A Guide to IPM and Hygiene Standards in Okra Production

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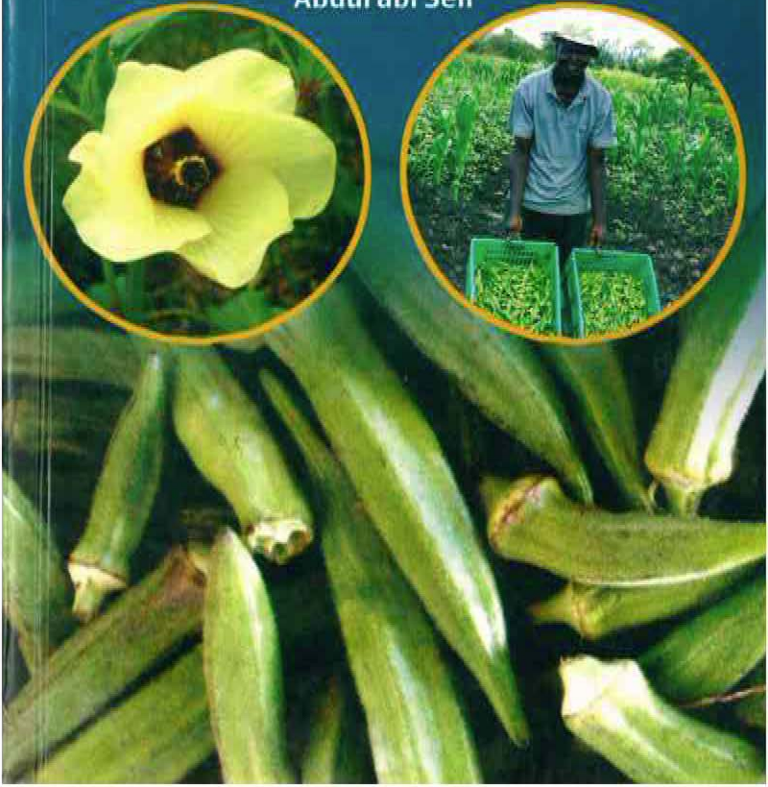

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Introduction

Okra, *Abelmoschus esculentus* (L) Moench, originated in Africa and, as a member of the Malvaceae family, is related to cotton. It is cultivated for its pods, which are harvested when immature and used in preparing curries and stews. In Kenya, smallholder farmers supply about 80% of okra under contract to exporters. Their average farm size is less than 0.3 ha. The crop is grown in semi-arid areas and coastal lowlands primarily for export to Europe, particularly the United Kingdom. It is cultivated under basin or furrow irrigation. The varieties grown in Kenya are Pusa Sawani, Clemson Spineless, Green Emerald, Dwarf Green Long Pod and White Velvet, with Pusa Sawani as the most popular among smallholders. Variety preference by smallholders is dictated by market demands. The estimated area under okra in Kenya in 2001 was 814 ha, fetching about US$ 4,413,773, according to the Ministry of Agriculture.

As an agricultural export commodity to the European Union (EU), okra is subjected to stringent EU and EUREPGAP (Euro-Retailer Produce Working Group on Good Agricultural Practices) regulations, maximum pesticide residue limits, food safety and traceability of the produce from the field to the exporter. Okra is a minor crop in the EU and therefore the range of chemical products registered in or acceptable to the EU for the management of its pests and diseases is very narrow. This situation is compounded by the fact that the permitted products are not available or registered locally for use on okra or are prohibitively expensive to smallholder farmers, who constitute the majority of the producers. In addition, according to EUREPGAP regulations (which are not legally binding in the EU although they are religiously enforced by supermarket chains), outgrowers and smallholder farmers' groups must be certified by EUREPGAP accredited institutions, all of which are based in Europe. Certification is annual, and the overall costs for compliance with EUREPGAP standards are high. Thus, outgrowers and smallholders face huge obstacles in maintaining the EU market niche and in sustaining their livelihood.

The USAID Project 'Preparing Kenya Smallholder Export Vegetable Growers for Compliance with European Union Regulations on Pesticide Maximum Residue Limits and Hygiene Standards' was initiated to assist smallholder growers of export vegetables to become compliant with EU regulations and to help them stay in business through training of trainers and farmers' groups in integrated pest and disease management, food safety and traceability requirements.

The information provided in this handbook was partially obtained through a knowledge, attitude and practice (KAP) study and a field survey conducted in the major okra growing areas in Kenya between June 2002 and January 2003.

The two main production constraints identified were pests and diseases, and marketing. The latter is controlled by exporters. There are no written contracts between producers and exporters for supply of produce. In addition, prices fluctuate drastically during the production period. Other problems encountered include high input costs, low seed quality and inadequate cultural practices such as dense planting and poor or no weeding. The major pests and diseases were aphids, flea beetles, pod borers, bugs, powdery mildew and root-knot nematodes.

This handbook is intended as a field guide and a reference tool in diagnosis and integrated management of pests and diseases of okra in Kenya. The major themes it covers include: growing okra; integrated pest and disease management; descriptions of pests and diseases of okra in Kenya, along with their pictures; crop scouting; and hygiene and food safety in horticultural production. The handbook also provides guidelines on best use of pesticides.

The primary audience for this handbook includes okra farmers, agricultural trainers, horticultural extension personnel, farm managers and agricultural consultants. It should also be useful to students, teachers and researchers who are interested in the practical aspects of okra production and identification of pests and diseases of okra and their management.

Growing okra

Ecological requirements

In Kenya, okra is grown at elevations ranging from sea level to 1600 m. The optimum temperatures for growth and production of high quality pods range between 24 and 30 °C. The crop is sensitive to frost and temperatures below 12 °C. The main okra producing areas are Kibwezi, Kilifi, Makindu, Matuu, Mitunguu, Mwea, Nguruman and Taveta.

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

Okra can grow in a wide range of rainfall regimes, from 400 to 1500 mm per annum. It is highly resistant to drought, although it requires considerable amounts of water for optimum growth and pod production. In Kenya, it is mostly grown in semi-arid areas under irrigation.

Varieties

A number of varieties are grown in Kenya:

- ***Pusa Sawani*** is a tall variety that grows to 2–2.5 m. Its pods are 18–20 cm long, dark green and smooth with five ridges. This is the most popular variety in Kenya and is mostly grown for the fresh produce export market.

- ***Clemson Spineless*** grows to 1.5 m tall. It is a spineless variety with medium dark green, angular pods that are about 15 cm long. It is also grown for the fresh produce export market.
- ***Green Emerald*** grows to a medium height of 1.5 m. It is spineless with dark green, smooth, round pods about 20 cm long. This is a processing variety.
- ***Dwarf Green Long Pod*** grows to 0.9 m high. It has several side branches. The pods are angular and green and about 18–20 cm long. It is also grown for the fresh produce market.
- ***White Velvet*** is of medium height (1.5–1.8 m) with pods that are 15–18 cm long, slender, tapered, smooth and creamy white.

Cultural practices

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

Planting: Okra plants may be established by direct seeding in the field, by growing seedlings in a nursery seedbed or by raising containerised seedlings in plastic trays. In Kenya, okra is sown directly in the field. The planting depth is 1.5 cm, and spacing varies: 45 x 45 cm, 50 x 30 cm or 60 x 15 cm between the rows and within the rows, respectively. In some parts of Kenya, okra is planted in 2 x 2 m flood irrigation basins. About 8–10 kg of seed is required per hectare.

The main export season for okra is October to May. Therefore, planting should start from July onwards for the peak export season. However, okra can be grown all year round for local and off-season export markets, but these offer lower prices.

Fertiliser use: According to EUREPGAP regulations, the soil should be analysed every 6 months to determine the fertility treatment needed. Without a soil test, the general recommendation in Kenya (issued by Horticultural Crops Development Authority) is as follows: well-composted manure should be applied at planting at the rate of 15–20 t/ha (or 17–20 gm/plant). It should be mixed thoroughly with the soil in the planting hole. Also, during planting, fertiliser (NPK 17:17:17) is recommended at the rate of 120 kg/ha (or 2 gm/plant). The fertiliser should be applied in bands on the side of the furrow where the seeds will be planted, and mixed well with the soil.

The plants should be top dressed using 140 kg of CAN/ ha split into two equal applications. The first application, at the rate of 70 kg/ha (68 gm/plant), should come 3–4 weeks after planting, and the second 3–4 weeks later. However, CAN should be applied only in places with acid or neutral soil reaction ($pH \leq 7.0$). In alkaline soils ($pH > 7.0$) sulphate of ammonia should be used instead, at the rate of 87 kg/ha (85 gm/plant).

Urea is an alternative to CAN but it should be applied only in moist soils, at the rate of 40 gm per plant. It should not be applied in soils with a pH 8 or higher, as high volatilisation of ammonia would occur.

Applying NPK (17:17:17) at flowering is recommended, at the same rate as at planting to boost flowering and pod production. **Caution:** Avoid fertilisers containing chlorides, since okra is sensitive to salinity.

Irrigation: Okra is a heavily foliaged crop, so its water requirements are high. No recommendations can be made on the amount of water it requires and the regularity of its application, since these will vary by locality, time of the year, soil type and type of irrigation. A general guideline for the semi-arid areas, where okra is mostly grown in Kenya, is to provide about 35 mm of water per week (this equals 35 litres per square metre). The critical times for irrigating okra are at emergence and from flowering to pod production. Avoid using saline or chlorinated water for irrigation.

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

Since root-knot nematodes are a major problem in all okra growing areas of Kenya, the following crops must not be included in a rotation with okra: tomatoes, karella, brinjals, pawpaw, bananas, capsicums, potatoes, squash and sweet potatoes.

Weed control: Okra is harvested over a long period and weed control remains important throughout the cropping season. Weeds may be controlled by cultivation or with herbicides. Smallholder growers in Kenya cultivate by hand (hoeing) to control weeds. Cultivation early in the season for weed control should be shallow so as not to injure young okra roots. Since okra is mostly grown in semi-arid areas in Kenya, mulching is recommended for weed control and conservation of soil moisture.

Harvesting and field handling

Most varieties grown in Kenya are ready to pick 45–55 days after planting. Pods are ready for harvesting about 4–6 days after flowering. They are harvested when still tender and have attained the length of 7–15 cm, depending on the variety and market demand. The crop will bear fruit for several months under ideal conditions, especially when over-mature pods are removed regularly. Under Kenyan conditions harvesting normally continues 45 days after the first harvest. Regular picking every 1–2 days is essential to ensure pods are within the size specification range. Okra should not be harvested when it is raining or when excessively wet, as excess moisture can induce mould development on the pods and the cut petioles. Owing to its perishability, okra should not be harvested more than 1 day before shipping.

Harvesting is done by hand. The pods can be snapped off or cut off, leaving a small stalk not longer than 1 cm. The pods must be handled carefully otherwise they may be bruised and may discolour. It is best to pick them into a waist bag to reduce skin damage and to avoid excessive bending over. Wearing rubber gloves when harvesting and handling pods protects the skin from the irritating sap. Yields of 8–15 t/ha can be expected in Kenya.

Packinghouse operations

Sorting: Pods with signs of the following problems are discarded during sorting:

- Disease
- Insect damage
- Discolouration
- Chemical residues on the surface
- Foreign odour
- Softness
- Over-maturity (random snapping can help identify overgrown pods, which normally have hard seeds).

Grading: Grading is done by hand according to size and shape specifications based on market requirements. Pods of the same size and shape are packed in the same carton. Most of Kenyan okra is exported to the UK and it fits grade sizes 7–11 cm in length with a maximum width of 15 mm.

Packaging: Okra pods are packaged in corrugated fibreboard cartons. In Kenya, cartons of 6 kg gross weight are normally used.

Pre-cooling: Pods should be pre-cooled to 10–12 °C immediately after picking to avoid wilting. Many smallholder growers use charcoal coolers, which are generally located near grading sheds.

Storage and transportation: Fresh pods for export should not be stored for more than 36 hours before shipping. However, okra can be stored for 1–2 weeks at 10 °C under high relative humidity of 95 to 100%. Okra has the same storage requirements as brinjals (eggplant), capsicums, cucumbers and French beans. These vegetables may be stored together with okra without deleterious effects. Okra should not be stored with apples, bananas, melons or other produce that emits ethylene gas, to avoid discolouration of the pods.

Cartons of okra should be properly packed and stacked together during transportation to avoid mechanical damage. Okra should be transported in the cool hours of the morning or late evening.

Hygiene and food safety in horticultural production

Globalisation of the food trade has focused on strengthening measures to ensure safety of imported foods, especially agricultural commodities, as outbreaks of food-borne illnesses regularly make news headlines in many countries around the world. The move to liberalise world trade and open up international markets has been accompanied by increased scrutiny of products for pesticide residues, heavy metals and microbiological contaminants.

Good agricultural practice

Good agricultural practice (GAP) is considered as a prerequisite for food safety, and aims to minimise fresh produce contamination on the farm. GAP procedures are regarded as the best measures for achieving reasonable and acceptable assurance of food safety from smallholder farmers. There are many opportunities for bacteria, viruses and parasites to contaminate produce from planting to consumption, and GAP procedures on field hygiene, manure management, irrigation water management, harvest container management, worker hygiene and record keeping are all very important in minimising the risk of such contamination.

Field hygiene

Poor field hygiene is a major source of contamination in the environment where crops are growing. Some examples of microbial field contaminants include *Escherichia coli* strains and *Salmonella* species. The sources of microbial contamination in the field are:

- Water of poor state of cleanliness, such as sewage water, flowing into or being used on the farm as manure, which directly contaminates the growing environment.
- Raw (not composted) domestic animal manure, which has an established link with *E. coli* and non-typhoid *Salmonella* and *Cryptosporidium parvum* hazards, three recognised sources of human infections and illnesses.
- Human excrement (when the growing environment is used as a defecating area), which can contaminate the growing produce with hepatitis, *Shigella*, protozoan parasites and *Cyclospora cayetenensis.*
- Rotting plant matter or crop debris, which may harbour hazardous microorganisms such as *Bacillus cereus, Listeria monocytogenes* and *Clostridium botulinum*. These can contaminate fresh vegetables.

Manure management

The two types of compost manure used for soil enrichment are farmyard compost derived from crop debris and domestic waste, and animal manure from domestic animals (cows, pigs, rabbits, goats, sheep and chicken). Raw animal manure potentially has a heavy load of harmful pathogens such as *E. coli* 0157:H7, which originates primarily from ruminants such as cows, and *Salmonella,* which comes from chicken. One important requirement is that neither of the manure types should be used before it is properly composted. Smallholder farmers can tell if manure is properly composted by its physical texture—it is fine, almost like farm soil.

Manure should be incorporated into the soil before or during planting to avoid direct contact with edible parts of the crop. It can also be used for top-dressing during the early stages of crop development.

Water management

Field water for either irrigation or washing produce should be guaranteed free of microbial contamination. If this is not possible, the following procedures should be encouraged:

- Use irrigation methods (furrow, basin or drip) that minimise contact between water and edible portions of the crop.
- Avoid washing harvested produce in the field with water whose cleanliness is uncertain, such as stagnant water.
- Avoid building pit latrines or septic tanks near the water source or within a distance of less than 200 m from the waterway.
- Wherever possible, keep animals away from the water source to avoid the risk of their droppings contaminating the water supply, especially during irrigation.
- Avoid upstream contamination by ensuring domestic or factory waste does not drain into the river or water source.

Worker hygiene

High standards of hygiene should be maintained by routine training in basic hygiene practices of all workers involved in harvesting and grading horticultural produce:

- Use a field toilet instead of defecating in the field.
- Wash hands properly after using the toilet, using soap and clean water.
- Screen and immunise workers against communicable diseases such as hepatitis and typhoid.
- Avoid eating food, smoking or chewing tobacco while harvesting or grading produce.
- Avoid handling produce when ill with flu, diarrhoea, open wounds, etc.

