Crops/ fruits/ vegetables
African Nightshade
Amaranth
Avocados
Bananas
Beans
Cabbage/Kale, Brassicas
Carrot
Cashew
Cassava
Citrus plants
Cocoa
Coconut
Coffee
Cotton
Cowpea

more Images

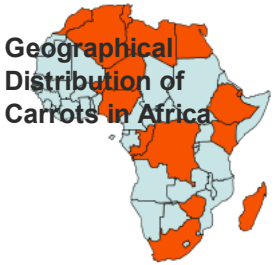
Carrot
Scientific name: *Daucus carota*
Order/Family: Araliales: Apiaceae
Pests and Diseases: African armyworm Bacterial soft rot Cottony soft rot Cutworms Damping-off diseases Leaf blight Powdery mildew Root-knot nematodes

General Information and Agronomic Aspects
Information on Diseases
Information on Pests
Fresh Quality Specifications for the Market in Kenya
Information Source Links

General Information and Agronomic Aspects

Carrot is a popular vegetable with a high vitamin A content, grown in East Africa mostly in the cooler highlands. The roots are consumed raw or cooked, alone or in combination with other vegetables (for example, peas), as an ingredient of soups, sauces and in dietary compositions. Young leaves are sometimes eaten raw or used as fodder. Carrots are an important source of vitamin A in human diets. Vitamin A deficiency can lead to blindness and especially for children to a greater risk of dying

- 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



from ailments such as measles, diarrhoea or malaria.

Nutritive Value per 100 g of edible Portion

Raw Vegetable	Food Energy (Calories)	Protein (g)	Carbohydrates (g)	Ash (g)	Calcium (g)	Phosphorus (mg)	Iron (mg)	Potassium (mg)	Vitamin A (I.U)	T (
Carrot	42	1.1	9.7	0.8	37	36	0.7	341	11000	(

Climatic conditions, soil and water management

Carrots can grow under a range of climatic conditions, but they perform best under moderate temperatures. They are mostly cultivated as a cool season crop. Seed germination occurs between 7°C and 30°C. Optimum air temperatures are 16-24°C. Soil temperatures above 25°C may reduce root quality, including root colour. High temperatures can cause burning of young seedlings. For economic yields, carrots should be grown in tropical regions at altitudes above 700 m. Early-maturing carrot cultivars may grow in the lowlands, but yields will be low and roots will have a poor colour.

Teff
Tomato
Wheat
Yam
Zucchini/Courgette

Carrots grow best in a well-drained friable loam free of stones and hard soil clods. It is a short season crop of 2-3 months with the potential of high yields for family food security and fresh market sales. It does well in the cooler areas of Kenya under both rainfed and irrigated conditions.

Pests/ diseases/ weeds

Medicinal plants

Fruit and vegetable processing

Natural pest control

Cultural practices

Propagation and planting

Carrots are propagated by seeds. Seeds are sown, often mixed with sand, 1/2 - 1 cm deep in drills 10-15 cm apart in finely prepared soils previously cultivated to a depth of at least 30 cm. Lightly aerate the soil by shallow digging before sowing carrots or sow them in ridge culture (small dams of 10 to 20cm height) to facilitate mechanical weeding, thinning, and to limit soil borne diseases. In addition, this will allow easier penetration by the carrot root and will also improve water holding capacity.

Seedlings are thinned to 5-8 cm in the rows. Seed requirements (200 plants/m² and 70% germination) for the dominant half-long carrot cultivars used in Asia, are 4-5 kg/ha. For bigger carrots, the density may be reduced to about 100 plants/m².

Examples of Varieties

Chantenay	Fresh market and canning
Nantes	Fresh market
Amsterdam forcing	Fresh market variety
Little finger	Suitable for canning
Touchon	Fresh market

Carrots that bolt (produce seed) in between normal carrots should be pulled out and fed to

livestock. Seed produced this way will not produce good quality carrots. Seed production under tropical highland (above 1200m) conditions is possible by selecting and harvesting the best quality mature carrot roots and replanting them separately in a corner of the field. Bolting and seed setting soon follows.

Husbandry

Crop rotation is essential to reduce soil borne diseases and pests. Mulching (rice straw or dried grass) after sowing is recommended to encourage germination. Seedlings may be earthed-up when roots start swelling to keep them cool and prevent green tops. Temperature of 15 to 20°C is optimal for seed development. In hot weather, light overhead shade is beneficial. Under such conditions carrots grow well under the canopy of fruit trees. Irrigation during dry spells is necessary to prevent irregular root development. Nutrient requirements of carrots are particularly high for potassium (200-300 kg/ha), low to medium for nitrogen (0-90 kg/ha), normal for phosphorus, calcium, magnesium and other elements. Carrots are sensitive to high Cl concentrations and more susceptible to diseases at very high soil pH. Liming is recommended when pH is below 5.5. Well-decomposed organic manures are beneficial when applied moderately (10-20 t/ha). Fresh organic matter such as farmyard manure or from a leguminous crop, can result in forked roots, which are difficult to clean and to market.

Young carrot seedlings are weak and grow slowly. Therefore, it is essential to keep weeds under control for the first few weeks after germination. Cultivate shallowly with a hoe.

Deep cultivation may injure the roots. Weeding and thinning of young plants can be very labour intensive, for which reason most families grow fairly small beds at any one time.

Intercropping

Because of their limited space requirements and early growing habits, carrots are ideal for intercropping between other crops such as tomatoes, lettuce or capsicums and because of their

fragrant leaves can help keep pest levels low. Other crops good for intercropping with carrots include garlic, dwarf bean, onion, parsnip, leek, small peas, pea mange-tout (snow peas), and radish. The most profitable example of an association is that of carrots and leeks. Carrots have very deep roots that extract nutrients deep in the soil, whereas leeks have extremely superficial roots, which help the crop to extract nutrients near the soil surface. Moreover, carrots can drive away worms from leeks, while leeks can drive away flies from the carrots (TOF Nr. 8, page 8).

Harvesting

Carrots are mostly harvested manually by pulling up the roots at the leaves as long as the soil is moist and soft. If the soil has dried, it will be necessary to use either a spade or similar tool to loosen the soil and harvest the roots. Carrots are usually ready for harvesting 60-85 days after sowing. Mature roots should be orange-coloured internally down to the blunt tip.

A good market price can be fetched from young carrots with a fresh top, but leaving the top on dries out the root quickly and reduces the marketing period of the crop. An alternative is to trim the top back to about 2 cm and package attractively.

For mature carrots the tops are trimmed down completely to avoid storage rots before marketing. Carrots can remain in good condition for 100-150 days when the foliage is removed and they are stored at 1-4° C with 95-100% relative humidity. Carrots should be stored separately from other vegetables to prevent a bitter flavour induced by ethylene (a colourless gas with a sweet odour that is produced by many fruits and vegetables that accelerates the ripening process). Generally carrots store better when they are mature and harvested under moist conditions, and undamaged and free of diseases and pests.

