of harvests. Yields will vary with the season of production, cultivar, and production system used. With proper management, cabbage can produce 10-12 tons per acre. Generally, most fresh markets prefer heads that weigh on average 2-5 pounds (1-2,5kg). For processing into coleslaw or sauerkraut, or for long-term storage, larger-headed cultivars are used.

Field sanitation

Remove crop residues immediately after harvest and also remove volunteer plants fom the field.

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Information on Pests

The major pest constraints of brassicas in Africa were identified as the diamondback moth (DBM), cabbage aphids, cabbage webworm and Bagrada bugs.

Aphids

Several species of aphids attack brassicas in East Africa:

- **The cabbage aphid (*Brevicoryne brassicae*)**
- **The false cabbage aphid (*Lipaphis erysimi*)**
- **The green peach aphid (*Myzus persicae*)**

In particular the cabbage aphid is a major pest in the region. Cool, dry weather is most favourable for aphid development. Large numbers of aphids may kill small plants. Their feeding can distort leaves of older plants and causes leaf curl.
Often, the most serious problem associated with aphids is virus transmission. The cabbage aphid and the false cabbage aphid are vector of diseases such as cabbage black ring spot, cabbage ring necrosis, and mosaic diseases of cauliflower, radish and turnip.

Cabbage aphids
Colony of the cabbage aphid (*Brevicoryne brassicae*) on kales. Cabbage aphids are about 1.5 - 2.5mm in size.

© A. M. Varela, icipe



Cabbag ap... **Cabbag ap...** **Cabbag ap...**

More Information on Aphids

What to do:

- **Aphid colonies in the heads of cabbage are almost impossible to remove before marketing. Natural enemies can provide control, but they usually do not build up fast enough to keep heavy aphid populations below damaging levels. Extensive use of broad-spectrum insecticides like pyrethroids might induce resistance development in aphids and will eliminate natural enemies. For more information on natural enemies click here.**
- **Insecticidal soaps provide control, and spot sprays of pyrethrum or neem can prevent build up of large populations.**

Sawflies (*Athalia* spp)

Sawflies are sporadic but serious pests of brassicas. The cabbage sawfly (*Athalia sjostedti*) has been reported as a major pest in Tanzania. Sawfly adults are wasps with dark head and thorax, bright yellow abdomen, and two pairs of membranous wings. They are about 1 cm long. Eggs are laid singly inside the leaf. Larvae are oily, black or greenish in colour with a swollen part just behind the head, which makes them appear humped. They look very similar to caterpillars, but they have 6 to 9 pairs of prolegs (abdominal legs), whilst caterpillars have 5 pairs or less. Larvae measure up to 2 cm when fully grown. Larvae eat the blades of leaves leaving just the main veins. They drop from the plant to pupate in the soil.

Sawflies larvae
Sawfly larva (*Athalia* spp) and damage on horseraddish

© A. M. Varela, icipe


Sawflie l... **Sawflie a...**

What to do:

- **Destruction of wild plants of the family of cabbages in the vicinity of the crop.**
- **Ploughing in of volunteer plants at the end of the season help reduce sawfly populations.**
- **Manual collection and destruction of larvae is feasible when there are few sawflies on the crop.**

Diamondback moth (DBM) (*Plutella xylostella*)

It is a serious pest of brassicas and attacks all Brassica species. A full grown diamondback caterpillar is about 1 cm long.

What to do:

- **To control DBM in small size farms, cover seedlings with row covers (fine nylon mesh) to prevent moths from laying eggs on the leaves and or next to the plant.**
- **Intercropping brassicas with trap plants such as Indian mustard, and repellent plants such as tomato, reportedly reduces DBM infestation in cabbage. In the case of Indian mustard, control measures are directed at DBM on the trap crop. When intercropping with tomato, the cabbage crop is planted 30 days after tomato.**
- **Biological control of DBM using parasitoid wasp Diadegma semiclausum has proven very effective in the highlands of Kenya, Tanzania and Uganda.**
- **Botanicals such as neem-based pesticides are very effective for control of DBM.**
- **Also Bt sprays are effective against DBM. For more information on Bt click here**

Diamondback moth
Diamondback moth damage on cabbage

© A. M. Varela, icipe


Diamor **Diamor**

More Information on Diamondback moth (DBM)

The cabbage looper (*Trichoplusia ni*)

The cabbage looper is a green caterpillar with faint white stripes along the body. Caterpillars are about 3.5 to 4 cm long when fully-grown. As they move, they arch their back in a looping fashion, hence the common name looper. Larvae (caterpillars) chew holes in the leaves, and larger caterpillars consume great amounts of plant material. On cabbage they eat into the heads,

reducing the marketability of the produce.

The adult is a moth, ca 2.5 cm in length and mottled, greyish-brown.

What to do:

- **Conserve natural enemies. These caterpillars are attacked by a large numbers of natural enemies, including parasitic wasps and flies. Birds and bats feed on the adults (moths).**
- **Pick caterpillars by hand and destroy them.**
- **When control is necessary use biopesticides such as neem-based products or Bt. Neem products control cabbage looper by interfering with the growth of the young caterpillar. Bt and neem should be applied when caterpillars (larvae) are still in the early growth stages.**
  For more information on neem click here.
  For more information on Bt click here.

Cabbage looper, caterpillar
Cabbage looper on cabbage. The first instar larvae is white and almost clear with a black head capsule. Later instars are green with a thin white line on each side. Mature larvae reach 3 to 4 cm in length.

© A.M. Varela, icipe


Cabbag lo... **Cabbag lo...**

More Information on Cabbage looper

The cabbage webworm (*Hellula undalis*)

Caterpillars are 1.5 cm when fully-grown, creamy-white in colour with brown stripes along the body and a brown head. Caterpillars feed on leaves, petioles, growing points, and stems.

What to do:

- **Use neem-based products and Bt.**

Cabbage webworm caterpillar (*Hellula undalis*) and damage on a kale leaf.

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More Information on Cabbage webworm

The cabbage moth (*Crocidolomia pavonana* (=*binotalis*))

Cabbage moth larva: When fully grown (1.6-1.9 cm long), larvae move to pupate in the soil. The pupal stage lasts about 10 days. It is primarily a pest of brassicas and is occasionally an important pest of cabbage and kales. Mature caterpillars measure 1.2-1.6 cm in length. Caterpillars are found in groups. Young caterpillars chew off top leaf surfaces, while older caterpillars feed under a web of silk on young leaves, petioles and growing point of the plant, often damaging it entirely.

What to do:

- **Spray with neem extracts and Bt.**

Cabbage moth larvae When fully grown (1.6-1.9 cm long), larvae move to pupate in the soil. The pupal stage lasts about 10 days.

© Ooi P. Courtesy of

Ecoport (www.ecoport.org)



Cabbag mo… Cabbag mo… Cabbag mo…

More Information on Cabbage moth

The Bagrada bug (*Bagrada hilaris*)

It is typically shield-shaped, 5-7mm long and 3-4mm wide. The upper surface has a mixture of black, white and orange markings. Feeding by sucking by both adults and nymphs causes damage to leaves, which wilt later and dry. A heavy attack on young plants generally results in death of the plant.

