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Beans

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

General Information and Agronomic Aspects

Geographical Distribution of Beans

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

However, presently, two distinct bean types are recognized in the region: French beans (green beans) and common beans (dry beans). French beans are the immature green pods of *P. vulgaris* and are primarily grown for export market to European Union and elite local urban markets. Common beans are the second most important staple food to maize for the local people.

in Africa

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

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

Nutritive Value per 100 g of edible Portion

Raw Vegetable	Food Energy (Calories)	Protein (g)	Carbohydrates (g)	Ash (g)	Calcium (g)	Phosphorus (mg)	Iron (mg)	Potassium (mg)	Vitamin A (I.U)	Thiamine (mg)	Ribof (mg)
Green Bean	32	1.9	7.1	0.7	56	44	0.8	132	600	0.08	0.11
Bean, Mature Seed, Dry	340	22.3	61.3	3.9	144	425	7.8	1196	-	0.65	0.22

Climatic conditions, soil and water management

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

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

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

Propagation and planting

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

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

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

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

Commercial varieties of French beans available in Kenya

Variety	Resistance to diseases
Amy	Anthracnose / Common bean mosaic virus
Emelia	Anthracnose / Common bean mosaic virus / Halo blight
Julia	Anthracnose / Common bean mosaic virus
Lausanne	Anthracnose / Common bean mosaic virus
Paulista	Anthracnose / Common bean mosaic virus / Common blight /
Olivia	Common bean mosaic virus

RS 1389	**Common bean mosaic virus / Bean rust**
RS 1391	**Common bean mosaic virus / Bean rust**
RS 1518	**Anthracnose / Common bean mosaic virus**
Samantha	**Anthracnose / Common bean mosaic virus**
Tanya	**Anthracnose / Common bean mosaic virus / Halo blight**
Xera	**Anthracnose / Common bean mosaic virus**

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

Husbandry

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

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

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

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

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

Intercropping
Beans are excellent for intercropping with other food crops, such as maize, potatoes, celery, cucumber etc. and can help supply the other crops with nitrogen to a limited degree. Longer season varieties of beans can fix higher amounts of nitrogen than short season varieties. Intercropping with chives or garlic helps repel aphids (KIOF - personal communication).

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

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

Harvesting / Storage

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

Farmer practices: Solar drying of bean seeds before storage is essential. Also before storing, mix bean seeds with
a) ashes or ash/chilli mixture
b) diatomite (Commercially available as Kensil Lagging from most hardware shops in Kenya)
c) store completely dry seeds in a sealed container such as a metal or plastic bucket with air tight lid, checking regularly that no weevils are developing and closing tightly again.

Fresh Quality Specifications for the Market in Kenya

The following specifications constitute raw material purchasing requirements

PRODUCE:	Bean
TYPE:	Broad
IMAGE:	
VARIETY:	Various
	General appearance criteria
COLOUR:	Mid green pod; light green to whitish flesh; green, red or purple seeds depending on variety.
VISUAL APPEARANCE:	Firm bean with thick, slightly leathery skin; soft, fibrous flesh; large, firm seeds which virtually fill the pod; free from foreign matter.
SENSORY:	Crisp bean pod which snaps reasonably easily when bent; tender seeds with strong, distinctive flavour; free from foreign and 'off ' smells or tastes.
SHAPE:	Long thickened pods round to oval in cross section; flat, oval to kidney shaped seeds.
SIZE:	As pre-ordered per requirements.
MATURITY:	With pod slightly swollen around seeds; seeds tender and light coloured, not fibrous or woody (over mature).
INSECTS & PHYSICAL DAMAGE:	With no obvious live insects. With no holes due to feeding by insect larvae. With no crushed areas, deep bruises or unhealed splits in the bean skin. With no soft, wilted, shrivelled pods which bend without breaking (dehydration)

PRODUCE:	French Bean
IMAGE:	
VARIETY:	Various
	General appearance criteria
COLOUR:	Mid green pod; light green to transparent flesh; green seeds depending on variety.
VISUAL APPEARANCE:	Firm bean fibrous flesh; small firm seeds which free from foreign matter.
SENSORY:	Crisp bean pod which snaps reasonably easily when bent; tender seeds with free from foreign and 'off ' smells or tastes.
SHAPE:	Long slender pods round to oval in cross section; flat, oval to kidney shaped seeds.
SIZE:	As pre-ordered per requirements.
MATURITY:	With pod not swollen around seeds; seeds tender and light coloured, not fibrous (over mature).
INSECTS & PHYSICAL DAMAGE:	With no obvious live insects. With no holes due to feeding by insect larvae. With no crushed areas, deep bruises or unhealed splits in the bean skin. With no soft, wilted, shrivelled pods which bend without breaking (dehydration)

Information on Pests

The bean seed fly (*Delia platura*)

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

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

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

What to do:

- **Limit the amount of organic matter before planting in areas with a known history of bean seed flies.**
- **Avoid sowing into recently ploughed land in areas where this fly is a problem.**

Bean seed fly
Bean seed fly (*Delia platura*) damage on French beans
© A.M. Varela, icipe

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

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

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

very small moths.

What to do:

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

Whiteflies
Whiteflies (*Bemisia tabaci*) on French Beans
© A.M. Varela, icipe

Bugs

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

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

minor disease of beans in Africa.

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

What to do:

- **Bugs can be collected by hand regularly and killed, especially during flowering and pod formation.**
- **Natural enemies such as assassin bugs, spiders, praying mantises and ants are important natural enemies of bugs. They kill or deter bugs. Conserve and attract predatory natural enemies to your crop by planting flowering plants. For more information on natural enemies click here**
- **Neem products are reported to repel bugs. If necessary spraying should be done in the morning when the immature stages are exposed**

Spiny brown bug
Spiny brown bugs (*Clavigralla tomentosicolis*) measure about 1 cm in length.
© A.M. Varela, icipe


Spiny brow..


Tip wilter..


Riptort ...


Stink bug

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

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

What to do:

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

Thrips
Thrips damage on bean pods
© A.M. Varela, icipe

Flower or blister beetles (*Mylabris oculata*)

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

What to do:

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

Blister beetle
Blister beetle (*Mylabris oculata*)
© Botha AD (Courtesy of EcoPort, www.ecoport.org)

African bollworm and other pod borers

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

Pod borers usually do not cause significant yield reduction in beans. However, they are quarantine pests, and are particular important in French beans grown for export. If only one caterpillar is found in a consignment

send to Europe, the whole consignment may be rejected. If pod borers are found in a field, the beans harvested should be sorted very thoroughly to remove the bollworms manually.
Monitor the crop regularly Handpick and destroy affected pods and pod borers Spray crop with biological pesticides (e.g. Bt products or neem). Use of bio-pesticides such as botanicals (e. g. neem extracts) and Bt. For more information on neem click here. For information on Bt click here If pod borers are found in a French beans field, sort harvested pods very thoroughly and remove pod borers manually

What to do:

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

African bollworm
African bollworm *(Helicoverpa armigera)* on beans. Caterpillars are 3 to 4 cm in length.
© A.M. Varela, icipe

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

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

What to do:

- **Bruchids can be controlled through good storage hygiene. Remove infested residues from last season's harvest**
- **When small lots of beans are stored, daily turning of the storage container can significantly reduce infestation**
- **Complete control of bruchids can be achieved by coating stored seeds with vegetable oil such as cotton seed or coconut oil (small or medium amounts of grain).**
- **Farmer experience: Solar drying of bean seeds before storage is essential. Before storage, treat or mix stored seed with a mixture of plant parts (e.g. neem, lantana, pyrethrum and others), vegetable oil (e.g. neem, coconut, castor bean, cottonseed, groundnut, maize, among others) or mineral substances (e.g. sand, diatomite among others). (Diatomite is commercially available as Kensil Lagging from most hardware shops in Kenya)**
- **Pyrethrum (botanical) is effective in controlling weevils. For more information on Pyrethrum click here**

Bruchid
The Mexican bean weevil (*Zabrotes subfasciatus*) is a very small weevil, it is about 2 - 3 mm long.
© Georg Goergen, Courtesy of EcoPort (www.ecoport.org)


Bruchi


Bruchi da…


Bruchi o…


Bruchi da…

Bean flies (*Ophiomyia* spp.)

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

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

conditions such as infertile soils and drought.

What to do:

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

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

Bean fly

Bean fly

Cutworms

Cutworms attack young seedlings. First instars are 0.7-1cm, later instars are 3.5-5cm long. The caterpillar emerges from the soil at night, encircles the plant with its body and cut through the stem of young plants just above ground level. They may also damage the plants underground. Cutworm damage causes plants to wilt and die. Cutworm damage is usually minor and does not normally warrant control. However, in severe outbreaks a young crop may be destroyed.

What to do:

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

preparation some cutworms may be alive and attack the new crop.

Cutworm
Cutworm damage to French beans
© A.M. Varela, icipe

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

The black bean aphid (*Aphis fabae*) and the black legume aphid (*Aphis craccivora*) are are black to dark brown brownish in colour and winged or wingless and vary in size from 1.5 to 3.0 mm. Aphids feed by sucking plant sap. Small aphid populations may be relatively harmless, but heavily infested plants usually have wrinkled leaves, stunted growth and deformed pods. Plants, in particular young plants, may dry out and die under heavy aphid attack. Heavy attack on older plants may cause crop loss by decreasing flower and pod production. Damage may also reduce seed viability.

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

What to do:

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

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

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

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

continuous growing of beans.

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

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

What to do:

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

Foliage beetle damage
Foliage beetles damage on French beans
© A.M. Varela, icipe


Foliage beetles

Striped bean weevil (*AIcidodes leucogrammus*)

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

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

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

What to do:

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

Stripped bean weevil
Stripped bean weevil (*Alcidodes leucogrammus*) adult on beans (real size 1-1.5cm)
© A.M. Varela, icipe


Stripp(b…


Stripp(b…

Leafmining flies (*Lyriomiza* spp)

Leafminers are are small flies, about 1.5mm in length. The maggot makes long, slender, white mines (tunnels) in leaves.

Severely mined leaves may turn yellow and drop. Severely attacked seedlings are stunted and may eventually die. Control measures are necessary when attack is severe, especially on young plants.

What to do:

- **Conserve natural enemies. They are very important in natural control of leafminers. See also under**
- **Handpick and destroy mined leaves**
- **Whenever necessary spray the crop with neem products. Neem water extracts and neem oil give good control of leafminers. See also under**

Leafminers
Leafminer (and pupae) (*Lyriomiza* spp) damage on French beans
© A.M. Varela, icipe

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

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

What to do:

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

Leafhopper
Leafhopper - Adults are 2 mm long.
© Ooi P. (Courtesy of EcoPort, www.ecoport.org)

Spider mites (*Tetranychus* spp.)

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

What to do:

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

Spider mites
Red spider mite damage on beans
© A.M. Varela, icipe


Spider mit…


Spider mit…


Spider mit…

Information on Diseases

Common diseases in the tropics are:

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

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

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

What to do:

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

Common blight

Beans with common blight
© Jürgen Kranz, (www.ecoport.org)

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

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

Fusarium wilt is a manifestation of Fusarium root rot.

What to do:

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

Fusarium wilt
Fusarium wilt on beans
© A.M. Varela

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

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

What to do:

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

Bean rust
Rust on French beans
© A. M. Varela, icipe

Anthracnose (*Colletotrichum lindemuthianum*)

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

What to do:

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

Anthracnose
Anthracnose (*Colletotrichum lindemuthanium*) on beans pod. Symptoms are similar on green grams.
© Jim Sheppard (Courtesy of EcoPort, www.ecoport.org)

Bean common mosaic virus

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

What to do:

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

Bean common mosaic virus
Common mosaic virus on beans
© A.A. Seif, icipe

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

The most characteristic halo blight symptoms occur on bean foliage. Initially, small water-soaked spots resembling pin pricks appear on the lower leaf surface. These spots turn brown in a few days, and the

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

What to do:

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

Halo blight
Halo blight (*Pseudomonas syringae* pv. *phaseolicola*) on beans
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Angular leaf spot (*Phaeoisariopsis griseola*)

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

What to do:

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

Angular leaf spot
Angular leafspots (*Phaeoisariopsis griseola*) on beans
© A.M. Varela, icipe

Powdery mildew (*Erysiphe polygoni*)

A white powdery mould appears on the upper leaf surfaces. Severely diseased leaves turn yellow and die. Leaf

petioles, stems and pods can also be affected.

What to do:

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

Powdery mildew
Powdery mildew on French beans.


Powde mi…


Powde mi…

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

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

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

What to do:

- **Practise a 2-3 year crop rotation with cereals, maize or grasses**
- **Direct surface irrigation water from new to old bean fields**
- **Maintain fields weed-free**
- **Uproot and destroy entire plants after harvest**
- **Amend soil with neem cake or green manure of marigold or sunnhemp**
- **Maintain high levels of organic matter in the soil**

Root-knot nematodes
Root-knot nematodes on French beans
© A.M. Varela, icipe

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Peppers

Peppers
Scientific name: *Capsicum* spp. (*C. annuum* / *C. frutescens*)
Family: Solanales: Solanaceae
Local names: Pilipili (Swahili)
Common names: Sweet pepper, Bell pepper, Chilli, Hot pepper
Pests and Diseases: African bollworm Anthracnose Aphids Bacterial soft rot Bacterial spot Bacterial wilt Broad or yellow tea mite Cercospora leaf spot Collar rot Cutworms Damping-off diseases Fruit flies Fusarium wilt Leafmining flies (leafminers) Phytophthora blight Powdery mildew Root-knot nematodes Spider mites Thrips Viral diseases Whiteflies

General Information and Agronomic Aspects

Geographical Distribution of Peppers in Africa

Capsicum pepper is the most popular and most widely used condiment all over the world. Its fruits are consumed in fresh, dried or processed form as table vegetable or spice. Capsicum peppers are extensively pickled in salt and vinegar. Colour and flavour extracts are used in both the food and feed industries, for example, ginger beer, hot sauces and poultry feed, as well as for some pharmaceutical products. Sweet, non-pungent capsicum peppers are widely used in the immature, green-mature or mature-mixed-colours stage as a vegetable, especially in the temperate zones. Capsicum extracts show promise against some crop pests.

Nutritive Value per 100 g of edible Portion

Raw Vegetable	Food Energy (Calories)	Protein (g)	Carbohydrates (g)	Ash (g)	Calcium (g)	Phosphorus (mg)	Iron (mg)	Potassium (mg)	Vitamin A (I.U)	Thiamine (mg)	Ribof (mg)
Pepper, (Hot), Mature, Red	65	2.3	15.8	1.2	16	49	1.4	564	21600	0.10	0.20
Pepper, (Hot), Immatur, Green	37	1.3	9.1	0.6	10	25	0.7	-	770	0.09	0.06
Pepper, (Sweet), Immature, Green	22	1.2	4.8	0.4	9	22	0.7	213	420	0.08	0.08
Pepper, (Sweet), Mature, Red	31	1.4	7.1	0,5	13	30	0.6	-	4450	0.08	0.08

Climate, soil and water management

Climatic requirements and cultural practices for production of sweet peppers and chillies are the same. They also share a same complex of pests and diseases. Capsicum peppers tend to tolerate shade conditions up to 45% of prevailing solar radiation, although shade may delay flowering. Capsicum peppers grow best on well-drained loamy soils at pH 5.5-6.8. They grow at a wide range of altitudes, with rainfall between 600 and 1250 mm. Severe flooding or drought is injurious to most cultivars. Seeds germinate best at 25-30°C. Optimal temperatures for productivity are between 18 and 30°C. C. frutescens are more tolerant to high temperatures. Cooler night temperatures down to 15°C favour fruit setting, although flowering will be delayed as temperatures drop below 25°C. Flower buds will usually abort rather than develop to maturity if night temperatures reach 30°C. Pollen viability is significantly reduced at temperatures above 30°C and below 15°C.

Propagation and planting

Capsicum peppers are propagated by seed. Seeds should be harvested from mature fresh fruit after 2 weeks of ripening after harvest. Seeds remain viable for 2-3 years without special conservation methods if they are kept dry. They rapidly lose viability if they are not properly stored at high temperature or humidity. Seed dormancy may occur to a small extent, especially if seed is harvested from under-ripe fruits. Some 200-800 g of seed is required per ha, depending on plant density.
For information on hot-water treatment of seeds click here.
Seedbeds are usually covered with straw, leaves or protective tunnels. For better production, seedlings should be transferred to seedling pots (plastic pots, paper cups, banana leaf-rolls, etc.) when the cotyledons are fully expanded. Transplants are planted out in the field at the 8-10 true leaf stage, usually 30-40 days after sowing. Hardy transplants can be produced by restricting water and removing shade protection, starting 4-7 days before transplanting. Transplanting should be done during cloudy days or in the late afternoon, and

should be followed immediately by irrigation. Direct sowing in the field is practised to a limited extent. Capsicum peppers are well adapted to sole cropping and intercropping systems. Capsicum peppers are often relay-cropped with tomatoes, shallots, onions, garlic, okra, *Brassica* spp. and pulses. They also grow well among newly established perennial crops.

Cultivars commonly grown in Kenya:

Sweet pepper (*C. annuum*):

- **California Wonder**
- **Yolo wonder**
- **Emerald Giant**
- **Ruby Giant**

Hot pepper (*C. frutescens*):

- **Anaheim**
- **Fresno**
- **Jalapeno**
- **Long Red Cayenne**
- **Rocket**
- **Short Bullet**

Husbandry

Capsicum peppers thrive best if supplied with a generous amount of organic matter. A reasonable recommendation is to supply 10-20 t/ha of organic matter. General nutrient requirements are 130 kg/ha of N, 80 kg/ha of P and 110 kg/ha of K. Nutrient availability is subject to soil type and environmental conditions, so local recommendations vary. Manual weeding is usual for weed control. It is most critical at the reproductive phase. Organic or plastic mulches are very effective for weed control, and reflective mulches help to minimize

insect vectors of plant viruses. Staking can help minimise lodging. Capsicum peppers may be grown under rainfed or irrigated conditions. To avoid certain diseases, pests or allelopathic damage, capsicum peppers should not be planted after other solanaceous crops, sweet potato or jute.

Harvesting

Capsicum peppers are ready for harvest 3-6 weeks after flowering depending on the fruit maturity desired. Green fruits are mature when firm, if gently squeezed they make a characteristic popping sound. Harvesting is done by hand or with the aid of a small knife. Sweet capsicum peppers are often harvested at the green mature stage, although sometimes they are harvested red. Assorted fruit colours such as yellow, orange, chocolate and purple are also available in specialized markets. Hot capsicum peppers are harvested green or red depending on their utilisation. For the fresh market, fruits are harvested mature but firm, whereas capsicum peppers sold as dried pods may be left to partially dry on the plants before harvesting. Yields under irrigated conditions tend to be higher than for rainfed production, but vary with other management practices. Unless sold for the fresh market, hot capsicum peppers can be sun-dried. Sun-drying usually takes place in a vacant field or roadside, on mats or a well-swept area. In the sun, capsicum peppers will dry adequately in 10-20 days, with frequent turning of fruits. Steaming of hot and capsicum pepper before being sun-dried tends to improve the appearance, making dried fruits look glossy.

