

# PIP

## CROP PRODUCTION PROTOCOL OKRA (*ABELMOSCHUS ESCULENTUS*)



COLEACP is an international network promoting sustainable horticultural trade.

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In accordance with the Millennium Development Goals, the global objective is to: "Maintain and, if possible, increase the contribution made by export horticulture to the reduction of poverty in ACP countries".

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FOR SUSTAINABLE DEVELOPMENT OF  
THE ACP HORTICULTURAL INDUSTRY

**Programme PIP**  
**COLEACP**  
Rue du Trône, 130 - B-1050 Brussels - Belgium  
Tel.: +32 (0)2 508 10 90 - Fax: +32 (0)2 514 06 32



Document drafted by PIP with technical cooperation of:

M. DOUMBIA from CUECDA and A. A. SEIF from ICIPE



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The document « Technical Itinerary » (fruit or veg.) describes all the agricultural practices linked with the (fruit or veg) and suggests control of pests and diseases based mainly on active substances supported by the pesticides manufacturers in the European Directive 91/414 review and due to comply with European pesticides residues limits . Most of these active substances have been tested through a field trials programme and the residue level of each active substance has been measured. The pests and diseases control suggested is therefore dynamic and will be adapted continuously integrating all information gathered by the PIP (see the web site [www.coleacp.org/pip](http://www.coleacp.org/pip)). Nevertheless, each grower has the possibility to select among the products listed a set of active substances of no concern regarding residues.

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The PIP's crop protocols and guides to good phytosanitary practices are regularly updated. For further information, see the PIP website [www.coleacp.org/pip](http://www.coleacp.org/pip)





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# I. Plant Systematics



Seedlings, plant with flower and okra pods (Photo, DOUMBIA, 2003)





**Branch:** Spermatophyta  
**Sub-branch:** Angiospermae  
**Class:** Dicotyledonae  
**Order:** Malvales  
**Family:** Malvaceae  
**Genus:** *Abelmoschus*  
**Species:** *Abelmoschus esculentus*

# II. Crop cycle

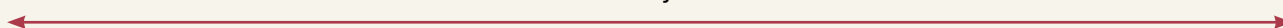
For the phenological development of the plants we can distinguish:

- 1 = emergence and vegetative development before the appearance of flower buds
- 2 = flower bud stage (appearance of flower buds)
- 3 = flowering stage with opening out of flower buds
- 4 = fructification stage with the fall of flower parts and isolation of the fruit

The classification can be represented in schematic form as follows:

			
1	2	3	4
Emergence and vegetative growth	Flower bud stage	Flowering (opening out of flower buds)	Fructification (fall of flower parts) and production

Okra cycle



## III. Okra Cultivars

Table 1: Physiological characteristics of some okra cultivars

Cultivars	Earliness (days)	Plant height (m)	Plants growth habit	Pod			Local Market	Export
				Cross-section	Length (cm)	Colour		
Clemson Spineless	60 - 70	0.7 - 1.5	Medium	Pentagonal	15 - 18	Medium green		X
Emerald Green	50 - 60	0.6 - 1.5	Vigorous	Round	17 - 22	Dark green		X
Indiana	45 - 55	0.8 - 1.2	Vigorous	Pentagonal	12 - 16	Dark green		X
Locals	90 - 120	1.2 - 1.7	Highly vigorous	Decagonal	15 - 20	Dark green	X	
Mexicana	50 - 55	0.8 - 1.5	Vigorous	Hexagonal	16 - 20	Medium green		X
Pop 12	50 - 60	1.3 - 1.7	Vigorous	Hexagonal	16 - 20	Medium green	X	X
Puso	50 - 60	0.7 - 1.4	Vigorous	Round	12 - 16	Medium green	X	X
Pusa Sawani	45 - 55	2 - 2.5	Vigorous	Hexagonal	18 - 20	Dark green	X	X
Anokhee F1	50		Not vigorous	Octagonal - Hexagonal	17 - 20	Dark green		X
White Velvet		1.5 - 1.8			15 - 18	Creamy white		X
Dwarf long pod green		0.9		Slightly ridged	18 - 20	Green		X



## IV. Main Requirements of the Plant

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### ▪ **Type of soil**

Okra grows best in deep, well-drained, light soil (sandy loam) with high organic material content and good water-holding capacity. Okra is sensitive to salinity.

### ▪ **pH of soil**

The best soil pH for okra development is close to neutrality, with an acceptable range of between 5.8 and 7.5, ideally 6 to 7.

### ▪ **Seedling emergence**

To germinate, okra seedlings optimally require ground temperatures of between 25 and 35°C. Daytime temperatures ranging from 20 to 35°C are optimal for plant development. On the other hand, the optimum night-time temperature is above 22°C. Temperatures below 15°C and above 35°C hold up growth.

### ▪ **Water requirements**

Okra grows well in soils that contain some moisture but not in hydromorphous soils. Water needs for a growing season are in the region of 900 to 1200 mm. The water needs vary depending on the plant's phenological stage, the season and the type of soil.

### ▪ **Producing areas**

In Kenya okra is grown in semi-arid areas under irrigation. The main producing areas are Kibwezi, Kilifi, Makindu, Matuu, Mitunguu, Mwea, Nguruman and Taveta.

## V. Field Cultivation Techniques

### ▪ Choice of plot

When choosing a production site for okra, a well-ventilated location should be preferred to ensure proper aeration of the vegetation. Proper aeration reduces ambient humidity in the field thereby diminishing the risk of certain fungal diseases developing such as *Cercospora* Leaf Blight. Furthermore, areas where there is too much shade over the field or ones where heavy dew occurs should be avoided because this maintains a high degree of humidity in the plants that fosters fungal disease development. Hence, okra should not be grown in poorly ventilated, heavily shaded forest areas.

### ▪ Rotation

For best results in okra production from a plant health viewpoint, and mainly to avoid big losses due to root-knot nematodes, it is advisable to implement appropriate crop rotation methods. Indeed, no Malvaceae (sorrel, okra, cotton) should be cultivated in succession on the same plot for two to three years. Okra can come after amaranth, mint, daikon, corn, onion, radish and digitaria- or panicum grass-based fallow. Since root-knot nematodes are a major problem in many growing areas, the following crops must not be included in a rotation with okra: tomatoes, karella, brinjals (eggplants), pawpaw, bananas, capsicums, potatoes, squash and sweet potatoes.

### ▪ Cropping history

To avoid a number of fungal or viral diseases as well as nematode infestation, okra should not be grown on soil where previous crops were plants that belong to the Cucurbitaceae, Solanaceae or Malvaceae families.

### ▪ Adjacent crops

It is not advisable to grow okra close to fields where other plants in the family of the Malvaceae such as cotton, roselle, are grown. This is intended to prevent flea beetles and other insects or diseases these plants share with okra from moving to the new crop. It is also preferable to avoid the vicinity of crops that are highly susceptible to *Aphis gossypii* (cucumber, melon, eggplant) and to jassid (eggplant, etc.).

### ▪ Preparing the soil

#### Soil tests

Prior to preparing the soil for okra culture, it is highly advisable to conduct soil tests so as to examine its structure, texture, physical and chemical composition, pH and microbiological profile (nematodes, fungi responsible for damping off). These tests are helpful in deciding on dressings to correct the pH, the required quantities of base dressing, type of preventive plant protection treatment on the basis of okra culture requirements.