What to do:

- **Crop hygiene including destruction of weeds of the family Cruciferae prevents population build-up.**
- **Remove bugs by hand.**

Bagrada bug
The adult bagrada bug (*Bagrada hilaris*) is typically shield-shaped, 5-7mm long and 3-4mm wide. The upper surface has a mixture of black, white and orange markings.

© F. Haas, icipe



Bagrad bu... Bagrad bu... Bagrad bu...

More Information on Bagrada bug

Cutworms (*Agrotis* spp)

Cutworms cut the stem of plants below the soil surface. The damaged plant wilts and withers. First instars are 0.7-1 cm, later instars are 3.5-5 cm long.

What to do:

- **Cutworm damage is usually minor and does not warrant control measures. When damaged plants are detected, the cutworms normally can be found near the damaged plant and can be removed by hand.**

Cutworm
Cutworm (*Agrotis* sp.

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More Information on Cutworms

Leafmider, Leafmining flies (*Lyriomiza brassicae*)

Leafmining flies are small flies, 1.3-1.6 mm in length. Maggots of leafmining flies cause mines while feeding within the leaf. Small,

individual leafminers do not produce much damage, but when larvae occur in large numbers, entire leaves can be eaten out. Heavy attacks on seedlings weaken them and may result in dying off of young plants.

What to do:

- **Leafminers are usually well controlled by existing natural enemies, particularly parasitic wasps. However, this balance can be disrupted by the use of non-selective pesticides.**

Leafminer
Mines cause by maggots, and a pupa of leafminer flies (*Lyriomiza brassicae*)

© A.M. Varela, icipe
More Information on Leafmining flies (leafminers)

Thrips (*Thrips tabaci Frankliniella* spp)

Thrips feeding on cabbage cause rough bronzed blisters on leaves inside the cabbage head. hey are less than 2 mm long. Thrips attacks are not common on brassicas in the eastern and southern Africa region.

What to do:

- **Plough and harrow before transplanting. This can be useful in reducing thrips attacks by killing pupae in the soil.**

Thrips
Thrips damage on lower surface of cabbage leaf.

- **Conservation of natural enemies, such as predatory bugs, predatory mites and predatory thrips are important.**

Note rough brown patches and small dark spots (*thrips faeces*)

© A.M. Varela, icipe
More Information on Thrips

Whiteflies (*Bemisia tabaci, Trialeurodes vaporariorum* and *Aleyrodes proletella*)

Whiteflies feed on brassicas. Adult whiteflies are about 1 mm long.
In East Africa whitefly populations on brassicas usually do not build up to such an extent that control measures are required.

What to do:

- **Natural enemies such as ladybird beetles, predatory mites and lacewings can play an important role in reducing whiteflies. For more information on natural enemies click here.**
- **The application of high doses of nitrogen fertiliser favours development of the pest.**
- **Use mineral oils and neem. For more information on neem click here.**
- **Spray with soapy water solutions.**

Cabbage whitefly
Adults and eggs of the cabbage whitefly (*Aleyrodes proletella*).

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More Information on Whiteflies

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Information on Diseases

The most important diseases are blackrot, blackleg, black spot and Turnip Mosaic Virus.

Black rot

Black rot is caused by the bacterium *Xanthomonas campestris* pv. *campestris*, and is one of the most serious cabbage diseases in warm climates. The black rot bacterium can over-season on infected cabbage seeds, in weeds from the family Cruciferae (including: black mustard, field mustard, wild turnip, wild radish, shepherd's purse, and pepperweed); or in infected plant material in the soil.

Bacterial black rot
Black rot on cabbage. Characteristic yellowish V-shaped areas at the leaf margin, sites of infection by black rot, *Xanthomonas campestris* pv. *campestris*.




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

What to do:

- **Disease-free transplants should be used or seeds must be treated with hot water treatment as described below.**
- **Hot water treatment of own seed to prevent seed borne diseases such as black rot, black leg, black spot and ring spot is recommended where the disease has appeared before. However, the specified temperature and time interval should be strictly followed in order to maintain seed viability. Use a good thermometer or better ask for assistance from qualified personnel from your local agriculture office. Recommended time for heat treatment for cabbage:**

122°F/50°C: 30 minutes, for broccoli, cauliflower, kale, kohlrabi, turnip:122°F/50°C: 30 minutes.
For more details on hot water treatment click here.

- **Establish crops in black rot-free soils that have not grown crops from the family Cruciferae for at least 3 years.**
- **Growing cabbage on raised beds with mulching helps eliminate conditions that induce black rot.**
- **When possible, remove, burn, or deep plough all crop debris immediately after harvest to reduce the ability of the bacterium to survive in the soil where there is no crop.**

More Information on Black rot

White rust (*Albugo candida*)

It affects every known cruciferous crop. However, this disease is generally less common on cabbage, Brussels sprouts, broccoli and cauliflower than on radish, horseradish, mustard and turnip. Leaves have chlorotic or necrotic spots on their upper surface. Pustules form on the lower side of the leaves, small stems and floral parts.

What to do:

- **Clean up crop refuse and destroy cruciferous weeds.**
- **Crop rotation of at least three years can help reduce the disease.**

White rust
White rust on kales. Note pustules on the lower side of the leaf

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Alternaria leaf spot

Alternaria leaf spot or black spot is caused by the fungus *Alternaria brassicae*. The disease can severely damage cabbage if uncontrolled. The initial symptoms are small, circular, dark spots on older leaf surfaces. As the spots enlarge, concentric rings develop within lesions surrounded by a yellow halo. The tan-coloured centres of lesions may eventually fall out, producing a hole, or under wet conditions, may become covered with masses of black spores. In storage, spots enlarge and soft-rot bacteria may enter lesions.
The pathogen can over-season on crop debris. Weeds from the family Cruciferae may also harbour the fungus. Spores of Alternaria can be spread by wind and water. The disease is most damaging under wet, warm (20-30.5°C) conditions.

Alternaria leaf spot/Black spot
Cabbage black spot - The spots darken with age, and the centers may become thin and papery or drop out, to produce a shot-hole effect.

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


Alterna Alterna

What to do:

- **Cabbage should never be grown in fields where other Brassica crops have been grown in the past 3 years.**
- **Always remove infected plant debris or destroy it after the season.**
- **Use disease-free transplants.**
- **Crop rotation will reduce the severity of black spot disease.**
- **Hot water treatment of own seed to prevent seed borne diseases such as black leg is recommended where the disease has appeared before.**
  For more details on hot water treatment click here.

Clubroot

Clubroot caused by the slime mould fungus *Plasmodiophora brassicae* is particularly serious in Malawi. Its distinctive symptom is an abnormal enlargement of roots or even the underground stem. Its development is favoured by wet, cool, acidic soils.

What to do:

- **Practise crop rotation.**
- **Irrigate properly.**
- **Adjust pH to 7.2 with hydrated lime**

Clubroot
Clubroot on cabbageNote warty growth in the root system

Bacterial soft rot

Bacterial soft rot is caused by *Erwinia carotovora* var. *carotovora*. It is quite common on Chinese cabbage in the field. On cabbage, turnip and rutabaga the disease may be found in the field, but is most severe during storage. On cabbage, an initial infection occurs on the outer petiole (leafstalk) which is in contact with the soil, and then progresses to its head. An infected head is watery and often has a complete head rot. The affected area becomes soft and mushy and generally turns dark in color. Soft rot infection on crucifers almost always emits a foul odor. Eventually the leaves, sterns and roots are entirely decayed by the bacteria. The bacterium is spread in the field by water splashes or contact with tools such as hoes or knives. If

Bacterial soft rot
Bacterial soft rot. Note slimy rot (whitish) of the centre of the cabbage head

contaminated knives are used to harvest cabbages, the stored crop may also rot quickly.