Information on Diseases

Damping-off and root rot (*Rhizoctonia solani* / *Pythium* spp. / *Fusarium* spp.

Seedlings fail to emerge (pre-emergence damping-off); small seedlings collapse (post-emergence damping-off); seedlings are stunted through root rot and / or collar rot. Nursery beds show irregular patches. The fungi causing seedling diseases are soil inhabitants. Pythium spp. are favoured by low temperatures while *R. solani* and *Fusarium* spp. thrive at higher temperatures.

What to do:

- **Growing certified disease-free seed**
- **Nursery beds be located on well drained sites not previously under vegetable production**
- **Proper watering regime**

Damping-off disease in chilli field
© A. A. Seif & B. Nyambo, icipe

Powdery mildew (*Leveillula taurica*)

Yellowish blotches or spots appear on the upper leaf surface. The leaf surface is covered with a white to grey powdery fungal growth. The disease progresses from the older to younger leaves and shedding of the foliage is pronounced. Leaf defoliation leads to reduction in size and number of fruits. It also results in fruits being sun-burned. The disease is favoured by warm, humid and dry weather. The fungus causing powdery mildew also attacks eggplants and tomatoes. Overhead irrigation reduces disease severity.

What to do:

- **Plant resistant cultivars, if available**
- **Apply sulphur based fungicides at the onset of disease symptoms**
- **Remove and destroy crop debris after harvest**

Powdery mildew
Powdery mildew on leaves and fruit of chilli. Note fungal growth on pod.

Viral diseases

About 17 viruses have been reported to attack peppers. Those considered economically important in Africa include alfalfa mosaic, chilli veinal mottle, cucumber mosaic, pepper veinal mottle, potato Y, tobacco etch, tobacco mosaic, tomato spotted wilt and chilli leaf curl.
Most of these viruses are transmitted by insects, infected seed and a few by mechanical means and infected seed: the first six above listed viruses are spread by aphids; tobacco mosaic is mechanically transmitted and infected seed; tomato spotted wilt by thrips; and chilli leaf curl by whiteflies.

Viral diseases are particularly difficult to firmly diagnose by symptoms because there is so much overlap in symptomatology. Furthermore, symptom expression can be altered by many factors among which are cultivar, age of host plant, environmental conditions, host plant nutrition, and viral strains, not to mention the occurrence of virus mixtures. General symptoms include mosaic patterns on leaves, yellowing , ring spots, leaf deformation or distortion, curling of leaves, and/or stunting of plants. They may also cause reduction of fruit size, distortion, and/or ring patterns.

What to do:

- **Plant resistant cultivars, if available**
- **Select planting dates to avoid high population of vectors**
- **Close plant spacing to compensate for diseased plants**
- **Use barrier crops to minimize virus spread**
- **Use oil sprays to reduce virus transmission by aphids**
- **Use reflective mulches to repel aphids and thrips. For more information on mulching click here.**
- **Use certified disease-free seed in case of tobacco mosaic virus.?**

Virus diseases
Chilli plant affected by a virus disease
© A. A. Seif, & B. Nyambo, icipe

Anthracnose (ripe rot) (*Colletotrichum capsici*)

Anthracnose caused by *Colletotrichum* spp. is a major problem of ripened fruits. The fungus produces dark, sunken spots up to 2.5 cm across on sweet pepper. The spots occur on green and ripe fruits and their surface may be covered in moist weather with salmon-pink mass of spores. The fungus is seed-borne.

What to do:

- **Use certified disease-free seeds**
- **Hot water treat own produced seeds. For more information on hot water treatment click here**

- **Practice field sanitation (removal of crop debris after harvest)**

Anthracnose
Anthracnose (*Colletotrichum capsici*) on sweet pepper (*Capsicum annuum*)
© Jürg Kranz (Courtesy of EcoPort, www.ecoport.org)

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

Soft rot often begins in the peduncle and calyx tissues of harvested fruit. Infection can occur through wounds anywhere on the fruit. Fruit infected on the plant collapses and hangs on the plant like a water-filled bag. When the contents leak out, a dry shell of the fruit remains.

The bacteria are soil-borne. Soft rot is primarily a post-harvest problem although it can occur in the field being facilitated by injuries to the fruit by insects and water splash. The disease is serious during rainy periods because the bacteria are splashed from the soil onto the fruit, which are more susceptible due to their high moisture content.

What to do:

- **Rotation with beans or maize**
- **Control of insects that cause injury to fruits.**
- **Post-harvest decay can be reduced by harvesting fruits when dry, minimizing injury during handling, and**

store at cool temperatures.

- **]If fruits must be washed, add free chlorine in the wash water to eliminate soft-rot bacteria. However, this treatment prevents infection during washing but does not prevent soft rot development in fruits that were already infected before washing.**

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

Leaves, fruit and stems can be attacked by the disease. Leaf spots begin as circular, water-soaked that become necrotic with brown centres with yellowish borders. The spots are sunken on the upper leaf surface and slightly raised on the lower surface. On stems spots are elongated. Affected leaves turn yellow and drop. Affected fruits have raised brown spots that are wart-like in appearance. The disease has a wide distribution wherever peppers are grown. It spreads rapidly during warm, rainy conditions. High relative humidity with free moisture on leaves for long periods favour infection. Ideal temperatures for infection are above 20° C. The bacterium is seed-borne and survives in crop debris.

What to do:

- **Use of resistant varieties, if available**
- **Use disease-free seed**
- **Crop rotation**
- **Copper sprays can reduce the rate of disease development**

Bacterial spot
Bacterial spot of pepper (*Xanthomonas vesicatoria*)
© Volcani Center Archives, Bet Dagan, Israel, www.insectimages.org (Courtesy of EcoPort, www.ecoport.org)

Bacterial wilt (*Ralstonia solanacearum*)

The disease occurs in scattered plants or groups of plants in the field. Characteristic symptom is wilting of the entire plant with no leaf yellowing. Cross sections cut from roots and lower stems of diseased plants exude milky streams of bacteria from the vascular system when suspended in water. The bacteria have a wide host range and can survive in the soil for long periods.
The disease is favoured by wet, warm conditions. Peppers are not as susceptible as eggplants, potatoes, tobacco or tomatoes. Rotation is not effective as the pathogen can survive for a long period - several years - in the soil and also attack a wide range of crops and solanaceous weeds.

What to do:

- **Plant varieties that are tolerant / resistant, if available**
- **Do not grow crops in soil where bacterial wilt has occurred**
- **Remove wilted plants from the field to reduce spread of the disease from plant to plant**
- **Control root-knot nematodes since they could facilitate infection and spread of bacterial wilt**
- **Soil amendments (organic manures) can suppress bacterial wilt pathogen in the soil**

- **Rotation is of limited value since the disease has a wide host range, but still it is recommended to avoid continuous planting of solanaceous crops.**

Bacterial wilt
Bacterial wilt (*Ralstonia solanacearum*) on sweet pepper
© A.M. Varela, icipe



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Cercospora leaf spot (Frogeye) (*Cercospora capsici*)

Spots on leaves are brown and circular with small to large light grey centres and dark brown margins. Spots on stems, petioles and peduncles are typically elliptical and also have light grey centres with dark borders. Infected leaves are shed. Extensive defoliation occurs under severe disease pressure. Fruits are not attacked. The fungus survives on seeds and in crop debris. The disease is favoured by prolonged periods of wetness.

What to do:

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

- **Practice good field sanitation**

Cercospora leaf spot
Cercospora leaf spot (here on soybean)
© Clemson University, USDA (EcoPort, www.ecoport.org)

Collar rot (*Sclerotium rolfsii*)

It is a common and destructive disease of peppers widespread in the tropics. The fungus attacks the stem at ground level eventually girdling and killing it. White fungal growth usually is visible on the base of the stem and on the soil line around the base of the plant. On the white fungal mat, sclerotia (resting fungal spores) about the size of mustard seed that are tan to brown when mature are produced. High soil moisture and temperatures (30-35° C) favour disease development. Symptoms are more severe during dry conditions following a wet period. The fungus has an extremely broad host range and it is also a good saprophyte.

What to do:

- **The disease can be reduced by liming and deep ploughing**

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

Disease symptoms include drooping and yellowing of lower leaves followed by wilting of the entire plant. Leaves on infected plants remain attached and the vascular system of the plant is discoloured, particularly in the lower stem and roots. The fungus lives indefinitely in the soil and is spread in irrigation water. It is very susceptible to changes in temperature and soil moisture. The optimum temperature for disease development is 24 to 27° C.

Soil moisture has the greatest influence. The wilt does not occur in dry soil, but it is serious in poorly drained fields.

What to do:

- **Plant resistant cultivars, if available**
- **Lime the soil**
- **Ensure the soil has a good drainage**
- **Apply soil antagonist Trichoderma spp., which is commercially available in Kenya**

Fusarium wilt
Chili plant infected with fusarium wilt (*Fusarium oxysporum* f.sp. *capsici*).
© A.A. Seif & B. Nyambo, icipe



Fusari Fusari Fusari

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Phytophthora blight (*Phytophthora capsici*)

All parts of the pepper plant can be affected. Seedlings can be killed. Collar rot and wilt phase is most common and is characterised by a dark brown stem discolouration extending upward from the soil line accompanied by a sudden wilt of the entire plant. Upper stem lesions (spots) are also dark brown and occur primarily at branch points causing death of branches above the lesions. Leaf spots are round or irregularly shaped, dark green and water-soaked. They later dry and become light tan.

Fruit infection begins as water-soaked, dull green spots that expand rapidly to cover the entire fruit. Later the fruits become flaccid and wrinkled but do not detach from the affected plants. The host range of the fungus includes cucurbits, eggplants and tomatoes. The fungus can survive on and in seeds, in soil and in crop debris. The collar rot and wilt phase is most severe in over-irrigated or poorly drained fields. Aboveground infection is associated with extended periods of rainfall or overhead irrigation.

What to do:

- **Plant resistant cultivars, if available**
- **Use certified disease-free seeds**
- **Grow on elevated beds**
- **Practice good water management**
- **Practice crop rotation (avoid in the rotation crops such as cucurbits, eggplant and tomatoes)**
- **Remove and destroy crop debris after harvest**
- **Copper sprays can minimise disease losses**

Information on Pests

Root-knot nematodes (*Meloidogyne* spp.)

Symptoms of infestation by root-knot nematodes are similar in all crops: wilting of plants and if infested plants are pulled from the soil the roots can be seen to be distorted, swollen and bearing knots (galls). The galls on pepper are much smaller than those on cucurbits or tomatoes. The infested roots eventually rot and affected plants die.

What to do:

- **Use of resistant varieties**
- **Crop rotation**
- **Mixed cropping / growing African marigold (Tagetes spp.)**
- **Maintaining high levels of organic matter in the soil (manure or compost). For more information on compost click here.**
- **Presently, some bioproducts are available for control of the root-knot nematodes (e.g. neem extracts). For more information on neem click here.**

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

Spider mites (*Tetranychus* spp.)

Spider mites suck the sap of the plants, causing mottling of the upper leaf surface. Infested leaves first show a white to yellowing speckling, and then eventually turn bronze and fall off as the infestation becomes heavy. Spider mites prefer the lower surface of the leaves, but in severe infestations occur on both leaves surfaces as well as on stems and fruits. High infestations cause defoliation.

What to do:

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

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

Aphids (*Aphis gossypii, Myzus persicae*)

Aphids (cotton aphid and green peach aphid) occur in colonies initially around tender plants parts (growing points, young stems and leaves, flower buds) and on the lower leaf surface. When numerous they can be found on all above ground parts of the plant. Aphids damage plants in three ways: by sucking their sap,

excreting a sticky substance (honeydew) that coats the plants, or/and by transmitting viral diseases.

Feeding by aphids causes distortion (curling, wrinkling, or cupping) of young leaves, chlorotic spotting and mottling of older leaves, and may lead to stunting and wilting of plants. Growth of sooty mould on honeydew excreted by aphids reduces photosynthesis and affects fruit quality.

Aphids cause indirect damage as vectors of important viruses such as alfalfa mosaic, chilli veinal mottle, cucumber mosaic, pepper mottle, pepper severe mosaic, pepper veinal mottle, potato Y and tobacco etch virus.

What to do:

- **Monitor regularly the crop.**
- **Aphids are naturally controlled by parasitic wasps; predators such as ladybird beetles, rove beetles, hoverflies, cecidomyiid flies, anthocorid bugs, spiders and lacewings; and by fungal diseases.**
  The parasitic wasps Aphidius spp are common in Kenya, and help to maintain aphids under control provided compatible pesticides are used for control of aphids or other pests.
- **Whenever necessary spray only affected plants (spot spraying).Use biopesticides that are not harmful to natural enemies (for instance neem, ashes, soapy water).**
- **Use biopesticides that are not harmful to natural enemies (for instance neem, ashes, soapy water). Neem products have a repellent effect and have been effective in reducing numbers of aphids on peppers. at 10 days intervals.**

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

Cutworms (*Agrotis* spp., *Spodoptera* spp.)

Cutworms are the caterpillars of various moths, belonging mostly to the genus *Agrotis*. Young caterpillars feed on leaves making small holes. After few days they drop to the soil where they live until pupation. Caterpillars remain in the soil during the daytime coming out at night to feed. They cut stems of young seedlings at the level of the soil, killing them and affecting establishment of the crop. Some *Spodoptera* species, in particular *S. littoralis* act sometimes as cutworms.
Caterpillars, in particular under hot conditions, hide during the day in the soil around the base of the plants, and may cut them, especially seedlings, at the base of the stem. At night they climb into plants to feed.

What to do:

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

Black cutworm
Black cutworm (*Agrotis ipsilon*). Early instars are about 7 to 12 mm long. Fully grown caterpillars are 3-5 cm long.
© Ooi P., Courtesy of Ecoport (www.ecoport.org)

Fruit flies (*Ceratitis* spp. *Bactrocera* spp., *Dacus* spp.)

Fruit fly females lay eggs under the epidermis of the fruit. After emerging from eggs maggots generally move to the core to feed, but they may also feed on the walls of the fruit. This causes secondary rot and premature fruit fall. An infested fruit usually has a small dimple where the female fly deposited an egg. As the maggot matures inside the fruit, the fruits turn red prematurely, becoming soft and rotten.
Soft spots can often be seen where the maggot has fed on the fruit. When infested fruit is picked, the cap usually separates from the fruit because the maggot has eaten the core. Fruit may drop from the plant. Maggots remain in peppers until fully grown (from 2 to 3 weeks). At this time the maggot leaves the pepper, drops to the soil to pupate. Yield losses can be considerable. One maggot can destroy an entire fruit.

What to do:

- **Plough and harrow before planting. This exposes pupae in the soil to natural enemies and desiccation**
- **Monitor fruit flies to determine when they arrive in the crop. Check the crop regularly and use bait traps**
- **Collect and destroy damaged fruit**

Fruit fly
Fruit fly (*Daccus bivittatus*) on a chilli pod. Adults are 4-7mm long.
© A. M. Varela, icipe

Fruit borers (*Helicoverpa* spp., *Spodoptera* spp.)

Moths of fruitborers are active at dusk and at night, feeding on nectar and laying eggs on leaves. Caterpillars feed on leaves, flowers and fruits. Although severe leaf damage by feeding of African bollworm (*Helicoverpa* spp.) caterpillars may slow plant growth due to reduced leaf area, caterpillar feeding on leaves is usually of not economic importance. The bollworms are about 2-3.5cm long.

The main damage occurs on flowers and fruits. Attack on flower buds results in flower abortion. Caterpillars usually bore holes in fruits, causing extensive damage and promoting decay from secondary infection by diseases.

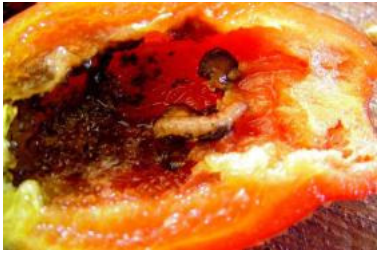
African armyworm (*Spodoptera* spp.) species are basically leaf-eaters and may cause defoliation when present in large numbers. They also feed on fruits, rendering them unmarketable.

What to do:

- **Plough the soil before planting. This exposes pupae to natural enemies and desiccation.**
- **Check the crop regularly. Early detection and destruction of eggs, or young caterpillars before they bore**

into the fruits is very important.

- **Handpick and destroy damaged fruits, eggs and caterpillars. This helps when their numbers are low and in small fields.**
- **Conserve natural enemies. Parasitic wasps, ants, pirate bugs are very important for natural control of the African bollworm.**
- **Whenever necessary use biopesticides such as Bt, neem products or other plant extracts. This is particularly important from the onset of flowering. Target caterpillars before they enter the fruit. For more information on neem click here. For information on Bt click here.**



Fruit borer
Caterpillar damage in chilli fruit, they are about 2-3.5cm long
© A.M. Varela, icipe

Fruit bore…

Fruit bore…

Leafmining flies (Leafminers) *Liriomyza* spp.

Female flies make numerous small, whitish punctures on the foliage when feeding and depositing eggs. These punctures can serve as entry points for disease-causing organisms such as bacteria and fungi. The eggs hatch into tiny yellow maggots that feed on leaf tissues leaving a wandering track known as mines. Full-grown

maggots come out of the mines to pupate in the soil beneath the plants or on the foliage. Maggots are the most destructive stage.
The mines may reduce photosynthetic activity, affecting development of flowers and fruits. In severe infestation, the leaves might be completely mined, dry and fall off prematurely, causing loss of vigour and turgidity of the plant. This may eventually result in wilting, in particular in warm weather, leading to yield loss, fruit sunscald, or in serious cases death of the plant, especially of young pants.

What to do:

- **Control by natural enemies is important.**
- **Ploughing can help in exposing pupae to desiccation and natural enemies.**
- **Neem products are effective for controlling leafminers. For more information on neem click here.**

Leafminer
Mining of a chilli leaf by leafmining flies (*Liriomyza* spp.)
© A. A. Seif & B. Nyambo, icipe

Thrips (*Frankliniella* spp., *Scirtothrips dorsalis, Thrips tabaci*)

Thrips usually feed on all above ground parts of plants, preferring the underside of young leaves, flowers and fruits. Often they are concealed under the calyx. Plant damage results from thrips puncturing leaves and sucking the exuding sap. At the initial stage of infestation leaves have a silvery sheen and show small, dark

spots of faecal material on the underside. When the attack increase leaves curl upward, wrinkle and finally dry up. This may cause fruit sunscald.