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Information on Diseases

Cottony soft rot

The disease is caused by the fungus *Sclerotinia sclerotiorum* and is characterized by development of soft, watery rot of leaves, crowns and roots. Affected areas become covered with white, cottony fungal growth in which black, irregular, fungal resting bodies (sclerotia) form. The sclerotia enable the fungus to survive for long periods in the soil. This disease is a serious field and storage problem. If diseased roots are packed, extensive breakdown may occur during transit and storage.

What to do:

- **Practice 3-year rotation using cereals and forage grasses**
- **Soil flooding is helpful where feasible**
- **Do not pack and store damaged and or diseased roots**
- **Use clean containers in storage**
- **Maintain temperature near 0°C and a relative humidity no higher than 95% during storage**

Cottony soft rot (*Sclerotinia sclerotiorum*) on carrot Greyish, white mold forms at the base of stem. Black round structures appear as disease progresses. Can extend underground to the root.

Leaf blight

The disease is caused by the fungus *Alternaria dauci*. Dark-grey to brown, angular spots form on leaves. Surrounding tissue yellows and affected leaves eventually die. Older leaves are attacked first and only in very severe cases are younger leaves

affected. Large spots can girdle leaf petioles and kill leaves without spots developing on individual leaflets. During warm moist weather, dying of affected leaves may occur so rapidly that plants appear scorched. This fungus can also cause seedling damping-off. The fungus is seed-borne and survives in the soil crop debris.

Leaf blight (*Alternaria dauci*)
Small, irregular, black to purplish coloured spots. Spots may coalesce to cover the entire leaf.

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

What to do:

- **Use resistant hybrids where available.**
- **Use certified disease-free seeds. In case of using own seeds hot water treat seeds. For information hot water treatment of seeds click here**
- **Avoid parsley in crop rotation and practice good field hygiene.**
- **Enhance aeration of crop field by less dense crops and ridge cultivation.**
- **No or little N-fertilisation.**
- **Monitor fields regularly to be able to react properly.**
- **Copper treatments can reduce infection. For more information on copper click here**

Powdery mildew

The disease is caused by the fungus *Erysiphe polygoni (E. heraclei)*. It is characterised by the development of white, powdery fungal growth on leaves. Affected leaves become chlorotic and eventually die. The fungus is seed-borne.

What to do:

- **Use certified disease-free seeds if using own seeds hot water treat the seeds.**
- **Practice good field hygiene**
- **Practice over-head irrigation where feasible**
- **Spray with sulphur based products where acceptable**

Powdery mildew on carrot
Powdery mildew on carrot caused by Erysiphe heraclei

© www.poljoberza.net
More Information on Powdery mildew

Damping-off on carrot (*Phytium* sp.)

Damping-off diseases are caused by a complex of plant pathogens (disease inciting agents) including *Alternaria* spp., *Fusarium* spp., *Pythium* spp. and *Rhizoctonia* spp. These pathogenic fungi may cause rotting of seeds before emergence or death of seedlings after emergence. The most disposing factors are use of non-certified disease-free seeds and excessive watering of seed-beds or field plots.

Damping-off
Damping-off on carrot (*Phytium* sp.)

© David B. Langston, University of Georgia, Bugwood.org
More Information on Damping-off diseases

What to do:

- **Always use certified disease-free seeds. If using own seeds hot water the seeds. For more information on hot water treatment of seeds click here**
- **Avoid overwatering of seed-beds or field plots where direct sowing is done**

Bacterial soft rot (*Erwinia carotovora* var. *carotovora*)

Erwinia carotovora **subsp. *carotovora* is a bacterium. Bacteria survive in decaying refuse and enter the root principally through cultivation wounds, harvest bruises, freezing injury, and insect openings. After infection, high humidity is essential for progress of the disease. When soft rot occurs in the field, it usually follows a period of water logging in low areas following excessive rain or irrigation. Carrots, potatoes, onions, crucifers, and celery are only a few of the many plants attacked.**

The disease causes a soft, watery, slimy rot. The rotted tissues are grey to brown and may have a foul odour. It decays the core of the root. Also prolonged wet weather favours disease development. It is a serious transit and storage problem if affected carrots are not discarded. In the field, tops of rotted carrots turn yellow and wilt as roots break down.

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

What to do:

- **Follow a crop rotation of cereals and fodder grasses**
- **Destroy by burning of infected plants**
- **Carefully handle carrots at harvesting to minimize bruising**
- **Discard affected carrots before transport and storage**
- **Store carrots in well ventilated places**

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Information on Pests

Root-knot nematodes *(Meloidogyne* spp.)

Various species of *Meloidogyne* cause galls or swellings on the fleshy tap-root. In warm climates *M. incognita, M. javanica* and *M. hapla* are the main species causing problem. The disease is a problem in carrots grown in sandy soils.

Root-knot nematodes of carrot Root knot (nematodes, Meloidogyne spp.): | galling and deformation of carrot roots

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

More Information on Root-knot nematodes

What to do:

- **Plant resistant hybrids where available**
- **Practice crop rotation with cereals and fodder grasses**
- **A 3-year stop for all Apiaceae and Chenopodiaceae crops and a 4 to 5 year stop for Legumisosae is needed to interrupt the life-cycle of these nematodes**
- **Soil amendments with neem cake or extracts are recommended**
- **Where feasible, practice at least one year fallow cultivation**

Cutworms (*Agrotis* spp)

Cutworms such as the black cutworm (*Agrotis ipsilon*) and the common cutworm, also known as the turnip moth (*Agrotis segetum*), attack carrot roots. Feeding on roots causes holes ranging from small and superficial to very large deep holes[link. /]

What to do:

- **Conserve and encourage natural enemies. For more information on natural enemies click here.**
- **Plough fields to expose caterpillars to predators and dessication by the sun**
- **Destroy weeds and vegetation before planting**
- **Flood fields for a few days before planting**
- **Spread ash thickly in the seedbeds, around seedlings or mixed with the soil in the planting holes**

Cutworms
Black cutworm (*Agrotis ipsilon*). Early instars are about 7 to 1.2 cm long. Fully grown caterpillars are 3.5 to 5 cm long.

© Ooi P., Courtesy of Ecoport (www.ecoport.org)
More Information on Cutworms

The African armyworm (*Spodoptera exempta*)

The African armyworm can cause serious crop losses. Armyworms may cause indirect injury to the taproot by cutting stems and/or consuming foliage above ground.