#### Tillage

Okra is more successful in mellow, well-drained and loosened soils. Tillage involves a number of operations:

##### - Debris removal and weeding

This consists in removing plant material (trees, shrubs, weeds). Care must be taken during this operation to remove rhizomes and runners which may grow back (e.g. Cyperaceae). This can be done manually. However, if the field is covered only by weeds, chemically weeding prior to sowing can be implemented. An active ingredient such as Paraquat (2 to 3 litres/ ha) is effective against grassy weeds and annual dicotyledons.

##### - Stump removal

This operation consists in clearing the soil in depth to extract tree and shrub stumps that are damaging to tools and could interfere with the development of the okra root systems. A winch can be used to remove large stumps.

#### - Prior irrigation

The purpose of prior irrigation of the plot is to facilitate subsequent tillage operations. It consists in generously irrigating the plot (manual or mechanical sprinkling) by applying some 20 mm of water (20 litres or 2 watering cans/ m<sup>2</sup>).

#### - Application of organic material

The base dressing can be either of animal origin (horn meal and meal from other parts of animal carcasses, fish residues, poultry, sheep, goat or cattle dung) or of plant origin (green fertiliser, ground-nut shells and dust, cacao pods, etc.). The best organic manure, however, is compost, i.e., a mixture of various fermented and well-decomposed organic materials. The manure should be evenly spread over the field at a dose of between 40 and 100 tonnes/ha (i.e., 4 to 10 kg/m<sup>2</sup>).

#### - Ploughing and incorporation of organic material

Okra plant develops well on loosened, aerated soil. It is therefore important to plough through a depth of at least 20 cm to allow the plant to develop properly. Either a tractor or a draft animal may pull the plough. Incorporation of the organic material, on the other hand, can be done locally in the seed spots without mixing it with the soil. This has the additional benefit of restricting root-gall nematode infestation.

#### - Application of base mineral dressing and harrowing

Depending on the soil, the base mineral dressing can be applied at a dose of 250 to 400 kg/ha (in medium fertile soil), or 750 to 900 kg/ha (poor soil) of 10 - 20 - 20 fertiliser. The mineral dressing should be evenly applied directly on the soil surface. Harrowing consists in breaking down the clumps that subsist after ploughing and optimising soil aeration by loosening it. A rake can be used for small surface areas, while on large surface areas in the case of mechanised farming, a harrow or a semi-manual walking tractor is used.

#### - Preparing seeding in seed spots

Okra seeds should be directly drilled. To abide by seed density requirements and align plants so as to facilitate upkeep while the plant is growing, plots should be staked out along a 40 x 60 cm grid, which makes for a density of 41,750 plants per hectare (single row), or 25 x 50 x 80 cm, i.e., a density of 61,500 plants per hectare (double row). Seed spots should be 10 x 10 x 15 cm so they can contain from 1 to 2.5 kg of mature, well-decomposed organic manure when dressings are applied locally. The soil at the bottom of the seed spot should be loosened to encourage growth of the taproot system. Seed spots can be directly fertilised rather than applying organic or mineral fertiliser prior to digging out the seed spots. If this option is chosen, 1 to 2.5 kg of organic manure per seed spot should be applied, or 18-21 g. of base mineral fertiliser in poor soils and 5-10 g. per seed spot in medium soils.

### ▪ Seeding

In Kenya 8 to 10 kg of seeds are needed to seed one hectare of okra (but only 3 to 6 kg in Ivory Coast). The germination capacity of seed batches should be laboratory tested using soaked filter paper on 3 sub-batches of 100 randomly selected seeds each. This test is performed to improve chances of high emergence rates in the field by determining the seeds' germination percentage before using them. Soaking seeds in water 24 hours prior to seeding fosters germination.

3 seeds should be placed in a triangular fashion in each seed spot 1.5 to 2 cm below the soil line, and then covered with earth and slightly pressed down.



In Ivory Coast, the planting densities that ensure adequate aeration of the field and development of the plants are in region of 41,750 plants/ha (single row, 40 cm spacing within the row and 60 cm between rows), or 61,500 plants/ha (double rows, 25 cm spacing within the row, 50 cm between two adjacent single rows, and 80 cm between two adjacent double rows).

In Kenya, spacing varies: 45 x 45 cm, 50 x 30 cm or 60 x 15 cm between the rows and within the rows, respectively.

The seed spots should be lightly watered after seeding. When good quality seeds are used and the right degree of moisture is maintained in the soil, seedlings generally emerge within 4 to 6 days after seeding. In the case of irrigated crops, seeding can be performed any time during the year especially with export varieties such as Indiana, Clemson Spineless, Emerald Green, Mexicana, etc.

## ▪ Upkeep

### - Emergence inspection and replacement of non-germinated seeds

Okra is a plant that flowers and bears fruit continuously. Seed spots where seeds fail to germinate can therefore be re-seeded 4 to 6 days after the emergence of more than 50% of the seedlings. A certain percentage of seeds does not germinate, even when no pathogens are present, for several reasons: defective seeds, unsatisfactory seeding technique (depth of seeding, soil compaction), or excess moisture that may cause seeds to rot in the soil. Missing seedlings can be replaced in this way after making sure that pathogens are not the cause of inadequate emergence.

### - Irrigation

In the initial okra growing stage, and particularly following seeding, it is advisable to water twice a day for one week. Thereafter the plants should be watered once a day up until three weeks post-seeding. At subsequent stages, the plant should be watered less frequently - watering intervals should be no greater than 7 to 15 days at doses of 25 to 50 mm per application. Juvenile pods will drop off in conditions of drought. The schedule and quantities of water applied should be adjusted to consider the type of soil, the phenological stage of the plant and the time of year. The most appropriate irrigation system is drip irrigation inasmuch as spraying causes steam to condense on the field thereby increasing the relative moisture. Furthermore, spraying wets leaves which is conducive to fungal spore germination. These conditions foster the development of fungal diseases. In the case of manual watering, the water should be poured at the base of the seedlings.

### - Singling

This is an operation whereby the 2 least vigorous of the 3 seedlings that emerge in a seed spot are removed. This is done when the seedlings have reached a height of between 8 and 15 cm, i.e. some 10 to 14 days post-seeding. Singling increases the overall success rate for the crop.

### - Hoeing

Fields should be regularly weeded in the initial cultivation stages to minimize competition for soil nutrients between okra seedlings and weeds. If many weeds are visible after seeding but prior to emergence of the seedlings, a pre-emergence herbicide such as Pendimethalin can be applied. Hoeing can begin once plantlets have emerged and been singled. Weeding and hoeing at this stage can be performed manually. Nonetheless, post-emergence herbicidal control between the rows can be performed after singling and hoeing by applying a herbicide such as Paraquat or Fluazifop-p-butyl. After this stage, the field should be regularly weeded until fruiting.

### - Fertilisation

Okra exports per tonne harvested are approximately 10.9 kg of N, 4.1 kg of P<sub>2</sub>O<sub>5</sub> and 18.1 kg of K<sub>2</sub>O per hectare. A distinction must be made between the base dressing and maintenance dressings that are applied during the growing and fruiting phase of okra. Applications of maintenance dressing should be divided to accommodate the changing needs of the plant. An initial maintenance dressing based on a complete mineral fertiliser 12 - 10 - 25 (S) + 3 MgO (S) at a dose of 250 kg/ha should be applied 20 days after seeding. 40 days post-seeding (when fruiting begins), a second maintenance dressing in liquid form such as Folialm (11 - 8 - 6) at a dose of 250 to 500 ml/ha should be applied. The purpose of applying mineral fertiliser in liquid form at this stage is to allow more rapid uptake of phosphorus and potassium (important during okra fruiting) as compared to a soil-applied equivalent. 60 days post-seeding, fertiliser in the form of calcium nitrate (15.5 N; 26.5 CaO) at a dose of 90 kg/ha should be once again applied, followed by a final maintenance dressing 80 days post-seeding of calcium nitrate (15.5 N; 26.5 CaO) again at a dose of 90 kg/ha.