What to do:

- **Plant on ridges or raised beds to prevent waterlogging around the plants.**
- **Prevent other diseases (e.g. black rot; damping-off) or damage that may provide opportunities for soft rot to develop.**
- **Avoid harvesting when conditions are warm and moist. These conditions favour the development of soft rot.**
- **Harvest healthy cabbage heads first and store in a cool, dry, airy place.**
- **Wash hands and harvesting knives.**
- **Remove and destroy diseased crop or left over stems in the field after the crop has been harvested.**
- **Avoid growing brassica crops in the same field for a period of at least three seasons.**

Cercospora leafspots

Cercospora leafspots is caused by the fungus *Cercospora brassicicola*. Leafspots vary in color from pale green to white and generally are bordered by brown tissue. They may be circular or appear angular. Severely affected plants may become defoliated (Kühn). This disease is not economically important in the East African region.

Cercospora leaf spot

What to do:

- **Use certified disease-free seed and, in case of using own seed, hot water treat the seed. For more information on hot water treatment click here**
- **Practise proper weed management, particularly, cruciferous weeds such as mustard.**
- **Remove crop residues from the field after harvest.**

Cercospora leaf spot on soybean

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

Cauliflower Mosaic Virus (CaMV)

It shows systemic symptoms such as a clearing along the leaf veins (vein clearing). This often is seen first at the base of a leaf. Later symptoms appear as dark green areas along veins (vein banding) and necrotic spotting of the leaf. Chinese cabbage is particularly susceptible to CaMV. In addition to vein clearing a striking mosaic may develop with light and dark green areas seen on the leaves. Plants can be stunted. The main source of CaMV are plants of an infected brassica crop or cruciferous weeds on which a vector has over-seasoned. The virus is transmitted by many species of aphids, such as the cabbage aphid.

Cauliflower Mosaic Virus Cauliflower mosaic virus on kales

© A. M. Varela, icipe

What to do:

- **Adequate weed control and sanitation should be practiced.**
- **Plough-down previous crops rapidly.**
- **Transplant beds should be isolated from commercial crop fields and overwintering cruciferous weed hosts.**

Damping-off diseases (*Pythium, Rhizoctonia, Fusarium*)

In crucifers, several fungi (e.g. *Pythium, Rhizoctonia, Fusarium*) can cause damping-off diseases.

Characteristic is wirestem of seedlings caused by *Rhizoctonia solani* in the seedbed, bottom rot and head rot in the field, and storage and root rot of horseradish, radish, rutabaga and turnip.

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

What to do:

- **Use certified disease-free seeds. If using own seed, treat seeds with hot-water, if necessary. For more information on hot-water seed treatment click here**
- **Practice proper irrigation, avoid planting in wet, cold soils**
- **Plant on raised beds to reduce moisture content in the root zone and provide the appropriate drainage in the field to prevent waterlogged conditions**
- **Practice crop rotation: seedbeds and production fields should not have had crucifers for at least 3 years. All seedlings with wirestem symptoms should be discarded. During cultivation, take care to avoid throwing soil into plant heads.**

Damping-off disease Damping-off (*Rhizoctonia solani*) on brassica.

© McKenzie, LandCare Ltd., Courtesy of EcoPort


Dampir of... **Dampir of...**

More Information on Damping-off diseases

Turnip mosaic virus (TuMV)

The first symptoms to develop when Brassica seedlings are

inoculated with TuMV are chlorotic spots on inoculated leaves, mottling followed by systemic vein clearing, mosaic and/or necrosis, leaf distortion and often stunting.

What to do:

- **Remove TuMV-infected plant debris and the eradicate infected plants around fields as this can help to reduce virus inoculum and hence spread.**

Turnip Mosaic Virus
Turnip Mosaic Virus symptoms on cabbage leaves

More Information on Turnip Mosaic Virus (TuMV)

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Other diseases

Importance of other diseases such as cottony rot (*Sclerotinia sclerotiorum*), downy mildew (*Peronospora parasitica*), powdery mildew (*Erysiphe polygoni*), ring spots (*Mycosphaerella brassicicola*) and yellows (*Fusarium oxysporum* f.sp. *conglutinans*) varies between and within countries and is primarily depending on weather conditions and crop husbandry.

What to do:

- **Treat own seed with hot water**

For more details on hot water treatment click here.

Powdery mildew on cabbage

© A.M. Varela, icipe

Ring spots on cabbage

© A. M. Varela, icipe

Downy mildew on cabbage. Symptoms on the lower leaf surface

© A.A. Seif, icipe

Cottony rot (*Sclerotinia sclerotiorum*) on a kale plant

© A. M. Varela

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Fresh Quality Specifications for the Market in Kenya

The following specifications constitute raw material purchasing requirements

PRODUCE:	Red Cabbage
IMAGE: © S. Kahumbu, Kenya	

PRODUCE:	KALE
IMAGE:	
VARIETY:	Various
GENERAL APPEARANCE CRITERIA	
COLOUR	Mid green leaves, may have purple, whitish or red tinge depending on variety; light green to white stems.
VISUAL APPEARANCE	Thick, loose leaves, usually curly., coarse texture; fleshy central rib; stems cut cleanly; free from foreign matter.
SENSORY	Moderately coarse texture; strong cabbage type flavour and aroma; may be slightly bitter; free from foreign and 'off ' smells or tastes.
SHAPE	Loose leaves supplied bunched or as whole plants, depending on variety.
SIZE	Leaves > 35cm long, bunches >30cm diameter at banding.
MATURITY	No evidence of flowering.
INSECTS	With no evidence of live insects or virus damage (e.g. slugs, insect larvae).

© S. Kahumbu, Kenya

PRODUCE:	Chinese Cabbage
IMAGE: © S. Kahumbu, Kenya	

PRODUCE :	Broccoli
IMAGE:	
VARIETY	Various
General appearance criteria	
COLOUR	With blue-green to purple-green florets; olive green leaves; light green stalks; white to cream cut flesh at base. Nil with brownish or reddish florets
VISUAL APPEARANCE	Fresh, compact heads; 3-6 narrow outer leaves retained; stalks with even, clean fresh cuts; no leaves growing through or above the head; no foreign matter.
SENSORY	With firm, crisp heads; pleasant flavour; no persistent 'off' odours or tastes
SHAPE	With compact, domed heads; tightly grouped branch lets, not loose or spreading; floret size relatively even over the head.
SIZE	Preferred Head diameter is **8 – 14cm (small/medium).** Stalk length: trimmed, per requirements, cut not >20mm below the join (lower side) of bottom lateral to main stalk.
MATURITY	Full firm stalks, no evidence of bud opening (over mature).
INSECTS AND PHYSICAL DAMAGE	With no evidence of live insects, e.g. insect larvae, slugs, snails. With no broken or crushed branch lets, or with cuts or splits in the stems which break the skin.