Management of harvest containers and grading shed

Containers for harvesting produce should be kept clean and used only for this purpose. They should not be stored together with chemicals or foodstuff. If they are washable (e.g. plastic crates) they should be cleaned after each harvest. Those used for other domestic purposes such as shopping should not be used for harvesting, as they are a likely source of contamination.

Grading sheds should be easy to clean and maintain and should be away from animal foraging areas, to avoid animal droppings coming into contact with produce and contaminating it. They should be cleaned after grading. As much as possible avoid building grading sheds near the road, as dust and exhaust fumes from passing motor vehicles could contaminate the produce during grading. Pest control and other disinfection procedures should be routinely carried out to keep the sheds clean.

Record keeping

Each farmer must keep simple, clear records of all aspects of crop production of both pre- and post-harvest activities for monitoring and traceability. Examples of record forms for food safety procedures are presented on the next page.

Pre-harvest records

Name of the farmer or farmers' group...

Location or area..

Field no./ crop	Planting date	Manure composting date	Compost removal date	Compost application method	Irrigation water source	Irrigation method

Grading/ packing shed location	Location of toilet	Location of wash water	Grading/ packing shed cleaning schedule	Harvest container type and storage site	Cleaning schedule for harvest containers

Integrated pest management for okra

Integrated pest management (IPM) is a strategy that focuses on the use of as many methods as possible to minimise damage by arthropod pests, diseases and weeds. When integrating several methods of controlling pests, the possibility of interference or synergism among them should be taken into consideration. For example, a pesticide applied to control a pest may also kill beneficial insects that would otherwise have fed on the pest. Therefore, pesticide use must be minimal and only when necessary.

An important tool in IPM is scouting. This entails regular field observation during the production cycle for pests, diseases, weeds and general aspects of crop health like nutrition and water requirements. Proper field observation provides the necessary information for decision-making on all aspects of crop management, including fertiliser application, irrigation or pest and disease control.

IPM programmes for okra have been developed in India, Sudan and USA. The complex of okra pests varies from one region to the other, with some pests distributed worldwide, some restricted to one continent or smaller areas, and others limited to localities. IPM programmes cannot be transplanted, but the principles and techniques can be adapted to local conditions. Knowledge of the pest–host plant interrelationship is vital in developing an IPM programme.

It is very important for growers to correctly identify the insect or disease causing damage, the extent of the damage and the stage of the crop attacked, before making any control decision.

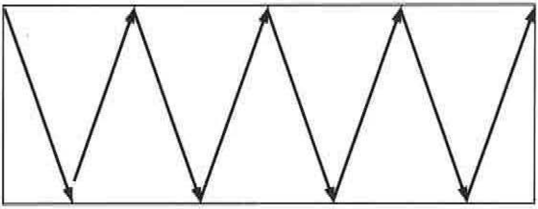
Crop scouting

Crop scouting must be regular, at least once a week. It is essential to detect a problem in the crop early and to take action before serious damage occurs. It helps to reduce the use of preventative tactics, most of which may become unnecessary. Regular scouting also aids assessment of previous interventions (i.e. whether effective or not, and if not, to check what went wrong).

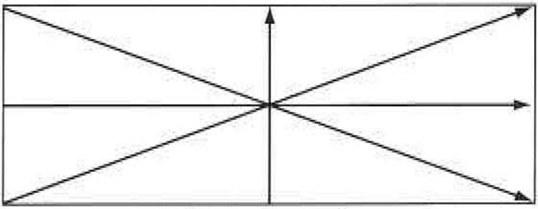
Crop scouting methods include plant sampling and use of insect traps and indicator plants. To scout a crop the farmer surveys the crop area to get an overview of the major problems and the general condition of the crop. This is followed by methodical inspection of the crop, picking plants at random at sampling sites and filling observations in a prepared inspection sheet. Different sampling sites should be chosen each time the crop is inspected. The number of sampling sites on each stretch will depend on the size of the field. The number of plants to be inspected on each site will depend on the size of the plants, the crop and spacing. For a smallholder's okra plot, 10 sites per farm unit and 10 plants per sampling site are adequate. While carrying out random sampling, the farmer should be alert to unusual problems and conditions in the rest of the field.

Sampling techniques vary depending on farm size and crop. Examples include the zigzag, multi-bisectoral and 'W' patterns (Figure 1).

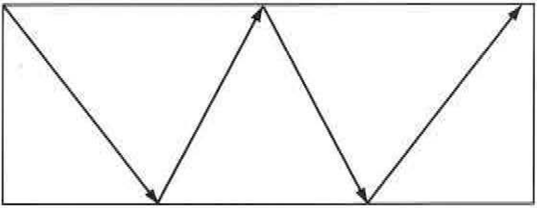
Scouting involves thorough inspection of the whole sample plant from soil and roots to the top of the newest shoot, carefully checking both the upper and lower sides of all the leaves, flowers and pods.



Zigzag pattern



Multi-bisectoral pattern



'W' pattern

Figure 1. Examples of scouting patterns

Problem recognition

For proper management, it is important for a farmer to know what a healthy crop looks like, to be familiar with normal crop development and to recognise the typical damage from pests and diseases during the various stages of crop development. It is also important to be able to differentiate a pest or disease damage symptom from a nutritional problem, a chemical burn, weather damage or physiological disorders.

Record keeping

Proper record keeping is important. A logbook or record sheet should be kept of the problem type, locality and abundance or any other disorder observed. A record of all remedial measures taken should also be kept. If a pesticide is applied, all its details must be recorded (name, dosage, sprayer type, crop sprayed, target pest or disease, application date, weather conditions and name of the person applying the product). Such records are important in determining the effectiveness of interventions and will also be of long-term benefit in understanding the trends or patterns of arthropod pest and disease development in relation to weather conditions. In the short term, the records serve as the basis for decision-making on strategies for managing the production problems. In addition, record keeping is a must for compliance with traceability requirements for export crops like okra.

Decision-making on optimising production

Once the field has been inspected, the farmer has to decide what to do to optimise production. To make a valid, informed decision the farmer has to consider the following:

- Prevailing weather conditions
- Crop growth stage
- Yield potential
- Pest or disease stage
- Pest or disease damage
- Previous field records
- Results of interventions already implemented
- Presence and activity of beneficial arthropods such as bees, ladybird beetles, predatory mites, etc.
- Potential management options.

Control methods in IPM for okra

Biological control

Biological control involves conservation, augmentation and importation of natural enemies such as predators, parasitoids, pathogens and antagonists.

Although natural enemies cannot always prevent economic damage, they are important for pest management. Often, the effectiveness of natural enemies in regulating pest populations is affected by adverse farming practices such as the use of broad-spectrum pesticides. One example is leafminers, which are normally controlled by naturally occurring parasitoids.

However, using broad-spectrum insecticides to control other pests has disrupted the natural control of leafminers, making them secondary pests of okra.

Conservation and encouragement of natural enemy populations are important elements in pest management. One way of preserving existing natural enemies is to avoid or reduce the use of pesticides, particularly broad-spectrum types that kill a wide range of pests. If pesticides must be used, selective pesticides that target specific pests are preferable. For example, pathogens such as commercial products based on *Bacillus thuringiensis (Bt)* have been used alone or in combination with parasitoids and predators for successfully controlling bollworms.

The effectiveness of natural enemies can be improved by cultural or environmental manipulation, such as augmentation of food sources. This could be done, for instance, by providing flowering plants as nectar sources or by providing artificial food sources. For example, ants and lacewings could also be attracted with sugar baits to the crops. A mixture of yeast, sugar and water has been found to increase the numbers and fecundity of lacewings. The application of compost improves the soil condition and the effectiveness of soil microbes that inhibit the build up of plant pathogens in the soil.

Natural enemies could be attracted to crops through such methods as encouraging the growth of plants that are attractive to them (by overlapping different crops on adjacent plots) or by intercropping. These measures would involve changes in the pattern of planting and would require studies on parasitoid-pest-crop interaction.

In some cases where locally occurring natural enemies cannot control pests, commercially produced natural enemies may be released. This is known as augmentation biocontrol.

There are no records on the use of natural enemies for controlling okra pests. However, the main okra pests are naturally attacked by a range of natural enemies, and the conservation of these enemies is an important component of IPM in okra. (*For more details on natural enemies refer to page 29.*)

Mechanical control

- ***Mass trapping:*** This method makes use of traps to catch large proportions of the pest population. The traps used for pest monitoring (pheromone, coloured sticky traps, etc.) can be used for this when pest densities are low. Yellow sticky traps have been used for controlling leafminers and whiteflies, and have been fairly effective in catching immigrating insects in greenhouse vegetables. Several types of pheromone traps have been developed for monitoring and mass trapping of bollworms (*H. armigera*) and cutworms on several crops. *This method is predominately used for crops in protected environments. It is possible to use traps for monitoring purposes in okra fields, but such traps must be available and affordable to smallholder okra growers, which at present is not the case in Kenya.*

- ***Hand picking:*** Removal of pests by hand can be practical and effective in small plots. This could be done for bollworm eggs and caterpillars. But farmers must be able to distinguish between pests and their natural enemies.

- ***Ploughing:*** Ploughing kills pests in the soil such as pupae of caterpillars, thrips and cutworms, together with weeds, by exposing them to the sun and to their natural enemies.

Use of plant resistance

Plant breeding for increased genetic resistance to pest damage can be an important component of IPM programmes. The development of insect and mite populations on resistant varieties is relatively slow and this favours other pest control measures. Moreover, once such a variety is available, no extra labour is required, making this method economical. Breeding for disease, nematode or virus resistance has been an essential part of commercial breeding programmes. Lately, attention has been given to breeding for resistance to insect and mite pests.

Cultural methods

Managing the habitat in which or the way a crop is grown prevents or reduces pest damage. Some cultural methods are described below:

- ***Mixed cropping systems:*** Mixed cropping involves planting two or more crops in a field. Opinions differ as to the value of mixed cropping in arthropod pest and disease control, but it definitely can have other benefits. Intercropping involves planting alternate rows of two or more crops in a field. Intercropping okra with legumes such as cowpeas has been successful not only because the legumes fix atmospheric nitrogen in the soil but also because they attract natural enemies that attack pests, such as aphids and caterpillars.

- ***Trap crops:*** Trap plants (plants that are attractive to pests) such as castor bean and pigeon peas cultivated on boundaries of an okra field can be used to attract pests such as whiteflies away from okra. When they become severely infested, they can be either removed and buried to compost along with the pests or sprayed with a pesticide. Maize and sorghum have been recommended as trap crops to divert the African bollworm from cotton and okra. Female moths of the bollworm are particularly attracted to these crops for laying eggs, but the survival of the caterpillars is low. In addition, these plants, particularly sorghum, attract natural enemies such as anthocorid bugs during flowering. These measures would entail changes in the pattern of planting and require further studies on the pest–host plant relationship.

- ***Pest and disease avoidance:*** Pests can be avoided by controlling the timing of planting. Whenever possible, crops should be grown when conditions are favourable for them but not for pests and diseases. For example, in the coastal lowlands of Kenya, okra is planted during the rains when weather conditions are not conducive to attacks by aphids and powdery mildew, the main problems in okra production. This would be feasible against one particular pest, however. Different pests attack okra almost every season and it is not possible to escape all of them.

- ***Providing conditions for growing healthy plants to better withstand pests*:** This would include ensuring good growing conditions for the crop, such as good soils and proper irrigation, fertilisation and spacing.

- ***Sanitation:*** This involves destroying the source of infestation, such as crop residues (stems, leaves, fruits, etc.), and weeds. Crop residues can be composted, buried or burned.

- ***Avoiding dense planting:*** Proper spacing should be used for each variety. Dense planting creates a humid microclimate that is conducive to the development of foliar diseases.

- ***Early planting:*** Avoid late sowing. Early planting is a good tactic for managing aphids, bollworms, jassids, thrips and whiteflies. It also means that the crop matures early, escaping damage by pests.

- ***Crop rotation:*** Rotation can help reduce the build-up of soil pests and diseases. *(Refer to the section on growing okra, page 7.)*

- ***Solarisation:*** After irrigating the soil, it is covered with a clear or transparent polyethylene sheet for 2–3 months, depending on the intensity of sunshine.

Successful solarisation results from adequate sunshine, good land preparation and land availability for rotation and fallowing for up to 6 weeks. Solarisation is more suitable for nursery beds and small plots but can also be used in the field. But this may require changing how okra is planted. To solarise the soil:

- Prepare the land by ploughing, harrowing and irrigating.
- Apply the mulch, making sure that it is properly tacked in, to prevent heat and moisture loss.
- Retain the mulch until the defined period is completed.

Solarisation has several advantages:

- It reduces soil-borne pests (insects, diseases, nematodes and weeds).
- It increases the range and effectiveness of soil-inhabiting antagonists that compete with or inhibit microorganisms causing soil-borne diseases.
- It improves plant health, vigour and yield.
- It improves soil condition.
- It reduces soil salinity by preventing the upward capillary movement of soil water and its concentration by reducing evaporation on the surface.

Pesticides

Pesticides (insecticides, fungicides, acaricides, bactericides, nematicides, etc.) should be used as a last resort, only when other measures have failed to maintain arthropod pests and diseases at acceptable levels. *(See also Annex 1 on guidelines on best use of pesticides.)*

When pesticides are needed, preference should be given to selective pesticides (IPM-compatible) that have little or no effect on natural enemies. These include biopesticides (pesticides whose active ingredient is a living organism) such as microbial pesticides (e.g. *Bt*) and botanical pesticides (those derived from plants such as the neem tree).

Some botanical pesticides are good alternatives to synthetic types in IPM programmes. For instance, neem-based pesticides are effective for the control of a broad spectrum of pests (insects, mites, fungal diseases and nematodes) and are not usually harmful to natural enemies. However, products based on neem oil have stronger side effects on non-target pests than do oil-free products. Neem-based pesticides discourage feeding in many homopteran insects. This is particularly important for vectors of virus diseases such as whiteflies. Amending the soil with neem leaves or neem cake is a common method used against root-knot nematodes.

The amount of pesticide to be used can be reduced by:

- Avoiding preventive spraying whenever possible. Decision on spraying should be based on the outcome of regular scouting of the crop.
- Avoiding blanket application. The preferred application methods include seed treatment, use of granules or baits and spot treatment.

In many countries, the overuse and careless use of pesticides have resulted in the development of resistance in pests such as spider mites, bollworms, leafminers and whiteflies to the major classes of insecticides. Repetitive use of synthetic pyrethroids, particularly using them for several consecutive seasons, can result in the development of resistance and in increased pest pressure. The development of resistance to pesticides can be avoided or delayed through rotating pesticide groups (different chemical types) to minimise selection for resistance. Preventive application and application of lower than recommended dosages should be avoided, since they too may lead to resistance.

Natural enemies as biological control agents

Natural enemies (living organisms that thrive on crop pests) are usually present in okra fields and include predators, parasitoids and pathogens.