What to do:

- **Monitor regularly field margins, low areas where plants have lodged, beneath plant debris around the base of plants, on the ground, and underneath the plant leaves. Check daily young crops if conditions are known to be favourable to the pest.**
- **Spray Bt or botanicals such as neem and pyrethrum extracts. Spray when caterpillars are small. Once caterpillars are mature (about 3 to 3.5 cm long) they may have cause serious**

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

© University of Arkansas
More Information on African

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

- **Conserve and encourage natural enemies. For more information on natural enemies click here**
- **Practise field sanitation. For more information on field sanitation click here**

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Fresh Quality Specifications for the Market in Kenya

The following specifications constitute raw material purchasing requirements

PRODUCE:	CARROT
IMAGE:	
VARIETY:	Various
GENERAL APPEARANCE	
COLOUR	Mid to bright orange skin and flesh.
VISUAL APPEARANCE	Fresh, bright colour; tops removed; minimal remaining stalk (<10mm); no secondary roots; no excess foreign matter (slight soiling in skin depressions allowable).
SENSORY	Firm with relatively smooth skin; crisp and juicy, not yellowed or dry and woody; slightly sweet taste (not bitter). no 'off' odours or tastes.
SHAPE	Straight; conical, with even taper; rounded to slightly rounded shoulders according to variety. Uniform within box.
SIZE	Bulk Loose Produce graded by length; small < 100mm, medium 100-150mm; medium-large 150-200mm; large >200mm. A 10% size overlap between size grades is allowable. (as per pre-ordered size)
MATURITY	Not fibrous or woody.
INSECTS	With no obvious live insects (e.g. borers, slugs).

© S. Kahumbu, Kenya

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Mar 22, 2010 - Disclaimer

Spider plant
Scientific name: *Cleome gynandra*
Order/Family: Capparidales: Capparaceae

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
Passion fruit

more Images

Local names: Mwangani (Swahili), thageti (Kikuyu), tsisaka (Luhya), alot-dek (Luo), saget (Kalenjin), chinsaga (Kisii), mwianzo (Kamba), jjobyu (Luganda), yobyu (Lusoga)
Common names: African cabbage, spider flower, spider wisp, cat's whiskers
Pests and Diseases: Aphids Beetles

General Information and Agronomic Aspects
Recipes
Information on Pests, Diseases and Weeds
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General Information and Agronomic Aspects

Geographical Distribution of Spider Plant in Africa

Spider plant is an erect herbaceous annual herb with hairy, often purple stems and many branches growing to a height of about one meter. The plant has edible leaves; each leaf has up to 7 leaflets spreading like fingers, which are usually 2-10 cm long and 2-4 cm wide. The flowers are rather showy, long and bearing many small white or pink flowers. The elongate fruit resembles a pod, but is referred to as a capsule, containing many small, dark seeds. Spider plant originated in Africa and Tropical Asia but now has a worldwide distribution. The plant is either cultivated or harvested from the wild. It is a fast-growing plant that is read for harvest in as few as three weeks. The leaves are eaten as a cooked green vegetable, have a mildly bitter taste and contain 5% protein, 6% carbohydrates and are high in vitamins A and C, calcium, phosphorus and iron. Spider plant is used as a vegetable, and as such adds important nutrients to the diet in rural areas of East and Southern Africa. The leaves are usually cooked when fresh but may also be dried and stored for up to two years although this practice greatly reduces the crop?s nutrition value. In East Africa, fresh leaves are used as ingredients in other mashed foods, and the dried leaves are ground and incorporated in weaning foods. Spider plant is believed to replenish blood and therefore referred to as a "traditional meat" by some Kenyan

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

Medicinal plants

communities (Chweya and Mnzava, 1997; Woomer and Imbumi, 2003).

Climatic conditions, soil and water management

Spider plant is commonly found throughout East and Southern Africa during the rainy season. (AVRDC). In Kenya, it grows from sea level to 2400 metres (FORMAT). The crop grows well during the warm season under irrigation. Spider plant is sensitive to cold and does not grow well when temperatures drop below 15 °C. It thrives on sandy loam soils but does not perform well on wet, marshy and heavy clay soils. It requires exposure to sunlight and does not do well in the shade.Although the plants are able to tolerate short-term drought, periods of drought will hasten development of flowers and lower the yields (AVRDC). Seeds should be sown at the onset of rainfall. This ensures availability of adequate soil moisture throughout the growth period. When rainfall is inadequate, frequent watering is necessary during the vegetative growth period (Chweya and Mnzava,1997; Woomer and Imbumi, 2003).

Propagation and planting

Propagation is done by seed. Seeds are sown directly in a well prepared seedbed. Transplanting has proved unsuccessful. (EcoPort)

Seeds can be extracted when the pods are fully ripe (yellow or black), but before they open naturally. Seeds should be kept in a dry, closed container for at least three months to reduce dormancy (ACRDC).

It requires a well-prepared seedbed without weeds and dug to a depth of about 15 cm followed by a light harrowing. It may be planted on traditional raised or flat beds. After digging, the soil is harrowed to a fine tilth. Organic manure is applied and worked into the soil. The seedbed is then levelled before planting. Plants can be grown on flat beds or on traditional raised beds, which are normally one m wide. The appropriate bed length depends on the amount of the crop to be grown, but may not exceed three m. There are usually narrow pathways between the beds to facilitate weeding and harvesting. These pathways also act as drainage channels during the

Fruit and vegetable processing

Natural pest control

Cultural practices

very wet season, as plants do not withstand waterlogging. When raised beds are used, application of organic manure is delayed until the beds have been dug (Chweya and Mnzava,1997).

Shallow planting at one cm depth and with 30 cm between rows or broadcasting followed by raking on prepared seedbeds is recommended. Some farmers mix the seeds with sand when broadcasting them. About four g of seed per m2 or 40 kg per ha are required. Emergence is normally from 6 to 8 days after sowing. Thinning is done three weeks after emergence to leave 10 to 15 cm between plants. (EcoPort)

Husbandry

Plants do not have dense foliage, and as such are unable to compete with weeds. It is therefore essential that seedbeds are kept weed-free at all times, but especially during the first six weeks. Shallow cultivation or hand-pulling of weeds should be practised (Chweya and Mnzava, 1997) Spider plant responds well to well-decomposed manure. Flowering is delayed when adequate manure is available, allowing more, larger leaves to be harvested. Optimum yields could be obtained with an application of 20 to 30 tons of manure per hectare. Topping and removing inflorescences as soon as they appear are other practices that increase leaf production for harvesting. This crop grows rapidly and requires weeding only in the open space between the rows. Plants require water two or three times a week. Periods of drought will hasten development of flowers and lower the yields. Pests and diseases are not usually serious and spraying with insecticides is not recommended even when aphids appear to become problematic. (AVRDC; Chweya and Mnzava, 1997)

Harvesting

The first harvests consist of thinned plants. Plants are brought to the market with their roots attached; roots are removed just before selling to maintain freshness. Where possible, roots should be placed in water overnight to absorb moisture. In case of a mixed cultivation with amaranths or nightshades, spider plants are uprooted to make more space for the companion

crop. In case of monocropping, which is more common, the tops are removed 10 cm from the ground. This encourages the development of side shoots. Harvesting is repeated several times, depending on the soil fertility and moisture conditions. The harvested shoots are kept in a bag without water during the night. In the following morning, the shoots are dipped in water for 30 minutes. Sprinkle water on heaps of produce sparingly. After several successive leaf harvestings, the plants are left to flower and produce seeds. Growers harvest the ripe capsules at the end of rainy season, to save seed for the next crop (AVRDC).