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Groundnut
Maize
Mango
Millet

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Beans
Scientific name: *Phaseolus vulgaris* L.
Order/Family: Fabales: Fabaceae
Local names: Maharagwe / mishiri
Common names: Bush beans, common beans, dry beans, dwarf beans, field beans, French beans (also known as green beans or snap beans), garden beans, haricot beans, kidney beans, pole beans or string beans
Pests and Diseases: African bollworm Angular leaf spots Anthracnose Aphids Bean common mosaic virus Bean flies Bean rust Bean seed flies Bugs Common blight Cutworms Flower or blister beetles Foliage beetles Fusarium wilt Halo blight Leafhoppers Leafmining flies (leafminers) Powdery mildew Root-knot nematodes Snails (Giant East African Snail) Spider mites Storage pests Stripped been weevil Thrips Whiteflies

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General Information and Agronomic Aspects

Many names are used for *Phaseolus vulgaris*. These include bush beans, common beans, dry beans, dwarf beans, field beans, French beans, garden beans, green beans, haricot beans, kidney beans, pole beans, snap beans or string beans.

However, presently, two distinct bean types are recognized in the region: French beans (green beans) and common beans (dry beans). French

Geographical Distribution of Beans in Africa

beans are the immature green pods of *P. vulgaris* and are primarily grown for export market to European Union and elite local urban markets. Common beans are the second most important staple food to maize for the local people.

Beans were introduced to Africa from Latin America several centuries ago. To date beans is a vital staple in Africa, providing the main source of protein. Common beans are mainly grown by women for subsistence and for the local market. French beans (green / snap beans) are grown as a cash crop by large scale and smallholder farmers. They are a major export vegetable commodity in Eastern Africa. The main producing countries in the region are Kenya, Tanzania, Uganda, and more recently Rwanda. In Kenya, most of the crop is grown by smallholders and virtually all is exported to Europe. Estimates indicate that up to 50,000 smallholder families are involved in French bean production in Kenya.

The growth habit of common beans varies from determinate dwarf or bush types to indeterminate climbing or pole cultivars. Bush beans are the most predominant types grown in Africa. However, improved climbing beans introduced to Rwanda in the 80's have since spread to other countries in the region. They are particularly grown in areas with limited land and high human population.

Nutritive Value per 100 g of edible Portion

Raw Vegetable	Food Energy (Calories)	Protein (g)	Carbohydrates (g)	Ash (g)	Calcium (g)	Phosphorus (mg)	Iron (mg)	Potassium (mg)	Vitamin A (I.U)	T (
Green Bean	32	1.9	7.1	0.7	56	44	0.8	132	600	(
Bean,	340	22.3	61.3	3.9	144	425	7.8	1196	-	(

diseases/ weeds	**Mature Seed, Dry**										

Medicinal plants

Fruit and vegetable processing

Natural pest control

Cultural practices

Climatic conditions, soil and water management

Common beans grow within a range of temperatures of 17.5-27°C. Above 30°C flower buds are likely to fall and seeds are rarely formed at temperatures over 35°C. They are sensitive to night frost. Common beans are usually grown at altitudes between 600 - 1950 m in many tropical areas.

A moderate well-distributed rainfall is required (300-400 mm per crop cycle) but dry weather during harvest is essential. Drought or waterlogging are harmful. Climbing cultivars will give economic yields in areas of high rainfall but the dwarf types appear to be more sensitive to high soil moisture levels. Suitable soil types range from light to moderately heavy and to peaty soils with near-neutral pH and good drainage. Common bean is susceptible to salinity.

The optimum temperature range for growing French beans is 20-25°C, but can be grown in temperatures ranging between 14 and 32°C. Extreme temperatures result in poor flower development and poor pod set. However, French beans mature faster in warmer areas. French beans can be grown between 1000 and 2100 metres above sea level.
Rainfed cultivation is possible in areas with well distributed, medium to high annual rainfall (900-1200 mm) but to maintain a continuous production especially during the dry season, irrigation is essential. During the dry season up to 50 mm of water per week is required. This could be applied through furrow or overhead irrigation. French beans grow best on well drained, silty loams to heavy clay soils high in organic matter with pH 5.5-6.5.

Propagation and planting

Normal propagation is by seed but for special purposes stem cuttings can be rooted easily. French beans, grown for fresh consumption, canning or freezing should be planted at 2-3 week intervals in order to harvest all year round, but main export season for fresh beans is October to May. Hence planting for export at 2-3 week intervals should start mid-August and cease end February. Single rows of 30 x 15 cm (one seed per planting hole) or double rows 60x30x10 cm is used. For single rows it is advisable to plant in blocks of four single rows separated by a path of 50 cm for ease of management. Seed rate is 50-60 kg per hectare.

For good pest and disease management avoid planting French beans too close. A spacing of not less than 30x15 cm between the rows and within the row is recommended in Kenya. New plantings should be sited up-wind where continuous bean cropping is practiced. Plant maize, cereals or sunflower between French bean fields to minimize the spread of wind-borne diseases such as bean rust.

Plant population densities are 150,000 - 200,000 plants/ha for dwarf cultivars and half that for climbing types in sole cropping. In intercropping, densities are much lower. For climbing beans, 4-6 seeds are usually sown together in hills spaced 1 m apart. They may also be sown in rows at a spacing of 90-120 x 15-30 cm. Depth of sowing is 3-6 cm. Seed rate depends on seed size and intended plant population densities, up to 120 kg/ha for dwarf beans and 60 kg/ha for climbers in sole cropping. Climbing cultivars require support by stakes or trellis up to 2.5 m in height unless they are intercropped with tall plants such as maize or sorghum - an increasingly common practice in Kenya Rift Valley - the maize or sorghum plants acting as stakes for the bean plants.

Avoid planting beans near cowpea, soybean and many other leguminous crops, that may be the source of bean flies.

Commercial varieties of French beans available in Kenya

Variety	Resistance to diseases
Amy	Anthracnose / Common bean mosaic virus
Emelia	Anthracnose / Common bean mosaic virus / Halo blight
Julia	Anthracnose / Common bean mosaic virus
Lausanne	Anthracnose / Common bean mosaic virus
Paulista	Anthracnose / Common bean mosaic virus / Common blight /
Olivia	Common bean mosaic virus
RS 1389	Common bean mosaic virus / Bean rust
RS 1391	Common bean mosaic virus / Bean rust
RS 1518	Anthracnose / Common bean mosaic virus
Samantha	Anthracnose / Common bean mosaic virus
Tanya	Anthracnose / Common bean mosaic virus / Halo blight
Xera	Anthracnose / Common bean mosaic virus

Source: PIP Technical Itinerary French Beans. www.coleacp.org/pip

Husbandry

Beans are comparatively light feeders and require as a guide line about 25-35 kg P/ ha (equivalent to 1-2 bags of Mijingu rock phosphate/ha) and 75-80 kg K/ha. Like all legumes, beans are able to fix nitrogen from the atmosphere, so do not require nitrogen fertilisation. However a soil conducive to nitrogen fixing with the natural nitrogen fixing bacteria present is preferable.