Predators

Predators often feed on various stages of the host (pest): eggs, larvae, pupae and adults. Each predator requires a number of prey individuals to reach maturity. The main predators include:

- ***Ladybird beetles:*** Adult ladybird beetles are small, oval to nearly spherical in shape, with a short antenna. They are often brightly coloured with black markings, black with bright spots, or shiny black (Plate 1). The eggs of ladybird beetles are elongated, usually yellow to orange in colour. They are normally laid in groups near aphid colonies (Plate 2). The larvae are soft-bodied and usually long and thin in shape. Their colour varies from black to dark brown with various types of markings (Plates 2 and 3). The adults and larvae of most ladybird beetles are important predators of aphids, scales and mites. However, they are most abundant when the prey populations are large, by which time the crop may have been damaged. Several species of *Cheilomenes* and *Hippodamia* are commonly found on aphid-infested okra plants. ***Note:*** *there are several species of plant-feeding ladybird beetles (particularly beetles of the subfamily Epilachninae). Both the larvae and the adults feed on leaves and fruits, and can be pests of crops such as tomatoes, potatoes and cucurbits.*

- ***Lacewings:*** The wings of the adults are usually greenish (green lacewings) (Plate 4, left) or brownish (brown lacewings) (Plate 4, right) and semi-transparent. The eggs are laid at the end of tiny stalks, usually on foliage (Plate 5, left). The larvae have long, sickle-shaped mouth parts (Plate 5, centre). The pupae are whitish and spherical and can be confused with spider egg sacs (Plate 5, right). The larvae feed on aphids, insect eggs and small caterpillars, while the adults feed on nectar from flowers and other sugar sources such as honeydew.

- ***Predatory flies***
  Hoverflies: The adults are usually brightly coloured with yellow-brown or black stripes (Plate 6, left). The eggs are white, cylindrical and 1–2 mm long. The larvae are usually greenish or brown with one to three white stripes along the body (Plate 6, right). They resemble maggots and are often mistaken for

caterpillars although they do not have a distinctive head or legs as do caterpillars. The pupae are pear-shaped and may be green or brown (Plate 7). The adults feed on nectar of flowering plants and can often be seen floating in the air. The larvae feed on aphids and small caterpillars.

Cecidomyiid and chamaemyiid flies: The adults are minute flies (about 3 mm). Chamaemyiid flies resemble tiny houseflies (Plate 8 lower right inset) while cecidomyiid flies (midges) are usually slender, mosquito-like flies with long legs and antenna. Larvae of chamaemyiid flies are small, yellow-orange maggots (Plate 8, upper right inset), and some species are predaceous on aphids and mealybugs. They are commonly found feeding on aphids on okra. Most species of cecidomyiid larvae are plant feeders, causing galls on plants. However, the aphid midge *Aphidoletes aphidimyza* (Rondani) is an effective predator of aphids. This midge is available commercially in the United States and Europe, where it is an important component in biocontrol programmes for greenhouse crops.

- ***Predatory bugs:*** The main group of predatory bugs includes anthocorid bugs (Plate 9), nabid bugs and assassin bugs (Plate 10). Other families of bugs that include many plant-feeding bugs such as lygaeid bugs, mirid bugs and shield bugs also contain predatory species. The nymphs of bugs are similar to the adults in shape, but are smaller and may vary in colour. Young nymphs are wingless, but wings develop gradually and wing pads can be seen as the nymphs develop. Anthocorid bugs, or pirate bugs, are tiny insects (up to 2–3 mm long). The nymphs are brown, black or orange, while the adults are black with black and white patches on their wings (Plate 9). The adults and nymphs of *Orius* and *Anthocoris* spp. are important predators of thrips, mites, aphids, insect eggs and small caterpillars.

- ***Predatory mites:*** Predatory mites eat plant-feeding mites, thrips and insect eggs. They may be red, dark or even translucent, depending on the species and the growth stage. They are distinguished from spider mites by their larger size, longer legs and faster movement (Plate 11).

- ***Praying mantis:*** The nymphs and adults have characteristic forelegs that assume a praying posture, hence their common name, and that are used for grasping the prey. The nymphs resemble the adults but are smaller and initially have no wings. The wings develop gradually as nymphs age (Plate 12). The eggs are laid in a sac containing hardened foam. Both nymphs and adults feed on moths, flies, crickets, etc.

- ***Other predators*** such as spiders (Plate 13), ants, predatory wasps and ground and rove beetles, which feed on many different types of insects, are important in the natural control of pests. Non-specific predators with good searching ability such as carabid and staphylinid beetles are particularly useful for keeping pests at low numbers, and are good complements to other predators such as ladybird beetles, which are more common when pest numbers are high.

Parasitoids

Most of the parasitoids are parasitic wasps. Their immature stages (larvae) live on (external parasitoids) or in (internal parasitoids) the host (pest). They complete their development (egg to adult) on a single host, killing it. Parasitic wasps are important natural enemies of leafminers, aphids, and eggs and larvae of moths and butterflies (caterpillars).

Several species of parasitic wasps attack caterpillars, leafminers and aphids on okra. Plate 14 presents a parasitised leafroller caterpillar. *Diglyphus isaea* Walker, a parasitoid of leafminers, is common in Kenya. Parasitised aphids are commonly found in all okra growing areas. The wasp *Diaeretiella rapae* (McIntosh) has been reported as one of the common aphid parasitoids in okra in Kenya. The larvae of the parasitic wasps feed on the internal organs of the aphid, stopping its reproduction, retarding its development and finally killing it. When the parasitic larvae pupate, the parasitised aphids turn brown and hard and remain stuck to the leaves. They are known as mummies and can be easily recognised. The parasitic wasps emerge through a round hole in the aphid's abdomen a few days later (Plate 15).

Pathogens

Pathogens include fungi, bacteria and viruses. They attack pests in the field. Plate 16 shows the cotton aphid attacked by an unidentified fungus on okra. Naturally occurring pathogens often are too rare to serve as important control agents or occur when the damage is already done. A few of them, such as the bacterium *Bacillus thuringiensis (Bt)* and the fungus *Trichoderma viride*, are commercially available in many countries including Kenya. *Bt* is used for controlling caterpillars, and *T. viride* for soil-borne pathogens. The larvae must eat *Bt*-treated foliage for these insecticides to work, so thorough coverage of the leaves and use of a sticker are advisable. *Bt* should be applied when the larvae are small. The larvae stop feeding within a few hours after eating *Bt*-treated foliage and die within a couple of days. *Bt* formulations have the advantage of being specific, that is, they affect only caterpillars and do not harm natural enemies.

Farmers can produce homemade bio-pesticides by collecting diseased larvae and crushing and mixing them with water in a blender. They then filter out the large tissue masses to leave the liquid for spraying the crop. The pathogen will infect other pests in the crop and kill them.

Arthropod pests

Cutworms

(Plates 17–19)

Agrotis spp. (Lepidoptera: Noctuidae)
A. segetum Denis & Schiffermüller, the black cutworm, the common cutworm
A. ipsilon (Hufnagel), the black cutworm, the greasy cutworm

Status and distribution: Cutworms are the caterpillars of various species of moths especially of the genus *Agrotis*. They attack a wide range of plants worldwide. Similar damage can be caused by chafer grubs, which are the larvae of scarab beetles. Chafer grubs live in the soil, feeding on humus and plant roots (Plate 17).

Description and biology: Cutworm adults are grey-brown moths, about 22 mm long with a wingspan of 40–45 mm. The forewings have dark brown markings in form of rings and lines (Plate 18). The females lay eggs singly or in small patches on lumps of soil, on the stem and lower leaves of plants, or on low growing vegetation. Young larvae are yellowish-green with a blackish head. They feed on leaves during the day; later they descend to the soil. Older caterpillars feed at the base of plants or on roots or stems underground during the night and hide in the soil during the day. When fully grown, the larvae are grey-black, smooth-skinned caterpillars, about 4–5 cm long (Plate 19). They normally curl up when disturbed. They are active mainly at night; during the day they hide in the soil or in debris at the base of plants.

Damage: Caterpillars girdle and cut off young seedlings at the soil level, causing them to wilt and die (Plate 19). They occasionally climb mature plants to feed on leaves, but this kind of damage in general is not of economic importance. Damage is worst where cutworms are present in large numbers before planting. Cutworms often reoccur in the same field, coming with crop residues or dense stands of weeds. Field preparation usually destroys the food of existing cutworms. If the field is planted soon afterwards, the cutworms may still be alive and start feeding on the new crop. Cutworms tend to be more frequent in land that has plenty of decaying organic matter or where organic manure has been applied.

Control options:

- Cutworm damage in okra is usually minor and does not warrant control measures.
- A large number of natural enemies of cutworms have been recorded, the most common of which are larval parasitoids, mainly parasitic wasps and flies. Predatory beetles and pathogens such as viruses, bacteria and fungi are also seen in fields. Conservation of these natural enemies is important to avoid cutworm outbreaks. *(Refer to sections on biological control and natural enemies, pages 21 and 29.)*
- Vegetation and weeds should be destroyed before planting.
- Ploughing exposes caterpillars to predators and to desiccation by the sun.
- Flood irrigation kills cutworm caterpillars in the soil.
- Control is normally not needed after plants are about 25–30 cm tall. Newly planted fields

should be monitored for cut plants during the day. Monitoring of cutworm larvae should be done at dawn.

- If plants damaged by cutworms are found, the cutworms can be located near the damaged plants in the soil and removed or destroyed physically.
- Ashes deter cutworms: They can be spread thickly around plants or mixed with the soil in the planting hole.
- A thin, dry stick inserted at the side of the young plant acts as a mechanical barrier, reducing the loss of plants caused by cutworms.
- When insecticide use is necessary, the amount applied can be kept to a minimum by banding the insecticide over the rows rather than broadcasting it.
- Chemical control of cutworms when they are in their first to third instars (when they feed on foliage) using synthetic pyrethroids has proved very effective.
- Baits made from maize flour, water and insecticides are recommended. These are more effective when cutworm food is limited. It is recommended to ensure weeds and other vegetation are removed and to check for cutworms in the field. The bait, if necessary, should be applied before planting.
- Biopesticides such as *Bacillus thuringiensis (Bt)* or botanicals such as pyrethrum and rotenone are recommended as alternatives to conventional insecticides.

Aphids

(Plates 20–22)

Aphis gossypii Glover (Homoptera: Aphididae), the cotton aphid

Status and distribution: *Aphis gossypii* is an important pest of a large number of crops worldwide. The host range includes food and fibre crops and ornamentals. The cotton aphid can be very destructive to crops, mainly through transmitting plant viruses. This aphid is an important pest of okra in India and Sudan. It has been identified as one of the major pest problems in all okra growing areas in Kenya.

Description and biology: Aphids are soft-bodied, pear-shaped insects with a pair of cornicles and a cauda protruding from the abdomen. They live in colonies (clusters) (Plate 20). Adult aphids are small to medium-sized. They may be winged (alate) or wingless (Plate 20). Wingless forms are the most common. Production of winged aphids is triggered by nutritional factors and crowding. Aphids usually do not lay eggs, but the females (winged or wingless) give birth to wingless offspring called nymphs. The nymphs develop into adults and give birth to further nymphs. Initially wingless females are produced, but when they overcrowd the plants, winged females are produced that fly away to start new colonies.

The body length of the adult cotton aphids ranges from 1 to 3 mm. Their colour varies widely, from yellow to yellowish-green, or very dark (almost black) green with black cornicles and yellowish-green abdominal tips (Plate 20). Aphid colour may be influenced by the host plant, temperature or crowding. Usually large specimens are dark green, almost black, while the adults produced on overcrowded leaves at high temperatures may be small (less than 1 mm long) and very pale yellow to almost white.

Aphis gossypii reproduction in the tropics is asexual (no males are produced). In warm conditions, the nymphal period lasts 7–9 days. The adults live for 10–20 days, and a female can produce 20–140 young nymphs. The colonies can expand rapidly.

Damage: Aphids damage plants by sucking their sap, excreting a sticky substance (honeydew) that coats the plants, or by transmitting virus diseases. Both adults and nymphs of the cotton aphid suck sap from the tender leaves, twigs and buds, weakening the plants. The initial symptom of attack is yellowing of the leaves. As the number of aphids increases, the leaves become puckered and curled (Plate 21). Further population increases drive aphids to younger leaves, stems, flowers and pods. The plants become covered with a black, sooty mould that grows on the honeydew secreted by the aphids (Plate 22). Clusters of aphids on the pods, drops of sticky honeydew produced by aphids or patches of sooty mould on the pods may lead to their rejection in the market. Plants with high aphid infestation may become deformed and stunted (Plate 21). Aphids are often visited by some species of ants that, while feeding on the honeydew excreted by the aphids, give them protection by disturbing the natural enemies.

Aphis gossypii aphids are serious vectors of viral diseases. They are reported to transmit the

Yellow Vein Mosaic Virus in okra. This disease was not found in Kenya during the countrywide surveys conducted in 2002 and 2003.

Control options:

- Early detection and monitoring of initial aphid infestation build-up are important.
- Numerous natural enemies of *A. gossypii* were found in aphid-infested okra in Kenya, among which were parasitic wasps and several predators such as ladybird beetles, predatory flies and lacewings *(see page 29)*. Conservation of natural enemies is important to reduce aphid outbreaks. (*For more information refer to page 21.*)
- Avoid planting near an aphid-infested crop or on land from which an infested crop has been removed recently.
- Do not apply too much nitrogenous fertiliser, as it may make the plants more attractive to aphids.
- At low infestations the aphids may be removed mechanically.
- Spraying should be carried out only for heavy infestation, since frequent and inappropriate use of pesticides may result in elimination of natural enemies. Great care must be taken in pesticide use. In addition, resistance development has been a problem associated with a number of pesticides.
- Whenever possible, spray only infested plants (spot spraying).
- Choose a systemic pesticide (this type of pesticide passes through the leaf surface and is carried in the plant sap, which the aphids suck).
- Spraying with a soap and water solution helps to wash off the aphids.

Beetles

A number of leaf beetles have been identified attacking okra in Kenya. The most important are flea beetles *Nisotra* spp. and *Podagrica* spp. (Chrysomelidae) (Plates 23–26), which are particularly damaging in the early stages of the crop. Other foliage feeding beetles include the chrysomelids, *Leptaulaca fissiocollis* Blanchard and *Copa delata* Er; the long joined beetle *Lagria villosa* Fabricius (Lagridae) (Plate 27); *Lixus* spp. (Curculionidae); and *Apion* spp. (Apionidae). The flower beetles *Mylabris* spp. and *Coryna* spp. (Meloidae) are important pests during the flowering and fruiting stages.

Flea beetles

(Plates 23–26)

Nisotra spp. and *Podagrica* spp. (Coleoptera: Chrysomelidae)
Nisostra (Podagrica) sjostedti Jacoby
Podagrica uniforma (uniformis) (Jacoby)

Status and distribution: Several species of flea beetles feed on okra. In Ghana, *N. sjostedti* is considered a minor pest, whilst *P. uniforma* can be a serious pest especially during the dry season and where water is in short supply. *Podagrica decolorata*, *P. uniforma* and *P. sjostedti* are reported as pests of okra in Côte d'Ivoire and Nigeria. In Kenya, *Nisostra* spp. have been reported as important pests of okra, particularly in the early stages of the crop.

Description and biology: Flea beetle adults are tiny to small, with well-developed, spring-like muscles in their enlarged hind legs that enable them to jump long distances when disturbed. The adults may be black, brown, black and yellow striped or metallic blue-green, depending on the species (Plates 23 and 26). The eggs are very small, white and cigar-shaped. They are laid in gnawed-out areas in roots or the surrounding soil. The eggs hatch in about 10 days. The larvae are whitish, very small (3–6 mm long) and have tiny legs and a dark head. They generally feed on the roots. After feeding for 3–4 weeks they pupate in the soil and emerge in 7–10 days.