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Recipes

Recipe: Spider plant with coconut milk

Ingredients

- **1 kg spider plant leaves**
- **1 medium onion**
- **0.250 liter water**
- **3 medium tomatoes**
- **1 tsp salt**
- **0.25 liter coconut milk**

Preparation

Harvest the young spider plant leaves including the stem tips then remove the leaf stalks. Wash the leaves with clean water and cut into small pieces. Place into a pot containing 0.25 liter of water, add 1 teaspoon of salt then vegetables and boil over a medium fire for 10 minutes. Next add 0.25 liter of dilute coconut milk and boil for 10 minutes. When leaves are cooked, mash in pot and add oil (or cow fat). Using a separate sufuria fry onions till brown, add tomatoes then vegetables and 0.25 liter of thick coconut milk (or fresh cow's milk), then cook for 5 minutes, stirring occasionally. Provides 4 to 6 medium portions. Best served with chapati, rice or ugali.

To mix with other vegetables, boil Amaranth leaves and spider plant separately. When cooked, mix both then mash in one pot.
(FORMAT, http://www.formatkenya.org/ormbook/Chapters/chapter17.htm) (FORMAT, contributed by Maryam Imbumi).

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Information on Pests, Diseases and Weeds

Information on Diseases

There are no records of plant diseases, possibly as a result of natural plant selection (EcoPort: Wilfried Baudoin).

Information on Weeds

Spider plant is a poor competitor with weeds. Control at early growth stages is critical.

Information on Pests

Beetles

Pure stands in Nairobi were observed to be attacked by flea beetles *Phyllotreta mashonana*. (EcoPort: Wilfried Baudoin).

Flea beetle
A related species of flea

Flea beetles are tiny to small with enlarged hindlegs that enable them to jump long distance when disturbed. The adults vary in colour from shiny black or metallic grey to black with yellow stripes on the wing cases. Eggs are laid in the soil near the host plant. The larvae generally feed on the plant roots, but usually do

not cause economic damage. The characteristic symptom of flea beetle attack is small, round holes all over the leaf surface. Damage may be of importance when flea beetles are present in large numbers, especially during the seedling stage.

What to do:

- **Weeding in and around fields may help to eliminate flea beetle shelters and breeding sites, reducing crop damage.**
- **Covering the seedbed with a fine-mesh material is useful to protect seedlings and older plants.**

beetles, *Phyllotreta cruciferae* feeding damage to a young oilseed canola leaf. Adults are about 2-3mm long.

Aphids

Aphids can be serious pests during dry weather. Aphids are a major pest, causing leaves to curl and become unattractive to customers.

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

Aphids
Green peach aphids (*Myzus persicae*) on pepper leaf. Adult wingless females are oval-bodied, 1.2-2.1 mm in body length, of very variable colour.

What to do:

- **Check the plants regularly. Aphids tend to be more common**

along upwind field borders and next to other leafy vegetable crops or weeds; so initial sampling should be focused in these areas. Because aphid populations are generally clumped within fields, each field should be uniformly sampled.

- **Destroy aphids by rubbing them off, or by gently pressing the infested stems or leaves between your fingers. This helps controlling low, initial infestations.**
- **Apply a strong jet of water to dislodge aphids from attacked plants. When repeated at regular intervals, this method knocks aphid populations down to acceptable levels.**
- **Prune or remove and destroy infested leaves. This helps reduce further infestations.**
- **Conserve natural enemies. Ladybird beetles, lacewings, hover fly larvae, parasitic wasps and naturally occurring aphid diseases are common and effective natural enemies of aphids.**

More Information on Aphids

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Wheat
Scientific name: *Triticum aestivum*
Order/Family: Cyperales: Poaceae
Local names: Ngano (Swahili)
Pests and Diseases: African armyworm African bollworm Anthracnose Aphids Barley fly Birds Chestnut weaver Damping-off diseases Rats Storage pests Thrips Barley fly (hylemia arambourgi) / Birds (red billed

Beans
Cabbage/Kale, Brassicas
Carrot
Cashew
Cassava
Citrus plants
Cocoa
Coconut
Coffee
Cotton
Cowpea
Cucumber
Eggplant
Green gram
Groundnut
Maize
Mango
Millet
Okra
Onion
Papaya
Passion fruit
Peas
Peppers
Pigeon pea

quelea, chestnut weaver) / Brown leaf rust (Puccinia recondita) / stem rust (Puccinia graminis) / striple yellow rust (puccinia striiformis) / septoria leaf spot / yellow blotch / take all (ophiobolus graminis) / loose smut

General Information and Agronomic Aspects
Information on Diseases
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Information Source Links

General Information and Agronomic Aspects

Geographical Distribution of Wheat in Africa

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

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

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

Climatic conditions, soil and water management

Wheat is essentially a temperate-climate crop. Optimum temperatures for development are 10 to

Pineapple
Potato
Pumpkin
Rice
Sesame
Sorghum
Soybean
Spider plant
Spinach
Sugarcane
Sweet potato
Tea
Teff
Tomato
Wheat
Yam
Zucchini/Courgette

Pests/ diseases/ weeds
Medicinal plants
Fruit and vegetable processing

24°C. Relatively low temperatures result in the highest yields. Temperatures above 35°C stop photosynthesis and growth, and at 40°C the crop is killed by the heat. In tropical areas, wheat is best grown at higher elevations or in the cooler months of the year. The minimum amount of water required for an acceptable crop is 250 mm in the top 1.5 m of soil. Areas with 700 to 1000 mm rain per year will be able to grow rain fed wheat.

Wheat does not grow well under very warm conditions with high relative humidity, unless irradiation and nutrient availability are very favourable. In addition, wheat diseases are generally encouraged by such climatic conditions.

Soils best suited for production are well aerated, well drained, and deep, with 0.5% or more organic matter. Optimum soil pH ranges between 5.5 and 7.5. Wheat is sensitive to soil salinity.

Varieties

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

Recommended wheat varieties:

Variety Name	Altitude (m)	Yield (90 Kg bags/ha)	Maturity
"Pasa"	all	37	late
"Kenya Chirika"	all	36	medium
"Mbuni"	all	37	late
"Kenya Kwale"	all	32	late
"Kenya Popo"	all	32	medium

Natural pest control

Cultural practices

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

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

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

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

Seed selection

Certified seed are recommended for the following reasons:

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

Home selection of seed

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

Propagation and Planting

Wheat is propagated by seed. It requires a fine seed-bed that is free of weeds. Seed-bed preparation is usually done by tractor mounted equipment. Usually this can be rented in wheat

growing areas.