Heavy feeding damage turns leaves, buds and fruits bronze in colour. It may cause wilting, retardation of leaf development and distortion of young shoots resulting in stunted plants. Attack on fruits causes deformation and scarring (manifested as brown lines) of the fruits making them unmarketable, especially fruits for the export market. Thrips attack at the seedling and early stages of the crop delays crop development. Thrips transmit the tomato spotted wilt virus in peppers. *S. dorsalis* transmit the leaf curl disease of chillies.

What to do:

- **Natural enemies of thrips are important for natural control. Main natural enemies include anthocorid bugs (Orius spp.) predatory mites and spiders.**

Thrips
Thrips damage on a chilli pod.
© A.A. Seif & B. Nyambo, icipe

Thrips

Thrips

Whiteflies (*Bemisia tabaci, Trialeurodes vaporariorum*)

Whiteflies damage plants in three ways. Whitefly immature stages (nymphs) and adults suck sap from leaves. Their feeding, in addition to removing plant nutrients, produces chlorotic spots on infested leaves. Nymphs excrete a clear sugary liquid known as honeydew, which often completely covers the leaves during heavy infestation. Honeydew supports the growth of a black sooty mould, and as a result the leaves may turn black, affecting photosynthesis.
Whiteflies are vector of important viral diseases such as chilli leaf curl, tiger disease, Serrano golden mosaic, and Texas pepper geminivirus.

What to do:

- **In areas where whitefly-transmitted viral diseases are a problem keep the seedlings protected under a fine meshed insect netting until they are ready for transplanting. Make sure the netting is always properly closed**
- **Conserve natural enemies. Parasitic wasps, predatory mites, ladybird beetles, and lacewings are important natural enemies of whiteflies**
- **Whenever necessary spray with neem products. Neem products inhibit growth and development of immature stages, repel whitefly adults and reduce egg laying**

Whiteflies
Whiteflies on chilli leaf. Adults are about 1mm long.
© B. Nyambo, A. A. Seif, icipe

Broad mite or yellow tea mite (*Polyphagotarsonemus latus*)

Broad mites are tiny (0.1-0.2 mm long) and cannot be seen with the naked eye, and are even difficult to detect with a hand lens. An attack the broad mites can be detected by the symptoms of damage. They live on the underside of leaves, tender stems, fruits, flower peduncles and flowers. Their feeding produces discoloration, necrosis of tissues and deformation. Initial attack occurs on the stems of terminal shoots and the lower surface of young leaves.

Young leaves turn narrow, twisted or crumpled, fail to elongate and finally may wilt and dry, giving the plant a scorched appearance. Older leaves are generally cupped with corky brown areas between the main veins on the lower side of the leaves. The succulent part of the stem of young plants may become slightly swollen, roughened or russeted. The foliage becomes rigid. Attacked fruits become deformed with a cork-like surface or fail to develop. Severely infected fruits fall, and yield is significantly reduced. Symptoms remain for a long period of time after control.

What to do:

- **Broad mites are attacked by predacious mites. Phytoseiulus persimilisis not very much attracted to broad mites. Amblyseius spp are better predators of broad mites, in particular A. californicus is used for control of broad mites in different parts of the world.**
- **Broad mites can be effectively controlled with sulphur sprays. However, sulphur is toxic to predatory mites.**

Broad mite
Broad mite (*Polyphagotarsonemus latus*) damage on chillies
© A.M. Varela, icipe

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Information of www.infonet-biovision.org

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Cowpea

Cowpea
Scientific name: *Vigna unguiculata*
Family: Fabales: Fabaceae
Local names: Kunde (Swahili, Kipsigis), mathoroko (Kikuyu), likhuvi (Luhya),a lot-bo (Luo), nthooko (Kamba), egesare (Kisii), Kiyindiru (Luganda)
Common names: yard long bean
Pests and Diseases: African bollworm Anthracnose Aphids Bacterial blight Brown blotch Bugs Charcoal rot Cowpea mosaic diseases Cowpea seed beetle Damping-off diseases Flower or blister beetles Foliage beetles Fusarium wilt Leaf spots Legume pod borer Powdery mildew Purple witchweed Root-knot nematodes Rust Southern blight Storage pests Thrips Bean fly, Whiteflies

General Information and Agronomic Aspects

Geographical Distribution of Cowpea in Africa

Cowpeas are basically annual crops grown for their leaves and seed. The growth habit is climbing, spreading or erect and they belong to the bean family (*Leguminosae) (Papilionaceae)*. Cowpeas are native to Africa where they were domesticated over 4000 years ago. The crop exhibits much variation in growth habit, leaf shape, flower colour and seed size and colour.

Cowpeas are mainly important in the marginal rainfall areas because they are well adapted to dry climate and suitable for a variety of intercropping systems. Cowpeas are cultivated for the seeds (shelled green or dried), the pods or leaves that are consumed as green vegetables or for pasture, hay, silage and green manure. Tender cowpea leaves and shoots contain 4% protein, 4% carbohydrates and are rich in calcium, phosphorus and vitamin B.

Dried seeds contain 22% protein and 61% carbohydrates. The leaves may be dried and stored for later use. Cowpeas that are sprayed with pesticides should not be eaten as leaves unless pre-harvest intervals are

followed. In Africa, where cowpeas are the preferred food legume, they are consumed in three basic forms:

- **Cooked together with vegetables, spices and often palm oil, to produce a thick bean soup, which accompanies the staple food (cassava, yams, plantain)**
- **Decorticated and ground into a flour and mixed with chopped onions and spices and made into cakes that are either deep-fried (akara balls)**
- **Steamed (moin-moin)**

Climate conditions, soil and water management

Cowpeas are generally tolerant of drought and low light conditions, but are very susceptible to a variety of insects and diseases and do not do well in poorly drained and cool areas. Local land races of cowpeas grown by farmers in West Africa are well adapted so that they start to flower at the end of the rains at a particular locality. The optimum temperature to their growth and develop is 20 to 35°C. Cowpea can grow in a wide range of soils, well adapted to light sandy soils where most other crops produce poorly and they do well on acid soils. On heavy fertile soils they show a vigorous vegetative growth, but not necessarily a good grain yield. Most varieties need a minimum rainfall of 200 mm during a growing season.

Propagation and planting

Cowpeas are seed planted about 20 to 40 cm apart and are often grown as an intercrop with pearl millet, sorghum or maize at wide spacings (total plant population 10,000-20,000 plants per ha). When produced as a green vegetable, they are commonly grown as a monocrop in rows 30 to 40 cm apart with 8 to 12 cm between plants. Some very drought resistant types may grow for two seasons in the farm. Tillage normally follows the crop with which cowpeas are interplanted. When sown in rows, a seed-rate the seed-rate is 10-40 kg/ha.

Cowpea varieties and their characteristics:

Variety	Maturity Days	Remarks	Target areas of production	Recommended spacing(Kenya)
"Machachos 66" (M66)	85-95	Dual purpose variety. Erect, reddish colour and good for intercropping	Medium and higher altitudes 1200-1500m above sea level	60 cm between rows 20 cm between seeds
"Katumani 80" (K80)	75-85	Dual purpose variety, erect, improved, good for intercropping	Drier areas or areas below 1500m above sea level receiving less than 200 mm rain per season	60 cm between rows 20 cm between seeds
"KVU-419"	65-72	Has smaller seed than both "M66" and "K80". More of a grain type than a leaf type	Areas below 1200 m receiving less than 200 mm rain per season	50 cm between rows and 20 cm between seeds
"KVU HB 48E 10"	85-95	More vegetable type than grain type	Medium and higher altitudes 1200-1500 m above sea level	60 cm between rows 20 cm between seeds
"Ngombe"		Semi spreading, good for green leaf production, sweet taste of grain		
Local varieties (land races)		Varying colours and spreading or semi spreading		

Husbandry

Most cowpea crops are rain-fed, a few are irrigated and others use residual moisture in the soil after harvest

of a rice crop. Cowpeas are particularly well suited for rice-based cropping systems. Two to three weedings during the first 1.5 months after planting are recommended. Losses due to weeds can be 30-65%. Parasitic weeds, such as *Striga gesnerioides* (Purple withweed), generally associated with continuous cropping of cowpeas in Africa, may also cause severe damage.

One additional benefit of cultivating cowpeas is their ability to fix atmospheric nitrogen in root nodules through symbiosis with a *Rhizobium* bacteria that are common in most soils. An effective cowpea-*Rhizobium* symbiosis fixes more than 150 kg/ha of N and supplies 80-90% of the total N required. Inoculation may be advantageous, if the crop has not been grown for many years. In general, no fertilisers are applied. Cowpeas are commonly incorporated in crop rotations in semi-arid, humid and subhumid environments.

A cowpea crop of the leafy types grown before a maize or millet crop and incorporated green into the soil, can produce a good grain crop without any addition of more nitrogen. Intercropped cowpeas also share nitrogen with the other crops (for example maize, millet, sorghum and cotton). For intercropping choose a cowpea variety carefully - the spreading types may over power other crops such as cotton by entangling their branches and interfering with fieldwork.

Cowpeas do not normally respond to nitrogen or phosphorus fertilisers, so none need adding. However where soils are highly eroded an application of 5 tons/ha of dry compost or manure is beneficial.

Weed during early stages of crop, later the cowpeas will cover the ground and suppress weeds including purple witchweeds. Two weedings are recommended, one two weeks after emergence and the second weeding just before flowering.

Harvesting

Leaves for eating must be young and tender. Three leaf pickings (starting 2 ½ -3 weeks after planting at weekly intervals have little effect on grain yields of five to six 90kg bags of seed per acre. Green pods are

harvested by hand when they are still immature and tender (12-15 days after flowering). When grown as a grain, harvesting is complicated by the prolonged and uneven ripening of many cultivars. Time of harvesting is critical as mature pods easily shatter, so hand-picking can be advantageous. Sometimes plants are pulled when most of the pods are mature. For hay, the crop is cut when most of the pods are well developed.

Information on Pests

The legume aphid (*Aphis craccivora*)

It is a widespread pest of cowpeas. Aphids suck sap on stems, terminal shoots and petioles of seedlings, and on pods and flowers of mature plants.

A heavy attack can cause death of young seedlings, stunting and delay in flowering on older plants. However, it is more important as vector of virus diseases (e.g. the cowpea mosaic virus) is more important.

What to do:

- **Use resistant varieties where available.**
- **Monitor build-up of aphids and natural enemies.**
- **Use neem seed or leaf extracts if necessary.**

Black legume aphid

Black legume aphid (*Aphis craccivora*) is a relatively small aphid. Immatures are slightly dusted with wax, adults without wax. They are about 1-2mm long.

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Black legu… **Aphids**

African bollworm (*Helicoverpa armigera*)

The African bollworm caterpillars are 3 to 4 cm long. Several leaf-eating caterpillars feed on cowpeas. Several species of *Spodoptera* are sporadic cowpea pests. The hairy caterpillar *Amsacta moorei* causes extensive damage to seedlings and it has been considered the most important pests of cowpeas in Senegal. African bollworm (*Helicoverpa armigera*) can cause extensive damage on young pods. Natural enemies are important to keep pest populations at low level.

What to do:

- **Monitor regularly for caterpillar eggs and just emerging caterpillars.**
- **Hand pick eggs and young caterpillars. This helps when their numbers are low and in small fields.**
- **Use of bio-pesticides such as botanicals (e. g. neem extracts) and Bt. For more information on neem click here. For information on Bt click here**

African bollworm
African bollworm (*Helicoverpa armigera*) on French beans. Fully grown caterpillars are 3-4 cm long.
© A.M. Varela, icipe

Foliage beetles (*Ootheca*) spp.

A large number of beetles chew leaves and flowers of cowpea plants. The most important are the foliage beetles Ootheca mutabilis, and *O. bennigseni*, they are about 4-7mm long. They have been reported causing extensive damage in several countries in West and East Africa. High beetle population can cause complete defoliation of young plants. In addition, *O. mutabilis* is an efficient vector of the southern bean mosaic and cowpea mottle viruses.

Foliage beetles chew small round holes in the leaves. They may be a serious problem when present in large numbers or when attacking young plants. Heavy attacks may cause defoliation. Attack on young plants may reduce plant vigour, plant size and yield. The problem is more acute in fields with continuous growing of beans. *Ootheca* beetles are also pests of French beans, and important pests of common beans in East Africa.

The larvae (grubs) of foliage beetles live in the soil feeding on roots. Their feeding may cause stunted growth and premature ageing of the plants. Grubs of weevils live in the soil feeding on roots or may bore into the stem of the bean plant causing swellings or galls, as is the case of the striped bean weevil. Plants attacked by grubs of this weevil show stunted growth and may die. The stem of the plant breaks easily during harvesting

What to do:

- **Adults can be picked manually and destroyed.**
- **Apply neem seed extracts. This has been shown to reduce beetle numbers and damage.**
- **Practice post harvest tillage to expose the grubs in the soil to the sun heat and to predators.**
- **Rotate cowpeas with non-host plants such as maize or sunflower to break the development cycle of the pest**

Foliage beetle
Foliage beetles damage on French beans
© A.M. Varela, icipe


Foliage be…


Foliage be…

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

These beetles can cause serious damage to cowpeas by feeding on flowers. The adults of the flower beetles, also known as blister beetles, feed on bean flowers (petals and / or pollen) reducing pod set.

The adults are medium to large sized beetles (2-5cm in length), usually black and yellow or black and red in

colour. The immature stages (larvae) do not feed on plants. They live in he soil and eat grasshopper eggs.

What to do:

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

Blister beetle
Blister beetle (*Mylabris oculata*). Adults are 2-5 cm in lenght.
© Botha AD (Courtesy of EcoPort, www.ecoport.org)

Thrips (*Megalurothrips sjostedti* and *Frankliniella schultzei*)

Thrips are among the most widespread and important pests of cowpeas in Africa. The cowpea flower thrips or African bean flower thrips (*Megalurothrips sjostedti*) causes yield losses of up to 100%.

During the pre-flowering period, nymphs and adults of this thrips may damage the terminal buds. However, the main damage is on the flower buds and flowers. Attacked flower buds become brown and eventually fall off, leaving behind dark red scares. Damaged flowers are distorted, malformed and show decolouration and may fall off. Attack on pods cause malformation of pods.

What to do:

- **Intercropping: There are several reports that thrips populations are reduced when cowpeas are intercropped with maize or sorghum. However, there are also conflicting reports (Ezueh, 1991) indicating increased pod borer and pod sucking bug populations in mixed cropping of cowpeas with sorghum (Nanpala et al, 2002).**
  In Kenya, populations of the African bean flower thrips (Megalurothips sjostedti) and Hydatothrips adolfifridericion cowpea buds were almost halved by intercropping the cowpea with sorghum and maize (Parella and Lewis, 1997).
- **Use resistant varieties. The varieties "IT90K-277-2", "KVx404-8-1", "Moussa Local", "Sanzisabinli", "Sewe", "TVu1509", "TVx34236", and "IT91K-180" are reported to show resistance against the cowpea flower thrips in West Africa (IITA).**
- **Spraying with neem extracts. In Ghana a threshold of 5 thrips per flower is recommended as a guideline before spraying (GTZ/PPRSD). In Uganda the economic injury level has been established at 7 thrips per flower (IPM CRSP).**

Flower thrips
Flower thrips (*Megalurothrips sjostedti*). Real size (0.9 to 1.1 mm) about the size of a flea, are barely visible to the naked eye.
© Georg Goergen (Courtesy of EcoPort, www.ecoport.org)


Flower thr…


Thrips dam…

Bugs

There are several pod sucking bugs. The tip wilter (*Anoplocnemis curvipes*), the spiny brown bug (*Clavigralla tomentosicollis*, Riptortus bugs (*Riptortus dentipes*), *Mirperus jaculus*, the green stink bug (*Nezara viridula*) and *Aspavia* sp.

These attack cowpeas in Africa. The spiny brown bug *Clavigralla tomentosicollis* and *Riptortus dentipes* are the most important, causing serious damage. Nymphs and adults attack young, tender pods and causing shrivelling and rotting of pods and malformation of seeds, which lose viability.

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

What to do:

- **Control weeds to destroy roosting sites.**
- **Monitor crops regularly. A threshold of 2 bugs/metre row has been recommended as a guideline for bug control in Ghana (GTZ/PPRSD).**
- **Conserve natural enemies such as assassin bugs, spiders, praying mantises and ants. These are important natural enemies of bugs. They kill or deter bugs. Conserve and attract predatory natural enemies to your crop by planting flowering plants. For more information on natural enemies click here**
- **A number of plants (lantana, garlic, oleander, African marigold, blackjack, goat weed, wormseed, among others) are reported as effective repellent crops against various species of bugs (Elwell and Maas, 1995).**
- **Alghali (1991) reported an integrated pest management strategy for cowpea production. In Nigeria, intercropping with sorghum reduced the numbers of Riptortus bugs in cowpea significantly.**

- **Bugs can be collected by hand regularly and killed, especially during flowering and pod formation.**
- **A commercial formulation of neem (Neemix®) gave effective control of stink bugs on cowpeas. This product was applied three times at the beginning at pod formation using 210.4 g azadirachtin per hectare (Abudulai et al., 2003).**
- **Pyrethrins are recommended for control of sucking bugs in organic production in USA (Layton, 2004).**

Spiny brown bugs
Spiny brown bugs (*Clavigralla* spp.) measure about 1cm in length.
© A.M. Varela, icipe


Spiny brow.. **Riptor ...**

Legume pod borer (*Maruca vitrata*)

This is the most important pod borer pest, causing severe damage to cowpeas. Losses over 80% have been reported on indigenous varieties and even on high yielding varieties.

Moths usually lay eggs on flower buds, flowers, or on terminal shoots of young plants. Young caterpillars may feed on any part of the flowers or foliage. Several young caterpillars may be found together among flowers. Older caterpillars are highly mobile, feeding continuously on flowers and newly formed pods, causing severe

damage to the crop. Upon reaching maturity the caterpillars drop from flowers or pods onto the soil and pupate beneath the plant under leaf debris. The caterpillar of the African bollworm bore into cowpea pods, but remain outside while eating whole seeds.

Caterpillars of the legume pod borer are dull to yellow-white and often reach a length of 1.8 cm. Each segment has dark spots that form a distinct series along the length of the body. The head is dark brown to black.

What to do:

- **In Ghana, spraying with neem extracts and use of the trap crop Crotalaria juncea has been recommended (GTZ/PPRSD). Neem products showed to be effective against the legume pod borer in Niger. Weekly applications of an aqueous neem seed extract proved to be more effective than neem oil at 12l/ha (Dreyer and Ostermann, 1995).**
- **Leaf and bark extracts of the forest trees Khaya anthotheca and K. grandifolia proved to have the same insecticidal and anti-feedant properties of neem on the legume pod borer in West Africa (IITA).**

Legume pod borer
Legume pod borer (*Maruca vitrata*) reach a length of 18mm
© Ooi P. Courtesy of EcoPort, www.ecoport.org

Cowpea weevils (*Callosobruchus* spp.)