Damage: Damage is caused by the adults, which feed on cotyledons, stem or foliage. The larvae feed on the roots without significant damage. The damage by beetles is manifested by many small, round holes in the leaves, known as 'shot-holes' (Plate 24). Young seedlings are the most vulnerable. Seedlings may wilt and die under heavy flea beetle attack or may be stunted if injury is not severe. Damage to cotyledons and young leaves is the major cause of crop loss, generally leading to uneven crop stand and development. Larger plants are more tolerant to flea beetle feeding and usually do not suffer economic damage unless beetle populations are unusually large. When big numbers of flea beetles are present, they can be seen feeding on flower buds and pods (Plates 25 and 26), causing yield loss by injuring the pods. Damaged pods are not acceptable for export.

Flea beetles are very mobile and disperse readily. Rapid invasion of fields by large numbers of these beetles can occur, particularly following rains, and can be very destructive to young plants.

Some species of flea beetles such as *P. decolorata*, *P. uniforma and P. sjostedti* are reported as vectors of the Okra Mosaic Virus in West Africa.

Control options:

- It is important to frequently scout the fields for the presence of and damage by flea beetles. This should be done at least three times per week during the seedling stage, and twice per week in later stages.
- Weeding in and around fields may help to eliminate flea beetle shelters and breeding grounds, reducing crop damage.
- Insecticide applications may be necessary if large flea beetle populations are present in the early stage of the crop, before foliage is well established. Foliar insecticides are recommended for quick control of large populations attacking vulnerable seedlings. Treatment is more effective on calm, sunny days, when flea beetles are active, than on cool or windy days.

Flower beetles

(Plates 28 and 29)

Mylabris spp. and *Coryna* spp. (Coleoptera: Meloidae), blister beetles

Status and distribution: Several species of flower beetles have been recorded on okra in Kenya, including *Coryna apicicornis* (Guer). Flower beetles are common at the onset of the flowering period.

Description and biology: Flower beetles have narrow necks and soft, elongated bodies. The abdomen is black with red or yellow transversal bands (Plates 28 and 29). *Mylabris* species are large (2–4 cm long), while *Coryna* species are smaller (1–2 cm long). Adult blister beetles feed on plants, but the larvae usually feed on grasshopper eggs.

Female flower beetles lay eggs in batches in the soil. The eggs hatch in 3–4 weeks. Young larvae are white and have six legs, a big head and two large bristles on the tail. They are very active, running over the surface of the soil seeking places where locusts and grasshoppers have laid their eggs. They eventually shed their skin, turning into fat, white maggots with very short legs, and remain in the soil where they pupate.

Damage: Adult flower beetles feed on flowers, reducing fruit set (Plates 28 and 29). They are also foliage feeders, biting off irregular patches on leaves. Sometimes they chew up the whole leaf.

Control options:

- In small fields, the adults should be picked manually and destroyed. However, care should be taken when hand-picking the adults, since when disturbed they release a fluid that could burn the skin. Whenever possible hands should be protected by wearing thick gloves. The larvae should not be destroyed since they are important predators of grasshoppers.

Bugs

Several species of bugs are common in okra fields. They occur from the early stages of the crop, but are particularly common during the mature stages. Cotton stainers are common pests of okra in Kenya.

Cotton stainers

(Plates 30–32)

Dysdercus spp. (Hemiptera: Pyrrhocoridae)
D. fasciatus Signoret
D. intermedius Distant
D. nigrofasciatus Stål
D. superstitious F.
D. cardinalis Gerstaecker

Status and distribution: Several species of cotton stainers feed on okra. They are major pests of cotton and okra. Their alternate host plants include kenaf, roselle, kapok and baobab. The last one is one of the major hosts of stainer bugs. Cotton stainers occur in most African countries south of the Sahara. *Dysdercus cardinalis* is the most common species found on okra in Kenya.

Description and biology: Stainer bugs are elongated, slender and about 1.5–2.5 mm long. The females are larger than the males. They have white bands across the abdomen, and the membranous portion of the forewings, the antennae and the upper thorax are black (Plates 30 and 31). The general colour of the body varies according to the species. *Dysdercus fasciatus* is red to yellowish-red with a relatively wide band on the wings. *Dysdercus intermedius* and *D. nigrofasciatus* are light grey with an orange tinge, and have a narrow black band on the wings. *Dysdercus nigrofasciatus* is generally smaller and has a black stripe at the posterior end, which is absent in *D. intermedius.*

The eggs are laid in moist soil or in crevices in the ground. They hatch in 7–8 days to produce reddish-orange nymphs. Initially, the nymphs are wingless, but wings develop gradually as the nymphs grow (Plates 30 and 32). The nymphal period lasts 5–7 days. The development process is completed in 50–90 days.

Damage: Adults and nymphs feed in large numbers on developing pods and seeds, sucking the sap, thereby reducing yield. Stainer bugs are late-season pests.

Control options:

- Plough deeply or hoe to expose the eggs.
- Destroy all plants after harvesting.
- Uproot and destroy wild alternate hosts.
- Pick the bugs during their early development stages and destroy them.
- If okra is grown where baobabs exist, trunks of infested trees and the soil around them should be sprayed with an appropriate insecticide to kill the nymphs hatching from the eggs deposited around the trunks.
- In some countries, chickens are released in the fields to feed on the bugs. According to reports, about 30 birds can clean 0.25 ha almost free of bugs.

Stink bugs

(Plates 33–35)

Nezara viridula (L.) (Hemiptera: Pentatomidae), green stink bug
Atelocera sp. and *Halydicoris* sp. (Hemiptera: Pentatomidae), brown stink bugs

Status and distribution: Stink bugs are widespread in the tropics and subtropics. They feed on a wide range of cultivated and wild plants. They are important pests of legumes, cotton and various vegetables. Several species of stink bugs have been recorded feeding on okra in Kenya.

Description and biology: Adult stink bugs are shield-shaped and 14–19 mm long. Green stink bugs are bright green, while brown stink bugs are a dull greyish-yellow to brown (Plate 33). When disturbed they emit an offensive smell. The females lay batches of 30–60 barrel-shaped eggs on the underside of leaves. In their first stages, the nymphs stay together near the egg batches and do not feed. They disperse after moulting and begin to feed. The nymphs are similar in shape to the adults but are smaller and wingless. Green stink bugs are wingless and predominantly black when small, but develop wing pads as they mature and become green with orange and black margins.

Damage: Stink bugs suck from the buds, blossoms, pods and seeds. Their feeding causes local necrosis, resulting in small, dark, raised, blister-like spots on the pod (Plate 34), or occasionally pod-shedding. On very young pods, it causes twisting and distortion of the pods, rendering them unmarketable (Plate 35).

Control options:

- Stink bugs are a minor pest and normally do not need control. But they can be a problem during podding. Chemical control is not recommended at that stage because most insecticides have extended pre-harvest intervals.
- Natural enemies, particularly egg parasitoids and ants (predators of eggs and nymphs), are important for natural control of stink bugs.
- Scouting for stink bugs should be done in the morning, since at that time nymphs and adults bask on the canopy. In the middle of the day, most bugs retreat into the canopy or shaded parts of the plants. Adult stink bugs quickly drop from the plant or fly away when disturbed.
- When chemical control is needed, spraying should be done in the morning when nymphs and adults bask outside the plant canopy.
- Neem-based pesticides reportedly reduce feeding by stink bugs.
- Adults are difficult to control, since they can readily move from neighbouring crops or wild plants into okra fields after the effect of pesticide application is over.

Cotton seed bug
(Plate 36)

(*Oxycarenus* spp.) (Hemiptera: Lygaeidae)
O. hyalinipennis Costa

Status and distribution: *Oxycarenus hyalinipennis* has been recorded in many countries including Kenya, the Near East, Southeast Asia and South America.

Description and biology: These bugs are small, ranging from 4 to 6 mm in length, and blackish in colour. Their wings are transparent, appearing pearly. Their back (thorax and head) has a triangular pattern in black and white (Plate 36). The nymphs have a round abdomen and resemble adults except in size. The eggs are laid in moist soil or soil crevices. The development period from egg to adult lasts 50–90 days.

Damage: The adults feed on developing pods. They attack open or damaged pods mainly at the end of the growing season. The nymphs and adults suck from immature seeds, preventing them from ripening. Groups of bugs are usually found between flower buds, flowers and pods.

Control options:

- These bugs are minor, mostly secondary, pests. Chemical control is not usually recommended for them.
- These bugs can be dislodged by shaking the plants.
- Control measures used for stainer bugs will usually work with cotton seed bugs.

Leaf-eating caterpillars

Various species of caterpillars feed on okra leaves. Semi-loopers chew irregular holes on leaves, giving them a ragged appearance. Some caterpillars cause windowing of leaves (Plates 37 and 38) while other species spin or roll leaves together (Plates 39 and 40). Leaf-eating caterpillars cause economic damage only when their numbers are large, especially in young or stressed plants. Well-established, healthy plants can tolerate considerable loss of foliage; however, seedlings may be killed by extreme defoliation.

Larvae of the African bollworm also feed on the leaves in the early stages of the crop, but they are important pests during flowering and fruiting stages. (*Refer to the section on pod borers, page 64.*)

Leaf roller

(Plate 40)

Haritalodes (Sylepta) derogata Fabricius (Lepidoptera: Pyralidae), the cotton leaf roller

Status and distribution: *Haritalodes derogata* is widespread throughout Africa and Asia. It feeds primarily on plants belonging to the Malvaceae family. It is an occasional pest of okra and cotton. It has also been reported on cassava, kapok, tomato and eggplant. In Kenya, it has been found feeding on okra at the coast.

Description and biology: The moths are yellowish-white with black and brown spots on the head and thorax and a series of dark brown wavy lines on the wings. Their wingspan is 28–40 mm. They are nocturnal and lay eggs singly or in clusters on the underside of leaves. The eggs hatch in about 3 days. Young caterpillars feed initially on the underside of leaves, but when older they roll a leaf around themselves and feed within it (Plate 40). Early instars may accumulate on leaves but later instars are usually solitary. The caterpillars are up to 30 mm in length when fully grown, pale dirty green in colour with a semi-translucent body and a dark brown head (Plate 40). The larvae pupate within rolled leaves (Plate 40) or in debris on the ground. The life cycle is completed in about 23–35 days.

Damage: Damage by caterpillars occurs when they roll the leaves and eat the leaf margins, causing the leaves to curl and droop. Leaf rollers usually do not cause economic damage in okra.

Control options:

- A number of parasitic wasps have been reported attacking leaf roller larvae and pupae. Most of the leaf rollers collected during the survey in Kenya were found to be parasitised. Predatory spiders and praying mantids are also considered important natural enemies of cotton leaf rollers.
- Removal and destruction of eggs, larvae and rolled leaves help to reduce damage.
- Usually chemical control is not warranted.

Semi-loopers
(Plate 41)

Anomis (Cosmophila) flava Fabricius (Lepidoptera: Noctuidae), the cotton semi-looper

Status and distribution: Semi-loopers have been observed in all okra growing areas of Kenya. They are sporadic pests in Kenya but have been reported to occasionally cause severe defoliation of okra in Ghana.

Description and biology: The adults of semi-looper caterpillars are stout moths with a wingspan of 25–35 mm (Plate 41 inset). They are nocturnal and lay eggs singly on leaves. The caterpillars have three pairs of legs near the head and three pairs of prolegs near their rear. As they move, the middle section of the body becomes arched or humped. Semi-loopers vary in colour from pale green to bright green with yellow spots (Plate 41). The caterpillars of the cotton semi-looper grow up to 35 mm in length and are green with yellowish bands between segments.

Damage: The caterpillars feed on leaves, making holes and sometimes leaving only the midrib and veins. The damage by semi-loopers on okra is not of importance in Kenya.

Control options:
- Semi-loopers are of sporadic importance and usually their control is not justified.
- In low populations, the caterpillars may be hand-picked and destroyed.
- Spraying with a *Bt*-based insecticide or neem products is required when large numbers of caterpillars are detected on plants.

Grasshoppers

(Plate 42)

Orthoptera: Acrididae

Status and distribution: Many species of grasshoppers are known, many of which are crop pests. They are found in all okra growing areas.

Description and biology: Grasshoppers are generally green or brown in colour. Their forewings are long, narrow and thickened. The hind wings, usually brightly coloured, are membranous, broad, with many veins and are folded fanwise under the forewings when the insect is at rest. The antennae are short. The rear legs are well developed, and in many species they have sharp spines (Plate 42). The eggs are laid in pods or in the soil, preferably in bare soil. Immature stages are similar to adults but have short or no wings. Grasshoppers can jump well and most of them can fly long distances.

Damage: Grasshoppers feed on foliage (eating chunks from the leaves) and stems of young shoots (Plate 42). They can be a problem at the seedling stage, but usually they do not cause serious damage to older plants. Generally, their damage is of no economic importance on okra.

Control options:

- Avoid destroying larvae of blister beetles, since they feed on eggs of grasshoppers.
- Ensure the ground is covered with crops, grass or mulch. This is reported to significantly reduce grasshopper numbers since they prefer laying eggs on bare soil.

- Chicken and wild birds help reduce grasshopper numbers by feeding on them and by digging up their eggs laid in patches of bare soil.
- Usually grasshoppers require no control measures.

Leafminers

(Plates 43–45)

Liriomyza spp. (Diptera: Agromyzidae)

Status and distribution: *Liriomyza* leafminers are serious pests of vegetables and ornamental plants worldwide. Three species have been recorded in Kenya: *L. trifolii* (Burgess), *L. huidobrensis* Blanchard and *L. sativae* (Blanchard). Leafminers have been found attacking okra in all growing areas in Kenya.

Description and biology: The adult leafminer is a tiny, blackish-yellow fly, about 2–3 mm long (Plate 43). The females make numerous small, whitish punctures on the foliage when feeding and depositing eggs. These punctures are easily seen if infestation is heavy (Plate 43). The eggs hatch into tiny, yellow maggots that feed on leaf tissues, leaving a wandering track in the form of S-shaped mines (Plates 44 and 45). Full-grown larvae come out of the mines and pupate in the soil or on the upper leaf surface (Plate 44). The egg, larval and pupal periods last 3, 5–7 and 4–5 days, respectively. The life cycle is completed in about 2 weeks. Pest incidence is high during warm or hot periods.

Damage: Feeding punctures made by adults can serve as entry points for disease-causing organisms such as bacteria and fungi. The larvae are the most destructive stage. The mines caused on leaf tissues by feeding by maggots may reduce photosynthetic activity, affecting development of flowers and pods. In severe infestation, the leaves might be completely mined (Plate 45). Subsequently, they dry and fall off prematurely, causing loss of vigour and turgidity in the plant and may eventually result in wilting.

Control options:

- Leafminers are normally controlled by naturally occurring larval parasitoids, but using insecticides on other pests disrupts the natural control of leafminers. (*For more information refer to sections on biological control and natural enemies pages 21 and 29.*)
- Leafminers can be monitored by foliage examination for the presence of mines and larvae and by trapping adult flies with yellow sticky traps. Mass trapping can effectively control the pest if its densities are low.
- Pupae in the soil can be destroyed by cultivation and solarisation.
- *Liriomyza* leafminers are difficult to control with chemicals owing to their feeding habit and their enormous capacity to develop resistance to insecticides. Neem-based pesticides and insect growth regulators are recommended for their control in IPM programmes.

Leafhoppers (Jassids)

(Plate 46)

Empoasca spp. (Homoptera: Cicadellidae)

Status and distribution: Jassids have a very wide range of host plants and are major pests of cotton. Several species of *Empoasca* occur in many African countries including Kenya. They are not pests of economic importance on okra in Kenya.

Description and biology: Adult leafhoppers are 2.5–3.5 mm in length and pale green to yellowish-green in colour (Plate 46). The two pairs of wings are held rooflike above the abdomen. They are shiny and more or less transparent. The legs are slender with bristles. The nymphs resemble the adults but are smaller and do not have fully developed wings. The females deposit the eggs in the veins of the underside of leaves or on leaf stalks. The eggs are banana-shaped, whitish to greenish and 0.7–0.9 mm long. The adults and nymphs are found on the underside of leaves. If disturbed, the adults and nymphs run sideways rapidly to reach a shady part of the host plant.