Choose a suitable variety for the area and plant with the first rains. Advice on suitable varieties can be found at the KARI Njoro station. Sowing depth varies from 2-12 cm, with deeper planting required in dry conditions to reach the soil moisture. However, care must be taken not to sow too deep as the seed will then die. Seeding rate is commonly 100-150 kg/ha, resulting in 250-300 plants/m², but depends on the tillering ability of the cultivar. The recommended seeding rates when using precision planters for some varieties are:

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

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

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

Husbandry

Uniform crop stand and early vigour discourage weed growth. In this respect tillering allows the crop to compensate for poor stands and variable weather conditions. Yield losses due to weeds

are caused by early competition in the first 4-5 weeks. The more common weeds are: Amaranth (*Amaranthus* spp.), Couch grass (*Cynodon dactylon*), purple nutsedge (*Cyperus rotundus*), East African couchgrass (*Digitaria abyssinica*), goose grass (*Eleusine indica*), purslane (*Portulaca oleracea*) and horse purslane (*Trianthema portulacastrum*).Weeds can be controlled by hand weeding and proper crop rotation.

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

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

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

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

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

Fertilisation
Fertilization necessary for wheat depends on previous land use. As soils usually are deficient in

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

Harvesting

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

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

Large scale farmers use combine harvesters and can sometimes be persuaded to harvest smaller plots for a fee.
The grain should be dried to a maximum moisture content of 13% before storing. Tooth test: Bite a grain. If it is possible to crush the grain with the teeth it is not dry enough. If the grain

cracks under pressure it is probably dry. Also try the salt test method described in The Organic Farmer magazine Nr. 30, Nov 2007, page 3.

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

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

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Information on Pests

Pests

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

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

rope as a whip whenever the birds try to settle and eat in an area.

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

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

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

Unlike many important cereal aphids, the Russian wheat aphid is not a known transmitter of diseases, but causes damage by injecting a toxin into the plants during feeding. This toxin prevents the production of chlorophyll and causes, in susceptible cultivars, leaf chlorosis, longitudinal leaf rolling and white/yellow (warm weather) or purple reddish (cold weather) streaking on the leaves. Extensive chlorosis leads to death of plants while leaf rolling retards

plant development causing stunted growth. The tight rolling of flag leaves delays ear emergence, leading to floret sterile heads resulting in reduction of seed set. Aphid infestation also reduces the quality of the seeds produced, as shown by low kernel weight, increased rate of seed deterioration under accelerated ageing conditions, and reduced seedling vigour. The effect of infestation on seed quality is more pronounced under dry conditions. Infestation also may result in reduced seedling vigour.

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

What to do:

- **Scout your crop regularly. Check for damage signs (first noticeable sign is slight to moderate yellowing of small areas of crop within the field; in addition the crop may appear to be under drought stress, even if there is no drought.)**
- **Use the correct seed rate to ensure good plant density, as low plant densities are susceptible to heavy attack by the aphid.**
- **Plant as early as possible for your area.**
- **Provide good growing conditions for the crop. A crop that is not stressed is more tolerant to aphid attack.**
- **Remove volunteer plants and grasses because they act as the aphid's hosts even before the main crop has been planted.**

Sources of information KARI and Kiplagat (2005).

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

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Information on Diseases

Diseases

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

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

The major diseases caused by non-obligate pathogens are spot blotch (*Cochliobolus sativus*), head scab and foot/root rot (*Fusarium* spp.), and sclerotium foot rot (*Corticium rolfsii*). Regionally important diseases are tan spot (*Pyrenophora tritici-repentis*), powdery mildew (*Erysiphe graminis*), speckled leaf blotch (*Mycosphaerella graminicola*), glume blotch (*Phaeosphaeria nodorum*), alternaria leaf blight (*Alternaria* spp.), rhizoctonia root rot (*Rhizoctonia* spp.), bacterial leaf streak or black chaff (*Xanthomonas translucens pv. undulosa*) and Barley yellow dwarf virus. The most common fungi in stored wheat are various species of *Aspergillus* and *Penicillium*.

The economic losses from diseases may range from slight to 100%. In order to reduce or

minimize losses following practices are recommended:

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

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

Yellow rust (Puccinia striiformis)

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

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

Wheat bunt (Tilletia tritici)
Infected plants have reduced height. The smutted wheat heads are bluish green when thet emerge from the boot. The healthy heads are yellowish green. The disease also induces excessive tillering. The spores are blown by wind to developing ears which they invade. Bunt infected flowers have green ovaries while healthy ones are white. The grain of wheat is replaced by a black mass of spores (spore ball) accompanied by a a smell like of rotting fish.
What to do:
Use certified diseased-free seeds

Plant resistant varieties, if available

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

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

Glume blotch [Phaeosphaeria (Leptosphaeria) nodorum]
It can cause considerable damage in wet years, especially where wheat has been grown for several years in succession. Symptoms consist of brown lesions on the glumes and around the nodes. At advanced stage of the disease black spots just like dots can been seen on the lesions. These are fungal spore bodies (pycnidia). The affected leaves become shriveled with light brown patches on them. Glume blotch is spread by use of infected seeds, rain splash and infected crop residues.

What to do:
Use certified disease-free seeds
Burn stubble and crop debris after harvest
Rotate with nonsusceptible crops such fodder grasses or maize

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

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Crops/ fruits/ vegetables

African Nightshade
Amaranth
Avocados
Bananas
Beans
Cabbage/Kale, Brassicas

more Images

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

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

Leafrollers

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General Information and Agronomic Aspects

Geographical Distribution of Amaranth in Africa

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

Amaranth is an herbaceous annual belonging to the family Amaranthaceae with green or red leaves and branched flower stalks (heads) bearing small seeds, variable in colour from cream to gold and pink to shiny black. There are about 60 species of Amaranthus, however, only a limited number are of the cultivated types, while most are considered weedy species and hence rarely preserved. Many amaranth species are collected from the wild for subsistence, while only few are cultivated or occur as protected weeds in backyards and home gardens (Stallknecht and Schulz-Schaeffer, 1993; Ouma ; Keller, 2004).

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

Rice
Sesame
Sorghum
Soybean
Spider plant
Spinach
Sugarcane
Sweet potato
Tea
Teff
Tomato
Wheat
Yam
Zucchini/Courgette
Pests/ diseases/ weeds
Medicinal plants
Fruit and vegetable processing
Natural pest control
Cultural

Schulz-Schaeffer, 1993).