### - Plant protection treatments

Okra is susceptible to attacks from many insects, fungi and viruses at all stages of development. These pests and diseases may entirely jeopardise successful okra production if no plant protection measures are taken. As a general rule, chemical treatment can be applied to reduce the impact of these parasitic loads depending on the development stage of the plants and their exposure to health hazards. The table below provides an overall indication of the types of chemical treatments that can be performed during the growing cycle depending on the phenological stage of the plant and the associated plant health hazards.

Table 2 - Example of a plant protection schedule for okra production

Time of application	Possible treatment to be undertaken
Pre-seeding	Soil treatment against damping off ( <i>Pythium</i> , <i>Rhizoctonia</i> , <i>Sclerotium</i> ), <i>Fusarium</i> , soil-inhabiting insects and root-knot nematodes
Seeding	Seed treatment against damping off ( <i>Pythium</i> , <i>Rhizoctonia</i> , <i>Sclerotium</i> , <i>Xanthomonas</i> ) and soil-inhabiting insects
10 days post-seeding	Foliar spraying against diseases (Bacterial blight, Cercospora Leaf Blight, powdery mildew) and insects (aphids, caterpillars, scale insects, whiteflies, flea beetles, crickets and leaf hoppers)
24 days post-seeding (start of flowering)	Foliar spraying against diseases (Bacterial blight, Cercospora Leaf Blight, powdery mildew), insects (aphids, caterpillars, scale insects, whiteflies, flower beetles, thrips and leaf hoppers) and mites.
38 days post-seeding (flowering- fruit-set)	Spraying against diseases (Bacterial blight, powdery mildew, Cercospora Leaf Blight) and insects (aphids, caterpillars, scale insects, whiteflies, flower beetles, bugs and leaf hoppers)
52 days post-seeding (mid-harvest)	Spraying against piercing-sucking insects and caterpillars (carpophagous or phyllophagous)
66 days post-seeding (mid-harvest)	Spraying against piercing-sucking insects and caterpillars (carpophagous or phyllophagous)
80 days post-seeding (mid-harvest)	Spraying against piercing-sucking insects and caterpillars (carpophagous or phyllophagous)

NB: Don't spray systematically but apply pesticides only according to actual risk of infestation at the moment of the crop growing or on crop scouting basis. Also strictly adhere to PHIs.

The data concerning okra enemies and management methods are dealt with in section VII « **Okra enemies and plant protection methods** »

When spray treatment is performed during the growing season, it should be done between 7 and 10 am, or after 5 pm, when pests are relatively stationary and bees are not very active. In addition, these are also usually the times when there is little wind thereby reducing the risk of scalding.

### ▪ Harvesting

Okra begins to produce fruit 41 days after seeding and can begin to be harvested at 45 days in the case of export varieties such as Indiana, Emerald, Clemson Spineless. Harvesting can run over an economically viable period lasting 45 to 65 days at intervals of between 2 and 3 days at most. Fruits grow up very quickly (pods are ready for harvesting about 4-6 days after flowering), so when the crop is intended for export, fruit can be harvested on a daily basis so as to meet export grade sizing requirements (6 to 8 cm). The growing season as of seeding to the end of the economically viable harvesting period therefore lasts some 90 to 110 days.

Okra plants bear prickles to which some people are allergic. Pickers should therefore protect their skin by wearing gloves and appropriate clothing. Export grade fruit should preferably be picked using a secateur, leaving a 1 cm stem on the fruit. Fruit should not be harvested during rainfall or when they are wet as this can cause rapid spoilage. Fruit that is oversized for export should be removed from the plant to encourage further fruiting. Harvested fruit should be placed in bags and then well-ventilated, shallow crates to avoid problems arising from evapotranspiration when temperatures rise. Fruit for export should be picked at the earliest 1 day prior to being shipped, or preferably the same day for shipment by air. At suitable sites, the average yield is in the region of 8 to 10 T/ha in the case of Indiana and 10 to 12 T/ha for Clemson.

In Kenya the main production period is from October to May.

## VI. Post-harvest Practices

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Okra fruit intended for export must be clean, green, firm, as straight as possible and not show any signs of mould or damage due to insect punctures. Okra pods are very rapidly susceptible to decay if appropriate storage measures are not taken. When no cold storage facilities are available, fruit should be prepared for shipping the same day just after being picked. Depending on market requirements, this entails sorting the freshly picked fruit (discarding discoloured or crooked pods) and grading them according to export grade sizes (4 to 8 cm). The sorted pods are then put directly into special boxes (2 to 5 kg) and dispatched to the airport for shipment.

Where there are storage facilities, the quality of the fruit can be maintained for 4 to 7 days depending on post-harvest practices. When temperatures are high, the respiration rate of okra fruit is high requiring rapid refrigeration. They can be satisfactorily stored for 7 to 10 days at a relative humidity of 90 to 95 %. Below 7°C, the fruit spoil (discoloration, decay). Storage can be extended by an additional week in a controlled atmosphere with 5 to 10 % carbon dioxide. Fruit that are cold-stored should be packed in perforated plastic bags but not washed. To achieve best marketing conditions, however, okra should not be stored for more than 36 hours before shipping. When shipment by air is in non-ventilated containers, it is strongly recommended that the fruit be taken out of cold storage 2 to 3 hours prior to being loaded into the containers to allow condensation to evaporate.

## VII. Okra enemies and plant protection methods

### PLANT PATHOGENIC FUNGI

Okra is susceptible to attacks from several species of plant pathogenic fungi with economic effects of varying degrees. We shall describe the most damaging among them:

- Fungi that cause damping off (*Pythium* spp. (Pythiales: Pythiaceae), *Rhizoctonia solani* Kühn (Ceratosporales: Ceratobasidiaceae), *Sclerotium rolfsii* Sacc. (Stereales: Corticiaceae).
- *Fusarium oxysporum* f. sp. *vasinfectum* (G.F.Atk) W.C. Snyder & H.N. Hansen (Hypocreales)
- *Cercospora malayensis* (Stev. & Solheim) (Moniliales)
- *Pseudocercospora abelmoschi* (Ell. & Ev.) Deighton Syn.: *Cercospora abelmoschi* Ell. & Ev (Moniliales)
- *Erysiphe cichoracearum* Dc. Ex Méral (Erysiphales: Erysiphaceae) Syn.: *Oidium abelmoschi*

### Fungi that cause damping-off

Damping-off is caused by a broad variety of soil-borne, plant pathogenic fungi, including the major ones listed below.