Damage: Leafhoppers feed principally on leaves, inhibiting food translocation, and may also transmit diseases and cause curling of leaves. Their feeding activity causes discoloration of the leaves to pale green and yellow. The edges of leaves curl down and turn first yellow and then red. Heavy leafhopper infestation may retard plant growth and cause yield loss.

Control options:

- Leafhoppers are a minor pest; hence their control is usually not justified.
- In India, the okra varieties Clemson Spineless and Early Long Green have been reported to be resistant to leafhoppers.

Planthoppers

(Plates 47 and 48)

Hilda patruelis (Stål) (Homoptera: Tettigometridae), the groundnut hopper

Status and distribution: The groundnut hopper is found only in Africa. It infests a wide range of plants including okra. It can be a serious pest of groundnuts but it is considered a minor pest on other crops.

Description and biology: The hopper is about 5 mm in length, brown or green in colour with white marks and stripes on the wings (Plates 47 and 48). The nymphs resemble the adults but are smaller and their wings are not fully developed. They live in colonies, which are attended by ants that eat the honeydew produced by the hoppers (Plate 48).

Damage: Sucking by the groundnut hopper is reported to cause withering of groundnut plants owing to the toxicity of its saliva. However, no direct damage has been observed on okra. Colonies on flower buds and pods may contaminate them with honeydew and sooty mould when the hoppers are not attended by ants.

Control options:

- Infestations of okra by the groundnut hopper are sporadic, and normally they are present in low numbers. Hence control measures are usually not justified.
- At low infestations the hoppers may be removed mechanically.

- Whenever possible, spray only infested plants (spot spraying).
- Measures to control other sucking pests would normally take care of hopper infestations.

Mealybugs

(Plates 49 and 50)

Homoptera: Pseudococcidae

Status and distribution: Mealybugs feed on many species of plants and are distributed countrywide. They are a minor pest of okra in Kenya.

Description and biology: Female mealybugs are soft-bodied, elongated, oval insects with well-developed legs. They are about 3–5 mm long. Their body is usually covered with a waxy secretion (Plate 49). They are wingless and do not move unless disturbed. They usually remain clustered around the terminal shoots, leaves or fruits (Plate 50). They live for several months (depending on the species). The short-lived males are up to 3 mm long. Male adults have one pair of wings and several pairs of eyes but no mouthparts. They go through two feeding immature instars and two successive pupal stages. Reproduction may be either sexual or asexual. The eggs are laid under a white, woolly wax, which remains attached to the abdomen of the females (Plate 50). Crawlers (young mealybugs) are extremely mobile and may disperse over large distances. The subsequent two to four immature instars are more or less sessile. Some species give birth to crawlers.

Damage: Mealybugs are occasionally found attacking roots (Plate 49) and aerial parts of okra plants (Plate 50). Heavy infestation may result in yellowing, withering and drying of plants and shedding of leaves and fruit. The foliage and fruit also may become covered with sticky honeydew, which serves as a medium for the growth of black sooty moulds. The sooty moulds and waxy deposits may result in a reduction of photosynthesis, and may cause contamination of pods, resulting in loss of market value. Ants are attracted by honeydew and might hamper the activities of natural enemies such as ladybird beetles and parasitic wasps.

Control options:

- Mealybugs are normally kept under control by natural enemies such as parasitic wasps, predatory ladybird beetles and lacewings, and usually do not need control measures.
- Conservation of natural enemies is important to reduce mealybug outbreaks. Protect natural enemies by limiting sprays against other pests and diseases, and avoiding use of broad-spectrum pesticides. (*For more information refer to pages 21 and 29.*)
- When their infestation is low, mealybugs may be removed mechanically.
- Spraying should be carried out only for heavy infestation.
- If spraying is necessary choose a systemic pesticide. Mineral oils alone or combined with pesticides afford good control of mealybugs.
- Spraying with a soap and water solution is reported to control mealybugs.
- Whenever possible, spray only infested plants (spot spraying).

Pod borers

African bollworm
(Plates 51–53)

Helicoverpa armigera Hübner (Lepidoptera: Noctuidae)

Status and distribution: The African bollworm attacks a wide range of crops throughout the tropical and temperate regions of the world. It is found in all okra growing areas in Kenya.

Description and biology: The adult moth is fleshy, yellowish-brown with a dark speck, greyish wavy lines and a black kidney-shaped mark on the forewings. The hind wings are whitish with a blackish patch along the outer margin (Plate 51, inset). The eggs are deposited singly on tender parts of the plant. They hatch after 3–5 days. Young larvae are generally yellowish-white to reddish-brown. They have a black head and several rows of black tubercles (each with two bristles) along their backs that give them a spotted appearance. Mature larvae are about 35–40 mm long. They vary in colour from almost black, brown or green to pale yellow with dark grey yellow stripes along the sides of the body (Plates 51 and 52). The full-grown caterpillars drop from the plant and burrow into the soil to pupate. The pupa is light brown and 14–18 mm long with two spines at the posterior tip. Larval and pupal periods last 17–35 and 17–20 days, respectively. The life cycle is completed in 25–60 days.

Damage: African bollworm caterpillars feed on leaves (Plate 51), flowers and pods, but the main damage occurs on flowers and pods. Attack on flower buds results in flower abortion. The larvae usually bore clean, circular holes in pods, causing extensive damage and thus promoting decay from secondary infection by disease (Plates 52 and 53).

Control options:

- The African bollworm has a wide variety of natural enemies, the main ones being egg parasitoids (e.g. *Trichogramma* spp.), larval parasitoids and predators such as lacewings and ladybird beetles. The conservation of these enemies is important for the control of the pest. (*For more information refer to section on biological control and natural enemies, pages 21 and 29.*)
- Early detection of eggs or caterpillars before they bore into the pods is important. Once the caterpillars have entered the pod they are difficult to control and by then they have caused damage. Early detection can be achieved by regular scouting of the crop.
- Monitoring moth populations using traps reduces crop inspection time considerably and leads to timely intervention. Several types of pheromone traps have been developed for monitoring and mass trapping of this pest on several crops. Pheromone-based sticky paper traps are recommended for their effectiveness, low price and ease of use.
- Hand picking and destruction of eggs and small caterpillars is feasible when their numbers are low.
- Destruction of weeds that may harbour caterpillars is important to prevent African bollworm infestation.

- Pesticide use may be needed in severe infestation. A number of insecticides afford good control of the African bollworm. However, selective pesticides, which preserve natural enemies, should be preferred. For example, pesticides based on *Bacillus thuringiensis (Bt)* or some plant-based extracts such as neem products can be used with minimal negative effects on natural enemies.

Spiny bollworm (spotted bollworm)
(Plates 54–56)

Earias spp. (Lepidoptera: Noctuidae)
E. vitella (Fab.),
E. insulana (Boisduval)
E. biplaga Walker
E. cupreoviridis Walker

Status and distribution: The recorded hosts of *Earias* spp. are generally confined to plants of the Malvaceae family. They are important pests of cotton and okra. *Earias vitella* is widely distributed. It is a major pest of cotton, but studies have shown okra to be its most suitable and preferred host plant. It has been reported feeding on okra in Sudan, India and the central and eastern provinces of Saudi Arabia. *Earias insulana* has an extremely wide host range. It has been reported in many African countries. *Earias vitella* is abundant in high rainfall areas, and *E. insulana* in areas of scanty rainfall. *Earias cupreoviridis* is widespread in Africa and Asia, where it is reported attacking cotton, jutes and okra. *Earias biplaga* is recorded in Africa only on cotton and cocoa.

Description and biology: The adult is a moth, about 12 mm long with a wingspan of 20–22 mm. It is covered with a soft, fairly dense coating of scales. The abdomen and hind wing are a plain silvery or creamy white colour (Plate 54). The forewings (front) of *E. vitella* are white or peach with a central, wedge-shaped, green band running from the base to the outer margins. The forewings of *E. biplaga* are metallic green, often with a large, brown spot and a distinctly dark brown marginal fringe. The forewings of *E. insulana* are silvery green to straw yellow, and the marginal fringe has the same colour as the whole wing (Plate 54).

Adult moths are nocturnal, although they could fly during the day if disturbed. The adults may lay several hundred eggs. These are laid singly on most parts of the plant. The eggs are very small (slightly under 0.5 mm in diameter), light blue-green in colour and roughly round. The larvae hatch after an incubation period of 3–10 days, depending on the weather. They feed on soft growing tissue. They have five larval instars. The entire larval period may take 8–25 days. The full-grown caterpillars are up to 18 mm long. They are stout and their body bears numerous fleshy spines (Plates 55 and 56). The larvae of *E. biplaga* are usually brown and deep orange, while those of *E. insulana* and *E. vitella* are greyish-brown or grey to green with a distinct pale or white median line. *Earias insulana* caterpillars have black marks and orange spots on the thorax while *E. vitella* caterpillars are pale yellow ventrally and have white streaks dorsally.

When ready to pupate, the full-grown larvae spin cocoons (Plate 56, inset), which may be attached to the plant, between pods, to a twig or to withered leafs. Alternatively, the larvae may pupate among the surface debris on the ground or in cracks up to 30 cm deep in the soil.

Damage: Spiny bollworms bore into terminal shoots of young plants, causing death of the tip and subsequent development of side shoots. When podding starts, the larvae move to the flower buds, small pods and eventually mature pods. Damaged flower buds and young pods are shed, causing yield reduction. Damaged pods and pods contaminated with insect frass (excrement) are not marketable. High doses of nitrogen fertilisers have been found to increase spiny bollworm infestation.

Control options:

- The measures used to prevent or control the African bollworm will also work with the spiny bollworm.
- Conservation of natural enemies (egg and larval parasitoids and predators) is important to prevent spiny bollworm outbreaks.
- Regularly scouting the crop is important for early detection of eggs or caterpillars, before they bore into the pods. This is particularly important during the critical period of flower set.
- Hand-picking and destruction of eggs and small caterpillars, and of damaged tips and pods help reduce infestation. This is feasible in small plots.
- Regulating fertilisation is important. Over-fertilisation with nitrogen should be avoided, particularly in areas where spiny bollworms are common, since it has been related to high spiny bollworm infestation.
- Destruction of old crops and crop debris after harvesting is important to prevent or to reduce spiny bollworm infestation.
- If the infestation is severe, pesticides may be needed. Selective pesticides, which preserve natural enemies (e.g. *Bt*-based pesticides or neem products), are preferred.

Spider mites

(Plates 57–61)

Tetranychus spp. (Acarina Tetranychidae)
T. urticae Koch, the two-spotted or common spider mite
T. lombardinii Baker & Pritchard, the crimson spider mite

Status and distribution: Spider mites attack a wide range of crops. They are more common in areas with hot, dry weather such as semi-arid areas. The two-spotted spider mite has a worldwide distribution, while the crimson spider mite is found in Africa south of the Sahara, Madagascar and Australia. It occurs predominantly in subtropical areas.

Description and biology: Spider mites are tiny, about 0.5 mm long. They are oval in shape (Plate 57) with an arched back and eight legs, except at the larval stage, when they have six legs. The females of the two-spotted spider mite are yellowish-green to brownish-red with two dark spots on each side of the body. Adult males are yellowish-green, sometimes with a pinkish tone, and bear small, dark spots. The females of the crimson spider mites are dark red with two dark spots on each side of the body. The males are straw coloured. Spider mites spin silk threads that anchor them and their eggs to the plant. This fine web protects them from some of their enemies and even from pesticide applications.

Spider mites are normally active within a temperature range of 16–37 °C. They are most numerous in hot, dry weather. The lifespan of a spider mite is 13–32 days and includes five stages: egg, larva, two nymphal stages and adult. A female may lay over 100 eggs during its lifetime, on leaves, stems or pods. The eggs, which can be seen only with a magnifying lens, are spherical, translucent and whitish to pinkish in colour. At temperatures of 24–26 °C, a new generation may develop every 10–13 days.

Spider mites prefer the underside of leaves (Plate 58) but in severe infestations they occur on both leaf surfaces as well as stems and pods. Spider mite populations normally decline after it has rained. Wind plays an important role in their dispersal. Other crops, wild plants or weeds can serve as a source of spider mite infestation. They can also be spread through clothing and farm implements.

Damage: The nymphs and adults suck the sap of plant tissues. Infested leaves first show a white to yellow speckling and then turn pale or a reddish bronze colour as infestation becomes heavy (Plates 59 and 60). The leaves curl up under severe attack and finally wither and are shed, leading to plant defoliation. In severe infestation, spider mites will also attack pods, causing pod contamination (Plate 61).

The main factors in spider mite outbreaks are very hot and dry conditions, destruction of natural enemies through injudicious use of broad-spectrum pesticides and the presence of other highly infested crops in the vicinity of the okra field.

Control options:

- Before any control measures are taken, regular crop inspection should be conducted to determine the presence and level of infestation of spider mites.

- A number of predators are known to feed on spider mites. (*Refer to the section on natural enemies, page 29.*) In most cases, naturally occurring predators are capable of controlling infestation of the two-spotted spider mite, provided broad-spectrum insecticides are not applied and the crop is irrigated properly.
- To minimise the risk of infestation, the field should be kept free of weeds, crop residues should be removed and burned or composted immediately after harvest and planting next to an infested field should be avoided.
- Spider mites rapidly develop resistance to pesticides, particularly when these are used for several consecutive seasons. When spraying, rotation of acaricides with different chemical active ingredients is essential to avoid or delay development of resistance. *Preventive application or application of lower than recommended dosages should be avoided since it may cause development of resistance.*
- The indiscriminate use of broad-spectrum insecticides eliminates natural enemies, and some insecticides can enhance spider mite reproduction. Their use may lead to mite outbreaks. When chemical intervention is necessary, it is important to avoid pesticides that are harmful to natural enemies. Acaricides should be applied at the recommended dosage.
- To keep spider mite populations low, avoid using broad-spectrum insecticides, especially pyrethroids, as much as possible and irrigate plants regularly.
- Spot spraying of localised infestations usually controls initial infestation. Good coverage of the plant (including the underside of the leaves) is essential for successful control of the mites.

Thrips
(Plates 62–64)

Frankliniella spp. (Thysanoptera: Thripidae)
F. occidentalis Pergande, the western flower thrips
F. schultzei (Tryborn), the cotton bud thrips
Haplothrips gowdeyi Franklin (Thysanoptera: Phlaeothripidae) the gold-tipped tubular thrips

Status and distribution: *Frankliniella* species feed on a wide variety of plants, including okra. The western flower thrips, has been reported as a pest of okra in Kenya, particularly during the flowering and fruiting stages. The cotton bud thrips has been found in okra flowers in Kenya. The thrips *Haplothrips gowdeyi* has been reported on okra in Kenya during the flowering period. However, although this thrips can be found within the flowers of many different plants, there is no evidence that it is a pest of any crop.

Two other species of thrips, *Thrips hawaensiis* (Morgan) and *Thrips palmi* Karny, have been reported elsewhere as pests of okra. These two thrips species are present in several countries in Africa, but have not yet been reported in Kenya.