Varieties

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

Nutritive Value per 100 g of edible Portion

Raw or Cooked	Food Energy (Calories / % Daily Value*)	Carbohydrates (g / %DV)	Fat (g / %DV)	Protein (g / %DV)	Calcium (g / %DV)	Phosphorus (mg / %DV)	Iron (mg / %DV)	Potassium (mg / %DV)	Vitamin A (mg / %DV)
Amaranth grain cooked	102 / 5%	18.7 / 6%	1.6 / 2%	3.8 / 8%	47.0 / 5%	148 / 15%	2.1 / 12%	135 / 4%	-

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

Climatic conditions, soil and water management

practices

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

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

Propagation and planting

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

Direct seeding

When direct seeding is used, seeds are either broadcasted or sown in rows. Broadcast seeds

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

Transplanting
There are two steps to transplanting:

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

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

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

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

Harvesting

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

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

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Information on Pests

Amaranth is susceptible to damage by foliar insects such as leafminers, leafroller caterpillars, cutworms, aphids, flea beetles, and mites.

An effective method of controlling insect pests is to cover the bed with a fine screen or nylon mesh netting (32-mesh or finer). (AVRDC 2003)

Aphids (*Aphis* spp.)

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

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

What to do:

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

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

© Magnus Gammelgaard
More Information on Aphids

biopesticides click here

- **Conserve natural enemies. They are important in natural control of aphids. For more information on natural enemies click here**

Cutworms

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

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

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**

Leafminers (*Liriomyza* spp.)

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

What to do:

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

Leafminers
Damage on leaf by leafminers (*Liriomyza* spp.)

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

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

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

What to do:

- **Avoid planting next to infested fields**
- **Avoid frequent use of broad-spectrum pesticides, in**

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

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

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

More Information on Spider mites

Weevils

Several species of weevils feed on amaranth. Adult weevils feed on leaves, but the larvae (grubs) are more damaging because they bore into roots and stems, causing rotting and potentially lodging and predisposition to diseases. Stem-boring weevils such as the pigweed weevil (*Hypolixus haerens*) are the most damaging causing plants to wither and lodge. The adult weevil lays its eggs in branch crotches, and the larvae bore through stems to the root collar hollowing the stems. Feeding by larvae results in stems that are more susceptible to wind breakage, increasing crop losses. The larvae pupate in the stem.

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

Adult weevil in amaranth stem


Adult weev...


Weevil lar...


Amarar p...


Canker and...

What to do:

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

Bugs

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

Bugs
Bugs feeding on amaranth flowering head

© A. M. Varela

What to do:

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

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Information on Diseases

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

See detailled information below.

Damping-off diseases (*Pythium* spp.)

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

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

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

What to do:

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

Choanephora fruit rot

Choanephora blight (also called Choanephora fruit rot) is caused by fungus *Choanephora cucurbitarium*. It causes wet rot of stems and leaves. Affected plant parts have hairy appearance (silk-like

threads) consisting of fungal spores. Infection is predisposed by injuries. During rainy season it can cause heavy defoliation. The disease is spread by air currents and infected seeds. Warm, moist conditions favor disease development.

What to do:

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

Choanephora fruit rot Choanephora fruit rot (*Choanephora cucurbitarum*) on pumpkin (*Cucurbita maxima*)

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Information on Weeds

Weeds

Weeds compete for light, water, and nutrients, thereby resulting in reduced yield. Thorough land preparation is the first key to effective weed control. Amaranth is small-seeded and slow to

germinate, therefore, weed control is essential early in the season. A seedbed free of weed seeds allows amaranth seedlings to get a head start on the weeds and establish a canopy that can shade out emerging weed seedlings.

What to do:

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

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

More Information on Weeds

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Fresh Quality Specifications for the Market in Kenya

The following specifications constitute raw material purchasing requirements.

PRODUCE:	Amaranthus (Terere, Mchicha)
IMAGE:	
VARIETY:	Various
General appearance criteria	
COLOUR:	Mid green to dark green.
VISUAL APPEARANCE:	Freshly cut non wilted healthy stems covered with medium sized green shiny leaves. Free from seedy brushes.
SENSORY:	Crisp stems and leaves, free from any signs of wilting
SHAPE:	Bunches of stems approximately two hands width
SIZE:	Approximately 35 cm long stem each 0.6 cm width . Weight approximately 500g
MATURITY:	Not tough or fibrous, young and succulent
INSECTS & PHYSICAL DAMAGE:	With no evidence of live insects. With no unhealed cuts, holes or splits from physical or pest damage

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Information Source Links

- **Amaranth (*Amaranthus* spp.) Gobal Facilitation Unit for Underutilized Species- Enabling deployment of underutilized species. www.underutilized-species.org**
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Mar 23, 2010 - Disclaimer

Peas
Scientific name: *Pisum sativum*
Order/Family: Fabales: Fabaceae

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
Passion fruit

more Images

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

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

General Information and Agronomic Aspects

Geographical Distribution of Peas in Africa

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

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

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

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 (
Pea, Edible Podded	53	34	12.0	1.1	62	90	0.7	170	680	0
Pea, Green, Immature	84	6.3	14.4	0.9	26	116	1.9	316	640	0
Pea, Mature, Dry	340	24.1	60.3	2.6	64	340	5.1	1005	120	0

Pests/ diseases/ weeds

Climatic conditions, soil and water management

Medicinal plants

Peas produce best yields and quality in cool and moist growing conditions. They grow reasonably well between 10 and 30°C with an optimum of 20°C. Temperatures above 30°C will cause poor pollination, early maturity and lower yields. Good soil moisture content is a requirement of peas, particularly at flowering and pod development. A minimum of 400 to 500 mm rainfall per cropping season (about three months) is required for growing peas without

supplementary irrigation In tropical regions, the crop has to be grown above an altitude of 750 m. Peas can grow on a wide range of soils but thrive best on a well-drained soil with an optimum pH of 6 to 7.7 and a high content of soil organic matter. Time of sowing and place in the crop rotation depend on regional climate, variety and purpose of growing, whether for export or for local use. Dry peas are primarily grown as a break or catch crop in cereal rotations.

Varieties

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

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

Some varieties of green peas:

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

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

Sugar snaps are also an edible pod pea but have larger and sweeter seeds and a thicker pod

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

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

Propagation and planting

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

In soils with low organic matter, up to 20tons/ha of manure or compost should be applied before planting, as well as up to 200 kg/ha of rock phosphate. Being a legume, peas are not responsive to nitrogen fertilizer, however it is recommended to inoculate the seeds with rhizobium (any of a genus (Rhizobium) of nitrogen-fixing bacteria found in nodules on the roots of certain leguminous plants) to encourage the plants to fix enough nitrogen from the atmosphere. Inoculating with rhizobium has been shown to increase yields by up to 100%. Mix crop residues and organic matter in the top 20cm of the soil prior to planting. This destroys current weed growth and provides a granular bed for seeding.

Husbandry

The first key need of peas is moisture. They have to be irrigated when conditions become dry.

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

Harvesting

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

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Information on Pests

Cutworms

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

What to do:

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

Black cutworm
Black cutworm (*Agrotis ipsilon*). Early instars are about 7 to 12 mm long. Fully grown caterpillars are 35 to 50 mm long.