- **Scientific names:** *Pythium* spp. (Pythiales: Pythiaceae), *Rhizoctonia solani* Kühn (Ceratosporales: Ceratobasidiaceae), *Sclerotium rolfsii* Sacc. (Stereales: Corticiaceae).
- **Distribution:** Cosmopolitan.
- **Phenological stages of crop susceptibility:** Seeds and seedlings.
- **Appropriate periods for intervention:** On seeds and prior to seeding.
- **Other host plants (and adverse previous crops):** Eggplant, tomato and other Malvaceae.
- **Description of symptoms / damage and % of losses:** Seed germination is irregular. This very widespread disease mostly affects either seed germination (pre-emergence damping off) or seedlings (post-emergence damping-off). In the case of pre-emergence damping-off, seeds are unable to germinate either because they have rotted or because young sprouts are destroyed. As for post-emergence damping off, the young seedling's stem is infected at or below the soil line causing it to topple. Emergence is uneven and seedlings are weak. They appear wilted, yellowed and either depressions, light brown ring-shaped lesions or water-soaked, dark green lesions are found on the collar. This disease can cause an 80% reduction in okra seed emergence.
- **Conditions conducive to infection:** These fungi are stored in the soil as oospores (*Pythium*), sclerotia (*Sclerotium*) or on decaying plant debris (*Rhizoctonia*). These infections are most liable to occur in poorly drained, acid soils along with high ambient humidity and temperatures of around 28° to 30° C.
- **Methods of observation and intervention thresholds:** As a general rule, okra germinates 3 to 4 days, or 6 at most, post-seeding. When damping off occurs, seedlings emerge later and are sparse. Subsequently, the few seedlings that have emerged show symptoms of damping off. No intervention threshold has been established inasmuch as by the time symptoms occur, there is no way to treat infected plants nor to prevent these pathogens from spreading.
- **Prevention:**
  - Choose well-drained, adequately aerated sites.



Damping-off symptoms on okra seedling (Photo, DOUMBIA, 2003)

- Destroy any plant residues from the previous harvest.
  - Do not grow okra in succession with eggplant, tomato or other plants in the Malvaceae family.
  - Planting density should not be too high.
- **Plant Protection Products application:** The main means of preventive chemical control is seed treatment with Thiram (500 g a.i./100 kg of seeds) or Mefenoxam + Difenoconazole (Apron Star 42 WS - 250 g/100 kg of seeds). However, once seedlings have emerged, when there is a damping off risk, copper oxychloride at low doses can be applied in an aqueous solution that should be poured at the base of the seedlings or with Iprodione (pelleted Iprodione (2000 g of a.i./ha).

*Fusarium oxysporum* f. sp. *vasinfectum* (G.F.Atk) W.C. Snyder & H.N. Hansen (Hypocreales)

- **Common names:** Fusarium wilt.
- **Distribution:** Cosmopolitan.
- **Phenological stages of crop susceptibility:** All developmental stages of okra are susceptible. The disease is especially likely to be perceptible in the pre-flowering stage.
- **Appropriate periods for intervention:** Where circumstances are conducive to the development of fungal infections, steps should be taken prior to seeding by treating the seedbed, considering that the fungus is stored in the soil in the form of chlamydo spores. It is also liable to be stored on okra seeds. In this case, treating seeds with Thiram may be advisable.



Respectively, symptoms of Fusarium on seedling (Photo, DELHOVE, 1998) and damage to vascular system of okra (Photo, DOUMBIA, 2003)

- **Other host plants (and adverse previous crops):** Eggplant, tomato and other Malvaceae.
- **Description of symptoms / damage and % of losses:** Symptoms occur at all stages of development. When the seedling is attacked at an early stage, its vascular system is plugged by fungal spores, which leads to water stress and wilting of the entire seedling and subsequent death. In the case of late infections, generally 1 month post-seeding (flowering stage), symptoms are seen on older leaves located on the lower parts of the plant, in the form of lateral chlorosis resembling a hemiplegia. Leaves initially become chlorotic at the edges, gradually extending throughout the lamina. In the event of a severe attack, many leaves droop and become chlorotic. This produces overall wilting of the plant which subsequently dries out and dies. When attacks are perceptible on seedlings, losses of more than 60% may occur if no steps are taken.
- **Conditions conducive to infection:** The fungus is stored in the soil in the form of chlamydo spores and on plant debris. Infections are most likely to occur in soils with low potassium content and high acidity. The optimum temperature for development of the disease is about 25° C.
- **Observation methods and intervention thresholds:** When wilting of seedlings or chlorosis on mature okra leaves is seen, a cross-section of a plant stem should be examined. If vessels are found to be browned, a Fusarium attack can be suspected.
- **Prevention:**
  - Destroy any plant residues from the previous harvest.
  - Do not grow okra in succession with eggplant, tomato or other plants in the Malvaceae family.
  - A crop rotation schedule of at least 5 years should be implemented excluding Malvaceae in any previously infected fields. Rotation should include laying the fields fallow or planting cereals.
  - Avoid any unnecessary movements of soiled farming equipment from infected to healthy areas.
  - During vegetative growth, drip irrigation is preferable to spray irrigation.



- One solution is to use resistant okra varieties but a limited one considering the emergence of new pathogen breeds.
- A recommended preventive measure is to control nematodes of the genus *Meloidogyne* which cause wounds on plant roots that act as entry points for the fungus.
- **Plant Protection Products application:** Spraying with fungicides will not control this disease.

***Cercospora malayensis* (Stev. & Solheim) (Moniliales)**

- **Common name:** Cercospora Leaf Spots / Cercospora leaf blight
- **Distribution:** Cosmopolitan.
- **Phenological stages of crop susceptibility:** Okra is susceptible at all stages of development.
- **Appropriate periods for intervention:** In circumstances that are conducive to the development of fungal infections (heat and moisture), especially during the vegetative growth phase up to flowering, chemical treatment is useful. The disease weakens the plant's assimilation capacity by diminishing the leaf area which adversely affects fruit yield.
- **Other host plants (and adverse previous crops):** Other Malvaceae.
- **Description of symptoms / damage:** Symptoms occur at all stages of development. The disease produces small, round, necrotic spots on the leaves. These spots are 3 mm in diameter surrounded by a purple-coloured area, turning grey in the middle. The first leaves to be affected are mature ones. As the necrotic spots enlarge, their centre becomes greyish-brown surrounded by a purplish band of variable width. The diameter of the lesions can be 1.5 to 2 cm. The centre subsequently dries out, breaks and pieces of tissue becomes detached producing holes surrounded by purplish haloes. In very moist weather and high temperatures, the disease affects juvenile leaves. When severe attacks of Cercospora Leaf Blight occur, a significant amount of the leaf area for assimilation is lost with damaging consequences on fruit yield.
- **Conditions conducive to infection:** The fungus is stored in harvest residues and on diseased plants. Once lesions begin to appear, conidia are produced and then disseminated by the wind, thereby infecting other plants. The disease is aggravated by high temperatures together with high levels of humidity.
- **Methods of observation and intervention thresholds:** When Cercospora Leaf Blight symptoms are seen during very humid, hot weather, remedial steps can be taken depending on how severely the plants are attacked. There is no specific intervention threshold leaves fulfilling the assimilation function are produced continuously in okra. However, if severe attacks occur during the vegetative growth stage (10 to 20 days post-seeding), harvest may be adversely affected.
- **Prevention:**
  - Destroy any plant residues from the previous harvest.
  - Do not grow okra in succession with eggplant, tomato or other plants in the Malvaceae family.
  - Apply appropriate manure or fertiliser doses to encourage plant growth.
  - Drip irrigation is preferable to spray irrigation during vegetative growth.
  - It may be advisable to use varieties with acceptable levels of resistance such as Puso, Mexicana or Emerald.
- **Plant Protection Products application:** When conducive weather conditions (moisture and high temperatures) prevail during okra vegetative growth and symptoms occur on a large proportion of plants, spray treatments should be performed every 7 to 14 days with active substances listed in annex 1 and taking into account PHI of annex 2.



Symptom of *Cercospora malayensis* on okra leaf (Photo, DOUMBIA, 2003)

*Pseudocercospora abelmoschii* (Ell. & Ev.) Deighton Syn.: *Cercospora abelmoschii* (Ell. & Ev.) (Moniliales)

- **Common names:** Cercospora Leaf Spots / Cercospora leaf blight / Black mould.
- **Distribution:** Cosmopolitan.
- **Phenological stages of crop susceptibility:** Okra is susceptible at all stages of development.
- **Appropriate periods for intervention:** In circumstances that are conducive to the development of the fungal infection (heat and moisture), especially during the vegetative growth phase up to flowering, chemical treatment is useful. The disease weakens the plant's assimilation capacity by diminishing the leaf area which adversely affects fruit yield.