Description and biology: Adult thrips are small (0.5–2.0 mm), slender and usually winged. The wings are long, narrow and fringed with long hairs and at rest are tied dorsally along the body (Plate 62). The female inserts single eggs into the plant tissue. Eggs are white or yellowish and cylindrical in shape. They hatch within a few days. The first two larval stages are small, wingless and active feeders. These are followed by two preadult instars, the prepupa and pupa, which usually have short wing pads, are inactive and do not feed. They usually pupate in the soil or under debris near host plants. Thrips have a short generation time of 2–3 weeks in warm conditions. The adult's lifespan is 2–3 weeks. Thrips migrate actively between different hosts. Adult thrips of the genus *Frankliniella* are small (0.9–1.2 mm in length) and pale brownish-yellow in colour (Plate 62).

Damage: Thrips usually feed on the lower surface of the leaves, flowers and fruits. Plant damage results from both larvae and adults puncturing the leaves and sucking the exuding sap. Attacked leaves frequently have a silvery sheen and show small dark spots of faecal material on the lower leaf surface; the upper side of older leaves turns brown. With heavy thrips infestation the leaves become curled, wrinkled and finally dry up. Any environmental stress that weakens the plants makes them more susceptible to thrips attack.

Thrips can attack okra in the seedling and early juvenile stages, delaying crop development. Flower thrips feeding on the flowers may result in deformed fruits (Plate 63). Attack on fruits may scar them (Plates 63 and 64). Affected fruits are not marketable.

Control options:

- Natural enemies, particularly predators, are important in natural control of thrips. Main natural enemies include predatory bugs, predatory mites and predatory thrips. Conservation of these natural enemies is important. *(Refer to sections on biological control and natural enemies, pages 21 and 29.)*

- Ploughing and harrowing before planting can be useful in reducing subsequent thrips attacks by killing pupae in the soil.
- Thrips are difficult to control with insecticides owing to their secretive habits. Some species of *Frankliniella* thrips are known to very rapidly develop resistance to pesticides.
- When chemical control is necessary, insecticides should only be used up to the early flowering stage. Spraying after flowering at a later stage could lead to pesticide residues on the pods.

Whiteflies

(Plates 65 and 66)

Bemisia tabaci (Gennadius) (Homoptera: Aleyrodidae), the tobacco whitefly, the sweet potato whitefly

Status and distribution: *Bemisia tabaci* occurs throughout most tropical and subtropical regions of the world, mostly in hot and dry areas. It attacks a very wide range of wild and cultivated plants. This whitefly has been reported as a pest of okra in countries such as Sudan, India and Kenya. However, whitefly numbers observed on okra in Kenya are low.

Description and biology: Whitefly adults are 1–3 mm long and have two pairs of wings, which are held rooflike over the body. Their body and wings are coated with a white to yellowish powdery wax (Plates 65 and 66). Adults of *B. tabaci* are about 1 mm long, the male slightly smaller than the female. They hold the wings over their body at a 45-degree angle to the leaf surface, which gives them a narrow (triangular) appearance (Plate 65). They are often found clustered in groups on the underside of leaves and readily fly away when the plant is shaken. They can fly only short distances but may be dispersed over large areas by wind. The females can lay over 100 elliptical eggs, about 0.2 mm long, which are attached vertically to the leaf surface by a short stalk inserted into the leaf tissue. The eggs are normally laid on the underside of young leaves in an arc or a circle, in groups of 20–40 (Plate 66). The juvenile stages are scale-like in shape and greenish-white or yellowish in colour (Plate 66). The first juvenile stage crawls on the leaf surface for some time before settling and fixes itself on the underside 1–2 days after hatching. Once feeding begins, nymphs do not move again. The life cycle in warm weather takes 3–4 weeks to complete.

Damage: Whitefly nymphs and adults suck sap from leaves. Infested plants have low vigour and may wilt, turn yellow and die if whitefly infestations are severe or of long duration. Damage may be accentuated when plants suffer water stress.

Whiteflies excrete 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 their efficacy of respiration and photosynthesis.

Bemisia tabaci is an important virus vector. It transmits leaf curl and mosaic viruses on cotton, tobacco, tomato, beans and cassava, among others.

Low populations of whiteflies do not cause heavy direct plant damage and therefore do not justify chemical intervention. However, even small numbers of whiteflies may need to be controlled if they are vectors of viral diseases.

Control options:

- Whiteflies are attacked mainly by parasitic wasps (*Eretmocerus* spp. and *Encarsia* spp.) and predators such as phytoseiid mites (*Amblyseius* spp. and *Typhlodromus* spp.), lacewings (*Chrysopa* spp.) and ladybird beetles. Conservation of these and other natural enemies is important.

- Yellow sticky traps can be used to monitor the presence of whitefly adults for timing of interventions. Yellow traps have also proved useful as a control method for low infestations.
- Weeds are important in harbouring whiteflies and often also harbour whitefly-transmitted viruses. Therefore they should be removed.
- Whiteflies rapidly develop resistance to many insecticides, and resurgence of their populations is common. When chemical treatment is needed, it is essential to carefully choose insecticides and methods of application that are not damaging to biological control agents. *(Refer to section on biological control, page 21.)* Rotation of pesticides is essential to minimise or delay the development of resistance.
- Most insecticides used are effective only against the adults, so repeated treatment every 3–5 days is necessary for several weeks before control can be achieved.
- Mineral oils alone or combined with some insecticides are reported to effectively control whiteflies.
- Spraying with soap and water solutions reportedly controls whiteflies. The amount of soap needed depends on the soap type. Using strong soaps or high concentrations of soft soaps can scorch leaves. Whenever possible use soft soaps made from potash. The concentration should not exceed 1 part of soap to 20 parts of water. It is best to initially experiment on small plots to find the right concentration.
- Neem-based insecticides are reported to control young nymphs, inhibit growth and development of older nymphs and reduce egg laying by adult whiteflies.

Diseases

Damping-off
(Plate 67)

Cause: *Pythium* spp., *Rhizoctonia solani* (Kühn)

Type of organism: Fungus

Distribution: All okra growing areas in Kenya

Symptoms: Damping-off diseases are of two types: *pre-emergence damping-off*, which causes rotting of seeds before germination and emergence or death of seedlings before they reach the soil surface, and *post-emergence damping-off*, which occurs after seedlings have emerged from the soil but are still small and tender. Pre-emergence damping-off is aggravated by excessive wetness of the soil, low soil temperatures, inferior quality seeds and failure to treat seeds with appropriate fungicides. It is the common cause of poor stands in seedbeds and fields.

In post-emergence damping-off, the roots may be killed, and affected seedlings show water soaking and shrivelling of the stem at the soil level, eventually falling over and dying. Some seedlings do not die at once but their roots are damaged and the stem girdled at the soil level. Such plants remain stunted (Plate 67).

Damping-off usually occurs in small patches in seedbeds or fields where direct planting has been done. Seedlings are extremely susceptible for about 2 weeks after emergence, but as the stem hardens and increases in size, it becomes resistant to infection.

Several species of the soil fungus *Pythium* cause mostly pre-emergence damping-off, while *Rhizoctonia solani* is more likely to be associated with post-emergence damping-off. In addition, there are many other seed- or soil-borne organisms (pathogens) that can cause damping-off, including *Colletotrichum* spp., *Fusarium* spp. and *Thielaviopsis* spp.

Disease management:

- Avoid fields with a history of the disease, and practise crop rotation.
- Avoid fields previously planted with cotton or other related crops.
- Deeply plough fields.
- Use certified, disease-free seed.
- Treat seed with suitable fungicides and insecticides. Use products that are locally registered and permitted by EU regulations for use on okra.
- Avoid over-irrigation and excessive fertilisation with nitrogen.

Bacterial blight

(Plates 68–71)

Cause: *Xanthomonas campestris* p.v. *malvacearum* (Smith) Dye

Type of organism: Bacterium

Distribution: Only in Kibwezi, Matuu and Mwea (Kenya)

Symptoms: Leaf spots are initially soaked with water and are more obvious on the underside of leaves. They are restricted to the veins and are angular in shape (Plates 68 and 69). Spots on petioles are elongated, sometimes slightly sunken and blackish (Plate 70). Spots on pods are initially soaked with water and round. Later, they join together and turn oily black (Plate 71). All spots appear waxy and shiny.

Source of infection and spread: The bacterium is transmitted through seed and by splashing water.

Disease management:

- Use certified, disease-free seed.
- Avoid dense planting.
- Avoid overhead irrigation.
- Avoid working the field while it is wet.
- Remove crop debris after harvest.
- Spray the crop with a copper-based fungicide at the first appearance of symptoms.
- Follow instructions given on the product's label for dosage, frequency of application, pre-harvest intervals and safety precautions.

Black mould

(Plates 72 and 73)

Cause: *Cercospora abelmoschi* Ellis and Everhart

Type of organism: Fungus

Distribution: Humid coastal areas of Kenya

Symptoms: This fungus causes leaf spots of various shapes. It grows as a sooty to dark olivaceous mould on the underside of leaves (Plate 72), but in severe infection and under very humid conditions it also appears on the top surface (Plate 73). Seriously injured foliage rolls, wilts and falls to the ground.

Source of infection and spread: The fungus survives from season to season in diseased crop debris. It is spread by air currents and splashing water.

Disease management:

- Avoid overlapping okra crops in the same field.
- Rotate okra with baby corn, maize, small grains or pulses.
- Remove crop debris after harvest.
- Deeply plough the field during land preparation.
- Avoid overhead irrigation.
- Spray with registered fungicides if black mould is severe. However, this should be determined by scouting the crop. Check with HCDA, FPEAK or PCPB, if unsure.
- Follow the instructions on the product label for dosage, frequency of application, pre-harvest intervals and safety precautions.

Collar rot

(Plates 74 and 75)

Cause: *Rhizoctonia solani* (Kühn)

Type of organism: Fungus

Distribution: Semi-arid areas of Kenya

Symptoms: Though this fungus is a seedling pathogen, it also causes wilting of okra plants. The lower leaves of affected plants droop and eventually die (Plate 74), and the stems of affected plants are girdled (sunken and constricted) at the soil level (Plate 75), a condition that is also known as 'sore-shin'.

Source of infection and spread: This fungus is common in most soils and becomes a parasite when susceptible crops are grown. It persists indefinitely in the soil and survives unfavourable conditions as tiny brown sclerotia (special type of spores) that are extremely resistant to cold, heat, drought and most chemicals. It spreads from one place to another through soil infestation. The disease is favoured by high temperatures, high soil moisture and low soil pH (acidic soils).

Disease management:

- Plough deeply during land preparation.
- Incorporate organic matter into the soil (farmyard or green manure). Do not use chicken manure, which is very acidic.
- Apply lime if the soil is acidic.
- Avoid excessive watering.
- Avoid damaging roots when weeding.
- Rotate okra with baby corn, maize, small grains or fodder grasses.

Fusarium wilt
(Plates 76 and 77)

Cause: *Fusarium oxysporium* f. sp. *vasinfectum* (Atk.) Synder & Hansen

Type of organism: Fungus

Distribution: Semi-arid areas of Kenya

Symptoms: The affected plants are stunted. The leaves turn yellow, wilt and are later shed. Usually the lower leaves are the first affected (Plate 76). When a stem or the main root is cut crosswise, brown discoloration is usually found in the ring just beneath the bark (Plate 77). Wilting of plants is mostly gradual.

Source of infection and spread: The fungus is both seed- and soil-borne. It may be inadvertently introduced into the fields through infected seeds, farm equipment and shoes of farm workers. It can survive in plant residues and weed hosts such as *Amaranthus, Digitaria* and *Malva* and can re-infect new crops of okra. The fungus can also survive in the soil for many years even when okra is not grown, by producing special spores. Water stress worsens the disease, the reason the disease causes a lot of damage in areas with light sandy soils and high temperatures. The fungus is most active at temperatures between 25 and 32 °C. Acidic soils (pH 5.0–5.6) and nitrogenous fertilisers, particularly ammonium nitrate and urea, are favourable for the disease, and infestation by root-knot nematodes enhances disease development.

Disease management:

- Avoid fields with a long history of *Fusarium* wilt.
- Deeply plough the fields and leave them fallow for 2–3 months, where feasible.
- Use certified, disease-free seed.
- Treat seeds with a biopesticide preparation of *Trichoderma viride*, which is commercially available in Kenya. Follow label instructions when using this product.
- Raise soil pH by applying lime or farmyard manure where soil is acidic. Do not use chicken manure, which is very acidic.
- Avoid excessive nitrogen fertilisation and excessive cultivation.
- Control root-knot nematodes.
- Keep fields weed-free.
- Regularly irrigate the crop.
- *Spraying with fungicides will not control this disease.*

Leaf spots

(Plates 78–81)

Cause: *Alternaria hibiscinum* (Thuemen)
Cercospora gossypina (Southw.)
Cercospora malayensis (Stevens & Solheim)
Phyllosticta hibiscini (Ellies & Everhart)

Type of organism: Fungus

Distribution: All okra growing areas of Kenya

Symptoms: *Alternaria hibiscinum* produces brown, subcircular spots of various sizes, sometimes with concentric rings (Plate 78).

Cercospora gossypina causes irregular brown spots often surrounded by chlorotic tissue (Plate 79).

Cercospora malayensis creates leaf spots with grey centres and red to purple borders (Plate 80).

Phyllosticta hibiscini creates round spots with light grey centres and sometimes black dots on both leaf surfaces (Plate 81).

Source of infection and spread: Disease-causing fungi of leaf spots survive from season to season in crop debris. They are spread by air currents and splashing water. Rains and overhead irrigation are conducive to the development of leaf spot diseases.

Disease management:

- Avoid overlapping okra crops in the same field.

- Remove crop debris after harvest.
- Plough deeply during land preparation.
- Avoid overhead irrigation.
- Rotate okra with baby corn, maize, small grains or pulses.
- Follow a balanced fertilisation programme.
- Leaf spots are of minor importance and do not warrant fungicide spraying.

Powdery mildew

(Plates 82–84)

Cause: *Leveillula taurica* (Lev) Arnaud (*Oidiopsis taurica* Tepper)

Type of organism: Fungus

Distribution: Semi-arid and highland areas (during dry seasons) of Kenya

Symptoms: This disease is characterised by a white coating resembling a fine talcum powder on lower and upper leaf surfaces (Plate 82). This coating is a fungal growth. Severe infection will cause the leaves to roll upward and result in leaf scorching. The disease also attacks stems, flower buds and pods (Plates 83 and 84).

Source of infection and spread: The fungus survives in crop debris and reproduces under dry conditions. Its spores are blown from field to field by wind. Infection occurs when humidity is in the range of 52–75% and air temperatures are around 26–27 °C.

Disease management:

- Remove and destroy crop debris after harvest.
- Keep okra fields free of weeds.
- Do not grow okra or related crops like cotton in succession. This fungus has many strains (types) but the type that attacks okra does not infect brinjals (eggplants) or tomatoes.
- Irrigate regularly to avoid drought stress on ageing plants.
- Spray fungicides when mildew is severe. This is likely to happen when prevailing weather

conditions are hot and dry. The decision to spray should be based on crop scouting. Ensure the fungicides are locally registered and permitted by EU regulations for use on okra. Seek advice from exporters, FPEAK or HCDA if unsure.

- Read the product label carefully and follow the instructions.
- Observe the pre-harvest interval recommended on the label.

Root-knot nematodes

(Plate 85)

Cause: *Meloidogyne* spp.

Type of organism: Nematode (eelworm)

Distribution: All okra growing areas of Kenya

Symptoms: Affected plants are stunted and yellow and have a tendency to wilt or even die in hot weather. Affected plants appear in patches. The roots of affected plants have small lumps known as galls or root knots (Plate 85).

Source of infestation and spread: Root-knot nematodes are soil inhabitants. They attack a wide range of crops, particularly vegetables. They are spread in soil washed down slopes or in soil sticking to farm implements and farm workers. They may spread through irrigation water. Root-knot nematode infestation is most serious in light sandy soils and in furrow-irrigated crops. They can survive in soil without a suitable host plant for about two years.