Adults are 2.0-3.5 mm long. They are also known as the cowpea seed beetles and are the principal storage pest of cowpea. These bruchids may infest up to 100% of the stored seeds within 3 to 6 months under ordinary storage conditions. A positive relationship between pod damage by field pest (pod sucking bugs and pod borers) and bruchid infestation in storage was found in Uganda. Controlling pests infesting pods of cowpeas in the field significantly reduce bruchid carryover in storage (IPM CRSP).

What to do:

- **Use neem extracts**
- **Dry seeds for storage to a moisture level below 13%**

Cowpea weevils
Cowpea damaged by cowpea seed beetles and weevils (*Callosobruchus* spp.)
© A. M. Varela, icipe

Cowpe wee…

Cowpe see…

Root-knot nematodes (*Meloidogyne* spp.)

Relatively small galls or knots develop on roots of affected plants. Do not confuse root knot galls with

naturally occurring bacterial nodules that are beneficial.

What to do:

- **Use resistant or tolerant varieties if available**
- **After harvest, uproot entire plants and destroy crop debris. Tops can be composted but any infested roots should be burnt since nematodes may survive the relatively low heat of compost heap.**
- **Flooding the soil for a few weeks will reduce nematode populations, as will bare fallow**
- **Use mixed cropping or grow African marigolds (Tagetes spp.). These have nematicidal properties that will help to reduce nematode populations.**
- **Rotate with nematode resistant or tolerant crops (e.g. cereals, onions or fodder grasses).**

Root-knot nematodes
Roots infected with Root-knot nematodes
© H.J. Jensen (Reproduced from CABI 2006)

The pod weevil (*Piezotrachelus varius*)

The pod weevil (*Piezotrachelus varius* or *Apion varium*), its a common pest of cowpeas in West Africa. Generally 13-26% of the pods are damaged. Losses of seeds up to 92% have been reported in Nigeria. The shiny black weevils bore holes in fresh green cowpea pods and lay eggs into the pods. The grubs feed on the seeds and pupate within the pods.

Pod weevil
The pod weevil Apion species on bean pod.
© Frank Peairs, Colorado State University

Information on Diseases

Cowpea mosaic diseases

These viruses produce a mosaic pattern on cowpeas. They may be found singularly or in combination with others. They cause irregular light and dark green mosaic patterns in the leaves. Some virus cause thickened, malformed leaves. The mosaic patterns are best observed on the younger foliage. Plants may be stunted and fail to produce normal pods. If the disease attacks plants at the early growth stage, no pods should be expected.

The most common virus disease on cowpeas is cowpea aphid-borne mosaic potyvirus. It is transmitted by aphids.

Mosaic diseases include:

- **Cowpea mosaic comovirus (CpMV)**
- **Blackeye cowpea mosaic potyvirus (BlCMV)**
- **Cowpea severe mosaic virus (CPSMV)**

- **Cowpea aphid-borne mosaic potyvirus (CAMV)**
- **Cowpea mottle carmovirus (CPMoV)**
- **Cowpea golden mosaic bigeminivirus.**

What to do:

- **Plant resistant varieties, where available.**
- **Use healthy, disease-free seeds rather than saving seed from a crop that could be infected.**
- **Practise crop rotation with non-legumes (e.g. cereals).**
- **Remove alternative hosts of virus diseases (legumes).**

Cowpea mosaic virus
Cowpea mosaic virus (CpMV)
© Thorben Lundsgaard, KVL, Denmark

Damping-off diseases (*Rhizoctonia* sp., *Phythium* sp., *Fusarium* sp.)

Seeds may rot before emergence from the soil and young seedlings may die. The condition is most common on early plantings or when soil contains a large amount of undecomposed plant residue.

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

What to do:

- **Avoid planting in wet, cold soils.**

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

Bacterial blight (*Xanthomonas axonopodis* pv. *vignicola*)

This disease appears as tan to brown angular leaf spots with yellow margins on leaves, pods, and stems. It may cause severe defoliation during periods of high humidity. It is seed borne.

What to do:

- **Use certified disease-free seeds.**
- **Avoid working in the fields when it is wet.**
- **Practise good field sanitation.**

Bacterial blight
Bacterial blight (here on soybean leaf)
© Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org

Anthracnose (*Colletotrichum lindemuthanium*)

This is a major cowpea disease, which can be very severe in areas where cowpeas are grown as the sole crop. Stems affected by anthracnose exhibit dark brown areas that later join up to cover the entire stem as well as branches, peduncles and petioles. The disease also attacks the pods.

Lesions on pods are sunken and brownish and under wet conditions they are covered with a pink fungal spore mass. Under severe infection, stems die. The disease attacks all legumes. Anthracnose is most prevalent during cool, humid weather. It is transmitted through infected seeds and survives in crop debris.

What to do:

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

Anthracnose
Anthracnose (*Colletotrichum lindemuthanium*) on beans pod. Symptoms are similar on cowpea.
© Jim Sheppard (Courtesy of EcoPort, www.ecoport.org)



Anthra Anthra Anthra

Powdery mildew (*Erysiphe polygoni*)

Symptoms consist of a light, greyish, powdery growth on the leaves, pods and occasionally the stems. This powdery growth is easily rubbed off. When the disease is severe, plants turn yellow and defoliate. Generally, powdery mildew does not damage early-planted cowpeas. It can, however, be quite destructive on a late-planted crop. A fairly dry soil and heavy application of nitrogen-based fertilizer tend to increase disease severity.

What to do:

- **Plant resistant varieties where available**
- **Practise good field sanitation**
- **Avoid close planting**
- **Control weeds**

Powdery mildew
Powdery mildew on peas
© A. M. Varela, icipe


Powde mi… **Powde mi…**

Leaf spots (*Cercospora* sp., *Aristastoma* sp., *Ascochyta* sp., *Colletotrichum* sp., *Stagnospora* sp.)

Various sized spots often yellowish in colour or with a yellow halo, others brown to purplish; these normally develop first on lower leaves. With *Cercospora* leafspot a dark, mouldy growth develops on the lower leaf surface corresponding to the spot. Leafspot diseases are most serious during periods of prolonged moist weather and on late plantings. Severe leaf spotting results in defoliation with subsequent yield reductions.

What to do:

- **Use certified disease-free seeds**
- **Practise crop rotation with non-legumes (e.g. cereals).**
- **Avoid cultivating fields when foliage is wet**

Cercosphora leafspot
***Cercospora* leafspot on soybean**
© Clemson University, USDA (EcoPort, www.ecoport.org)

Brown blotch (*Colletotrichum truncatum*)

The fungus causes pre-emergence and post-emergence damping off when infected seeds are planted. The former rots the seed before emergence from the soil while post-emergence kills the seedlings after emergence. The disease also attacks the foliage, stems and pods. Sunken, oval spots may be seen on stems; circular spots on leaves. Lesions are reddish-brown. Under prolonged wet weather heavy defoliation occurs. During late reproductive stages, infected tissues are covered with black fungal fruiting bodies, which produce minute black spines (setae) that can be seen with the unaided eye. It is transmitted through infected seeds and survives in crop debris.

What to do:

- **Use certified disease-free seeds.**
- **Use resistant varieties where available.**
- **Practise good field sanitation.**

Brown blotch
Brown blotch (*Colletotrichum truncatum*) (here on soybeans
© Tadashi Yorinori J. (Courtesy of EcoPort, www.ecoport.org)

Rust (*Uromyces vignae*)

Small, reddish-brown pustules (blisters) appear on both upper and lower leaf surfaces. Rust can develop rapidly, resulting in severe leaf damage and defoliation.

What to do:

- **Use sulfur based products or potassium carbonate. Do not spray sulphur when it is hot, as it can burn the foliage and flowers.**

Rust

Rust on cowpea (*Uromyces vignae*)
© Jackson G. (Courtesy of EcoPort, www.ecoport.org)

Cowpea wilt (*Fusarium oxysporum*

Cowpea wilt (*Fusarium oxysporum* f. sp. *tracheiphilum*)
Fusarium wilt usually causes the lower leaves on one side of the plant to turn yellow. Infected plants usually are stunted and wilted as the organism develops in the food and water conducting tissues. Brick red tissue can be observed in the stem when it is split lengthwise.

What to do:

- **Use resistant varieties, if available**
- **Control root-knot nematodes since nematodes increase plant susceptibility to Fusarium wilt**

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


Fusari w…


Fusari w…


Fusari w…

Southern blight (*Sclerotium rolfsii*)

It attacks roots and stems of cowpeas. The first visible symptom of southern blight is a progressive, yellowing and wilting of the foliage beginning on the lower leaves. The plant dies within a few days after the rust symptoms appear. A brownish vascular discolouration inside the stem may extend several inches above the soil line. During warm, moist conditions, the coarse, white mycelium of the fungus makes characteristic fan-shaped patterns of growth on the stem at the soil line. In this white-mat of the fungus, numerous smooth, round, light-tan to dark-brown mustard seed-like bodies called sclerotia are formed.

What to do:

- **Practise good field sanitation.**
- **Practise crop rotation with non-legumes.**
- **Plough the soil deep.**

Southern blight
Southern blight (*Sclerotium rolfsii*) on soybean
© Clemson University - USDA Cooperative Extension Slide Series, www.insectimages.org\n

Charcoal rot (*Macrophomina phaseolina*)

Charcoal Rot (fungus - *Macrophomina phaseolina*). Many plants are susceptible to this soil borne fungus and

symptoms vary according to type. Infected stem tissue shows evidence of shredding with tiny black dots (sclerotia) between the remaining tissues. This gives those plant parts an ashy-grey appearance. This can be observed by splitting the stalk and noting the deteriorated soft pith tissue leaving the tougher vascular strands. Fungal structures (sclerotia) can be observed in the affected tissue which appears as though it has been dusted with black pepper

Grain sorghum plants affected by the charcoal rot fungus fail to fill grain properly and may lodge in the latter part of the season.

Charcoal rot occurs most consistently when plants are experiencing moisture stress due to drought. The fungus is widely distributed and builds up in soil when susceptible host plants are present and conditions favour its development.

Avoiding moisture stress, proper management of crop residue, crop rotation, avoiding excessive plant populations, balancing nitrogen and potassium fertility levels, and growing drought-tolerant, lodging-resistant hybrids represent the best means of control.

What to do:

- **Rotate with unrelated crops (e.g. cereals) helps reduce the population of the fungus in the soil.**
- **Avoid moisture stress by increasing the moisture holding capacity of the soil and, if available, using irrigation when needed.**
- **Rotate with crops that are not seriously affected by this organism.**
- **Practices that hasten decomposition of crop residue may help decrease the population of the fungus in the soil.**

Charcoal rot
Charcoal rot of sorghum, showing the typical charcoal-grey within the split base of the stem
© Joseph Krausz, Texas Agricultural Extension Service

Information on Weeds

Witchweed (*Striga hermonthica*)

The parasitic weed witchweed (*Striga gesnerioides*) is also a problem in cowpea.

What to do:

- **Practise crop rotation.**
- **Practise fallow**
- **Use resistant cultivars if available.**

Witchweed
Witchweed (*Striga hermonthica*) flowering on a sorghum crop.

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Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Groundnut

Groundnut
Scientific name: *Arachis hypogaea*
Family: Fabales: Fabaceae
Local names: Njugu (Swahili)
Common names: Peanut, earth nuts, monkey nuts
Pests and Diseases: Aphids Aspergillus crown rot Bacterial wilt Damping-off diseases Groundnut blight Groundnut hopper Groundnut rosette disease Leaf spots Leafmining caterpillars Milipedes Root-knot nematodes Rust Snails (Giant East African Snail) Spider mites Storage moths and bruchid beetles Storage pests Termites Thrips White grubs

General Information and Agronomic Aspects

Geographical Distribution of

Groundnuts originated in the area of South America from southern Bolivia to north-western Argentina. The Portuguese apparently took them from Brazil to West Africa and then to south-western India in the 16th century. Africa is now regarded as a secondary centre of diversity. Groundnuts are now grown in most tropical, subtropical and temperate countries between 40°N and 40°S latitude, especially in Africa, Asia, North and South America.

Groundnuts are a small erect or trailing herbaceous legume, about 15 to 60 cm high. The fruit is a pod with one to five seeds that develops underground within a needle-like structure called a peg. The seeds are rich in oil (38-50%), protein, calcium, potassium, phosphorus, magnesium and vitamins. Groundnuts have also considerable medicinal value. They are reported to be useful in the treatment of disease such as haemophilia,

Groundnut in Africa **stomatitis, and diarrhoea.**

Most of the world production of groundnuts is crushed for oil that is used mainly for cooking. The press cake from oil extraction is a feed rich in protein but is also used to produce groundnut flour, which is used in many human foods. The seeds or kernels are eaten raw, boiled or roasted, made into confectionery and snack foods, and are used in soups or made into sauces to use on meat and rice dishes. The vegetative residues from the crop are excellent forage.

In sub-Saharan Africa, groundnuts are a basic staple crop, cultivated mainly by small-scale farmers both as subsistence and as a cash crop. It is an important source of protein and other nutrients for poor rural communities. In Africa, groundnut yields are traditionally low, due to unreliable rains, little technology available to small-scale farmers, pest and disease occurrence, poor seed variety, and increased cultivation on marginal land (ICRISAT).

Climatic conditions, soil and water management

Groundnuts are grown in the warm tropics and subtropics below 1500 m above sea level, and in temperate humid regions with sufficiently long warm summers. Optimum mean daily temperature to grow is 30°C and growth ceases at 15°C. Cool temperatures delay flowering. Groundnuts cannot stand frost. Between 500 and 600 mm of water reasonably well distributed through the growing season allows a good production. Nevertheless, groundnuts are a drought-tolerant species and can withstand severe lack of water, but yield is generally reduced. If harvesting conditions are wet, aflatoxins (severe poison produced by some fungi such as *Aspergillus* spp.) may develop on the nuts. Aflatoxin contamination is a major hazard to human and animal health.

Because pods develop underground and must be recovered at harvest, crumbly, well-drained soils are preferred, but plants grow and develop adequately on heavier clay soils. For optimum growth, soil pH should be in the range 5.5 to 6.5, though Spanish types tolerate more acid conditions (pH 4.5) and some cultivars grow well in alkaline soils up to pH 8.5.

Propagation and planting

Ideally the seedbed should be deep and friable with an even particle size. Take care that the seedbed is weed-free. Cloddy and uneven seed beds can result in uneven emergence and heavy seed bed losses of plants. Recommended plant densities are near 200,000 to 250,000 plants/ha for the typically short-season Spanish cultivars. In most countries, cultivation is in rows with plant spacing ranging from 40 x 20 cm to 30 x 20 cm.

After ploughing and harrowing to a fairly good tilth, ridges, which are 80 cm apart with flattish tops, should be made so that two rows of nuts can be planted on each ridge. Seeds for planting should be well selected: they should be clean, well filled and without any blemishes. Seeds for planting should be kept in their pods and shelled a few days before planting. Planting depth is like maize about 5 to 8 cm. Seed rate is 40 to 50 kg/ha depending on the size of the seeds.
There are 2 types of groundnuts:

- **Bunch type**
- **Runner type**

Bunch varieties such as Red Valencia mature within 90 to 100 days, while runner types such as "Homa Bay" mature in 120 to 150 days (require a longer growing season).

Variety	Mean kernel yield Kg/ha
"Red valencia"	1500
"Severe 116" (white)	1250
"Texas peanut"	1360
"Bukene"	1530
"Manipintar"	2450
"Makulu red"	2720

"Altika"	900
"Homa Bay"	770
"Asirya Mwitunde"	1300

With good husbandry current farmers' yields of between 450-700 kg/ha could be doubled.

Intercropping

Groundnuts are grown as a sole crop and also intercropped with maize, soyabean and cassava. It is also a good intercrop for upland rice, sorghum, okra, sugarcane, and sunflower. To get a good yield however, proper planting distance should be observed along with the other recommended cultural practices. In some areas, they are grown under perennial tree crops such as coconut, oil palm or rubber. Groundnuts when used as intercrop for upland maize and planted along the contour reduces soil runoff. The plant also reduces population of African bollworm because it serves as a hiding place for beneficial insects. (OISAT)
There is an increase in the yield of groundnuts when intercropped with early maturing pigeon pea.

Husbandry

To achieve maximum economic yields, weeds must be eliminated. Groundnuts are very poor competitors with weeds during early stages of growth. Weeding should be done early while at the same time earthing up the ridges to encourage "pegging" i.e. young nuts penetration through the soil. Once pegging has started, only hand weeding should be undertaken to avoid disturbing the young nuts or damaging the flowers. Clean weeding should be done up to 6 weeks after which hand weeding should take over.
The only peculiar nutrient requirement is for calcium (Ca) in the podding zone. Calcium is absorbed directly by the pods, if soil moisture is adequate. A shortage of Ca in that zone will result in empty pods (especially in Virginia cultivars). The crop's needs for nitrogen should be satisfied with symbiotic fixation by strains of *Rhizobium* of the cowpea group, so nitrogen fertilisers are not generally required. In some areas of acid soils, lime is applied to raise the pH and supply Ca. Moisture stress during flowering or pod filling reduces yield so that irrigation during those periods to minimise or eliminate the stress increases production and seed quality. Where yields are unsatisfactory (heavily eroded soils) an application of 200 kg/ha of rock phosphate is

recommended.

Harvesting

Spanish cultivars are harvested 85-100 days after sowing and Virginia cultivars 110-130 days after sowing in the warm tropics.
Dig a few plants up to see if the nuts are ready. The nuts should be brown on the outside, firm and dry. Usually at maturity the inside of the pods is grey and some rattling occurs when pods are shaken. Severe disease of foliage sometimes results in harvesting before seeds are fully mature. Plants should be carefully dug out to avoid nuts breaking off and remaining in the ground. Dry for 2-3 days, then rip the pods from the bushes and place them on mats to dry for another 7-10 days to about 10% moisture.
Shelling should be done by hand. Broken, dirty or damaged nuts should be discarded as these will lower the quality and hence the selling price. Nuts to be used as seed the following year should not be shelled.

Information on Pests

White grubs (*Schyzonycha* spp.)

Whitegrubs are the larvae of scarab "chafer" beetles. They are white, C-shaped with a brown head and three pair of legs. Many species of white grubs are associated with groundnut damage in parts of sub-Saharan Africa. The most important are *Schyzonycha* species.

White grubs attack plants at all stages of growth. They eat roots and damage pods of groundnuts. White grubs feed mainly on the taproots and/or peripheral roots leading to stunting or death. They inflict cuts in the crown region of taproots; these lesions are often invaded by rot-causing fungi. White grubs also cut out pods from the base of groundnut pegs and destroy larger, soft pods. Plants are often attacked in a row. White grubs seem to prefer soils with sandy or loamy sand textures and are seldom observed in clay soils.