*Pseudocercospora abelmoschii* symptoms on respectively the lower and upper surface of okra leaf (Photos, DOUMBIA, 2003)

- **Other host plants (and adverse previous crops):** Eggplant, tomato and other Malvaceae.
- **Description of symptoms / damage:** symptoms occur at all stages of development. The disease shows on the lower surface of the leaves as greyish spores that later become black and sooty. On the upper surface of the leaves, there may be diffuse, irregularly shaped spots that are yellowish to dark green, often purplish red, round (about 1 cm), sometimes angular and bounded by the leaf veins. Infected leaves eventually roll, prematurely dry out and are shed.
- **Conditions conducive to infection:** The disease occurs most often in hot, moist climates. It is spread from one plant to another by wind-borne conidia. The fungus is stored on the soil surface. The severity of the disease increases in the event of heavy moisture combined with high temperatures.
- **Methods of observation and intervention thresholds:** If *Cercospora* Leaf Blight symptoms occur during periods of heavy moisture and high temperatures, remedial steps can be taken depending on the number of plants attacked. There is no specific intervention threshold, due to the fact that in okra, leaves that fulfil the assimilation function are produced continuously. However, severe attacks during the vegetative growth period (10 to 20 days post-seeding) may have an impact on harvest.
- **Prevention:**
  - Destroy any plant residues from the previous harvest.
  - Do not grow okra in succession with eggplant, tomato or other plants in the Malvaceae family. Rotate with baby corn, maize, small grains, pulses or fodder grasses
  - Apply appropriate manure or fertiliser doses to encourage plant growth.
  - Drip irrigation is preferable to spray irrigation during vegetative growth.
  - Destroy any plant residues from the previous harvest.
  - It may be advisable to use varieties with acceptable levels of resistance such as Puso, Mexicana or Emerald.
- **Plant Protection Products application:** Same control method as for *Cercospora malayensis*.

*Erysiphe cichoracearum* Dc. Ex Mérat (Erysiphales: Erysiphaceae) Syn.: *Oidium abelmoschii*

- **Common name:** Powdery mildew of okra.
- **Distribution:** Cosmopolitan (in Kenya *Leveillula taurica* is reported on okra).
- **Phenological stages of crop susceptibility:** Okra is susceptible at all stages of development.
- **Appropriate periods for intervention:** In circumstances that are conducive to the development of the fungal infection (hot, dry climate) particularly during the fruiting stage, chemical treatment is useful. Indeed, plant susceptibility increases with age, and because the disease affects the leaves and stems of okra, leaf area is diminished and hence so is the plant's assimilation capacity. Depending on the severity of the attacks, fruit yield may be adversely affected.
- **Other host plants (and adverse previous crops):** Plants in the Solanaceae, Asteraceae and Cucurbitaceae families are host plants for powdery mildew and hence adverse previous crops for okra cultivation.
- **Description of symptoms / damage:** Symptoms occur at all stages of development. On the leaves, the disease shows on both surfaces in the form of small greyish white downy spots. Infected tissue takes on a purplish hue. This downy mould is made up of the mycelium, conidiophores and conidia of the fungus. The spots spread until they cover the whole surface of the leaf which gradually dries out and abscises. In conducive circumstances, when there is an outbreak of powdery mildew at the beginning of the fruiting stage, yield and fruit quality may suffer.
- **Conditions conducive to infection:** The disease occurs most often in hot climates without rainfall and at locations with fairly high relative moisture. This may often be the case during the dry season due to the use of spray irrigation systems which create a humid microclimate in the vicinity of the okra plants living in a dry overall environment. Furthermore, okra susceptibility to powdery mildew increases with plant age. The disease spreads from one plant to another by windborne conidia. During the rainy season, the conidia are liable to be leached and hence unable to produce infection.
- **Methods of observation and intervention thresholds:** When powdery mildew symptoms appear on okra leaves in conditions that are conducive to the development of the fungus, remedial steps can be taken if justified by the number of plants affected, especially during the fruiting stage.
- **Prevention:**
  - Destroy any plant residues from the previous harvest,
  - Do not grow okra in succession with plant of Asteraceae, Cucurbitaceae or Malvaceae family.
  - Apply appropriate manure or fertiliser doses to encourage plant growth.
  - Drip irrigation is preferable to spray irrigation during fruiting.
  - It may be advisable to use varieties with acceptable levels of resistance such as Puso, Mexicana or Emerald.
  - A ladybird eats this mycelium of this fungus. So it is preferable to use insecticides safe for ladybirds (see photos below).



Powdery mildew symptom on okra leaf (Photo, DOUMBIA, 2003)



Adults



Larva eating *Oidium abelmoschi*



Eggs

(Photos, Dehove G., 2000)

- **Plant Protection Products application:** When weather conditions are conducive to development of the fungus during okra fruiting and a large number of plants show symptoms, alternate spray treatments using active substances listed in annex 1 and taking into account PHI of annex 2 should be performed every 10 days.

Table 3 is a summary of the main fungal diseases affecting okra and the associated phenological stages.

**Table 3 – Main plant pathogenic fungi for okra and associated stages of crop development**

Species	Extent of damage depending on development stage of the crop				
	Seedbed	From emergence to singling	From singling to first harvest	Harvest	Post harvest
<i>Damping off: Pythium spp., Rhizoctonia solani, Sclerotium rolfsii</i>	+++	+++	++		
<i>Fusarium oxysporium f. sp. vasinfectum</i>	+++	+++	++		
<i>Cercospora malayensis</i>		+	+++	+	
<i>Cercospora abelmoschii</i>		+	+++	+	
<i>Erysiphe cichoracearum</i>		++	+++	+++	

+: minor ++: moderate +++: major

## PLANT PATHOGENIC BACTERIA

The major bacterial disease of okra is bacterial blight. This disease is serious in subhumid and semi-arid areas where okra is grown under irrigation.

*Xanthomonas axonopodis* pv. *malvacearum* (Smith) Dye (Xanthomonadales: Xanthomonadaceae)



Bacterial blight symptoms (Photos, SEIF & VARELA, 2004)

- **Common name:** Bacterial blight of okra.
- **Distribution:** Cosmopolitan
- Phenological stages of crop susceptibility: Okra is susceptible at all stages of development.
- **Appropriate periods for intervention:** Since the bacterium is seed-borne, the most appropriate intervention period is at sowing: planting resistant variety where available and using certified disease-free seeds. In case of disease appearance in vegetative and generative growth stages, chemical treatment may be useful in reducing disease spread.
- **Other host plants (and adverse previous crops):** Plants in the Malvaceae family such as cotton.
- **Description of symptoms / damage:** Symptoms occur at all stages of development. It causes death of seedlings and loss of young plants. The first symptoms are small, circular, water-soaked spots on the cotyledons as they emerge from the seed coat. The spots furnish inoculum for the developing true leaves. Leaf spots are translucent, water-soaked and angular. Later they become browned and blackened. The angular spots are restricted by the veins and vary in size. Many infections often cause premature leaf fall. The bacteria may spread along the leaf veins, which appear blackish. Spots on petioles are elongated, sometimes slightly sunken and blackish. On pods, spots are initially water-soaked and round. They later join together and turn oily black. Since all spots become covered by bacterial cells, they appear waxy and shiny.
- **Conditions conducive to infection:** The world-wide distribution of bacterial blight is attributed to the seed-borne bacteria. Spread in the field is largely due to wind-blown rain water and splashing from plant to plant and leaf to leaf by falling water. Bacteria are also carried by flowing of surface water. In irrigated fields, the spread of the disease may be traced in the direction of the water flow. The disease can also be spread by stainer bugs (*Dysdercus* spp.). Free water is required for foliar infection and secondary spread is favoured by high temperatures and high humidity following periods of wind and rains.
- **Methods of observation and intervention thresholds:** Regular crop scouting is important and on first appearance of disease symptoms copper-based products may be applied to reduce spread of the disease.
- **Prevention:**
  - Use certified disease-free seeds.
  - Grow resistant varieties where available.
  - Do not grow okra in succession with plants of Malvaceae family. Rotate with baby corn, maize, small grains, pulses or fodder grasses.
  - Avoid dense planting.
  - Apply appropriate manure or fertiliser doses to encourage plant growth.