Hard soils with little organic matter will not give good yields of beans, unless organic matter is provided, preferably in the form of good quality compost or well decomposed farmyard manure. For pure stands of beans it is preferable to construct slightly raised beds of maximum 1 metre width in order to limit soil compaction around the bean plants. Application of good compost in the beds will improve yields as it will improve nitrogen fixation.
Timely and thorough weeding is essential for French beans. The first weeding should be done 2-3 weeks after emergence followed by a second weeding 2-3 weeks later. During weeding slight ridging of plants will help bean plants withstand attack of bean flies.
Cultivating beans when the soil is wet encourages spread of soil borne diseases such as anthracnose and fusarium root rot.

Shallow tillage is preferred especially in the period before flowering as damage to the roots or the collar of the plant encourages soil borne diseases. Common bean can be rain-fed or irrigated. Irrigation is beneficial in semi-arid regions, with overhead irrigation preferred over flood irrigation. In peasant farming, the crop is seldom manured. Crop rotation is necessary to limit soil borne diseases such as bean rust, powdery mildew, anthracnose and fusarium root rot.

Fertilise the soil properly and plant French beans on hills or ridges where root rot could be a problem. Avoid furrow irrigation in areas prone to root rot and root-knot nematodes.

Mulching
(e.g. with straw and cut grasses) helps conserve moisture, promote adventitious root development and enhances tolerance to bean fly maggot damage.

Intercropping
Beans are excellent for intercropping with other food crops, such as maize, potatoes, celery, cucumber etc. and can help supply the other crops with nitrogen to a limited degree. Longer season varieties of beans can fix higher amounts of nitrogen than short season varieties.

Intercropping with chives or garlic helps repel aphids (KIOF - personal communication).

Water management

A regular water supply is essential for French beans as moisture affects yields, uniformity and quality. Water stress during flowering reduces yields, as does waterlogging. Irrigation in dry spells is recommended as 35 mm per week at planting and 10 days post emergence, followed by 50 mm per week thereafter till end of production.

Pest and disease prevention with EM or BM

EM and BM (Effective Microorganisms and Beneficial Microorganisms) have been shown to prevent many diseases and a few pests in various crops when sprayed on a regular basis. It is organically acceptable and quite cheap.

Harvesting / Storage

French beans are harvested before the pods are fully-grown. Harvest starts 7-8 weeks after sowing in early cultivars. Pods should be picked every 2-3 days, and the number of pickings is greater in climbing cultivars than in bushy ones. Dry beans are harvested as soon as a considerable proportion of the pods (roughly 80%) are fully mature and have turned yellow. Some cultivars tend to shatter. Usually entire plants are pulled and further dried till ready for threshing. After threshing the beans are further sun dried to estimated 12 % moisture to avoid storage problems.

Farmer practices: Solar drying of bean seeds before storage is essential. Also before storing, mix bean seeds with

a) ashes or ash/chilli mixture

b) diatomite (Commercially available as Kensil Lagging from most hardware shops in Kenya)

c) store completely dry seeds in a sealed container such as a metal or plastic bucket with air

tight lid, checking regularly that no weevils are developing and closing tightly again.

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Fresh Quality Specifications for the Market in Kenya

The following specifications constitute raw material purchasing requirements

PRODUCE:	Bean
TYPE:	Broad
IMAGE:	
VARIETY:	Various
	General appearance criteria
COLOUR:	Mid green pod; light green to transparent flesh; green, red or purple seeds depending on variety.
VISUAL APPEARANCE:	Firm bean with thick, slightly leathery skin; soft, fibrous flesh; large, firm seeds which visibly fill the pod; free from foreign matter.
SENSORY:	Crisp bean pod which snaps reasonably easily when bent; tender seeds with strong, distinctive flavour; free from foreign and 'off ' smells or tastes.
SHAPE:	Long thickened pods round to oval in cross section; flat, [illegible]
SIZE:	As pre-ordered per requirements.
MATURITY:	With pod slightly swollen around seeds; seeds tender and [illegible]
INSECTS & PHYSICAL DAMAGE:	With no obvious live insects; with no holes due to feeding by insects larvae; With no crushed areas, deep bruises or [illegible] With no soft, unhealed splits in the bean skin. With no soft shrivelled pods which bend without breaking (dehydration)

© S. Kahumbu, Kenya

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Information on Pests

The bean seed fly *(Delia platura)*

The bean seed fly, also known as seed corn maggot, resembles small houseflies. It is about 1cm long.

Female flies are attracted to recently disturbed open soil, where they lay eggs, especially where there are plant residues or when large amount of manure has been applied. The maggots bore into germinating bean seeds or the cotyledons (first seed leaves) of the young plant eating them. This causes patchy emergence of seedlings. If damaged plants emerge, they are stunted, weak and fail to develop into productive plants.

Pupation takes place in the soil, 2-4 cm under the soil surface.

What to do:

- **Limit the amount of organic matter before planting in areas**

PRODUCE:	French Bean
IMAGE:	
VARIETY:	Various
	General appearance criteria
COLOUR:	Mid green pod; light green to transparent flesh; green, red or purple seeds depending on variety.
VISUAL APPEARANCE:	
SENSORY:	
SHAPE:	
SIZE:	
MATURITY:	
INSECTS & PHYSICAL DAMAGE:	With no soft, unhealed splits in the bean skin. With no soft shrivelled pods which bend without breaking

© S. Kahumbu, Kenya

Bean seed fly
Bean seed fly (*Delia platura*) damage on French beans

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with a known history of bean seed flies.
- Avoid sowing into recently ploughed land in areas where this fly is a problem.

Whiteflies (*Bemisia tabaci* and *Trialeurodes vaporariorum*)

Whiteflies
Whiteflies (*Bemisia tabaci*) on French Beans

© A.M. Varela, icipe

More Information on Whiteflies

Whiteflies are important pests of beans. Both the larvae and the adult pierce and suck the sap from leaves, which may cause reduced plant growth, yellowing of leaves, and wilting of the plant when present in large numbers. They produce honeydew, which may lead to growth of sooty moulds on leaves and pods. Heavy growth of sooty mould reduces photosynthesis affecting plant growth. French bean pods contaminated with sooty mould are unmarketable.
Control measures on beans are justified if large whitefly numbers attack the plants during the early stages of the crop. Whitefly infestations after the onset of flowering usually do not affect yield.

Adults are small (1-3 mm long), with two pairs of wings that are held roof-like over the body. They resemble very small moths.

What to do:

- Conserve natural enemies. Parasitic wasps are very important for control of whiteflies.
- Whenever necessary spray crop with neem products. Neem-based pesticides are reported to inhibit growth and development of immature stages, and to reduce egg laying by

adult whiteflies

Bugs

Several species of bugs feed on beans. The most common in East Africa are the spiny brown bug (*Clavigralla tomentosicolis*), Riptortus bugs (*Riptortus dentipes*), the green stink bug (*Nezara viridula*) and the tip wilter (*Anoplocnemis curvipes*).

Bugs suck on pods causing tiny lesions, and may cause shrivelling and rotting of the seeds, which lose viability. The whole pod may also shrivel. French bean pods showing signs of bug attack (pimples) are not marketable. Tip wilters sometimes suck the sap on shoots, causing them to wilt and turn necrotic and rot. The green stinkbug transmits a fungus to developing seeds, causing yeast spot, which is a widespread but a minor disease of beans in Africa.

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

What to do:

- **Bugs can be collected by hand regularly and killed, especially during flowering and pod formation.**
- **Natural enemies such as assassin bugs, spiders, praying mantises and ants are important natural enemies of bugs. They kill or deter bugs. Conserve and attract predatory**

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

© A.M. Varela, icipe


Spiny brow...