What to do:

- **Allow enough time between manure application and planting of groundnut. The excessive use of organic manure in groundnut farms has been observed to increase the incidence of white grubs, especially when manure is applied during the cropping season.**
- **Deep ploughing or hand hoe tillage exposes soil pests to desiccation and to predators, thus helping to reduce their numbers and damage.**

Whitegrubs
Chafer grub (*Schyzonycha* spp.)
© A. M. Varela.

Termites

Termites are serious groundnut pests throughout the southern African region and West Africa. Species of *Microtermes* and *Odontotermes* are the most damaging, while *Macrotermes* cause occasional damage. The small-sized *Microtermes* spp., in particular, attack and invade growing groundnut plants through the roots and stem near ground level, hollowing them out and causing the plants to wilt and die with a consequent reduction in crop stand.
Roots damaged by other soil pests, such as white grubs, are also prone to attack by termites. Some termite species (*Macrotermes* spp., *Hodotermes mossambicus*) cut off stem bases, and may cause 25-100% of plant losses. As the crop ripens the outer layers of the pods are scarified (removal of soft corky tissue between the veins of the pod) by termites allowing contamination of the seed with soil fungi, such as *Aspergillus flavus*, which produce lethal "aflatoxins".

Scarification of pods is by far the most common type of termite damage at plant maturity, a factor often aggravated by late harvest. Scarification as high as 30% has been reported. Infested plants are not obviously diseased and are frequently harvested with and contaminate the rest of the crop. Species such as *Microtermes* spp. also penetrate the pod to feed off the soft inner lining, filling the pod with soil. This form of attack leads to additional loss through premature germination of kernels. Stacks of plants left drying in the fields are also frequently attacked by species such as *Odontotermes* spp. with farmers losing between 30-40% of their crop at this stage.
Termite damage is generally most serious towards the end of the growing season just prior to harvesting, and it is particularly serious during periods of drought (ARC/LRN. 2007).

What to do:

- **Remove residues of previous cereal crops (sorghum, millet and maize). Plant residues left in the field serve as food for termites, which may infest the new crop. Termite infestation of 100% has been observed in groundnut crops with high plant residues.**
- **Planting should be carried out early enough to avoid drought periods. Moisture deficiency may stress a crop and lead to attack by termites due to low vigour.**
- **Harvest promptly. Research has shown that termite damage increases with delay in harvest. Furthermore, most groundnut-producing areas in sub-Saharan Africa experience drought and high temperatures during the later part of the growing season, conditions that favour termite infestation as well as fungus (A. flavus) infection of pods leading to aflatoxin formation in seeds.**
- **The complete destruction of mounds and removal of queen termites are effective control measures against mound-building species (Macrotermes spp.). Partial destruction of mounds is unlikely to solve the problem, since replacement reproduction may develop from the remaining termites.**
- **It has been reported that close spacing in groundnut helps to deter termite infestation, although the reason for this was not given. However, high density sowing, followed by thinning of surviving plants where necessary to reduce competition, offsets anticipated losses due to termites.**

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

Millipedes (*Peridontopyge* spp.)

Millipedes are among the economically important soil pest of groundnuts. They are brown to blackish in colour and curl when disturbed. They attack groundnut seedlings, between planting and approximately 20 days after planting, feeding on the emerging cotyledons and moving to the root system at the collar region. The cortex is often damaged serving as an entry point for secondary infection by microorganisms. The development of plants surviving the attack is often retarded.

Millipedes also attack maturing groundnut during pod formation, i.e. when the pods are still soft. Immature pods from severed pegs are often perforated and thus suffer secondary infection or invasion by rot-causing organisms such as *Aspergillus flavus*. Millipedes may also damage flowers. Birds are main predators of millipedes.

What to do:

- **Practice good sanitation.**
- **Prepare land properly.**
- **Select sites away from forest (breeding sites for millipedes)**

- **Cover exposed pods**
- **Close cracks in the soil.**
- **Use varieties with pods well buried.**

Millipedes
Millipedes (*Peridontopyge* spp.) are brown to blackish in colour and curl-up when disturbed.

Aphids (*Aphis craccivora*)

It is a serious pest as a vector of virus diseases, such as the rosette virus disease, a major constraint to groundnut production, particularly in the dry season. The groundnut aphid is black or dark brown in colour, variable in size (1.5 to 2.0 mm long) with two black cornicles (horns at the rear of the body), and a black tail.

What to do:

- **Early planting and dense close spacing are effective cultural practices.**
  Early planting allows plants to start flowering before aphids appear.
  Dense planting provides a barrier to aphids penetrating in from field edges, discourage population build-up of aphids and reduce incidence of "rosette" disease.
- **Monitor and observe build-up of aphids and of natural enemies.**
- **Conserve natural enemies. Ladybird beetles are reported as important natural enemies in groundnuts.**

- **Use neem seed or leaf extracts if necessary.**
- **Do not cultivate groundnut or other legumes continuously on the same ground.**
- **Use tolerant / resistent varieties. The groundnut variety "Nyanda" is reported to be tolerant to aphids.**

Groundnut aphid
Groundnut aphid colony on cowpea. Apterae are 1.4-2.2 mm long. Alatae (winged form) 1.4-2.1 mm.

Groundnut hopper (*Hilda patruelis*)

It is about 5mm in length, brown or green in colour with white marks and strips on the wings. The nymphs resemble the adults but without fully developed wings. These insects live in clusters or colonies, and are attended by ants that eat the honeydew excreted by the hoppers. These sucking insects attack the plants at the base of the stem, usually below ground level. The toxic saliva injected while feeding causes the plant to wither, turn yellow and die. The extent of damage can be important when the insect occurs in large numbers. The first sign of infestation is the presence of black ants.

What to do:

- **Use tolerant / resistant varieties. The groundnut variety "Nyanda" is reported to be tolerant to aphids and to the groundnut hopper (IAN, 2003).**

Thrips (*Megalurothrips sjostedti* and *Frankliniella schultzei*)

Several species of thrips attack groundnuts. They have been reported as important pests of groundnuts in Uganda. The flower thrips (*Frankliniella schultzei* and *Megalurothrips sjostedti*) infest mainly buds and flowers. Attacked flowers are discoloured and scarred; terminal leaf buds are blackened and distorted after unfolding. Other species of thrips (e.g. *Scirtothrips dorsalis* and *Caliothrips indicus*) infest foliage.

Thrips feeding causes yellowish-green patches on the upper leaf surface and brown necrotic areas and silvery sheen on the lower surface of the leaf; leaves become thickened and some curling occurs. In severe infestations, young leaves are severely deformed, plants are stunted and leaves are blighted.

What to do:

- **Conserve natural enemies. Thrips are attacked by predatory thrips, lacewings and predatory bugs.**
- **Whenever necessary spray the crop with botanicals. Some plant extracts (e.g. garlic, rotenone, neem, pyrethrum, etc.). A mixture of garlic and pepper has been recommended for organic growers in USA.**
- **Plough and harrow before transplanting. This can be useful in reducing thrips attacks by killing pupae in the soil.**

Thrips

Thrips damage on groundnut

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The groundnut leafminer (*Aproaerema modicella*)

It is a common pest of groundnuts in South and South-East Asia and a major pest in India, and it has recently invaded Africa. It was first found in Uganda in 1998 and is now recorded in Mozambique, Malawi, Democratic Republic of Congo and South Africa. In all African countries where this leafminer has been found, the pest has reached epidemic densities and severe yield losses have been observed on groundnut (The New Vision. 2004; Kenis and Cugala, 2006). The adult is a mottled moth, with a full wing span of up to 18mm. The moth lays eggs on the underside of the groundnut leaf and petioles. Yellowish green caterpillars hatch, tunnel into the leaves and feed between the upper and lower epidermis of the leaf. Mined leaves become distorted within a few days. Caterpillars are grey-green with a shiny black head. There are five larval instars. The first instar has an average length of 0.56 mm. At pupation, they rarely exceed 8 mm in length.

Three or four mines per groundnut leaflet can cause so much distortion that a leaf exposes as little as 30% of the potential photosynthetic area to the sun. Later, when the caterpillar become too large to occupy the mine, they emerge to the leaf surface and either fold over a single leaf and hold it down with silk, or web together two or more leaflets. They live and feed in the shelter they have constructed. Pupation takes place inside the webbed leaflets. Damaged leaves become brownish, rolled and desiccated, which results in early defoliation and affects the growth and yield of the plants.

What to do:

- **Use tolerant/resistant varieties. In Uganda, it has been reported that the variety "Egola-1" had shown signs of relative resistance.**
- **Plant during the first short rains when normally the miner population is low.**

- **Avoid drought stress by irrigating or sowing so as to avoid periods when drought is likely. Plants that are drought stressed are much more susceptible to leafminer attack than irrigated plants.**

Groundnut leafminer
Leafmining caterpillar on groundnut (*Aproaerema modicella*) are grey-green with a shiny black head. There are five larval instars. The first instar has an average length of 0.56 mm; caterpillars are ca 6 mm long at the time of pupation, and rarely exceed 8 mm in length.

Storage pests: moths and beetles

Stored groundnuts are attacked by moths (*Ephestia cautella, Plodia interpunctella*, *Cadra cautella*), and beetles (*Caryedon serratus, Tribolium castaneum, Trogoderma granarium*).

The larvae of moths and the grubs and adult beetles bore into and damage seeds. Moths cause extensive webbing. The bruchid beetle *Caryedon serratus* is the major pest of groundnut in shell in West Africa. A good post harvest pest management programme based on good storage practices is very important.
vel was very effective (INPhO Compendium)

What to do:

- **As most post-harvest groundnut pests except bruchids are unable to penetrate intact pods, leaving the crop in the shell for as long as possible during storage is an effective method of limiting damage.**
- **Research into low cost technology to protect stored groundnut showed that Samadaka (Swartzia madagascariensis), 2 kg of powder fruits to treat 100 kg groundnuts, was very effective against bruchids and moths for the groundnuts stored in granaries.**
- **Addition of sand as an abrasive material at the farm level was very effective (INPhO Compendium)**

Dried currant moth
Dried currant moth (*Cadra cautella*) - The larvae range from 1.5 mm to 1.5 cm (15 mm) in length and are light brown in colour with dark brown spots on the skin (cuticle).
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Root-knot nematodes

They are widespread but their seriousness in yield reduction is unknown. They cause plant stunting, gall or knot formation on roots, and in severe cases wilting of affected plants

What to do:

- **Rotate with cereals**

Root-knot nematode
Root-knot nematode galls on tomato roots. Root-knot nematodes (*Meloidogyne incognita* / *M. javanica*) affected plants are normally stunted and eventually wilt and die. The most characteristic symptom is formation of root galls (knots) and these can be seen with the naked eye. Affected roots rot.
© Bridge J., IIP. Courtesy of Ecoport (www.ecoport.org)

Information on Diseases

Leaf spots (*Cercospora* spp.)

Symptoms of early leaf spot (*Mycosphaerella arachidis*, *Cercospora arachidicola*) consist of sub-circular dark brown spots produced on the upper leaflet surface. The spots are of lighter shade of brown on the lower side of the leaflets. Yellow halo is seen around the brown spots. Oval to elongate spots are also seen on stems, petioles, and pegs. Late leaf spot can be distinguished from those of early leaf spot.

Late leaf spots (*M. berkeleyi*, *Cercosporidium personatum*) are darker with no or light yellow halo. The late leaf spots on the lower leaflet surface are rough in appearance. They exhibit circular rings of fungus fruiting structures on the lower leaflet surface with the aid of a hand lens. Severe disease attack leads to shedding of leaflets resulting in premature ageing of the crop. Oval to elongate spots similar to early leaf spot are also formed on stems and pegs. Late leaf spot attack is usually seen along with rust disease.

What to do:

- **Plant tolerant / resistant varieties, if available**
- **Collect and destroy the infected crop debris**
- **Follow cereal-cereal- groundnut crop rotation.**

Early leaf spot
Early leaf spot (*Mycosphaerella arachidis*)
© Jürgen Kranz (Courtesy of EcoPort, www.ecoport.org)\n

Rust (*Puccinia arachidis*)

Puccinia arachidis
Pustules (spots or blisters) can form on all aerial plant parts except flowers. Orange coloured pustules first appear on the lower surface of leaflets. Later, pustules may appear on the upper surface of the leaflets. The pustules on the stem are elongate and elevated. The pustules when mature rupture to release masses of reddish-brown spores, which blown by wind, spread the disease from plant to plant and far away to other groundnut fields.

What to do:

- **Plant resistant varieties if available**
- **Remove volunteer groundnut plants from the field to check build-up of rust infection**
- **Adopt cereal-cereal-groundnut crop rotation**

- **Adjust the sowing time to avoid the most conducive environmental conditions for rust development i.e., high humidity, cloudy weather.**

Rust
Rust (*Puccinia arachidis*)
© Gerlach W. Courtesy of EcoPort, www.ecoport.org

Aspergillus crown rot (*Aspergillus niger*)

Aspergillus niger
The fungus causes both seed and seedling rot and drastically reduces plant stand. In moist soil, seeds may be attacked and killed due to rotting. Seeds removed from soil show black sooty cover. The infected areas of seedlings are covered with black fungal spores. Mature plants are also attacked. Symptoms include wilt of branches permanently, and or wilting of entire plant. The dead and dried branches are easily detached from the collar region. Infected pods reveal patches of black sooty spores. Related species (*Aspergillus flavus*) causes deterioration of seeds.
It also produces the toxin (aflatoxin) in infected seeds that can cause death or other symptoms of toxicity when eaten by animals or humans.
***A. flavus* as a mould contaminant and toxin producer is much less serious during growth of the crop than during subsequent storage of kernels. Minimising moisture stress during growth can reduce invasion and toxin production by *A. flavus*.**

What to do:

- **Rapid drying to moisture content of about 10% is the only means of preventing infection by A. flavus.**
- **Minimise damage to the nuts during harvesting because the fungus can easily enter a broken shell.**
- **Remove diseased crop debris from the field to reduce source of infection.**

Aspergillus crown rot
Aspergillus crown rot (*Aspergillus niger*)
© Jürgen Kranz, Courtesy of EcoPort, www.ecoport.org

Groundnut blight (*Sclerotium rolfsii*)

Sclerotium rolfsii
The fungus attacks all parts of the plant, but stem infection is the most common and destructive. Yellowing and wilting of branches near the base of the plant is the first symptom. White fungus growth develops at or near the soil around the affected stem. Severely infected pods are completely covered with a white fungal growth, and eventually decay. In some cases the seeds from the diseased pods show a characteristic bluish-grey discoloration known as 'blue damage'. The incidence of blight is greatest in wet weather.

What to do:

- **Plough deeply**
- **Practise sanitation**

- **Control moisture**
- **Rotate with cereals, onion and garlic**

Groundnut blight
Groundnut blight (*Sclerotium rolfsii*)

Bacterial wilt *Ralstonia solanacearum*

It can cause serious losses, if a crop is infected early. Infected plants show water stress symptoms and may wilt suddenly without yellowing of the foliage, particularly, when temperatures are high.

What to do:

- **Rotate with cereals**

Bacterial wilt on pepper
Bacterial wilt (*Ralstonia solanacearum*) on pepper
© W. Gerlach. www.ecoport.org

Groundnut rosette disease

It consists of three types namely groundnut chlorotic rosette, groundnut green rosette and groundnut mosaic.

The disease is caused by a complex of different strains of groundnut rosette umbravirus. Symptoms vary depending on strain(s) present. They include yellowing, mottling and mosaic symptoms on leaves and stunting and distortion of the shoots. Older leaves are dark green, reduced in size, and show downward rolling of leaflet margins. If the plants are infected when they are young, they may not produce nuts.

The virus is transmitted by aphids (*Aphis craccivora* and *A. gossypii*), which feed on the undersides of the leaves.

What to do:

- **Sow early in the rains and plant close (high density planting).**
- **Plant tolerant / resistant varieties, e.g. "Asirya Mwitunde" .**
- **Remove virus-infected plants after harvest, and volunteer plants that are primary source of infection.**

Groundnut rosette disease
Symptoms in a field-infected groundnut plant in Malawi.

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Green gram

Green gram
Scientific name: *Vigna radiata*
Family: Fabales: Fabaceae
Local names: Pojo (Swahili)
Common names: Mung bean
Pests and Diseases: African bollworm Anthracnose Aphids Bacterial blight Bean flies Bugs Cowpea seed beetle Damping-off diseases Foliage beetles Powdery mildew Rust Storage pests Thrips Whiteflies Yellow mosaic virus

General Information and Agronomic Aspects

Geographical Distribution of Green gram in Africa

Grams are annual legume crops grown for their seed. Grams could be green, black or yellow in colour. The green grams are the most commonly grown in Kenya. Grams are native crops of India. Often called green gram or golden, it is cultivated in several countries of Asia, Africa, and the Americas. The dried beans are prepared by cooking or milling. They are eaten whole or split. The seeds or the flour may enter a variety of dishes like soups, porridge, snacks, bread, noodles and even ice cream. Green gram also produces great sprouts, which can be sold in health food shops or eaten at home. Crop residues of *V. radiata* are a useful fodder. Green gram is sometimes specifically grown for hay, green manure or as a cover crop.

Climatic conditions, soil and water management

Green grams grow best at an altitude of 0-1600 m above sea level and under warm climatic conditions (28 to 30°C). They are well adapted to red sandy loam soils, but also do reasonably well on not too exhausted sandy soils. Green grams are not tolerant of wet, poorly drained soils. They are drought tolerant and will give reasonable yields with as little as 650 mm of yearly rainfall. Heavy rainfall results in increased vegetative growth with reduced pod setting and development.

Propagation and Planting

Avoid planting green gram for more than one season because toxic residues and disease organisms from the previous green gram crop may affect the following crop adversely.
Land should be prepared to a medium tilth before planting and early enough so that planting can start immediately after the rain starts. When using oxen plough for planting, place the seed at the side of the furrow.
Propagation is by seed. There is no seed dormancy. Seeds may sprout in the pod under very humid conditions. In areas with higher rainfall, it is recommended to grow green grams on raised beds. Prepare the beds, raised about 20 cm and spaced 1 m from the centre of one bed to the centre of the next. Sow seeds on raised beds in two rows per bed, spaced 45 cm apart.
Green grams will respond to fertiliser or manure application but will normally give satisfactory results if grown on relatively good soil.

Green gram is grown mainly on smallholdings, often as mixed crops or intercrops. Associated crops are usually of longer duration than green gram (sugar-cane, cotton, sorghum). To make use of a short cropping period, short-duration green gram is often relay-cropped.

Varieties
Green grams usually mature in 60 to 90 days. The early maturing varieties can often produce before drought destroys many bean species. Two varieties can be distinguished in Kenya:

Variety	Maturity Days	Potential yield Bags/ha	Remarks
"KUR 22"	"80-90"	"11-14"	• Golden seed colour • Tolerant to aphids • Resistant to yellow mosaic • In the driest areas will perform poorly due to its lateness
KVR 26	60-65	14-17	• Green seed colour

- **Best performer in dry areas due to its earliness**

Husbandry

With the newer cultivars ripening in 60 to 75 days, maximum yields are obtained at plant densities of 300 to 400,000 plants per ha. The later-maturing traditional cultivars generally need wider spacing. Usually no fertilisers are applied to green gram. Over the centuries, green gram's adaptation to stable performance in marginal environments has resulted in a low yield potential, which limits responsiveness to better environments and improved cultural practices. However, if planted in heavily eroded soil gram will benefit from any kind of manure or compost.