- Avoid overhead irrigation.
  - Avoid working in the field when it is wet.
  - Destroy any plant residues from the previous harvest.
  - Destroy volunteer okra seedlings.
- **Plant Protection Products application:** Where use of pesticides is justified, use only locally registered products that are approved by EU regulations. Also observe label instructions for dosage, frequency of application, pre-harvest intervals and safety precautions during handling, application and storage.

**Table 4 – Bacterial blight of okra and associated stages of crop development**

Species	Extent of damage depending on stage			
	Seedbed	From emergence to singling	From singling to first harvest	Harvest
<i>Xanthomonas axonopodis</i> pv. <i>malvacearum</i>	+	++	+++	+++

+: minor ++: moderate +++: major

## VIRUSES

Several species of virus are liable to infect okra entailing varying degrees of economic impact. We will deal with the most common okra viral diseases:

- *Okra leaf curl virus* (OKLCV)
- *Cucumber Mosaic virus* (CMV)
- *Cotton Yellow Mosaic Virus* (CYMV)
- *Hibiscus Yellow Vein Mosaic Virus* (HYVMV)

### Okra leaf curl virus (OKLCV)



Symptoms of Okra Leaf Curl Virus on seedlings (Photos, DOUMBIA, 2000)

- **Common name:** Okra Leaf Curl Virus.
- **Distribution:** Cosmopolitan.
- **Phenological stages of crop susceptibility:** Seedling and vegetative growth stages.
- **Appropriate period for intervention:** The Okra Leaf Curl Virus is transmitted by whiteflies of the family of the Aleyrodidae (*Bemisia tabaci*) which are piercing-sucking insects. In infested area or as soon as the first vectors appear, chemical control must be implemented against whiteflies as infected plants remain stunted and do not bear fruit.
- **Other host plants (and adverse previous crops):** Plants in the family of the Malvaceae act as hosts for the virus and are hence adverse previous crops for okra culture.
- **Description of symptoms / damage:** Symptoms occur most often at the seedling stage. Blisters can be seen on juvenile leaves (photo 10) and mature leaves, the lamina becomes torn (photo 9). When a severe infection occurs at an early stage, the plant's entire development is affected and growth is retarded or stopped. In such a situation, there can be severe losses.
- **Conditions conducive to infection:** Both the occurrence and spread of the disease are dependent on conditions that foster whitefly proliferation (dry, hot periods).
- **Methods of observation and intervention thresholds:** Chemical control must immediately be implemented as soon as the first Okra Leaf Curl Virus symptoms appear on okra leaves by uprooting the infected plant followed, if whitefly populations are significant, by chemical treatment. This intervention is based on the fact that no remedial measures exist and the disease can spread very rapidly depending on the extent of whitefly abundance as assessed by means of yellow pan traps.
- **Prevention:** In this case prevention is essential since remedial steps are of little use. Prevention relies on the following:
  - Do not grow okra close to cotton or other wild Malvaceae of the genus *Hibiscus* which are host plants of the virus and for the vector, *B. tabaci*.
  - As soon as the first infected plant is seen, it should immediately be uprooted and burnt.
  - Monitor *B. tabaci* populations during the okra vegetative growth phase using yellow pan traps.
- **Plant Protection Products application:** Curative chemical treatment is virtually of no use. However, to hinder the spread of the disease, chemical treatments against the vector, *B. tabaci*, may be worthwhile. Recommended substances are provided in the section on whiteflies (*Bemisia tabaci*).

### Cucumber Mosaic virus (CMV)

- **Common name:** CMV Cucumber mosaic virus.
- **Distribution:** Cosmopolitan.
- **Phenological stages of crop susceptibility:** seedling, vegetative growth, flowering and fruiting.
- **Appropriate periods for intervention:** The main transmission vector for Cucumber Mosaic Virus are aphids (*Aphis gossypii*) in the non-persistent mode during the plant's vegetative growth stage. In infested area or as soon as the first vectors appear, chemical control must be implemented against aphids since infected plants remain stunted, leaves become chlorotic and fruit quality is depreciated.
- **Other host plants (and adverse previous crops):** Plants in the families of the Cucurbitaceae, Malvaceae, Solanaceae, Passifloraceae, Fabaceae, Poaceae, both wild and cultivated, are hosts for the virus and hence adverse previous crops for okra culture.
- **Description of symptoms / damage and % of losses:** Cucumber Mosaic Virus causes systemic infections that often do not produce any visible symptoms. Occasionally, chlorotic pale/yellow spots appear on the leaves. The leaves and fruit tend to develop necrotic areas. Plants that are infected at an early stage remain stunted. Losses are often huge (60 to 90 %) when early infection occurs in the wake of *A. gossypii* proliferation.
- **Conditions conducive to infection:** Both the occurrence and spread of the disease rely on conditions that foster aphid proliferation. However, the virus can be transmitted mechanically, and to some degree, via seeds.
- **Methods of observation and intervention thresholds:** When there are doubts on the origin of seeds, seed contamination can be detected by serological or PCR tests. Under field conditions, however, detecting symptoms is the only way of ascertaining the disease. As soon as the first infected plant has been observed, steps should immediately be taken by uprooting the plant followed, if aphid populations are significant, by chemical treatment. This intervention is based on the fact that no curative steps exist and the disease can spread very rapidly depending on the extent of aphid abundance as assessed by means of yellow pan traps.
- **Prevention:** In this case, prevention is essential since curative steps are of little use. Prevention relies on the following:
  - Do not grow okra close to the above-mentioned host plants.
  - As soon as the first infected plant is seen, it should be immediately uprooted and burnt.
  - Monitor *A. gossypii* populations during the okra vegetative growth phase using yellow pan traps.
- **Plant Protection Products application:** Curative chemical treatment is virtually of no use. However, to hinder the spread of the disease, chemical treatments against the vector, *A. gossypii*, may be worthwhile. Recommended treatments are provided in the section on this pest.



Symptoms of Cotton Yellow Mosaic Virus on the leaves of okra  
(Photo, DOUMBIA, 2003)

### Cotton Yellow Mosaic Virus (CYMV)

- **Common name:** CYMV Cotton Yellow Mosaic Virus.
- **Distribution:** Cosmopolitan.
- **Phenological stages of crop susceptibility:** Seedlings, vegetative growth, flowering and fruiting.
- **Appropriate periods for intervention:** Cotton Yellow Mosaic Virus is suspected to be field transmitted mainly by insects (aphids, whiteflies, flea beetles or thrips). In infested area or as soon as the first vectors appear, chemical control must be implemented against them as the disease causes stunting, leaf chlorosis and depreciation of fruit quality.