Tip wilter...


Riptort ...


Stink bug

natural enemies to your crop by planting flowering plants. For more information on natural enemies click here

- **Neem products are reported to repel bugs. If necessary spraying should be done in the morning when the immature stages are exposed**

Flower thrips (*Frankliniella* spp. and *Megalurothrips sjostedti*)

Feeding by flower thrips causes scars and blemishes on leaves and pods. Flower thrips can be found feeding on young plants. They are less than 2mm long. As soon as the plants start flowering, however, most thrips would be found in the flower buds, flowers and on the young pods. Heavy thrips feeding causes flower abortion and flower malformation. French bean pods become scarred (having a rough silvery surface) and malformed and are not marketable.

Thrips
Thrips damage on bean pods

© A.M. Varela, icipe
More Information on Thrips

What to do:

- **Monitor the crop regularly. Early detection is particularly important at the onset of flowering.**
- **Whenever necessary spray the crop with botanicals. Some plant extracts (e.g. garlic, rotenone, neem, pyrethrum, etc.). A mixture of garlic and pepper has been recommended for organic growers in USA.**

Flower or blister beetles (*Mylabris oculata*)

The adults of the flower beetles, also known as blister beetles, feed on bean flowers (petals and / or pollen) reducing pod set. The adults are medium to large sized beetles (2-5cm in length), usually black and yellow or black and red in colour. The immature stages (larvae) do not feed on plants. They live in he soil and eat grasshopper eggs.

What to do:

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

Blister beetle
Blister beetle (*Mylabris oculata*)

© Botha AD (Courtesy of EcoPort, www.ecoport.org)

African bollworm and other pod borers

Several caterpillars are important pests as pod borers in common beans and French beans. The most common are the African bollworm *(Helicoverpa armigera)* and the legume pod borer *(Maruca testulalis)*. They feed on leaves, flowers, pods and seeds. The African bollworm caterpillars are 3 to 4 cm long. They make clean circular holes in the pods. One caterpillar may damage several pods. Caterpillars of the legume pod borer attack pods at the point of contact with other pods, leaves or the stem. They frequently web together flowers, pods and leaves with excrements.

African bollworm
African bollworm *(Helicoverpa armigera)* on beans. Caterpillars are 3 to 4

cm in length.

© A.M. Varela, icipe

More Information on African bollworm

Pod borers usually do not cause significant yield reduction in beans. However, they are quarantine pests, and are particular important in French beans grown for export. If only one caterpillar is found in a consignment send to Europe, the whole consignment may be rejected. If pod borers are found in a field, the beans harvested should be sorted very thoroughly to remove the bollworms manually.
Monitor the crop regularly Handpick and destroy affected pods and pod borers Spray crop with biological pesticides (e.g. Bt products or neem). Use of bio-pesticides such as botanicals (e. g. neem extracts) and Bt. For more information on neem click here. For information on Bt click here If pod borers are found in a French beans field, sort harvested pods very thoroughly and remove pod borers manually

What to do:

- **Monitor the crop regularly**
- **Handpick and destroy affected pods and pod borers. This helps when their numbers are low and in small fields.**
- **Spray crop with biological pesticides (e.g. Bt products or neem). Use of bio-pesticides such as botanicals (e. g. neem extracts) and Bt. For more information on neem click here. For information on Bt click here**
- **If pod borers are found in a French beans field, sort harvested pods very thoroughly and remove pod borers manually**

Storage pests: Bruchids (*Zabrotes subfasciatus*, *Acanthoscelides obtectus*)

Bruchids such as the bean bruchid or dried bean weevil (*Acanthoscelides obtectus*), and the Mexican bean weevil (*Zabrotes subfasciatus*) are storage pests, attacking dried beans in Africa. They are small beetles (3-5 mm) and grey, brown to reddish-brown in colour. Females of the dried bean weevil lay eggs glued to the bean seeds, while females of the Mexican bean weevil lay eggs scattered between the bean seeds. Development takes place inside the bean and takes about one month before the adult emerges. The larvae feed on the seeds destroying them or reducing germination capacity. The adult emerges from the seeds leaving small round holes on the bean seeds. Heavy infestation can result in a large number of holed seeds, with adults moving across the stored beans. The dry bean weevil can initiate attack in the field laying eggs on ripening pods. The Mexican bean weevil attacks only beans in storage.

Bruchid
The Mexican bean weevil (*Zabrotes subfasciatus*) is a very small weevil, it is about 2 - 3 mm long.

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




Bruchi Bruchi da… Bruchi o… Bruchi da…

More Information on Storage pests

What to do:

- **Bruchids can be controlled through good storage hygiene. Remove infested residues from last season's harvest**
- **When small lots of beans are stored, daily turning of the storage container can significantly reduce infestation**
- **Complete control of bruchids can be achieved by coating stored seeds with vegetable oil such as cotton seed or coconut oil (small or medium amounts of grain).**
- **Farmer experience: Solar drying of bean seeds before**

storage is essential. Before storage, treat or mix stored seed with a mixture of plant parts (e.g. neem, lantana, pyrethrum and others), vegetable oil (e.g. neem, coconut, castor bean, cottonseed, groundnut, maize, among others) or mineral substances (e.g. sand, diatomite among others). (Diatomite is commercially available as Kensil Lagging from most hardware shops in Kenya)

- **Pyrethrum (botanical) is effective in controlling weevils. For more information on Pyrethrum click here**

Bean flies (*Ophiomyia* spp.)

Bean flies also called bean stem maggots are serious pests in Africa. The adult is a tiny (about 2mm long) fly, shiny black-bluish in colour. The female fly pierces the young leaves to lay eggs and sucks the exuding sap. This leaves yellow blotches on the leaves, which are the first signs of bean fly attack and may serve as early symptom useful for monitoring the presence of this pest in the field. Maggots mine their way from the leaves down to the base of the stem, where they complete their development.

Maggot feeding destroys the tissue causing the steam to swell and split and reducing formation of lateral roots. Attacked plants tend to produce adventitious roots in compensation. Maggots (yellow in colour) and pupae (brown or black in colour) can often be seen through the stem splits. Young seedlings and plants under stress wilt and die when attacked by bean flies. Older or vigorous plants may tolerate bean fly attack, but their growth will be stunted and their yield reduced. Damage

Bean fly
Bean fly maggot (*Ophiomyia* spp.) in a french bean stem.

© A.M. Varela, icipe

Bean fly

Bean fly

is more severe in plants growing under poor conditions such as infertile soils and drought.

What to do:

- **Plant early in the season. Bean fly numbers tend to be low during the early stages of the growing season and increase with time.**
- **Provide favourable growing conditions to improve plant vigour and to enhance tolerance to insect attack and damage. For instance, soil fertility can be improved by adding organic fertilizers and well decomposed farmyard manure.**
- **Mulch (e.g. with straw and cut grasses) helps conserve moisture, promote adventitious root development and enhances tolerance to maggot damage.**
- **Avoid planting beans near cowpea, soybean and many other leguminous crops, that may be the source of bean flies.**
- **Remove and destroying crop residues and all plant parts with symptoms of damage by bean flies.**
- **Earth up (building up) the soil around the plants to cover the roots at 2-3 weeks after the plant emerges help the adventitious roots to grow more quickly. Thus, provided there is enough moisture, the plants are able to recover from the damage.**
- **Use botanical insecticides such as neem. It has been shown that frequent foliar application with neem extract gives satisfactory control of this pest.**
- **Use resistant varieties: Several lines of dry beans have been identified as having good levels of resistance to bean flies in East Africa. These lines are available form the CIAT Regional Programme and from national agricultural research programmes in the region.**

Cutworms

Cutworms attack young seedlings. First instars are 0.7-1cm, 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.