More Information on Cutworms

Aphids

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

What to do:

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

Pea aphid
The pea aphid (*Acyrthosiphon pisum*) is a large, rather long-bodied aphid, with long slender appendages (legs and cornicles), which forms colonies on young growth and developing pods of many. Wingless forms of females are usually 2.5-4.4mm long, winged females range from 2.3-4.3 mm.

© Whitney Cranshaw, Colorado State University, Bugwood.org

Pea

Pea

aphid aphid

More Information on Aphids

African bollworm (*Helicoverpa armiguera*) and other caterpillars

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

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

What to do:

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

African bollworm
African bollworm (*Helicoverpa armiguera*) feeding on peas. Fully grown caterpillars are 3-4cm long.

© A.M. Varela, icipe


African bo... Damag by ...

More Information on African bollworm

here

The pea blue butterfly (*Lampides boeticus*)

Pea blue butterfly
Caterpillar of the pea blue butterfly and damage to peas (*Lampides boeticus*)

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

What to do:

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

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

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

Thrips
Thrips damage on snowpea

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

What to do:

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

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

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

Leafminer
Leafminer fly and damage caused by adult leafminer on

What to do:

- **Conserve natural enemies. Parasitic wasps usually keep leafminers under control. Avoid use of pesticides that kill**

these wasps and other natural enemies. For more information on natural enemies click here

- **If necessary spray crop with neem products. For more information on neem click here**

peas.

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More Information on Leafmining flies (leafminers)

Spider mites (*Tetranychus* spp.)

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

What to do:

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

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

© Warwick HRI, University of Warwick.

More Information on Spider mites

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Information on Diseases

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

Ascochyta blight Ascochyta spots on snowpeas

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Ascochyta ... Ascochyta ...

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

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

What to do:

- **Use certified disease-free seeds**
- **Use resistant varieties**
- **Plough deeply pea stubble**

- **Remove crop residues from the field after harvest.**

Powdery mildew (*Erysiphe polygoni*)

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

What to do:

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

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

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Powde Powde

mi... mi...

More Information on Powdery mildew

Downy mildew (*Peronospora pisi*)

The fungal growth over leaf and pod is the most striking symptom. The fungal growth occurs on the lower leaf surface as well as on pods. Initially it is white but later it changes to a shade of violet and eventually to almost black. The disease may appear on pods even when it is not apparent on leaves. Affected pods show yellowish brown areas. Inside of the affected pods a white fungal growth can be seen. Peas in such pods are small and have brown spots. The disease is favoured by cool and moist conditions.

Downy mildew
Downy mildew (here on cabbage leaves)

© A.M. Varela, icipe

More Information on Downy mildew

What to do:

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

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

The fungus can attack plants at any stage of development. Distinct symptoms consist of yellowing of foliage and wilting

leading to death of affected plants. The disease appears in scattered areas of the field and eventually may cover bigger areas. If stem of diseased plant is split, the pith is brick-red in colour. The disease can be seed-borne.

What to do:

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

Fusarium wilt
Fusarium wilt on peas

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More Information on Fusarium wilt

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

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

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

Bacterial blight
Bacterial blight on beans. Symptoms are similar on peas

What to do:

- **Use resistant varieties, if available**
- **Use certified disease-free seeds**
- **Avoid dense planting**
- **Control weeds**
- **Use surface irrigation**

Virus diseases

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

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

2) Bean yellow mosaic virus (BYMV)
Bean yellow mosaic virus is transmitted by at least 20 aphid species in a non-persistent manner. The symptoms depend upon the strain of virus involved. The pea strain, for example, causes a very bright yellow mosaic whereas the more typical isolates produce a dull light and

dark green mosaic. Symptoms are masked or delayed at low temperatures (below 15.6°C), but develop normally at 18.3° to 23.9°C. Seed transmission is absent or very rare in pea and several other legumes.

What to do:

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

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

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General Information and Agronomic Aspects

Geographical Distribution of Sesame in Africa

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

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

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

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

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

Climatic conditions, soil and water management

Sesame needs a constant high temperature, the optimum range of growth, blossoms and fruit ripeness is 26 to 30°C.
Sesame only grows well in a warm climate and in East Africa it is only grown from sea level up to 1500 m. Most varieties of sesame are photoperiod sensitive .

In Kenya sesame is grown in the following areas:

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

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

Medicinal plants
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Cultural practices

controlled in drier regions. Due to its tap roots, the plant is highly resistant to drought and can provide good harvests, when soil moisture is adequate.

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

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

Varieties
There are local varieties of sesame with black, white and brown seed colours. The black varieties are grown in the coastal region and the white in the western region.
Imported varieties have lower performance than local varieties. The best of the imported varieties is "Morada", identified by its purple stems and leaves. It originated in Congo and further selected in Venezuela. It is higher yielding and more resistant to aphid attack. The local sesame varieties are branched and drought resistant but have a low yielding capacity and are susceptible to most diseases.

Propagation and planting

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

There are several cultivation methods:

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

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

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

Husbandry

Young sesame plants grow very slowly during the first 25 days, due to the small seed size, and are not yet strong enough to compete against weeds. Natural weed resistance sets in when growth rapidly accelerates, after the plants have attained a height of 10 cm. For this reason, the field should be kept as weed-free as possible during the first 20-25 days after seeding. This is usually achieved through 2-3 hand cultivations or by slashing weeds at soil surface as soon as practically possible, and hand weeding the rows of crops.
Additional measures in weed control include:

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

growth (e.g. groundnuts)

Harvesting

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

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

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

Sesame is generally harvested by hand, and then left to dry for the first 2-3 days after cutting in a windrow. The leaves dry out quickly there, making it easier to bundle them into sheaves. The sheaves should be positioned so that the sun can shine down directly onto the capsules. The sheaves should be small (diameter of 15 cm, bottom: 45-80 cm). During harvesting, the planting seeds should not be allowed to come into contact with the ground to avoid an infestation of soil borne diseases. The seed shells must remain intact to protect the seeds from infection, and to maintain their ability to germinate.
When the sheaves have dried out fully, they are tipped out onto sturdy cloths or canvases and threshed with sticks. To achieve maximum quality (and market price) the threshing cloths/canvases should be at least 2mx3m to avoid contamination with soil particles. Directly following the threshing, the sesame seeds are sieved of leaves, stems and capsule residues, and then dried out to a moisture content of 6% as rapidly as possible. This can be done on a

clean, sun-drenched concrete base preferably covered by a clean plastic sheet to avoid contamination.

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

(Naturland e.V. 2002)

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Information on Diseases

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

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

What to do:

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

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

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

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

More Information on Fusarium wilt

What to do:

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

Leaf spot (*Alternaria* spp.)