Grams planted at the end of the long rains are normally intercropped into other major crop. In Meru, Kenya, green gram is a preferred intercrop for millet, each said to protect the other against diseases and pests. If grams are intercropped with maize, the maize spacing is the same as in pure stand, but the grams are interplanted mid-way between the maize rows.

Early weeding is recommended. First weeding should be done just after emergence and second weeding just before flowering.

Harvesting

Harvesting is generally by two to five hand-pickings at weekly intervals and is the most expensive single operation in growing green gram. Short-duration cultivars, which ripen more uniformly, may be processed as whole plants on small rice threshers. Cultivars differ markedly in harvesting efficiency, depending on position (above or within canopy) and size of pods. Harvesting before the maturity of crop, usually result in lower yields, higher proportion of immature seeds, poor grain quality and more chances of infestation during storage. Delay in harvesting results in shattering of pods and other losses caused by pests. In Kenya, harvesting when 95% of pods have turned black is recommended. The whole plant can then be uprooted and dried for about 2 days, then threshed and winnowed. Harvesting during adverse weather condition i.e. rains and overcast weather should be avoided. Such weather is conducice to fungal infection. The harvested bundles should be kept in one direction in order to ascertain efficient threshing. They should be stacked in a dry, clean place in cubical way to facilitate circulation of the air around.

Storage

Grams must be dry before storage. Like most pulses moisture content at storage should not be above 13%. Grams are very susceptible to bruchid (bean weevil) attack and are best stored immediately after sun drying either in airtight drums tins or gunny bags and be kept in a clean, ventilated place. Mixing seed with ash is effective against bruchids, also treatment with sunflower oil or mixing with neem leaves is said to be effective against storage pests. Proper drying of grains is very important to prevent the growth of fungi and contamination with aflatoxins. Infected grains should be separated from sound grains to avoid aflatoxin contamination.

Information on Diseases

Bacterial blight (bean blight) (*X. axonopodis* pv. *phaseoli*)

Leaf spots first appear as small, water-soaked or light-green areas on leaflets. They later become dry and brown. The spots may join to affect much of leaf surface eventually killing the leaflet. Similar water-soaked spots develop on pods. The spot margin is a shade of red. Severely diseased pods shrivel. In humid weather, a yellowish crust of the blight bacteria covers the spot surface.

What to do:

- **Cultural practices are important in controlling bean blights. Eliminate weeds, volunteer beans and other potential hosts of bean blight, as this will reduce disease incidence.**
- **Good weed control will also improve aeration around the crop so that the plants dry faster, this will reduce the chances for bacterial spread and infection.**
- **The bacteria are readily spread by water, and walking or working in the field while plants are wet will splash the bacteria and create wounds. Therefore avoid field operations when it is wet.**
- **A rotation of at least 2 years between bean crops will give time for the bacteria population to decline in**

the debris.

- **Deep ploughing will also encourage the breakdown of infected plant debris.**
- **The incidence of bean blight can also be reduced if beans are grown with maize rather than in a monoculture.**

Bacterial blight
Bacterial blight (*X. axonopodis* pv. *phaseoli*) on beans. Symptoms are similar on green grams.
© Sheppard JW (Courtesy of EcoPort, www.ecoport.org)

Powdery mildew (*Erysiphe polygoni*)

White powdery patches appear on leaves and other green parts, which later become dull coloured. These patches gradually increase in size and become circular covering the lower surface. When the infection is severe, both the surfaces of the leaves are completely covered by whitish powdery growth. Severely affected parts get shrivelled and distorted. In severe infections, foliage becomes yellow causing premature defoliation. The disease also creates forced maturity of the infected plants which results in heavy yield losses. The fungal agent (pathogen) has a wide host range and survives on various hosts in off-season. It is spread by wind and water splash.

What to do:

- **Plant resistant varieties, if available**

- **Plant early**
- **Remove weeds**
- **Practice a good field sanitation**

Powdery mildew
Powdery mildew on peas
© A.M. Varela

Rust (*Uromyces phaseoli*)

The disease appears as circular reddish brown pustules (blisters) which appear more commonly on the underside of the leaves, less abundant on pods and sparingly on stems. When leaves are severely infected, both the surfaces are fully covered by rust pustules. Shrivelling of pods is followed by defoliation resulting in yield losses. Long distance spread of rust is by wind. Plant to plant spread is by farm tools, and moving bodies within the crop.

What to do:

- **Plant resistant varieties, if available**
- **Avoid continuous cropping with legumes**
- **Practice crop rotation with non-legumes such as cereals**

Rust
Rust on lower surface of French beans. Symptoms are similar on green grams.

Anthracnose (*Colletotrichum lindemuthanium*)

It attacks all above ground parts of the plant. It does most serious damage on pods. Affected pods have brownish sunken spots, which under humid conditions are covered with a pink spore mass. Infected seeds become discoloured (brownish black).

What to do:

- **Plant certified disease-free seeds**
- **Plant resistant varieties, where available**
- **Practice crop rotation with non-legumes such as cereals**

Anthracnose
Anthracnose (*Colletotrichum lindemuthanium*) on beans pod. Symptoms are similar on green grams.
© Jim Sheppard (Courtesy of EcoPort, www.ecoport.org)

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

They are caused by a complex of fungi. They cause rotting of seeds before emergence and seedlings after emergence from the soil. Affected fields appear patchy. They are favoured by wet, cool weather.

What to do:

- **Use certified disease-free seeds**
- **Practice proper irrigation**
- **Treat seeds with hot-water, if necessary. For more information on hot-water seed treatment click here.**

Damping-off disease
Damping-off on beans (Rhizoctonia solani)
© Jürgen Kranz, Courtesy of EcoPort, www.ecoport.org

Yellow mosaic virus

Initially mild scattered yellow spots appear on young leaves. The spots gradually increase in size and ultimately some leaves turn completely yellow. Infected leaves also show necrotic symptoms. Diseased plants are stunted, mature late and produce very few flowers and pods. Pods of infected plants are reduced in size and turn yellow in colour. The virus is transmitted by whiteflies (*Bemisia tabaci*).

What to do:

- **Use certified disease-free seeds**
- **Plant tolerant/resistant varieties**
- **Weed properly**
- **Control whiteflies**

Information on Pests

Bean flies (*Ophiomyia phaseoli* and related species)

Bean flies are tiny (about 2mm long) flies, shiny black-bluish in colour. They can cause serious stand reductions at the seedling stage. Bean flies lay eggs in punctures of leaves near the petiole. The small white maggots feed inside the main stem just above the soil line. Pupation occurs inside the stem. The life cycle may be completed rapidly, often in less than 2 weeks.

Seedlings attacked by beanflies may wilt or die. Leaves of older plants may be yellow and stunted. Stems are thicker than normal and cracked lengthwise just above the soil. Maggot feeding facilitates the entry of disease-causing microorganisms leading to secondary infections. In cases of heavy infestation, many plants die. Bean flies are important only during the seedling stage (up to 4 weeks after germination).

What to do:

- **Plant early in the season. Bean fly numbers tend to be low during the early stages of the growing season and increase with time.**
- **Plant after green manure crop**
- **Avoid planting near cowpea, beans and other leguminous crops, that may be the source of bean flies. Practice crop rotation with non-legumes such cereals.**
- **Mulch with rice straw. The mulch covers the seed leaves (cotyledons) making them inaccessible for egg laying.**
- **Ridging the plants 2-3 weeks after germination helps to cover the adventitious roots produced by plants damaged by beanflies (these roots grow directly from stems and/or leaves). The soil support prevents lodging and improves the survival of the damaged plants.**
- **If necessary, spray neem extracts. Frequent foliar applications of neem extract give satisfactory control of bean flies.**
- **Remove and destroy crop residues and all plant parts with symptoms of damage by bean flies.**

Bean fly

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


Bean fly


Bean fly

Aphids

Aphids, mainly the legume aphid (*Aphis craccivora*) (also called groundnut aphids) are relative small aphids. Immatures are slightly dusted with wax, adults without wax. Apterae are 1.4 to 2.2 mm long. Alatae (winged form) 1.4 to 2.1 mm. They feed on young plants, leaflets, stem and pods of green gram. Attacked young leaves become twisted. Excretion of honeydew leads to growth of sooty mold. Aphids are also vectors of virus diseases.

What to do:

- **Plant early**
- **Cultivate clean**
- **Avoid excess use of nitrogen**
- **Conserve natural enemies**

Black legume aphid
The black legume aphid (*A. craccivora*) is a relatively small aphid. Immatures are slightly dusted with wax. Adult size 1.4-2.2 mm long.

Foliage beetles (*Ootheca* spp.)

Foliage beetles have been reported as pests of green grams in West Africa. They are a threat, when present in large numbers since they can defoliate young plants. They are 4-7mm long.

What to do:

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

Foliage beetle
Foliage beetle feeding on pumpkin leaf, the adult is 4-7mm long
© A.M. Varela, icipe


Foliage beetles


Foliage beetles

Pod-borers (African bollworm, Legume pod-borer, lima pod borer)

Pod borers such as the African bollworm (*Helicoverpa armiguera*), the legume pod borer (*Maruca vitrata*), and the lima bean pod borer (*Etiella zinckenella*) can cause serious economic damage. Young caterpillars of the African bollworm feed on leaves by scraping tissue for short time, and then bore into the pods and feed on the seeds with their heads thrust inside and most part of the body outside. The entry hole is large and circular. They also cause significant damage to flower buds and flowers.

Caterpillars of the legume pod borer (*Maruca vitrata*) are dull to yellow-white and often reach a length of 18 mm. Each segment has dark spots that form a distinct series along the length of the body. The head is dark brown to black. Caterpillars web together leaves, buds and pods and feed inside the web. Flowers attacked may be discoloured and have damaged or missing reproductive parts. Damage by this caterpillar also results in flower bud shedding and reduced pod production. Damaged pods have small, darkened entry holes on the surface.

Young caterpillars of the lima bean pod borer are green, later turning red. They feed inside the pod reaching a length of 14 mm. They are generally found in maturing and dried pods. Faeces in the form of granules are found inside the damaging pods. Once the caterpillars have entered the pods they are difficult to control and by then they have caused damage

What to do:

- **Monitor the crops frequently as there is only a brief period from hatching to entering buds or pods**
- **Hand pick and destroy eggs and caterpillars. This helps when their numbers are low and in small fields.**

- **Biopesticides such as Bt or neem products usually give good control of pod borers, provided they are applied to the young caterpillars before they enter into the pods. For more information on neem click here. For information on Bt click here**

Legume pod borer
Legume pod borer (*Maruca vitrata*) reach a length of 18 mm
© Ooi P. Courtesy of EcoPort, www.ecoport.org



Legum pod… Africar bo… Africar bo…

Pod sucking bugs

Pod sucking bugs such as giant coreid bugs (*Anoplocnemis curvipes*), spiny brown bugs (*Clavigralla* spp.), green stink bugs (*Nezara viridula, Acrosternum acutum*), and Riptortus bugs (*Riptortus* spp) are the most important pests of green gram at the podding stage.

They suck sap from pods and seeds and cause various levels of damage depending on the stage of growth of seeds at the time of attack. Feeding may cause necrosis, pod malformation, premature drying, shrivelling of seeds, loss of germination ability, and formation of empty pods. Bugs are difficult to control since they usually feed on a wide range of crops and are very mobile.

What to do:

- **Bugs can be collected by hand regularly and killed, especially during flowering and pod formation.**
- **Conserve natural enemies such as assassin bugs, spiders, praying mantises and ants. These are important natural enemies of bugs. They kill or deter bugs. Conserve and attract predatory natural enemies to your crop by planting flowering plants. For more information on natural enemies click here**

Spiny brown bugs
Spiny brown bugs (*Clavigralla* spp.) measure about 1cm in length.
© A.M. Varela, icipe


Spiny brow..


Tip wilter


Green stin…


Riptor …

Flower thrips (*Megalurothrips sjostedti*)

It may feed on petioles and leaves, but prefer flowers. Attacked petioles and leaves have tiny holes surrounded by discoloured areas. Affected flowers are brown, dried, or completely distorted. The flowers drop prematurely. Thrips also feed on pollen leading to decrease in pollination and seed set. Pod production is low and pods are deformed.

What to do:

- **Plough and harrow before planting. It can reduce subsequent thrips attacks by killing pupae in the soil.**
- **Conserve natural enemies. Natural enemies, particularly, predators are important in natural control of thrips. Main natural enemies include predatory bugs (Orius spp. and Anthocoris spp.) and predatory thrips.**
- **Spray with biopesticides (e.g. Spinosad), if infestation is severe.**

Thrips
Thrips (*Megalurothrips sjostedti* (black) and *Frankliniella occidentalis* (yellow). Real size (0.9 to 1.1 mm)
© GTZ-IPM Horticulture, Kenya

Thrips

Thrips

The cowpea weevil (*Callosobruchus maculatus*)

Cowpea bruchids (*Callosobruchus* spp.) are the most common and widespread insect pests in storage. Adults are 2 to 3.5 mm long. They are major pests of pulses (cowpeas, pigeon peas, soybean, green gram and lentils). They attack both pods in the field and seeds in storage. They attack nearly mature and dried pods. Infested stored seeds can be recognised by the round exit holes and the white eggs on the seed surface. Post-harvest losses are highly variable, but losses can be over 90%.

It is a serious storage insect, which can destroy whole seed-lots.

What to do:

- **Dry grains to moisture level below 13%**
- **Store grains in dry, well ventilated areas**

Cowpea seed weevil
The cowpea weevil *Callosobruchus maculatus* on cowpea (*Vigna unguiculata*) seeds. Adults are 2 to 3.5 mm long
© Peter Credland. Reproduced from the Crop Protection Compendium, 2006 Edition.

Cowpe see…

Pupa of th…

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- **Publications and Fact Sheets on Mungbean. AVRDC Extension Materials. http://www.avrdc.org**

Contact links

- **Meru Herbs Organic Farmers Kenya**

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Website: www.meruherbs.com
Products: Organic produced chamomile, hibiscus, and fruits (bananas & mango).

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Maize

Maize
Scientific name: *Zea mays*
Family: Cyperales: Poaceae (Graminae)
Local names: Mahindi (Kenya, Tanzania); mbembe (Kenya)
Pests and Diseases: African armyworm African bollworm African maize stalkborer Angumois grain moth Aphids Common rust Common smut Couch grass Cutworms Ear rots Grasshoppers Grey leaf spot Head smut Larger grain borer Maize ladybird beetle Maize leafhoppers Maize plant hopper Maize streak virus Northern leaf blight Purple witchweed Satintail Southern leaf blight Southern rust Spider mites Spotted stemborer Storage pests Termites White grubs

General Information and Agronomic Aspects

Geographical Distribution of Maize in Africa

Maize is the most important cereal crop in sub-Saharan Africa. It is a staple food for an estimated 50% of the population. It is an important source of carbohydrate, protein, iron, vitamin B, and minerals. Africans consume maize in a wide variety of ways (porridges, pastes and beer). Green maize, fresh on the cob, is eaten baked, roasted or boiled. Every part of the maize plant has economic value: the grain, leaves, stalk, tassel, and cob can all be used to produce a large variety of food and non-food products. In sub-Saharan Africa maize is mostly grown by small-scale farmers, generally for subsistence as part of mixed agricultural systems. The systems often lack inputs such as fertilizer, improved seed, irrigation, and labour. According to FAO data, Africa produced 7% of the 598 million tonnes produced worldwide in 138 million hectares in 2000 (IITA).

Maize is also an important livestock feed both as silage and as crop residue, grain and is also used industrially for starch and oil extraction.

Climate conditions, soil and water management

Maize is a versatile crop, growing across a range of agroecological zones. With its large number of varieties differing in period to maturity, maize has a wide range of tolerance to temperature conditions. It is essentially a crop of warm regions where moisture is adequate. The crop requires an average daily temperature of at least 20°C for adequate growth and development. Optimum temperature for good yields is around 30°C. The time of flowering is influenced by photoperiod and temperature. Maize is considered to be a quantitative short-day plant (short days can induce premature flowering). It is grown mainly from 50°N to 40°S and from sea level up to about 3000 m altitude at the equator. At higher latitudes, up to 58°N, it can be grown for silage.

Maize is especially sensitive to moisture stress around the time of tasselling and cob formation. It also needs optimum moisture conditions at the time of planting. In the tropics it does best with 600-900 mm of rain during the growing season. Maize can be grown on many soiltypes, but performs best on well-drained, well-aerated, deep soils containing adequate organic matter and well supplied with available nutrients. The high yield of maize is a heavy drain on soil nutrients. Maize is often used as a pioneer crop, because of the high physical and chemical demands it makes of the soil. Maize can be grown on soils with a pH from 5-8, but 5.5-7 is optimal. It belongs to the group of crops that is considered to be sensitive to salinity. Since a young crop leaves much of the ground uncovered, soil erosion and water losses can be severe and attention should be paid to adequate soil and water conservation measures.