Cutworm
Cutworm damage to French beans

More Information on Cutworms

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.**

Aphids (*Aphis fabae*) and (*Aphis craccivora*)

The black bean aphid (*Aphis fabae*) and the black legume aphid (*Aphis craccivora*) are are black to dark brown brownish in colour and winged or wingless and vary in size from 1.5 to 3.0

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

In addition, plants may become contaminated by honeydew produced by aphids and sooty mould growing on honeydew. French beans contaminated with honeydew and / or sooty moulds are not marketable. Aphids are also vectors of diseases, including the bean common mosaic virus. The black bean aphid is a widely distributed pest of beans. The black legume aphid usually attacks beans grown at low altitudes.

What to do:

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

Aphids
Black bean aphids (*Aphid fabae*) colony (nymphs and adults) on leaf of runner bean (*Phaseolus coccineus*). Note the presence of an attendant ant (*Lasius* sp.) and, in centre of the picture, a hymenopteran parasitoid ovipositing into the aphids.

More Information on Aphids

biopesticides click here

Foliage beetles (*Ootheca* spp.; *Monolepta* spp.)

In East Africa foliage beetles (*Ootheca* spp.; *Monolepta* spp.) are commonly found feeding on bean leaves. Foliage beetles chew small round holes in the leaves. They are about 4-7mm long. They may be a serious problem when present in large numbers or when attacking young plants. Heavy attacks may cause defoliation. Attack on young plants may reduce plant vigour, plant size and yield. The problem is more acute in fields with continuous growing of beans.

Foliage beetle damage
Foliage beetles damage on French beans

© A.M. Varela, icipe

Foliage be...

Foliage be...

***Ootheca* beetles are normally not serious pest of French beans, but are an important pest of common beans in East Africa. The larvae (grubs) of *foliage beetles* live in the soil feeding on roots. Their feeding may cause stunted growth and premature ageing of the plants.**

Grubs of *weevils* live in the soil feeding on roots or may bore into the stem of the bean plant causing swellings or galls, as is the case of the striped bean weevil. Plants attacked by grubs of this weevil show stunted growth and may die. The stem of the plant breaks easily during harvesting (see more below).

What to do:

- **Practice post harvest tillage to expose the grubs in the soil to the sun heat and to predators.**

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

Striped bean weevil (*AIcidodes leucogrammus*)

Several species of weevils (snout beetles) are commonly found feeding on bean leaves. Adult weevils chew the edges of the leaves cutting circular discs. Grubs of weevils live in the soil feeding on roots or may bore into the stem of the bean plant causing swellings or galls, as is the case of the striped bean weevil.

The adult of the striped bean weevil is 10-15mm long, dark brown in colour with whitish to yellowish longitudinal stripes. The females lay eggs in the soil near bean plants. Emerging grubs bore and feed inside the stem, causing cankerous swelling or galls. Fully-grown grubs are white, about 10mm long, have no less and are C-shaped. Pupation occurs in an earthen cell attached to the plant. Plants attacked by grubs of this weevil show stunted growth, lodging, and eventually may die. The stem of the plant breaks easily during harvesting.
In Kenya, stripped bean weevil only occurs occasionally, and to a minor extent and control measures are usually not required.

Stripped bean weevil
Stripped bean weevil (*AIcidodes leucogrammus*) adult on beans (real size 1-1.5cm)

© A.M. Varela, icipe


Strippe b... **Strippe b...**

Beetles can be collected manually and destroyed. Plants damaged by the grubs can be removed and the grubs destroyed.

What to do:

- **Collect weevils manually and destroy them**
- **Remove plants damaged by grubs and destroy grubs**

Leafmining flies (*Lyriomiza* spp)

Leafminers are are small flies, about 1.5mm 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. See also under**
- **Handpick and destroy mined leaves**
- **Whenever necessary spray the crop with neem products. Neem water extracts and neem oil give good control of leafminers. See also under**

Leafminers
Leafminer (and pupae) (*Lyriomiza* spp) damage on French beans

© A.M. Varela, icipe

More Information on Leafmining flies (leafminers)

Leafhoppers (*Empoasca dolichi* and *E. lybica*)

They are widely distributed in Africa. Leafhoppers are small (about 2.5 mm long), slender mobile insects and green in colour. They move sideways when disturbed. Numerous leafhoppers may be seen on the underside of leaves. Their feeding on beans causes down curled leaves with yellowish margins. Eventually the whole plant may turn yellowish brown and dry-up. In Africa, leafhopper damage is usually minor and does not warrant control.

Leafhopper
Leafhopper - Adults are 2 mm long.

What to do:

- **Look for leafhoppers on the undersides of leaves**
- **Wash nymphs from plants with a strong jet of water. Wash the undersides of the leaves in particular**
- **Set out yellow sticky traps near the infested plants if the infestation is severe. For more information on sticky traps click here**
- **If necessary spray insecticidal soap, neem or pyrethrum**

Spider mites (*Tetranychus* spp.)

Spider mites feeding on bean plants may cause reduction in plant growth, flowering, number and length of pods, and number of seeds per pod. Damage is most severe when mites attack young plants. Mite damage may be particularly severe during the dry season.

Spider mites

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.**

Red spider mite damage on beans

© A.M. Varela, icipe


Spider mit…


Spider mit…


Spider mit…

More Information on Spider mites

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Information on Diseases

Common diseases in the tropics are:

- **Common blight (*Xanthomonas axonopodis* pv. *phaseoli*)**
- **Fusarium root rot (*Fusarium solani* f. sp. *phaseoli*)**
- **Rust (*Uromyces appendiculatus* var. *appendiculatus*)**
- **Anthracnose (*Colletotrichum lindemuthianum*)**
- **The bean common mosaic virus (BCMV)**
- **Angular leaf spot (*Phaeoisariopsis griseola*)**
- **Halo blight (*Pseudomonas syringae* pv. *phaseolicola*)**
- **Powdery mildew (*Erysiphe polygoni*)**
- **Root-knot nematodes (*Meloidogyne* spp.)**

Common blight (*Xanthomonas axonopodis* pv. *phaseoli*)

This disease is a constraint to bean production in Kenya. Percentage crop losses of between 10 and 75% have been reported. The common blight produces similar symptoms on leaves, pods, stems and seeds. Small water-soaked spots are the first symptoms observed on leaves and appear within 4 to 10 days of infection. As the spots develop, the centre becomes dry and brown. The lesion is surrounded by a narrow band of bright yellow tissue. However, yellowed tissue is occasionally absent.