The pathogen attacks all parts of the plant at all stages. Small, dark brown water soaked, round to irregular lesions, with concentric rings, 1-8 mm in diameter appear on the leaves and

under excessive atmospheric and soil humidity the spot increases in size and number. The lesions may also appear on the midrib and veins of the leaves. Milder attacks cause only defoliation, in severe cases the plant may die. The pathogen is seed borne. Temperature of 20-30o C and high humid conditions favour the disease.

Leaf spot
Leaf spot (*Alternaria solani* (here on tomato)

© Clemson University, www.ecoport.org

What to do:

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

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

The disease can infect all aerial parts: leaves, flowers and pods. Characteristic of the disease is white greyish powdery fungal growth on affected plant parts. Small pale yellow chlorotic spots develop on the upper surface of leaves and the corresponding lower surface develops white greyish powdery fungal growth. With time the powdery growth covers the entire lower leaf area.

Powdery mildew on sesame

Severe infection causes heavy leaf drop. The fungus develops at temperatures ranging from 20 to 35º C, but 25º C is the optimum. The fungus survives on perennial pigeon peas and volunteer plants, and on the ratoon growth of the harvested plants.

What to do:

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

Powdery mildew (*Erysiphe cichoracearum*) on sesame

© Jürgen Kranz (Courtesy of EcoPort, www.ecoport.org)
More Information on Powdery mildew

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

Light brown angular spots with dark purple margin appear in the leaf veins. Defoliation and death of plant may occur in severe leave and stem infection. Sunken and shiny spots are appeared on the capsules. Early capsule infection render them black and seedless. The pathogen is seed borne. High temperature, rainfall and persistent humidity favours the disease.

What to do:

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

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

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

What to do:

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

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Information on Pests

Aphids (*Aphis* spp.)

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

Aphids feed by sucking plant sap. Small aphid populations may be relatively harmless, but heavily infested plants usually have wrinkled leaves, stunted growth and deformed pods. Plants, in

particular young plants, may dry out and die under heavy aphid attack. Heavy attack on older plants may cause crop loss by decreasing flower and seed production. Damage may also reduce seed viability.

What to do:

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

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

© Magnus Gammelgaard
More Information on Aphids

Cutworms (*Agrotis* spp.)

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

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

What to do:

- **Till weeds early, before harvest.**
- **Use light traps against moths, where feasible.**
- **Ploughing can help by exposing larvae to predators and can also bury others so that they cannot reach soil surface.**
- **Flooding of the fields a few days before planting can kill larvae in the soil.**
- **Use preparations made of neem or pyrethrum.**

Black cutworm
Black cutworm (*Agrotis ipsilon*). Early instars are about 7 to 12 mm long. Fully grown caterpillars are 35 to 50 mm long.

More Information on Cutworms

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

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

losses. Generally plants with green capsules appear to be more susceptible to attack than plants with black capsules.

What to do:

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

Whiteflies (*Bemisia tabaci*)

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

Whiteflies
Whiteflies (*Bemisia tabaci*)under leaf. Adult

What to do:

- **Parasitoids can play an important role in reducing whitefly numbers. Flowering plants should be grown around the field to provide food source to the parasitoids and pesticide**

spraying should be discouraged.

- **Neem seed extracts controls young nymphs, inhibits growth and development of older nymphs, and reduces egg laying capacity by adults. For further information on neem click here.**
- **Spraying with soapy water solutions can be effective in whitefly management**

whiteflies are about 1mm long.

© Clemson University, Department of Entomology
More Information on Whiteflies

Spider mites (*Tetranychus* spp.)

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

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

© Warwick HRI, University of Warwick.
More Information on Spider mites

What to do:

- **Field hygiene is important as an old crop or weeds infested with mites can cause infestation of any new crop grown nearby, particularly, if it is downwind of the old crop.**
- **Interplanting with garlic, basil and onion is said to give some**

protection due to their strong smell.

- **Encourage natural enemies. This can be achieved by planting flowering plants around the field**
- **Spray preparations made of garlic (click here), neem (click here) or soap (click here)**
- **Use a preparation of flour: 2 cups of fine, white flour, add 5-10 l water, mix well, spray infected plants early in the morning. The pests will drop off with the crust during the day. For more information on flour spray click here. For more information on natural enemies click here**

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

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General Information and Agronomic Aspects

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

Spinach is an important green leafy vegetable in temperate climates.

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

Geographical Distribution of Spinach in Africa

Leaves are eaten raw or cooked. Tender young leaves can be added to salads, older leaves are cooked and used in soups etc.

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 (
Spinach	26	3.2	4.3	1.5	93	51	3.1	470	8100	(

Climatic conditions, soil and water management:

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

Varieties

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

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

Propagation and planting

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

Husbandry

In temperate areas two types of spinach are recognised, the round seeded type, usually sown in the spring and harvested in the summer, and the hardier prickly seeded type sown end of summer or beginning of fall for use in the winter and spring. Spinach needs high doses of N and K as well as a regular water supply throughout the season for optimum yield and quality.

Summer crops may be intercropped with other vegetables to benefit from shade (CAB 2006).

Harvesting

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

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Information on Pests

Green peach aphid (*Myzus persicae*)

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

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

© Magnus Gammelgaard

What to do:

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

More Information on Aphids

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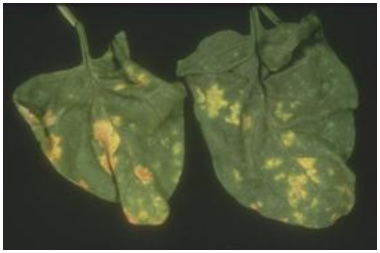
Information on Diseases

Downy mildew (*Peronospora spinaciae / Peronospora farinosa*)

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

What to do:

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



Downy mildew
Downy mildew *Peronospora spinaciae* spots on leaves of spinach.

© F. Rouxel, www.inra.fr \nSpinach downy mildew Spots of downy mildew on leaves of spinach.\n
More Information on Downy mildew

Bacterial soft rot (*Erwinia carotovora*)

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

What to do:

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

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

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

What to do:

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

Fusarium wilt
Fusarium wilt (*Fusarium oxysporum* f. sp. *spinaciae*) on spinach seedling

© http://ipm.wsu.edu

More Information on Fusarium wilt

White rust (*Albugo occidentalis*)

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

What to do:

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

White rust
White rust caused by *Albugo tragopogonis /Albugo ipomoeae-panduratae* on sunflower

Cucumber Mosaic Virus (CMV)

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

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

What to do:

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

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Fresh Quality Specifications for the Market in Kenya

The following specifications constitute raw material purchasing requirements.

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

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Information Source Links

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- **Sherf, A. F. and Macnab, A. A. (1986). Vegetable Diseases and Their Control. John Wiley & Sons, Inc. ISBN: 0-471-05860-2.**
- **University of Georgia, College of Agricultural and Environmental Sciences, Department of Horticulture**
- **East African Seed Co. Ltd. Africa's Best Grower?s Guide www.easeed.com**

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