Disease management:

- Rotate okra with onions, baby corn, sweet corn, maize, millet, sorghum, sesame, cassava or Sudan grass.
- Maintain high levels of organic matter (manure and compost) in the soil.
- Use mixed cropping with marigold (*Tagetes* spp.) or Indian mustard.
- Uproot entire plants and destroy crop debris after harvest.
- Incorporate neem cake powder into the soil if it is available.

Annex 1

Guidelines on best use of pesticides

Pesticides

Pesticides are among the most frequently used pest control tools. They have been the foundation of pest control for many years. However, solely relying on pesticides and their indiscriminate use have caused problems such as environmental contamination, toxic residues, side effects on non-target organisms, increased pest resistance to pesticides, secondary pest outbreaks and pest resurgence. Nowadays, chemical pesticides are regarded as important tools in pest management programmes only when used in combination with other control options. Only when no alternative is available should a pesticide be used. As with other control options, pesticide application should be based on pest monitoring or scouting. Preventive applications often are not advantageous in the long term and might lead to the development of resistance.

The proper use of pesticides requires the following:

- Proper identification of the target pest and knowledge of its biology, feeding habits and population dynamics. This allows selection of the most appropriate pesticide and proper timing of application.
- Information on the damage caused by the pest and on the value of the crop.
- Compatibility with other control options. For

instance, the effect of the pesticide on non-target organisms, particularly natural enemies.
- Use of recommended dosage and adherence to recommended application frequency and pre-harvest intervals.
- Use of appropriate application techniques.
- Observation of safety precautions for humans, livestock and the environment.

Pesticides can be classified according to the type of pest they control as follows:
- Insecticides: chemicals that kill insects.
- Acaricides (miticides): chemicals that kill mites.
- Fungicides: chemicals that kill or inhibit the growth of fungi.
- Bactericides: chemicals that kill or inhibit the growth of bacteria.
- Nematicides: chemicals that kill or inhibit the growth of nematodes.
- Herbicides: chemicals that kill weeds.

Chemical pesticides have been classified according to their toxicity by the World Health Organisation (WHO) as follows:
- Class Ia: extremely hazardous
- Class Ib: highly hazardous
- Class II: moderately hazardous
- Class III: slightly hazardous
- 'Table 5': product is unlikely to present acute hazard in normal use

Pesticides in Class Ia, Class Ib and Class II should not be used on vegetables because of their high toxicity.

Keys to responsible use of pesticides

- Use pesticides only when necessary. Get appropriate advice, if unsure.
- Choose pesticides according to the target pest (use insecticides to control insects, fungicides for fungal diseases, acaricides for mite control, etc.)
- Avoid pesticides in the WHO toxicity classes Ia, Ib and II. Select environmentally compatible pesticides (those that are not harmful to natural enemies, bees, birds, aquatic life or wildlife). Seek advice, if unsure.
- Use products that are officially registered for use for particular crops by the local regulatory agency or the EU. Products banned in the EU must not be used. Seek advice, if unsure.
- Buy pesticides from authorised dealers.
- Read the product label carefully.
- Never exceed the rates, timing or number of applications recommended by the manufacturers.
- Ensure the spraying equipment is clean, accurately calibrated and in good working order.
- Wear protective clothing when handling and applying pesticides.
- Do not apply pesticides when honeybees are visiting the plants or when there is high activity of beneficial insects. The best spraying time is very early in the morning or late in the afternoon.
- Avoid drift during application.
- Do not eat, drink or smoke while spraying or handling pesticides. Ensure hands are washed after application.
- Observe entry requirements for the fields after pesticide application. Read product label for this information.

- Strictly observe the pre-harvest intervals defined on the product label.
- Do not feed treated foliage to livestock.
- Do not clean spraying equipment or dump excess spraying material into or near water sources.
- Never use empty pesticide containers for carrying or storing milk, water, food or feed or for any other purposes. Always perforate and crash empty containers and bury them deep and far from water sources.
- Store pesticides in a secure, fire-resistant, well-ventilated, well-lit location and away from other materials. Shelving for pesticide stores should be made of non-absorbent materials, in case of spillage. The stores should be able to retain spillage, ensuring it does not leak or contaminate their exterior. In addition, the stores must have a facility with running clean water for washing eyes, a first-aid kit and a poster detailing accident procedures.
- Store pesticides in their original, tightly closed containers under lock and key. Ensure pesticides are kept in a cool and dry place, out of the reach of children and animals and away from food and feed.
- Store pesticide products in powder or granular form on shelves above those containing liquid pesticides, in case of accidental leakage.
- Place clear hazard warning signs on access doors of pesticide storage facilities.
- Train workers who handle and apply pesticides on their safe use and handling.

Note: No pesticides have been recommended in this handbook. For information on pesticides refer to page 95.

Useful links for information on pesticides

EU (MRLs sorted by pesticide)
http://www.europa.eu.int/comm/food/fs/ph_ps/pest/o9-99-2.pdf
EU (MRLs sorted by crop)
http://www.europa.eu.int/comm/food/fs/ph_ps/pest/09-99.pdf
Europe-Africa-Caribbean Pacific Liaison Committee for the Promotion of Horticultural Exports (COLEACP)
http://www.coleacp.org
http://www.coleacp.org/pip
Fresh Produce Exporters Association of Kenya (FPEAK)
http://www.fpeak.org
Kenya Plant Health Inspectorate Service (KEPHIS)
http://www.kephis.org
Email: kephis @ nbnet.co.ke.
Pest Control Products Board (Kenya)
Email: pcpboard@todays.co.ke
Pesticides Safety Directorate in UK
http://www.pesticides.gov.uk
Société Génerale de Surveillance
Email: sgsinquires_kenya@sgs.com

Glossary

Abdomen: The rear part of the body of an insect or mite.

Arthropod: Animal, usually very small, with a hard skin, segmented body and jointed legs (for example insects and mites).

Asexual reproduction: Reproduction without males.

Bacterium (plural bacteria): Extremely small, single-celled microorganisms, some of which are useful while others cause diseases such as bacterial blight.

Beneficial insects: Insects that are helpful to farmers by killing pests or pollinating plants.

Biopesticide: A pesticide whose active ingredient is a living organism (for example a bacterium, fungus or a virus that kills pests).

Broad-spectrum pesticides: Pesticides that kill many different types of pests.

Cucurbits: Vegetables and fruits in the family of cucumbers, sweet melon, watermelon, pumpkin and squash.

Cauda (plural, caudae): Tail or tail-like growth or attachment.

Chlorotic: Blanched or yellowed.

Cocoon: A covering with silk-like threads made by an insect larva to pupate.

Concentric: Circles with a common centre.

Cornicles: A horn or horn-like growth on the rear part of the abdomen of aphids.

Cotyledons: The first or primary leaf (leaves) of a growing plant embryo; also called seed-leaf.

Crucifers: Plants in the Cruciferae family (another name of the Brassicaceae family) such as cabbage, cauliflower and kale, etc.

Forewings: Front wings of insects.

Frass: Droppings or wastes left by feeding insects.

Fungus (plural, fungi): Organisms similar to plants but have no chlorophyll for trapping sunlight. Many are useful in nature but some cause diseases such as damping-off and powdery mildew.

Host: Plant or organism on which a pest, disease or natural enemy feeds.

Instar: Insect form between successive moults, the first instar being the stage between hatching and the first moult.

Larva (plural, larvae): Immature stage of an insect.

Malvaceae: The plant family containing cotton and okra.

Microorganism: Tiny organism (plant or animal) that cannot be seen without a microscope (e.g. bacteria, fungi or viruses).

Moulting: Process through which insects change from one form or stage to another (for example from the first to the second instar).

Mulch: Any material laid on the soil surface to decrease erosion, conserve water or reduce weed growth.

Nocturnal: Active at night.

Pathogen: An infectious microorganism that can cause disease, such as the fungus that causes powdery mildew.

Pheromones: Chemicals produced by insects that attract individuals of the same species.

Pupa (plural pupae): The stage of development between larva and adult in the life cycle of some insects (for example moths, flies). Pupae usually have a hard skin and do not move or feed.

Pupate: To develop into a pupa.

Ratoon crop: A crop derived from cut plants of the main crop after it has been harvested.

Seed-borne: A disease carried in or on the seed, for example bacterial blight.

Sessile: Permanently attached, not free-moving.

Sclerotium (plural, sclerotia): Hard lump of tissue, usually round in shape, formed by fungi on parts of an infected plant.

Soil-borne: Diseases that can survive and infect crops from soil in the field, for example *Fusarium* wilt.

Solanaceae: The plant family containing tomatoes and other crops such as eggplants, potatoes and peppers.

Symptom: A visible sign of damage by pest or disease.

Thorax: The middle section of the three main sections of an insect (between the head and the abdomen) to which the legs and wings are attached.

Tubercles: Raised growths bearing hairs in insect bodies.

Virus (plural, viruses): Some of the smallest of the living organisms. They cause diseases that discolour and deform the plant and may reduce vigour and yield.

Bibliography

Aguiar J. L. and Mayberry K. S. (Undated) *Okra Production in California*. University of California Division of Agriculture and Natural Resources Publication 7210. Available at http://anrcatalog.ucdavis.edu/pdf/7210.pdf.

Bohlen E. (1973) *Crop Pests in Tanzania and their Control*. Federal Agency for Economic Cooperation, Verlag Paul Parey, Berlin and Hamburg. 142 pp. (ISBN: 3-489-64826-9).

Brunt A. A., Crabtree K., Dallwitz M. J., Gibbs A. J., Watson L. and Zurcher E. J. (eds) Plant Viruses Online: Descriptions and lists from the VIDE Database, Version: 20th August 1996 (1996 onwards). http://biology.anu.edu.au/Groups/MES/vide/.

CAB International (2000) *Crop Protection Compendium*. Global Module, 2nd edition. Wallingford, Oxon, UK. Compact Disk. (ISSN: 1365-9065, ISBN: 0 85199 482 2).

Centre for Integrated Pest Management, North Carolina State University. Insect and related pests of vegetable pests of okra. http://ipm.ncsu.edu/AG295/html/index.html.

Critchley B. R. (1995) *Manual for the Integrated Pest Management of Diseases, Insects, Nematodes and Weeds of Garden Egg, Okra, Onion, Peppers and Tomato in Brong Ahafo, Ghana*. NRI. 65 pp.

Dobson H., Cooper J., Manyangariwa W., Karuma J. and Chiimba W. (2002) *Integrated Vegetable Pest Management—Safe and Sustainable Protection of Small-scale Brassicas and Tomatoes*. Natural Resources Institute, University of Greenwich. 179 pp. (ISBN: 0-85954-536-9).

Elwell H. and Mass A. (1995) *Natural Pest and Disease Control*. Natural Farming Network. Zimbabwe, Mambo Press, Gweru. 128 pp. (ISBN: 0-7974-1429-0).

HCDA (Horticultural Crops Development Authority, Kenya) (1996) Okra. *Export Crop Bulletin*: No. 9, June. http://www.hcda.or.ke

IDEA [Investment in Developing Export Agriculture] (2001) Okra. ADC Commercialisation Bulletin No. 7. Kampala, Uganda. 9 pp.

Kemble J. M., Sikora E. J., Zehnder G. W. and Patterson M. G. (1995) *Guide to Commercial Okra Production*. Alabama Cooperative Extension System. ANR-959. http://www.aces.edu/dept/extcomm/publications/anr/ANR-959/anr959main.html.

Medlicott A. (Undated) Postharvest handling of okra. (Fintrac). http://www.fintrac.com/gain/guides/ph/okra.html.

Mohammed E. S. I., Bashir N. H. H. and Abdelbagi A. O. (2003) Towards an integrated pest management on okra, *Abelmoschus esculentus* (L.) (Malvaceae), p. 67. In *Integrated Pest and Vector Management (IPVM) in the Tropics: Perspectives and Future Strategies: Abstracts.* Proceedings of the 15th Biennial Congress of the African Association of Insect Scientists (AAIS), 9–13 June 2003, Nairobi, Kenya (Edited by J. Bahana, A. B. Bal, D. Dakouo and C. O. Omwega). ICIPE Science Press, Nairobi.

Muchemi K. S. (2000) Studies on abundance, impact and natural enemies of insect pests of okra and chillies and efficacy of neem products in their control. MSc thesis, Kenyatta University, Kenya.

Myers C. (1998) Okra. http://www.sfc.ucdavis.edu/cgi-bin/spec_crop.exe/show_crop&ID=20. Small Farm Center, University of California.

Peet M. (2001) Sustainable practices for vegetable production in the South: Okra. http://www.cals.ncsu.edu/sustainable/peet/profiles/c13okra.html. NCSU.

Puri S. N., Sharma O. P., Murthy K. S. and Sheo Raj (1998) *Handbook on Diagnosis and Integrated Management of Cotton Pests.* National Centre for Integrated Pest Management (NCIPM), Pusa Campus, New Delhi-110 012, India.

Rice R. P., Rice L. W. and Tindal H. D. (1987) *Fruit and Vegetable Production in the Tropics.*

Macmillan Press Ltd, London and Basingstoke. 486 pp. (ISBN: 0-333-46850-3).

Sherf A. F. and Macnab A. A. (1986) *Vegetable Diseases and their Control.* (2nd ed.), Wiley-Interscience, New York. 728 pp. (ISBN: 0-471-05860-2).

Simone G. W. (1999) Disease control in okra (*Hibiscus esculentus*). http://edis.ifas.ufl.edu. Department of Plant Pathology, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida.

State of Queensland, Department of Primary Industries, Queensland Horticulture Institute, (2002) Growing okra. http://www.dpi.qld.gov.au/horticulture/5197.html.

Tindall H. D. (1983) *Vegetables in the Tropics.* Macmillan, London and Basingstoke. 533 pp. (ISBN: 0-333-24268-8).

Verkerk R. (2001) *Farmers' Friends'—Recognition and Conservation of Natural Enemies of Vegetable Pests in Zimbabwe.* Department of Biology, Imperial College of Sciences, Technology and Medicine, University of London. 112 pp. ISBN: 0-9540132-0-4. Also available at http://www.cpp.uk.com/downloads/FarmersFriendsEnglish.pdf.

Wanja E. W., Hallet R. H., Sears M. K. and Sithanantham S. (2001) Insect pest constraints of okra, *Abelmoschus esculentus* (L) Moench (Malvaceae) in Kenya. The ESA Annual Meeting. An Entomological Odyssey of ESA. San Diego, Ca. Available at: http://esa.confex-com/esa/2001/techprogram/paper_2414.htm.

Acronyms

COLEACP: Europe-Africa-Caribbean Pacific Liaison Committee for the Promotion of Horticultural Exports
EUREPGAP: European Retailers Programme on Good Agricultural Practice
FPEAK: Fresh Produce Exporters Association of Kenya
HCDA: Horticultural Crops Development Authority (Kenya)
KBS: Kenya Bureau of Standards
KEPHIS: Kenya Plant Health Inspectorate Service
PCPB: Pest Control Products Board (Kenya)
SGS: Société Génerale de Surveillance

Guide to implementation of IPM in okra production

Before you get started

Check the following:

- ***Soil fertility:*** Take soil samples for analysis of macro- and micronutrients and soil salinity. This should be done every 6 months. (Institutions that can do this analysis include KEPHIS and SGS.)
- ***Availability and quality of water for irrigation:*** Check sustainability of the water source; take water samples for analysis of N, P, K, pH, microbial and heavy metal contaminants and pesticide residues (KEPHIS, SGS and KBS can do this analysis).
- ***Disease history of the farm:*** Do not grow okra if the farm has a history of serious soil-borne problems such as collar rot, *Fusarium* wilt or root-knot nematodes. (Check the relevant sections of this manual for identification guidelines.)
- ***Suitable varieties:*** Grow varieties that are resistant and or tolerant to existing or expected problems, suitable to the agroecological zone, and preferred by consumers and the market. (This information is available from HCDA, FPEAK and seed dealers.)
- ***Market:*** Check market trends for the produce (HCDA, FPEAK and COLEACP have this information).