- **Other host plants (and adverse previous crops):** The main hosts of the virus are cotton and okra. Cotton is therefore a dangerous previous or adjacent crop for okra entailing a risk of Cotton Yellow Mosaic Virus infection.

- **Description of symptoms / damage and % of losses:** Cotton Yellow Mosaic Virus produces visible symptoms, particularly on juvenile leaves. Very juvenile leaves that are not yet fully extended appear to be embossed and are of a pale yellow colour. When the juvenile leaves are fully extended they are entirely pale yellow in colour, whereas older leaves at the lower levels are not affected and have a normal green colour. The fruit too are spotted with pale yellow here and there. When infection occurs at an early stage, the plants remain stunted. Losses can be huge (60 to 90 %) when insect vectors proliferate at an early stage.



Symptoms of Cucumber Mosaic Virus on okra leaves (Photo, DOUMBIA, 2000)

- **Conditions conducive to infection:** Both the occurrence and spread of the disease rely on conditions that foster proliferation of the insect vectors (vicinity of infected cotton, hot and dry weather).

- **Methods of observation and intervention thresholds:** Under field conditions, the disease is detectable by its symptoms. Chemical control should be implemented as soon as the first symptoms of the virus are observed. Intervention should begin by immediately uprooting the plant followed, if aphid, flea beetle or whitefly populations are significant, by chemical treatment. These steps must be taken because no curative measures exist and the disease can spread very rapidly depending on the extent of insect vector abundance.

- **Prevention:** In this case, prevention is essential since curative steps are of little use. Prevention relies on the following:

- Do not grow okra close to cotton, especially since okra seeding time is not concomitant with the end of cotton vegetative growth.
- As soon as the first infected plant is observed, it should be immediately uprooted and burnt.
- Monitor insect vector populations during the okra vegetative growth phase.

- **Plant Protection Products application:** Curative chemical treatment is virtually of no use against viral diseases. However, to hinder the spread of the Cotton Yellow Mosaic Virus, chemical treatments against the insect vectors may be worthwhile. See recommended treatments against aphids, whiteflies and flea beetles.

#### *Hibiscus Yellow Vein Mosaic Virus* (HYVMV)

- **Common name:** HYVMV Hibiscus Yellow Vein Mosaic Virus.

- **Distribution:** Cosmopolitan.

- **Phenological stages of crop susceptibility:** Seedlings, vegetative growth stage, flowering and fruiting.

- **Appropriate periods for intervention:** The Hibiscus Yellow Vein Mosaic Virus of okra is mainly transmitted by insect vectors that have not so far been fully identified. However, there are reasons for suspecting whiteflies and flea beetles since tests on aphids have not so far been conclusive. In infested area or as soon as the first vectors appear, chemical control must be implemented against them since infection of very juvenile plants causes stunting, chlorosis of leaves and yellowing of ribs with adverse effects on both yield and quality.



Symptoms of Hibiscus Yellow Vein Mosaic Virus on okra leaves (Photo, DOUMBIA, 2003)

- **Other host plants (and adverse previous crops):** Plants in the families of the Cucurbitaceae, Malvaceae, Solanaceae, both wild and cultivated, are hosts for the virus and as such adverse previous crops for okra culture.

- **Description of symptoms / damage:** Hibiscus Yellow Vein Mosaic Virus produces highly characteristic symptoms. The leaves of infected plants become chlorotic. The main vein and the secondary ribs thicken and become characteristically yellow together with the adjacent tissue. The leaves are subsequently deformed and take on an embossed appearance. The fruit are small, misshapen and very suberised. Early infection causes stunting. However, because this viral disease is uncommon, its economic impact is minor.
- **Conditions conducive to infection:** Both the occurrence and spread of the disease rely on conditions that foster proliferation of the insect vectors (dry, hot weather).
- **Methods of observation and intervention thresholds:** Under field conditions, the only way to detect the disease is by observing symptoms. As soon as any symptoms of the virus are seen, the infected plants should be immediately uprooted followed, depending on insect abundance, by chemical treatment. However, because the economic impact is minor, this intervention should not be done as a matter of course.
- **Prevention:** In this case, prevention is essential since curative steps are of little use. Prevention relies on the following:
  - Do not grow okra close to the above-mentioned host plants.
  - As soon as the first infected plant is seen, it should be immediately uprooted and burnt.
  - Monitor insect vector populations during the okra vegetative growth phase using yellow pan traps.
- **Plant Protection Products application:** Where chemical control is deemed necessary, the focus is on controlling insect vector populations (see recommended treatments against whiteflies and flea beetles). Because the incidence of this viral disease is minor, uprooting infected plants may be sufficient.

Table below is a summary of the major plant pathogenic viruses affecting okra and the associated phenological stages

**Table 5 – Main plant pathogenic viruses for okra and associated stages of crop development**

Species	Extent of damage depending on development stage			
	Seedbed	From emergence to singling	From singling to first harvest	Harvest
<i>Cotton Yellow Mosaic Virus</i> (CYMV)		++	+++	+
<i>Okra Leaf Curl Virus</i> (OKLCV)		+	+++	+
<i>Cucumber Mosaic Virus</i> (CMV)		+	+++	+
<i>Hibiscus Yellow Vein Mosaic Virus</i> (HYVMV)		+	+++	+

+: minor ++: moderate +++: major

## INSECTS

Among the plants of the Malvaceae family, okra is considered to be a prime entomological plant considering the number of insect species that attack it. Indeed, more than a hundred insect species are able to attack okra entailing various degrees of economic cost. We review the 24 insect pest species most commonly encountered in okra culture causing varying degrees of damage:

- *Acrosternum acutum* (Dallas); *Nezara viridula* (L.); *Atelocera* sp. and *Halydicoris* sp. (Heteroptera: Pentatomidae) okra green stink bug -
- *Agrotis* spp. (Lepidoptera: Noctuidae) cutworms
- *Aphis gossypii* Glover (Homoptera: Aphididae) cotton aphid
- *Bemisia tabaci* Gennadius (Homoptera: Aleyrodidae) tobacco whitefly
- *Brachytrupes membranaceus* (Drury) (Orthoptera: Gryllidae) cricket
- *Cosmophila flava* Syn. *Anomis flava* Fabricius (Lepidoptera: Noctuidae) cotton semi-looper
- *Dysdercus* spp. (Heteroptera: Pyrrhocoridae) cotton stainers
- *Earias* spp. (Lepidoptera: Noctuidae) spiny bollworms
- *Frankliniella* spp. (Thysanoptera: Thripidae) Thrips
- *Gryllotalpa* spp. (Orthoptera: Gryllotalpidae) mole-cricket
- *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) cotton bollworm
- *Jacobiasca lybica* (de Bergevin) (Homoptera: Cicadellidae) leafhopper or jassid
- *Lagria villosa* (Fabricius) (Coleoptera: Tenebrionidae) lagriid beetle
- *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae) leafminer
- *Mylabris* spp. (Coleoptera: Meloidae) blister beetles
- *Nisotra* spp. (Coleoptera: Chrysomelidae) flea beetle
- *Oxycarenus hyalinipennis* (Costa) (Heteroptera: Lygaeidae) cotton seed bug
- *Pachnoda* spp. (Coleoptera: Scarabaeidae) cetonid
- *Podagrica* spp. (Coleoptera: Chrysomelidae) flea beetle
- *Pseudococcus* spp. (Homoptera: Pseudococcidae) mealybug
- *Spodoptera* spp. (Lepidoptera: Noctuidae) armyworm
- *Sylepta derogata* (Fabricius) (Lepidoptera: Pyralidae) cotton leafroller
- *Schizonycha* sp., *Heteroligus* sp., *Heteronychus* sp. and *Oryctes* sp. (Coleoptera: Scarabaeidae) okra white grubs
- *Xanthodes graellsii* (Feisthamel) (Lepidoptera: Noctuidae) okra moth
- *Zonocerus variegatus* (Linnaeus) (Orthoptera: Acrididae) variegated grasshopper

***Acrosternum acutum* (Dallas) ; *Nezara viridula* (L.); *Atelocera* sp. and *Halydicoris* sp. (Heteroptera: Pentatomidae)**

- **Common name:** Green stink bugs (*Acrosternum acutum* and *Nezara viridula*) and brown stink bugs (*Atelocera* sp. and *Halydicoris* sp.).