- **Local seed. Low to medium yields, usually well sheathed and so more resistant to weevil attack in storage, possibly more palatable to local tastes. Example: Kikuyu maize. Exotic varieties of maize can be collected to add genetic diversity when selectively breeding new domestic strains.**
- **Hybrids. High yielding but also requiring large amounts of fertiliser. Seed from hybrids cannot be saved for planting so new hybrid seed is required each year.**
- **Composite (e.g. "Katumani", "Coast Composite"). These are stabilised varieties and new seed is not required each year. If proper selection procedures are followed, farmers can use their seeds selected from their harvest.**

Maize growing zones in Kenya and recommended varieties

Ecozone and main areas where found	Recommended varieties	Maturity (Months)	Yield potential (Bags/acre)	Resistance
Highland zones with high rainfall: Altitude: 1500-2100 m above sea level Areas: Trans Nzoia, Uasin Gishu, Nakuru, Kericho, Nandi, Bungoma, Laikipia, Kisii, Narok, and Tea zones of Central and Eastern Province West Pokot, Nyeri, Lower Nyandarua and upper Kiambu	"H 627" "H626" "H 625" "H 614 D" ---------- "H 6213" "H 6210" "KH600-14E" "KH600-15A"	6-8 6-8 6-8 6-8 ---------- 6-8 5-6	42 38 34 32 ---------- 52 50 34-38	---------- Rust, grey leaf spot, stem and leaf blight As above No resistance reported
Highland zones, high rainfall Altitude: 1000-1700 m above sea level Areas: Baringo, Siaya, Kisumu, Busia, Bungoma, Kakamega, Nakuru, South Nyanza, Taita Taveta	"H 632" "H 622"	6-8 6-8	24 22	
Coffee zone medium long growing Season Altitude: 1000-1800 m above sea level	"H 513"	4-5	20	

Areas: Coffee zones of Central and Eastern Provinces, Kisii, Narok, Nakuru, Siaya, Kisumu, Busia, Kakamega, Bungoma, West Pokot, Keiyo, Marakwet	**"pH B 3253"** **"H512"** **"H511"** **"CG 4141"** **"CG 5222"** **"H 516"**	**4-5** **4-5** **4-5** **4-5** **4-5** **3-4**	**20** **18** **16** **18** **18** **28**	**Ear rot, rust, GLS, stem and leaf blight**
Dryland Areas: Marginal areas with low rainfall (400-800 mm) Altitude: 1000-1800 m above sea level Areas: Kitui, Machachos, West Pokot, Makueni, Kajiado, Isiolo, Lower Meru and Embu, Siaya, Kisumu **Altitude: 800-1200 m above sea level: Drier areas, same as for Katumani composite**	**"Katumani Composite"** **"DH 01"** **"DH02"** **"Makueni"**	**3-4** **3-4** **3-4** **3-4**	**12** **14** **14** **11**	
Lowland Zones: Hot humid Altitude: 1-1200 m above sea level	**"pH4"** **"Pwani Hybrid 1"** **"Coast Composite"**	**3-4** **3-4** **4-5**	**18** **16** **14**	

AIC 2002 and The Organic Farmer Feb 2007

Propagation and planting

Maize is nearly always planted through direct seeding. Maize should preferably be sown early in the season, as soon as soil conditions and temperature are favourable. Delayed planting always leads to reduced yields. In Kenya there is a drop of expected yields of 1-2% every day planting is delayed (AIC 2002). Hand planting requires 5-10 man-days/ha. Seed is dropped in the plough furrow or in holes made with a planting stick. Planting may be done on hills or in rows, on flat land or on ridges. On heavy soils ridging is advisable, to improve drainage.

For pure stand of maize in Kenya the Ministry of Agriculture recommends spacing between rows of 75 cm and between seeds 30 cm for all areas with adequate rainfall, resulting in a total plant population of 44,000. In the coffee zones this can be increased to 75cm x 25 giving total plant population of 53,000 plants/ha. In dry or marginal areas the recommendation is to increase spacing to 90 cm between rows and 30 cm between seeds - total population 37,000 plants /ha. Approximate seed rate is 25kg/ha.The depth of planting is commonly 3-6 cm, depending on soil conditions and temperature. Deep sowing is recommended on light, dry soils. Animal manure or fertilizers are applied at the time of planting.

Weed control

Adequate weed control is very important. Maize is very sensitive to weed competition during the first 4-6 weeks after emergence. It should be planted as soon as possible after the preparation of the seedbed. Inter-row cultivation to control weeds and to break up a crusted soil surface may be done until the plants reach a height of about one m. In Kenya two weedings are necessary for most maize varieties, though a third weeding may be necessary for varieties that need 6 to 8 months. Weeding by hand requires a minimum of 25 man-days/ha.

Water management

Irrigation is used in areas of low rainfall and is particularly valuable at the time of tasselling and fertilization.

Fertilization

Maize usually responds well to fertilisers, provided other growth factors are adequate. The quantity of manure applied by smallholders is usually very limited. Improved varieties can only reach their high yield potential when supplied with sufficient nutrients. A maize crop of two t/ha grains and five t/ha stover removes about 60

kg N, 10 kg P2O5 and 70 kg K2O from the soil. Nitrogen uptake is slow during the first month after planting, but increases to a maximum during ear formation and tasselling. Maize has a high demand for nitrogen, which is often the limiting nutrient. High nitrogen levels should be applied in three doses, the first at planting, the second when the crop is about 50 cm tall, and the third at silking.

Many soils provide substantial amounts of the phosphorus (P2O5) and potassium (K2O) but this is not adequate enough, especially at the seedling stage. Apply P2O5 near the seed for early seedling vigour. K2O is taken up in large quantities but plants' requirement can usually be estimated by soil analysis. K2O deficiency results in leaves with burnt edges and yellow or light green colour and empty cob ends, while P2O5 deficiency results in purple tinged leaves and hollow grains. Nitrogen deficiency shows as yellow or light green stunted plants.
Phosphate is not taken up easily by maize and, moreover, some tropical soils are deficient in available phosphate. It is advisable to apply organic manures to improve soil structure and supply nutrients, all before ploughing.

Nitrogen (N) can be applied in organic farming via green manure (legumes fixing N directly from the atmosphere), farmyard manure (FYM) or compost. Phosphorus can be supplied through FYM, compost, and in the form of Rock Phosphate (available in East Africa as Mijingu Rock Phosphate). Rock Phosphate should be applied in the rows or planting holes at planting to promote root formation., Potassium can be supplied through FYM, compost and ashes.
However, fertiliser recommendations based on soil analysis provide the very best chance of getting the right amount of fertiliser without over or under fertilising. Ask for assistance from a local agriculturist office.

In rainfed maize growing areas, plant seeds along with the first rain. This will allow roots to absorb the natural nitrates formed with bacterial action in the soil. Roots are susceptible to poor drainage, which cause stunted and yellowing of leaves. Stagnant water results to loss in N through leaching and denitrification (FADINAP, 2000).
For more information on organic plant nutrition click here.

Intercropping

In Africa maize does well when intercropped with beans or other legumes. The intercropped legumes should be sown at the time of first weeding in order not to crowd out the young maize plants. As maize is a heavy feeder and takes considerable nutrients out of the soil, maize can only be grown continuously on the richest soils or when heavily fertilized. Recommended legumes for intercropping in Kenya are beans, pigeon peas, cowpeas, groundnuts and soybeans. Other crops that have been tried with varying success include potatoes, cassava and pumpkin.

Intercropping maize with beans and other legumes regulates pests (leafhopper, leaf beetles, stalk borer, and fall armyworm) and increases the land utility. Intercropping Canavalia (*Canavalia* spp.) with maize improves soil productivity. Sow Canavalia seeds four weeks after sowing maize. Place one seed/hole in a row between maize rows with 50 cm between holes. Allow Canavalia to grow after harvesting maize until it is time to plant the next crop. Then plough the plant materials into the soil (CIAT, 2000).

Intercropping maize with beans and squash enhances parasitism of caterpillars. This practice increases food sources for beneficial insects whereby increasing abundance of natural enemies. The intercropping system of maize-beans-squash is a low input and high yield strategy in the tropics. Maize yield is increased by as much as 50% over monoculture yield. Although the yields for beans and squash are reduced, the overall yield for the three combined crops is greater than when grown separately in monocultures (Agroecology Research Group, 1996).

Push-pull

Desmodium (*Desmodium uncinatum*) and molasses grass (*Melinis minutifolia*) when planted in between maize rows keep the stem borer moths away. These plants produce chemicals that repel stem borer moths. In addition Desmodium supresses the parasitic witchweed *Striga hermonthica*. Napier grass (*Pennisetum purpureum*) and Sudan grass (*Sorghum vulgare sudanese*) are good trap crops for stem borers. Napier grass has its own defence mechanism against crop borers by producing a gum-like-substance inside its stem, this prevents larva from feeding and causing damage to the plant. Both grasses attract stemborer predators such as ants, earwigs, and spiders. Sudan grass also increases the efficiency of natural enemies, in particular

parasitic wasps, when planted as border crops (Herren; Pickett, 2000; ICIPE, 2006). For more information on push-pull click here

Alternative uses of maize in mixed cropping

- **Shading of vegetable crops by planting single rows between vegetables in areas of high intensity of sunshine can increase yields of intercropped vegetables.**
- **Use as support for runner beans for export or local consumption.**

Harvesting

Maize can be harvested by hand or by special maize combine harvesters. The stage of maturity can be recognized by yellowing of the leaves, yellow dry papery husks, and hard grains with a glossy surface. Maize is often left in the field until the moisture content of the grain has fallen to 15-20%, though this can lead to attack by grain borers in the covered cobs. In hand harvesting the cobs should be broken off with as little attached stalk as possible. They may be harvested with the husks still attached. These may be turned back and the cobs tied together and hung up to dry.

Yield

The world average yield in 2000 was 4255 kg per hectare. Average yield in the USA was 8600 kg per hectare, while in sub-Saharan Africa it was 1316 kg per hectare. Average yields in Kenya 2001-2005 ranged from 15-19 bags/ha (1350-1750 kg/ha) (Economic Review of Agriculture 2006).

Handling after harvest

The major problems in most maize-producing areas are reducing the moisture content of the grain to below 13%, protection from insects and rodents, and proper storage after harvest. High moisture content with high temperatures can cause considerable damage such as development of aflatoxin producing fungi, making the

product unsuitable for human consumption.
Maize for home consumption is either sun-dried on the cob for several days by hanging up tied husks, or put in a well-ventilated store or crib. Easy test for moisture content: take a few grains and try to crush them with your teeth - below 13% moisture the grains are extremely hard and almost impossible to crush this way. Shelling (the removal of grains from the cob) is usually carried out by hand, though several hand and pedal-powered mechanical shellers are now available. The average recovery is about 75%. The shelled grain is dried again for a few days and then stored in bags, tins or baskets.
The optimum moisture content for storage is 12-13%, but often it is not below 18%. In Indonesia seed for the next crop is generally selected from the last harvest. The selected cobs are stored at home in the husk above the fireplace to prevent losses by insects. Crop residues are removed from the field and then used as fodder, fuel, etc.

Information on Pests

General information

Infestation and damage by pests have been ranked as the third most important constraint upon maize production in semi-arid eastern Kenya after moisture stress and poor soil fertility (Songa et al., 2002).

Stemborers and striga weed account for losses in maize in the eastern and southern Africa region of 15-40% and 20-100% respectively. When they occur together, farmers can lose their entire crop (ICIPE, 2006). Earworms and armyworms are other major pests.

The principal pests of stored maize are Angoumois grain moth (*Sitotroga cerealella*), the Larger grain borer (*Prostephanus truncatus*), maize weevils and rodents.

Examples of Maize Pests and Organic Control Methods

Cutworms (*Agrotis* spp. and other species)

Cutworms cut maize seedlings at or a little below ground level, make small holes along the initial leaves, or remove sections from the leaf margins.

What to do:

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

Cutworms
Cutworm (*Agrotis* spp.
© The University of Georgia, www.insectimages.org

The maize aphid or corn leaf aphid (*Rhopalosiphum maidis*)

It is dark green to bluish-green in colour with black cornicles. Particularly during dry/periods the colonies appear on the inflorescences and young leaves. Feeding by this aphid causes yellow mottling, but this damage is seldom of economic importance. Their role as vector of the sugarcane virus, maize dwarf mosaic virus and maize leaf-fleck virus makes a pest of considerable importance. This aphid usually attack maize plants at the end of the mid-whorl stage. Aphid colonies may completely cover emerging tassels, and the surrounding leaves, preventing pollen release. In severe outbreaks the ear shoot is also infested, and seed set may be affected.

What to do:

- **Conserve natural enemies. Aphids have a wide range of natural enemies, which normally keep them under control.**

Maize aphid
The maize aphid *Rhopalosiphum maidis*. Colony on leaf of maize
© www.inra.fr


Maize aphi…


Aphids


Maize aphi…

Termites (*Microtermes* spp., *Macrotermes* spp., *Allodontermes* spp., and *Odontotermes* spp)

Often referred to as "white ants", they occasionally cause partial or total defoliation of maize seedlings, but are mainly damaging to older maize plants. Severely damaged plants may lodge and be completely destroyed by termites. The longer a field has been cultivated, the greater will be the yield losses caused by termites. Their feeding inside the stems causes the plant to wither and sometimes die. Termites begin to attack the roots and stems about three months after planting, and eventually cover them with tunnels built of soil. As plants mature the amount of damage increases rapidly. Infestation is particularly serious in dry season. It has been established that termites can damage up to 25% of maize crops in Malawi (WISARD Project Information, 2001).

What to do:

- **Promote conditions for healthy plant growing to prevent termite damage.**
- **Plough field to destroy the termites' nest, runways, and tunnels and to expose them to predators, such as ants, birds, chicken, etc.**
- **Practice crop rotation to reduce the build-up of termites.**
- **Remove plant residues and other debris especially moist and decaying woods.**
- **Harvest at the right time, as termites often attack maize left in the field after maturity. Attacked stalks may fall down and the termites may attack the cobs and panicles.**
- **Where there is risk of termite infestation, avoid leaving the crop in the field after harvest on stooks, stacks or windrows.**

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

Grasshoppers and locusts

Several species of grasshoppers and locust feed on maize. The edible grasshopper *Homorocoryphus nitidulus vicinus* (*Ruspolia differens*), a long horned grasshopper has been reported to occasionally attack maize in Tanzania (Bohlen, 1973). This grasshopper attacks maize in the silking stage, arresting pollination. Other grasshoppers and locust attack maize from the mid-whorl stage to maturity, and may consume every part of the plants. Attacks vary in severity from location to location.

What to do:

- **Conserve natural enemies. Avoid destroying larvae of blister beetles, since they feed on eggs of grasshoppers. Other natural enemies include ants, parasitic flies, assassin bugs, predatory wasps, birds, lizards, snakes, frogs, and fungi. Robber flies are a major predator of grasshoppers.**
- **Domesticated poultry (e.g. chickens, turkeys, guinea fowl, geese, and ducks) and wild birds are good for keeping grasshopper populations in check. However, birds may damage the plants too. To avoid this enclose the birds in wire fencing along the perimeter so that they can prey on visiting grasshoppers while staying out of the crop.**
- **Ensure the ground is covered with crops, grass or mulch. This is reported to reduce grasshopper**

numbers since they prefer laying eggs on bare soil.

- **Catch grasshoppers by hand or with a butterfly net. Catching them in the early morning is easier, as they are less active in the mornings.**
- **Digg or cultivate the land before planting to expose the eggs to predators and to to the weather.**
- **Whenever necessary spray biopesticides. Neem extracts act as antifeedant (grasshoppers stop feeding when exposed to neem products) and affect development of grasshoppers. For more information on neem for control of grasshoppers link to section of grasshoppers in cassava datasheet. IITA (the International Institute of Tropical Agriculture) researchers and partners have developed an environmentalfriendly biopesticide "Green Muscle" based on a naturally occurring fungus strain indigenous to Africa (Metarhizium anisopliae). This fungus is deadly to locusts and grasshoppers but reportedly does not damage other insects, plants, animals, or people. Typically 70 to 100 percent mortality rates were obtained after 8 to 28 days of application. (www.iita.org)**

Grasshopper
***Ruspolia nitidula* in Uganda**
© Kurt Kulac

The larger grain borer (*Prostephanus truncatus*) and the grain weevils (*Sitophylus* spp.)

They attack stored maize grains. Both the adults and the larvae (grubs) of these beetles feed in the grains. Adults come from infested cobs in the field or from an infested maize store and lay eggs in the grains. They attack maize both in the field and after harvest. Attacked maize grains lose all their contents and are not fit to

eat. These pests become a serious problem in short time if not control measures are applied. The larger grain borer also attacks dried cassava roots and even the wooden structures of the stores.

What to do:

- **Conserve natural enemies. An imported predatory beetle Teretrius (formerly Teretriosoma) nigrensis has been released in several African countries in an attempt to control the larger grain borer.**

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


Larger gra…


Maize weev..

The Angoumois grain moth (*Sitotroga cerealella*)

The larvae of the Angoumois grain moth penetrate and feed inside maize grain. This insect may also infest the crop in the field prior to harvest. The moths are small (nearly 1 cm long) yellowish or straw-coloured, a have a fringe along the posterior margins of the wings. They can be observed flying around infested stores.

Female moths lay eggs at night. Eggs are laid singly or in clumps on the outside of cereal grains, in cracks, grooves or holes made by other insects. Eggs are initially white turning red near hatching. The larvae are whitish. The larvae prepare a round exit hole for the moth, leaving the outer seed wall only partially cut as a flap over the hole, resembling a trap door. The adult pushes its way out through this "window" leaving the trap door hinged to the grain. Infested grains can be recognised by the presence of these small windows. The adult lifespan may be up to 15 days, and one female can lay over 100 eggs.

What to do:

- **Practice store hygiene. All residual pockets of infestation should be cleaned out at the end of the storage season. This is important to minimise re-infestation of the new crop.**
- **Store old and new lots separately**
- **Do not leave maize in the field after drying, this increases the chances of infestation**
- **Whenever possible separate stores from fields. The grain moths are good flyers and adults from infested stores often infest growing maize in the field.**
- **Keep the temperature and humidity as low as possible. There are indications that storing grain in a dry place can reduce infestation.**
- **Prevent pest entry by sealing the store (windows, doors, ventilation facilities) with insect-proof gauze. Hermetic storage at low humidity gives good levels of control. In Malawi, plastering stores with mud to reduce water uptake was found to be effective (Golob and Muwalo, 1984, in CABI, 2000).**
- **Periodically inspect and remove any infestated maize.**

Angumois grain moth
Angumois grain moth on maize. The moth is small, pale brown, 5-7 mm long with wings folded, wingspan 1-1.6 cm
© Clemson University- www.insectimages.org

Spider mites

They can damage maize from the seedling stage to maturity. The presence of small, faint yellow blotches on the lower leaves is an indication of spider mite injury. As the colonies of mites increase in size they cause the lower leaves to become dry. The mites then migrate to the upper leaves. In Africa several species of spider mites have been reported on maize (mainly *Tetranychus* spp. and *Olygonichus* spp.). In Kenya, they are occasionally found on maize, but usually they are not of economic importance.

What to do:

- **Provide good growing conditions for the crop.**
- **Conserve natural enemies. Predatory mites and anthocorid bugs usually control spider mites.**

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

White grubs

White grubs are the larvae of scarab "chafer" beetles. They are white, C-shaped with a brown head and three pair of legs. Some species of whitegrubs (e.g. *Phyllophaga* spp, *Heteronychus* spp.) feed on roots of maize plants. Root damage is manifested by wilting seedlings, poor stands, and patches of tilted or lodged plants showing uneven growth. Injured plants can easily be pulled out of the ground.

Feeding of adults on maize leaves is usually not of economic importance. However, adults of the black maize beetles (*Heteronychus* spp.) are reported as major pests of cereals in many parts of Africa. They eat the stems of young shoots just below the ground. One adult beetle may destroy several seedlings in a row.