Common blight
Beans with common blight

© Jürgen Kranz, (www.ecoport.org)

What to do:

- **Intercropping bean with maize was shown to reduce the severity of common bacterial blight during 1987-88 in Tanzania**
- **Use certified disease-free seed**
- **Plant resistant varieties (e.g. French bean variety 'Paulista'**
- **Plough under bean debris after harvest**
- **Practise a 2-3 year crop rotation without legumes**
- **Do not work in bean fields when the plants are wet**
- **If blight is observed on scattered plants, spot application of copper hydroxide could be considered**

Fusarium root rot (*Fusarium solani* f. sp. *phaseoli*)

Seedlings infected with Fusarium root rot appear dwarfed. The primary leaves are often yellow, later turning necrotic and finally the seedlings wilt. Fusarium species infect bean roots when the soil is too wet, or too hot for good bean growth. The fungus survives in soil for long period.

Fusarium wilt is a manifestation of Fusarium root rot.

What to do:

- **Plough deeply bean debris after harvest**
- **Practise a 6 to 8 year crop rotation without legumes**
- **Do not feed livestock old bean straw if manure is to be used on bean fields**
- **Plant beans in hills or ridges in heavy soils**
- **Seed treatment with Trichoderma (a biopesticide registered in Kenya)**

Fusarium wilt
Fusarium wilt on beans

© A.M. Varela
More Information on Fusarium wilt

Bean rust (*Uromyces appendiculatus* var. *appendiculatus*)

Rust spots (pustules) appear on all parts above the ground. They are most numerous on leaves, particularly on the underside. They are less abundant on stems and occur sparingly on pods. Initial symptoms are minute, slightly raised yellow pustules, which later become distinct circles, reddish brown in colour and surrounded by a yellow halo. The disease is spread long distance by wind. Plant to plant spread of the disease is by farm tools, insects or water splash. Severely infected leaves drop off. The

Bean rust
Rust on French beans

disease is spread long distance by wind. Plant to plant spread of the disease is by farm tools, insects or water splash. **© A. M. Varela, icipe**

What to do:

- **Destroy crop residues after harvesting**
- **Avoid continuous cropping of beans**
- **Practise a 2 to 3 year crop rotation without legumes**
- **Intercrop with cereals**
- **Plant resistant varieties where available (e.g. French bean variety 'Theresa')**
- **A number of pesticides are available in the market. There are reports claiming that baking soda, compost tea spray, EM (effective microorganisms) and papaya leaf extract control bean rust**

Anthracnose (*Colletotrichum lindemuthianum*)

Symptoms of anthracnose can appear on any plant part. Pale brown sunken spots may appear on the cotyledons of infected seedlings. Water may spread the disease to the hypocotyl, which if girdled, kills the seedling. Lesions on leaves are dark brown. They are restricted to the veins on lower leaf surface. On stems, lesions are elongated and sunken. On the pods, the fungus produces black, sunken lesions. These lesions penetrate deep into the pods and may cause shrivelling of the young pods. Infected seed become discoloured changing to yellow through brown to black. In damp weather, the centres of anthracnose

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

lesions become covered with a pink spore mass. The disease is seed borne.

What to do:

- **Use certified disease-free seeds. Plant resistant varieties (e.g. French variety 'Paulista')**
- **Remove from the field and destroy crop debris after harvest**
- **Practise a 2 to 3 year rotation**
- **Avoid overhead irrigation**
- **Avoid movement of workers in the field when wet**

on green grams.

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

Bean common mosaic virus

Symptoms of bean common mosaic virus (BCMV) are cupping and twisting of leaves with a light and dark green mosaic pattern. The dark green tissue is often bubbled and/or in bands next to the veins. Affected plants produce smaller, curled pods with a greasy appearance, and yields are reduced. The virus is seed borne. It can be transmitted by several aphid species.

What to do:

- **Use certified and disease-free seeds**
- **Plant resistant varieties (e.g. French bean variety 'Paulista')**
- **Control attacks of aphids**
- **Remove infected plants from the field**

Bean common mosaic virus Common mosaic virus on beans

© A.A. Seif, icipe

Halo blight (*Pseudomonas syringae* pv. *phaseolicola*)

The most characteristic halo blight symptoms occur on bean foliage. Initially, small water-soaked spots resembling pin pricks appear on the lower leaf surface. These spots turn brown in a few days, and the surrounding tissue gradually become yellow-green. This zone of yellowed tissue around the spot resembles a halo, hence the name of the disease. Pod lesions first appear as small water-soaked pin pricks on the pod surface. These lesions gradually enlarge to form dark sunken spots of various sizes. A white bacterial ooze appears on the spots when wet.
Halos do not develop around pod lesions. Pod lesions are especially important to the French bean industry because they make the bean pod unacceptable to fresh market and processors. On dry beans, pod lesions are of less importance because the beans are shelled before marketing. When infected seed is used, the primary leaves of seedlings show interveinal chlorosis, suggestive of mosaic virus infection.

Halo blight
Halo blight (*Pseudomonas syringae* pv. *phaseolicola*) on beans

© A.M. Varela, icipe

What to do:

- **Use certified disease-free seed**
- **Plant resistant varieties (e.g. French bean variety 'Paulista')**
- **Practise a 2-3 year crop rotation without legumes**
- **Plough under bean debris after harvest**
- **Do not work in bean fields when the plants are wet**
- **If blight is observed on scattered plants, spot application of copper hydroxide could be considered**

Angular leaf spot (*Phaeoisariopsis griseola*)

Symptoms consist of small dark brown spots with angular edges and are often numerous to give the foliage a checker-board appearance. The spots may increase in size, join together, and cause yellowing and necrosis of the affected leaves. This may lead to premature defoliation. When humid, the fungus produces a grey mould on the lower surface of the spots. Infected pods have brown blotches. The disease is favoured by high moisture and moderate temperatures (20-25°C).

Angular leaf spot
Angular leafspots (*Phaeoisariopsis griseola*) on beans

What to do:

- **Use certified disease-free seed**
- **Plough under bean debris after harvest**
- **Practise a 2-3 year crop rotation without legumes**
- **Do not work in bean fields when the plants are wet**

Powdery mildew (*Erysiphe polygoni*)

A white powdery mould appears on the upper leaf surfaces. Severely diseased leaves turn yellow and die. Leaf petioles, stems and pods can also be affected.

Powdery mildew
Powdery mildew on French beans.

What to do:

- **Plough under bean debris after harvest**
- **Practise a 2-3 year crop rotation without legumes**
- **Avoid continuous bean cropping**

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Powde mi... Powde mi...

More Information on Powdery mildew

Root-knot nematode (*Meloidogyne incognita, M. javanica*)

Root-knot nematodes
Root-knot nematodes on French beans

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More Information on Root-knot nematodes

They cause stunting and yellowing of plants with a tendency to wilt in hot weather. If infested plant are pulled out from the soil, the roots can be seen to be distorted, swollen and bearing knots of various sizes. Infested roots under severe infestation decay.

These knots should not be confused with legume nodules, which are normally small and round, and are attached to the outside of the roots, whereas swellings of root-knot nematodes are within the body of the root. When active nodules are sliced, they are pinkish in colour.

What to do:

- **Practise a 2-3 year crop rotation with cereals, maize or**

grasses
- Direct surface irrigation water from new to old bean fields
- Maintain fields weed-free
- Uproot and destroy entire plants after harvest
- Amend soil with neem cake or green manure of marigold or sunnhemp
- Maintain high levels of organic matter in the soil

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