Standard recommendations for all production areas

Do's & don'ts

Planting and field operations

- Soak okra seed in water overnight to hasten germination.
- If using your own seed, treat it with an insecticide and a fungicide before sowing. Use locally registered products which are accepted by EU regulations and follow label instructions. Seed treatment is intended for managing damping-off diseases, pests in the soil and early-season foliar pests.
- Do not plant okra in fields previously under cotton, karella, pawpaw, squash, sweet potatoes or solanaceous crops (brinjals, peppers, potatoes, tobacco and tomatoes). These also are susceptible to root-knot nematodes. Since cotton belongs to the same family as okra, it shares its complex of pests and diseases.

- Avoid planting okra in a field next to or near an old crop of okra, to minimise spread of pests and diseases from crop to crop.
- Keep okra fields weed-free. Weeds compete for nutrients and soil moisture, and can also harbour pests and diseases.
- Avoid over-fertilising plants with nitrogen until fruiting, otherwise there will be an overgrowth of foliage at the expense of pod production.
- Regularly scout (monitor) plants for pests and diseases and other field problems (such as water stress, nutrient deficiency or weeds) and keep records of these throughout the crop cycle. Scouting data will guide timely intervention and indicate effectiveness of previous interventions. Records serve as a reference tool, especially in planning future field activities.
- Ensure proper identification of pests and diseases. Wrong identification could lead to wrong interventions and resource wastage. When in doubt, consult extension officers or the nearest research institution before taking action.
- Where pesticides are justified and are an absolute necessity, use only locally registered products that are approved by EU regulations. Observe label instructions for dosage, frequency of application, pre-harvest intervals and safety precautions during application.
- Remove crop debris from fields after the final harvest of each crop. If the debris is ploughed under, make sure it is decomposed before replanting, because it could be a source of disease.

Fruiting, harvest and post-harvest periods

- Avoid damaging pods when harvesting (where possible harvesters should wear soft cotton gloves to prevent pod damage).
- Place harvested crop in a cool, shaded area. Okra has a high respiration rate and therefore its pods easily bleach or discolour without ventilation or in excess heat.
- Okra should be sent to the market as soon as possible after harvesting. However, it can store for 1–2 weeks at 10 °C under high relative humidity of 95–100%. To avoid discoloration, okra should not be stored with apples, bananas, melons or other produce that gives off ethylene gas.
- Mature pods left on the plant will reduce flowering and fruit set.
- After harvest, the crop can be ratooned by cutting back the plants to about 15–20 cm high and re-fertilising.

Where do you grow okra?

Okra can be grown from sea level to 1600 m. The optimum temperature range for growth and pod quality is 25–30 °C. The ideal soil type is a well-drained sandy loam high in organic matter, although okra can grow on a wide range of soils. The optimum soil pH for growth is between 5.8 and 6.5. Okra is relatively sensitive to saline conditions. It is a heavily foliaged crop so its water requirement is high. Specific recommendations cannot be made on the amount and regularity of water application, since these depend on locality, time of the year, soil type and system of irrigation. As a general guideline, regardless of the irrigation method, for semi-arid areas—where okra is mostly grown in Kenya—35 mm of water (this equals 35 litres of water per square metre) should be provided to the crop per week.

In Kenya, okra is grown by smallholder farmers in Kerio Valley, Kibwezi, Kilifi, Lower Nyanza, Matuu, Mbeere, Mitunguu, Mtito Andei, Mwea, Nguruman, Perkerra and Taveta. It is grown year round under furrow or basin irrigation, mainly for export. The most popular variety is Pusa Sawani, which takes 45–50 days from sowing to harvesting.

Pests and diseases

What are the major pests and diseases of okra and when do they do the most damage?

Pests and diseases	*Critical crop growth stage(s)*
Root-knot nematodes (p. 90)	Seedling to pod formation
Aphids (p. 38)	Seedling to pod formation
Powdery mildew (p. 88)	Seedling to pod formation
Flea beetles (p. 41)	Seedling
Pod borers (African bollworm, spiny bollworm) (pp. 64–69)	Pod formation

What other diseases and pests attack okra?

Diseases

Damping-off (p. 79)
Fusarium wilt (p. 84)
Leaf spots (p. 86)

Collar rot (p. 83)
Bacterial blight (p. 81)

Pests

Cutworms (p. 35)
Leafminers (p. 56)
Leaf-eating caterpillars (leaf rollers, semi-loopers (pp. 51–53)
Whiteflies (p. 76)
Thrips (p. 73), Mites (p. 70)
Flower beetles (p. 44)
Bugs (cotton stainers, stink bugs, seed bugs) (pp. 46–50)
Leaf hoppers (p. 58), Planthoppers (p. 60)
Grasshoppers (p. 54), Mealybugs (p. 62)

Always remember that proper identification of pests and diseases is the first and most important step in managing pests and diseases. Wrong diagnosis leads to mismanagement and increased losses and costs. If in doubt after consulting this manual, check with a qualified crop protection specialist.

Pest and disease management measures

- Do not plant okra next to or near an old okra crop, since pests and diseases could spread from the old to the new crop.
- Uproot old okra fields and weeds and remove crop debris, since these are a source of pests and diseases.
- Plant new okra fields upwind to minimise the spread of pests carried by wind such as spider mites, thrips and whiteflies, and wind-borne diseases such as powdery mildew and leaf spots.
- Make sure that plant residues from previous crops are decomposed before planting, as residues increase the incidence of damping-off.
- Practice crop rotation. Do not include solanaceous crops, karella, pawpaw, squash, sweet potatoes or cotton in the rotation sequence because they all are susceptible to nematodes. Instead, preferably grow onions, fodder grass, baby corn or small grains after okra. If okra must be grown in an area where damage from nematodes is likely, neem products (such as neem seed cake powder) should be incorporated into the planting holes. Another alternative to nematicides or lengthy crop rotations

- Foliar feeders (such as flea beetles, beetles and various caterpillars) cause economic damage only when in large numbers or when plants are young or stressed. Therefore, young plants require frequent scouting for insects and foliar damage. Foliage feeding on well-established plants does not normally affect yield, since healthy plants can tolerate considerable loss of foliage before yield loss occurs. Tolerance to foliar damage increases with plant age and favourable growing conditions (that is, proper fertility and adequate soil moisture).
- Pod-feeding insects are a greater problem than foliar feeders because damage to pods or blossoms directly affects the edible part of the plant. Their control may be necessary if moderate damage is observed. Primary pod-feeding pests include pod borers and bugs such as stink bugs and cotton stainers.
- In dry seasons, powdery mildew can be a major problem on young crops. This disease may be controlled by an array of products, but use only locally registered products that are approved by the EU. An alternative is a mixture of baking powder (sodium bicarbonate or potassium bicarbonate) and oil-based neem formulations, or a white mineral oil and soap solution.
- Leaf spot diseases rarely cause significant damage on okra and therefore control measures are not suggested.

Always review what went wrong and what went right

- **Did the control measures work?**
- **Take a close look at the crop and compare pest and disease activity before and after treatment. What needs to be improved?**
- **Keep records of what you do and what you observe.**

Very few pesticides are registered for use on okra because it is a minor crop and few agrochemical companies can afford the required high registration costs for a product for such a minor crop. In addition, applying insecticides during harvesting may cause residue problems if pre-harvest intervals of the product used are long. Therefore, proper scouting and cultural controls are most important. Contact relevant institutions (PCPB , FPEAK or exporters) for up-to-date recommendations on the pesticides registered for use on okra. An approved list of products for use on okra is available at the COLEACP website (www.coleacp.org).

Natural enemies of okra pests

Plate 1: Ladybird beetles, *Cheilomenes lunata* (left) and *Cheilomenes propinqua* (right) commonly found on okra

Plate 2: Eggs (main picture) and larva (inset) of a ladybird beetle

Plate 3: Pupa of a ladybird beetle on an okra leaf

Plate 4: Green lacewing (left) and brown lacewing (right)

Plate 5: Egg (left), larva (centre) and pupa (right) of lacewing

Plate 6: Adult (left) and larva (right) of a hoverfly

Plate 7: Pupae of hoverflies

Plate 8: Larva (upper inset), pupa (main picture) and adult (lower inset) of a predatory fly commonly found feeding on the cotton aphid on okra

Plate 9: Close-ups of nymph (left) and adult (right) of an anthocorid bug

Plate 10: Adult of an assasin bug

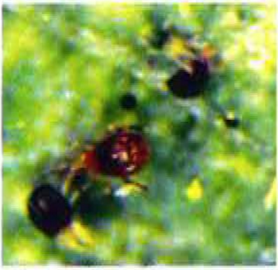


Plate 11: Close-up of predatory mite (bright red) feeding on spider mites (dark red)

Plate 12: A young praying mantis

Plate 13: Spiders common in okra fields: A crab spider (top), a common garden spider (middle) and a linx spider (bottom)

Plate 14: Parasitised leaf roller larva showing exit holes of the parasitoids and their white cocoons

Plate 15: Parasitised coccon aphids known as mummies (brown in colour)

Plate 16: A colony of aphids affected by an unidentified fungal disease (left) and a healthy aphid colony (right)

Arthropod pests

Plate 17: Okra seedling damaged by a chafer grub

Plate 18: Moth of cutworm

Plate 19: Okra seedling damaged by cutworm larva (right). Note healthy seedling on the left. Close-up of cutworm (inset)

Plate 20: The cotton aphid *Aphis gossypii* on okra. Note the different colours of the aphids. Close-up of winged aphids (inset)

Plate 21: Curling of leaves caused by aphid feeding

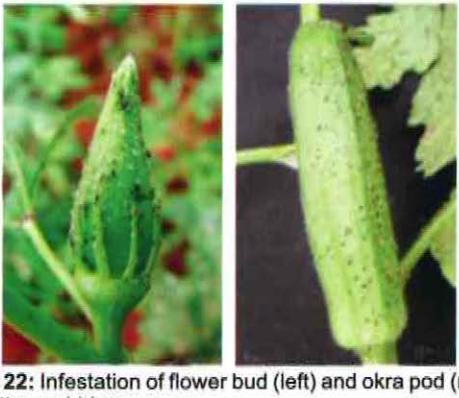


Plate 22: Infestation of flower bud (left) and okra pod (right) by cotton aphids

Plate 23: Flea beetles on okra

Plate 24: Shot holes made by flea beetles feeding on young okra plant

Plate 25: Flower bud damaged by flea beetles

Plate 26: Flea beetle damage on young okra pod

Plate 27: *Lagria* beetle feeding on okra leaves

Plate 28: Flower beetle (*Mylabris* sp.) feeding on pollen of okra flowers. Note the petals chewed by the beetle

Plate 29: Flower beetles *(Coryna apicicornis)* feeding on petals of okra flowers

Plate 30: Nymphs (the two at left) and adult of the cotton stainer *D. cardinalis*

Plate 31: A mating pair of cotton stainers *D. cardinalis*

Plate 32: Young nymphs of cotton stainers on an old okra crop

Plate 33: Adults of stink bugs: *Halydicoris* sp. (top), *Nezara viridula* (bottom left) and *Atelocera* sp. (bottom right) on okra

Plate 34: Stink bug damage on pods

Plate 35: Pods deformed by stink bug feeding

Plate 36: Cotton seed bugs on okra

Plate 37: Caterpillar damage on leaves

Plate 38: Windowing on okra leaves caused by caterpillars

Plate 39: Okra leaves spun together by caterpillars

Plate 40: Caterpillar (left) and cocoon (right) of the leaf roller *Haritalodes derogata* on okra leaf

Plate 41: Semi-looper caterpillar on okra; and moth (inset)

Plate 42: Damage by grasshoppers on okra plants

Plate 43: Punctures on okra seedling caused by the leafminer fly feeding and laying eggs. Close-up of leafminer fly (inset)

Plate 44: Damage by leafminer larvae mining on leaf of okra seedling. Note a larva at the end of the mine (right) and a pupa on leaf surface (left)

Plate 45: Okra leaf severely damaged by leafminer larvae

Plate 46: Nymphs (main picture) and adult (inset) of a green leafhopper on okra leaf

Plate 47: A colony of the groundnut hopper on okra flower buds

Plate 48: A colony of groundnut hoppers attended by ants on an okra pod

Plate 49: Mealybug infestation on okra roots

Plate 50: Mealybugs infesting okra pods

Plate 51: Young caterpillar of the African bollworm feeding on okra leaf; and a moth (inset)

Plate 52: Okra pods damaged by caterpillars of the African bollworm

Plate 53: Young okra pods damaged by the African bollworm

Plate 54: Moths of the spiny bollworm, *Earias insulana*

Plate 55: Okra pod damaged by a spiny bollworm caterpillar

Plate 56: Caterpillar (main picture) and pupa (inset) of a spiny bollworm. Note damage on seeds

Plate 57: Close-up of a colony of red spider mites

Plate 58: Mite infestation on lower leaf surface

Plate 59: Stippling of okra leaves caused by red spider mites

Plate 60: Reddish bronze coloration of an okra leaf from red spider mite infestation

Plate 61: Contamination of an okra pod by red spider mites

Plate 62: Flower thrips on okra flower (left). Close-up of the thrips *Frankliniella occidentalis* (right): Larva (top), adult male (centre) and adult female (bottom)

Plate 63: Pod damaged by thrips. Note scarring and deformation of the pod

Plate 64: Pod damaged by thrips. Note scarring, silvering and contamination by thrips droppings

Plate 65: Adults of the whitefly *Bemisia tabaci on Okra*

Plate 66: Eggs (left), and adults and nymphs (right) of a whitefly. Note the arc or semi-circle pattern in which the eggs are usually laid

Diseases

Plate 67: Okra seedlings affected by damping-off

Plate 68: Blackening of veins as a result of bacterial blight infection

Plate 69: Angular leaf spots resulting from bacterial blight

Plate 70: Lesions on petiole caused by bacterial blight

Plate 71: Bacterial spots on an okra pod

Plate 72: Black mould spots on the underside of a leaf

Plate 73: Black mould spots on the top side of a leaf

Plate 74: Wilting of okra plant due to collar rot

Plate 75: Stems of plants affected by collar rot. Note constriction at the soil level

Plate 76: Wilting of okra plant due to *Fusarium* wilt

Plate 77: *Fusarium* wilt. Note browning of water-conducting tissues

Plate 78: *Alternaria* leaf spots. Note concentric rings at the centre of the spots

Plate 79: Leaf spots caused by *Cercospora gossypina*

Plate 80: Leaf spots caused by *Cercospora malayensis*

Plate 81: Leaf spots from *Phyllosticta hibiscini* attack

Plate 82: Powdery mildew on upper leaf surface

Plate 83: Powdery mildew on an okra flower bud

Plate 84: Powdery mildew on okra pods

Plate 85: Okra roots damaged by root- knot nematodes (left) (note galls or root knots), and healthy roots (right)

From left to right • Flower beetle (*Mylabris* sp.) feeding on okra flower • Cotton stainers, *Dysdercus cardinalis*, on an okra pod • The ladybird beetle (*Cheilomenes lunata*), a predator of aphids on okra • Powdery mildew on upper surface of okra leaf

Front cover: ***Top left:*** Okra flower, ***Top right:*** Farmer with okra harvest, ***Main photo:*** Okra pods

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