What to do:

- **Remove old plants and weeds before planting**
- **Plough and harrow the field to expose eggs and grubs to predators (e.g. ants and birds) and to desiccation by the sun. Once exposed, they can also be picked by hand. This is feasible in small plots.**
- **Provide conditions for growing healthy plants. They can tolerate grub feeding without serious damage.**
- **Ensure proper drainage. Grubs love moist soil, especially with decaying organic matter. Female beetles prefer to lay eggs on moist-decaying organic matter.**
- **Avoid planting maize immediately after old pasture in areas where grubs are frequently seen.**
- **Practice crop rotation. In particular, in fields where whitegrubs are common**
- **Use trap crops and / or repellent plants. Good trap crops are African marigold, sunflower, and castor. Repellents plants are chives, garlic, tansy, and catnip. The crops trap and repel adult beetles from attacking the main crop grown (Golden Harvest Organics, 2003).**

Whitegrub
Chafer grub on French bean plant
© A.M. Varela, icipe

Stemborers: African maize stalkborer (*Busseola fusca*)

Stemborers are the most important insect pests of maize in sub-Saharan Africa. Yield losses vary between 10-70%. Several species have been reported. The importance of a species varies between regions, within a country or even the same eco-region of neighbouring countries. At least four species attack maize in eastern and southern Africa, with yield losses reported to vary from 20 to 40%, depending on agroecological conditions, crop cultivars, agronomic practices and intensity of infestation.

The most important are the African maize stalkborer (*Busseola fusca*) and the spotted stemborer (*Chilo partellus*) (see also below).

The pink stalkborer (*Sesamia calamistis*) and the sugarcane stalkborer (*Eldana saccharina*) are of minor importance in maize.

Early warning signs: Young plants have pinholes in straight lines across the newest leaves. This is the time to treat - before the caterpillars move on into the stem.

What to do:

- **Conserve natural enemies. Parasitic wasps and and predatory ants are important in natural control of stemborers.**
- **Destroy crop residues to kill pupae left in old stems and stubble and prevent carry-over populations. This helps in limiting initial establishment of stemborers on the following season's crops.**
- **Intercrop maize with crops that are non-hosts for stemborers (e.g. cassava and grain legumes).**
- **Intercrop maize with a repellent plant such as desmodium and plant an attractive trap plant, such as Napier grass, as a border crop around this intercrop to protect maize from stemborers. This technology is known as "push-pull". For more information on push-pull click here**
- **Use neem products. Simple neem products are reported to be effective for control of stemborers. Place a small amount of neem powder (ground neem seeds) mixed with dry clay or sawdust at a rate of 1:1 in the funnel of the plant. One kg powder should be sufficient to treat 1500 to 2000 plants. Rainwater dissolves the active substances in neem powder as it gathers in the funnel and washes out the powder. Where rainfall is irregular a liquid neem seed extract can be sprayed into the funnel.**

African maize stalkborer
African maize stalkborer (*Busseola fusca*) damage on maize. Caterpillars are relatively featureless and noctuid, growing to a length of up to 4 cm. They lack conspicuous hairs or markings and look smooth and shiny. Colour is variable but usually creamy-white



Africar ma… Africar ma… Sugarc …

Stemborers: Spotted stemborer (*Chilo partellus*)

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Spotted stemborer
Caterpillar of the spotted stemborer (*Chilo partellus*) is about 2.5cm long
© Stemborer team, icipe


Spotte st…


Spotte st…


Spotte st…

African bollworm (*Helicoverpa armigera*)

Caterpillars of the African bollworm also known as the corn worm or earworm attack mainly the developing cobs, although they may occasionally feed in the leaf whorl or on tender tassels. Eggs are laid on the silks. Caterpillars invade the cobs and feed on developing grain. Development of secondary infections is common. Local outbreaks of this pest are sometimes severe.

What to do:

- **Conserve natural enemies. Parasitic wasps, ants and predatory bugs are important in natural control of the African bollworm.**
- **Monitor the crop regularly**
- **Use bio-pesticides. Plant extracts (e.g. neem, garlic, chilli,) and Bt are reportedly effective against the African bollworms. However, timing of application is very important. Spraying when caterpillars are inside the cob would be ineffective. For more information on neem click here. For information on Bt click here**
- **Handpick and destroy pod borers. This helps when their numbers are low and in small fields.**

African bollworm
African bollworm (*Helicoverpa armigera*) on maize. Larvae and pupae on corn cob.
© Dr. Jan Breithaupt (Courtesy of EcoPort, www.ecoport.org)

The African armyworm (*Spodoptera exempta*)

The African armyworm is a very damaging pest, capable of destroying entire crops in a matter of weeks. Although they are regarded as occasional pests, in an outbreak large number of caterpillars will appear destroying the whole plant to ground level.

What to do:

- **Monitor regularly field margins, low areas where plants have lodged, beneath plant debris around the**

base of plants, on the ground, and underneath the plant leaves. Check daily young crops if conditions are known to be favourable to the pest.

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

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

The maize ladybird beetle (*Epilachna similes*)

The adult is oval in shape, about 6 mm in length and reddish brown in colour with black spots on the wing covers. The body is covered with short, light coloured hairs. The larvae are 7-9 mm in length, soft and covered with dark coloured spines. They pupate on leaves. Both larvae and adults of the maize ladybird beetle feed on leaves, scrapping them, usually on the underside, leaving the upper epidermis intact. This beetle will cause much damage only when present in large numbers. It also attacks cereals such as wheat and sorghum. The maize ladybird beetle rarely causes serious defoliation and therefore control is usually not necessary.

What to do:

- **In case of severe attack spray neem products. Weekly applications of simple neem products have given control of Epilachna beetles in other crops such as cucurbits**

Maize ladybird beetle
Damage by plant-feeding l (*Epilachna similes*) on maize leaf. Note close-up of beetle (inset).
© A. M. Varela

The maize leafhoppers (*Cicadulina* spp.)

The adults are about 3 mm long, slender and cream to pale yellow green in colour. These leafhoppers have two small black spots between the eyes and brown marks behind the eyes extending along the body. They have brown lines along the wings. They usually hop away when disturbed. The direct damage cause by maize leafhoppers by sucking plants is insignificant, but the indirect damage is high because they transmit the maize streak virus, a major disease of maize. *Cicadulina mbila* is the most important vector.

Control of the maize leafhoppers is difficult since they are very active, remain infectious for a long time and are very quick in transmitting the virus. Measures that help to reduce leafhopper attack and virus infection include:

What to do:

- **Plant maize well away from grassland or previously irrigated cereals; in particular, avoid planting downwind of such areas. The numbers of leafhoppers generally increase in irrigated cereals and grasslands, or in wild grasses during rainy seasons. Leafhoppers disperse away from these areas when dry.**
- **Plant early, and if possible planting in an area should be carried out at the same time. Staggered planting of crops will favour multiplication of leafhoppers and increase the risk of virus transmission to later plantings.**
- **Keep the fields free from weeds, in particular grasses.**
- **Leave a barrier of 10 m of bare ground between maize fields and previously infested crops. This is reported to reduce virus incidence, by restraining movement of leafhoppers.**
- **Remove residues of cereal crops since they serve as infection sources.**
- **Use resistant varieties where available.**

Maize leafhopper
Streaked foliage damage caused by maize leafhopper (*Cicadulina mbila*)

The maize plant hopper also known as corn lantern fly (*Peregrinus maidis*)

It is 4-5 m long and greyish in colour. The transparent wings are about twice as long as the body and show marked dark-brown veins. It is commonly found in groups in the funnel of the plants, the whorl, leaf sheath or underside of leaves. This insect produces large quantities of honeydew. As a result, sooty mould is often

evident near the sites of aggregation. Nymphs and adults are in close association with ants, which feed on the honeydew produced by this plant hopper.
This plant hopper transmits the maize mosaic nucleorhabdovirus (MMV), maize stripe tenuivirus (MSpV), and maize line virus that can become a limiting factor in maize production.

What to do:

- **Practice crop rotation (alternate maize with cotton, root crops, and other non-graminae crops) to break the lifecycle of plant hoppers.**
- **Plough under or burn stubbles and plant debris right after harvest to kill remaining eggs, nymphs and adults.**
- **Avoid excessive N-fertiliser applications (N makes plant susceptible and attractive to maize plant hoppers).**
- **Keep planting distance wide enough for sunlight to penetrate (shady areas favour the maize plant leafhopper.**
- **Conserve natural enemies. Important plant hopper natural enemies are parasitic wasps (parasitise eggs and nymphs), mirid bug (prey on eggs), dragonflies and damselflies (prey on moving adults), spiders and earwigs (prey on nymphs and adults). Intercropping with legumes is recommended as harbourage of natural enemies, as soil conditioners, and for added income.**

Maize plant hopper
Maize plant hopper (*Peregrinus maidis*)

Information on Diseases

Maize streak virus

The virus causes a white to yellowish streaking on the leaves. The streaks are very narrow, more or less broken and run parallel along the leaves.
The virus is transmitted by leafhoppers (*Cicadulina mbila* and *C. bipunctella zeae*). Maize streak virus is a serious constraint to maize production in sub-Saharan Africa. The reduction in yields depends on the time of infection. Plants infected at early stage usually do not produce any cobs. Yield losses in East Africa vary between 33 and 55% under natural infection conditions. In Nigeria, 75-100% of maize plants can be infected at the end of the growing season. However, resistant varieties in these areas appear to withstand these epidemics (Anon., 1983). Sugarcane, sorghum, millet, wheat, barley, oats, rye and wild grasses can also be severely affected.

What to do:

- **Use of tolerant / resistant varieties / hybrids, if available**
- **Plant early in the season**
- **Eradicate grass weeds**
- **Control vectors**

Maize leaf streak virus
© Ed Rybicki. Courtesy of www.ecoport.org

Northern leaf blight (*Exserohilum turcicum (Helminthosporium turcicum / Dreschslera turcica / Trichometasphaeria turcica*))

Small oval (egg-shaped) spots first appear as water-soaked areas. They are dark and greyish-green in colour, turning greenish tan. With age they get bigger and become cigar-shaped. After rains or heavy dews, spores develop abundantly on both surfaces of the spots, particularly at the centres, giving a dark-green, velvety look to the spots. The spots may join and form large areas, which may kill entire leaves. Heavily infected leaves appear dry as if affected by drought. The disease is favoured by heavy and frequent rains, high relative humidity (above 90%) and relatively low temperatures (20-25°C). Warm dry conditions check disease development.

What to do:

- **Use of tolerant / resistant varieties / hybrids, if available**
- **Practise good field sanitation. Remove or plough in crop residues after harvest.**
- **Practise crop rotation**

Northern leaf blight

Early development of light brown, elliptical lesions of Northern corn leaf blight (*Setosphaeria turcica*) on maize leaves.
© David C. Nowell, www.ecoport.org

Southern leaf blight (*Bipolaris maydis (Helminthosporium maydis / Cochliobolus heterostrophus)*)

Symptoms first appear as small yellow dots that become elongated between veins. They later become brownish to creamy white in colour with reddish to purplish brown borders. Light brown leaf spots with a brown margin, at first elliptical, becoming rectangular, up to 25 mm long and 2?6 mm wide. The spots are at first restricted by the leaf veins, but later they may merge. Leaves dry out and die prematurely.

Silks, portions of the husks and cobs may turn black. A black mould may develop on cobs. Disease development is promoted by prolonged wetness on foliage, extended dew, RH (97-100%) and relatively warm temperatures (24-35° C).

Spread is by airborne spores; and the fungus is also seedborne. Survival in soil occurs for up to 12 months.

What to do:

- **Use disease-free seed or treated seed (steam-air mixture at 53.9 - 55°C for 17 minutes or by treatment with fungicides)**
- **Practice field sanitation, destroy crop residues and volunteer plants**
- **Practice crop rotation**
- **Use tolerant/resistant varieties/hybrids, if available**

Southern leaf blight of maize
Southern leaf blight (*Cochliobolus heterostrophuson*) on maize

Grey leaf spot (*Cercospora zeae-maydis*

Symptoms are similar to Southern leaf blight but the spots are much narrower. They are initially light brownish in colour, and with age they bleach to ashen grey surrounded by narrow light-brownish border. When wet, spore mass is formed on the spots with a light shade. This disease is favoured by prolonged periods of high relative humidity. It can cause yield losses of 30 to over 50%.

What to do:

- **Use resistant varieties / hybrids, if available**
- **Practise field sanitation. It helps in reducing the inoculum (infection) source**

Grey leaf spot
Grey leaf spot on maize
© A.A. Seif, icipe

Common rust (*Puccinia sorghi*)

It is recognized by the appearance of circular to elongate pustules scattered over both surfaces of the leaf. Pustules are powdery and cinnamon-brown in colour. They contain masses of spores (uredospores). Pustules can appear on any above-ground part of the plant, but they are most abundant on the leaves. With time the pustules split exposing the spores, which are spread by wind and initiate new infection. As maize matures, colour of spores in pustules change from reddish to black due to formation of teliospores (resting spores). The disease is spread by air transport.

What to do:

- **Use of resistant varieties / hybrids, if available.**
- **Deep plough crop residue.**
- **Destroy the weed Oxalis sp. (an alternate host).**

Common rust
Necrotic rust lesions of common rust on sweet corn caused by *Puccinia sorghi*
© David C. Nowell. Courtesy of www.ecoport.org

Southern rust (*Puccinia polysora*)

Symptoms resemble those of common rust, particularly in the uredial stage (urediospores). The cinnamon-brown pustules tend to be smaller and more circular in outline than those of common rust. Pustules of telial stage (teliospores) are chocolate brown to black and circular to elongate. They are distinguished from common rust by retention of the epidermis of the leaf over the pustule for a long time. No alternate host has been reported for Southern rust.

What to do:

- **Use resistant varieties / hybrids, if available.**

Common maize smut (*Ustilago maydis*)

Characteristic symptom of common smut is formation of galls or tumuors on above-ground parts of maize

plant. Galls frequently are from one to several centimetres in diameter. The galls are at first covered by a shining, whitish-green membrane. As the gall enlarges, the membrane ruptures, exposing a powdery black mass of spores.

What to do:

- **Use resistant varieties / hybrids, if available.**
- **Practice crop rotation.**
- **Practice field sanitation. In smallholdings remove and destroy smut galls before smut spores are produced. This may help reduce prevalence of the disease in following years.**

Common maize smut
Blister-like galls of common maize smut (*Ustilago maydis*), up to 15 mm diam., on a corncob before they have ruptured to release spores.
© Grahame Jackson. Courtesy of www.ecoport.org

Head smut (*Sphacelotheca reiliana*)

The first symptoms become evident when tassels and cobs (ears) appear. These parts may be completely or partly converted into smut galls. Smut galls are initially covered by a delicate membrane that breaks open and exposes a mass of reddish-brown to black spores and strands of vascular tissue. The strands or fibers in the galls distinguish this disease from common smut. Head smut is seed-borne.

What to do:

- **Use resistant varieties / hybrids, if available**
- **Practise crop rotation**
- **Eliminate volunteer host plants.**

Head smut on maize
Partial infection by head smut fungus (*Sphacelotheca reiliana*) of the tassel of maize
© David C. Nowell. Courtesy of www.ecoport.org

Ear rots (*Gibberella zeae / G. fujikuroi*)

Characteristic symptoms include pink to brick-red colour on ears, husks and kernels. The fungi often gain entrance to the ears through channels made by earworms and borers. Bird damage to the ears also facilitates disease infection.

Symptoms
Roots: dry rot.
Seedlings: blight and subsequent death of the seedling.
Leaves: leaves become a dull green colour when rots and stalks are infected early.
Stalks: lesions are a dark brown to black colour in which black perithecia may be produced near the lower nodes. The pith is shredded and is pink to red in colouration.

Ears: the fungus infects the ear via the silk channel and causes a red rot of the kernels form the tip of the ear. This may spread over the whole ear.

What to do:

- **Use resistant varieties / hybrids, if available**
- **Manage pests attacking the ears.**

Information on Weeds

Purple witchweed (*Striga* spp.)

The parasitic weeds *Striga* spp. known as witchweeds, are important pests of maize, particularly in drier areas. The weeds grow on the roots of maize affecting development of maize plants. The young weeds tap the roots of maize plant and draw water and nutrients. A single weed plant produces many thousands of tiny seeds that survive in the soil for long periods. A heavy infestation can cause complete yield loss.

Striga weeds infest 40% of the arable land in the savannah region, causing annual crop losses of 7 to 13 billion dollars. Around the Lake Victoria basin infestation by *Striga hermonthica* causes 30 to 100% loss in maize yield. Striga infestation is associated with increased cropping intensity and declining soil fertility. Whichweed infestation has resulted in the abandonment of much arable land by farmers in Africa. The problem is more serious in areas with low soil fertility and rainfall.
None of these methods described will, alone, provide complete control and without complete control there is the certainty that surviving plants will mature and replenish the soil seed bank. Therefore, integration of one or more methods is essential for any substantial reduction of the problem. Furthermore, such integrated treatments will almost certainly need to be repeated over a number of years for long-term control.

What to do:

- **Weed regularly. This is the conventional method for striga control, but is time-consuming and labour-intensive.**
- **Rotate maize with trap crops. Some plants, such as such as sunflower, pulses and cotton, stimulate the germination of striga seeds, but also inhibit post-germination growth of the weed. Thus, although the seeds germinate, striga cannot develop successfully in these roots.**
- **Intercrop maize with Desmodium or other legumes. Desmodium have been shown to be more effective in reducing striga when interplanted with maize in the field than other legumes such as cowpea, soybean and sun hemp. Desmodium progressively reduces the number of striga seeds in the soil. For more information on push-pull click here**
- **Use resistant/tolerant varieties. Some maize varieties show partial resistance, such as "Katumani" in Kenya.**

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

Couch grass or Bermuda grass (*Cynodon dactylon*)

It is a spreading perennial grass with vigorous mat-forming stolons. It reproduces and spreads mostly by means of rhizomes but also propagates by seed. This grass is considered as one of the most important weeds

in the world. It is present in virtually every tropical and subtropical country and in virtually every crop in those countries. Couch grass and other species of Cynodon are common in East Africa, and some species are occasionally troublesome as a weed of arable land and perennial crops.
Couch grass is reported in Ghana as a problem in crops such as eggplant, okra, onion, peppers and tomato.

What to do:

- **Where couch grass is a problem, control it before planting maize, as it will not be possible to grow a profitable maize crop in a couch dominated field.**
- **Harrow with a tooth harrow during the dry season in order to uproot the rhizomes and letting them dry completely on top of the soil. If possible, collect and burn dry rhizomes. Burning them will increase the success of couch control.**
  The same tooth harrow can be used to sweep the dry rhizomes together in bands on the field which can then be burned on site or collected and used for fuel elsewhere (farmer experience).
- **Practice crop control. Introduce shade producing cover crops, within a crop rotational system.**

Couch grass
Couch grass (*Cynodon dactylon*) is a perennial grass, with underground rhizomes and on the ground runners.
© Charles T. Bryson, USDA ARS, www.insectimages.org



Couch gras… Couch gras… Couch gras…

Satintail (*Imperata cylindrica*)

In south-western Nigeria, satintail is a major weed reducing maize yields. The rhizomes of this weed often reduce the efficacy of farmers' weed control practice (slashing followed by 2-4 times of additional weeding) and contribute to high yield losses. In field trials grain yield was 62% less than in fields where rhizomes had been removed from soil before sowing maize.

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