- **Distribution:** Stinkbugs are widespread in the tropics and subtropics.

*Nezara viridula* is almost completely cosmopolitan, being widespread in the tropics and subtropics.

*Acrosternum acutum*: Africa.

*Atelocera* sp. and *Halydicoris* sp.: East Africa.

- **Description and bio-ecology:** Stink bugs are polyphagous, and are found in areas where okra and other vegetable crops in botanical families such as the Fabaceae, Solanaceae, Liliaceae and Brassicaceae are grown. Adult insects 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. When disturbed they emit an offensive smell. Females lay barrel-shaped, yellowish-white eggs usually in clusters on the lower surface of leaves. When they hatch, nymphs remain clustered for some time and do not disperse until the first moult. Generally speaking, the nymphs (immature stages) undergo 5 moults before reaching the adult stage. The nymphs are similar in shape to the adult but are smaller and initially wingless, but develop wing pads as they mature. All the insect stages feed on the sap of host plants. Nymphs of stink bugs are predominantly black when small become green as they mature.

- **Phenological stages of crop susceptibility:** Stink bugs attacks okra at all stages of development with a predilection for the floral buds and fruiting stages.

- **Appropriate periods for intervention:** Significant damage can occur during the floral bud and fruiting stages and measures should be implemented when large stink bug populations are apparent in those periods. Prior to the okra blossoming phase, it is not useful to take steps unless there are very large numbers of stink bugs in the dry season causing damage to young shoots that may prevent normal growth of juvenile plants.

- **Other host plants (and adverse previous crops):** Plants in the Malvaceae, Solanaceae, Cucurbitaceae, Fabaceae, Brassicaceae and Poaceae families are hosts for Stink bugs and hence adverse previous crops for okra culture.

- **Description of symptoms / damage:** Stink bug adults and nymphs pierce the plant to feed, injecting toxin that causes necrosis, resulting in small, raised blister-like spots on the pod. Attacked pods become yellow and wither and germination capacity of seeds is diminished. In moist weather, the puncture wounds can act as entry points for saprophytic fungi that contribute to fruit depreciation. Stink bug attack results occasionally on pod shedding. On very young pods, it causes twisting and distortion of the pods, rendering them unmarketable.

- **Conditions conducive to infestation:** The vicinity of wild or cultivated host plants, hot, dry periods of weather foster stink bugs abundance.

- **Methods of observation and intervention thresholds:** Stink bugs are detected by direct observation in the field. It is a large green stink bug that is conspicuous on the plants. No intervention threshold has been established so far for these okra pests. However, if insect populations proliferate during hot, dry weather that coincides with okra floral budding and fruiting stages, intervention may be worthwhile.

- **Prevention:**

- Do not grow okra in the vicinity of cotton or other wild or cultivated Malvaceae, Solanaceae, Cucurbitaceae, Fabaceae, Brassicaceae or Poaceae which act as host plants for Stink bugs.
- Monitor Stink bugs populations in the field by visual inspection.
- If small surfaces are involved, manually pick off the first specimens as soon as they are seen in the field.
- Conserve natural enemies. Egg parasitoids and ants (predators of eggs and nymphs) are important for natural control of stink bugs.



Adult *Acrosternum acutum* respectively on okra leaf and fruit (Photos, DOUMBIA, 2003)

- **Plant Protection Products application:** If stink bug infestation occurs from the seedling to the beginning of the blossoming stages, intervention is not advisable unless their numbers are high and weather is hot and dry. Otherwise, manually picking off the insects is sufficient. In the case of abundant populations, alternate treatments with substances listed in annex 1. Neem seed kernel extract (750 g seed extract/15 l water), can be effective in controlling the pest and restricting the damage it causes. If there is a risk of stink bug proliferation from floral budding stages to harvest, pesticides with low PHI should be used (see annex 2). If possible, use insecticides that are and do not adversely affect predators and parasitoids. Spraying should be done in the morning when nymphs and adults bask outside the plant canopy.

### *Agrotis* spp. (Lepidoptera: Noctuidae)

- **Common name:** Cutworm.
- **Distribution:** Cosmopolitan.
- **Description and bio-ecology:** The adult moth is about 20 mm long, with a wingspan of between 35 and 50 mm. Its body is grey-brown, with brown forewings with a zigzag shaped line running along the external margin outlining small black triangular markings. A centrally positioned moon-shaped spot on the forewing is prolonged externally by another wedge-shaped spot. The hind wings are white with well-defined dark brown veins and stripe on the margin. The larva is initially light green and becomes grey-brown, smooth with a light-coloured abdomen. Dorsally, it has two light-coloured longitudinal lines on each side of a darker midline. Four brown spots are perceptible laterally on each segment. Females tend to oviposit on grassy plots or ones with plant residues or debris. Eggs are laid either singly or in small clutches on the lower surface of the leaves close to the soil line or on moist soil. Young caterpillars are yellowish green with a blackish head. They feed on leaves while older ones feed on plant stems. When fully grown, caterpillars are grey black, smooth skinned and about 4-5 cm long. Pupation takes place in the soil and lasts some 5 to 6 weeks depending on the temperature. Both larvae and adults are active at dusk and at night.



Respectively, larva of *Agrotis* spp. and damage on okra seedling (Photo, DOUMBIA, 2003)

- **Phenological stages of crop susceptibility:** The seedling stage is the period of highest susceptibility to *Agrotis* spp. (from germination of seedling to singling).
- **Appropriate periods for intervention:** Steps must be taken as soon as the seeds germinate (4 to 5 days after seeding) until the singling stage (10 to 15 days post-seeding) whenever the characteristic damage caused by *Agrotis* spp. is seen in the field. If the stages of highest susceptibility coincide with the moist, rainy season, damage can be considerable if no steps are taken, as the insect proliferates far more rapidly during the period of moist weather or in humid areas such as shallows.
- **Other host plants (and adverse previous crops):** *Agrotis* spp. attacks a wide range of host plants, including most vegetable crops.
- **Description of symptoms / damage and % of losses:** Symptoms appear as the sudden wilting of seedlings, which then are severed at the soil line level. A characteristic sign of *Agrotis* spp. is that several seedlings on the plot are severed at the collar. In humid conditions, damage can be very extensive (30 to 50 % losses and sometimes more) thereby jeopardising the outcome of the okra culture.
- **Conditions conducive to infestation:** The vicinity of wild or cultivated host plants, periods of humid, rainy weather, heavy, moist, irrigated soil with dense vegetation.
- **Methods of observation and intervention thresholds:** Newly planted fields should be monitored for cut plants during the day. Monitoring of cutworm caterpillars should be done at dawn, since caterpillars hide in the soil during daytime (a depth of approximately 5 cm). They normally curl-up when disturbed. The caterpillars can also be trapped using boards that are laid out in the field under which they take shelter during the daytime. At the seedling stage, as soon as the first symptoms of cutworm attack appear (wilted seedlings, stalks severed at soil line level), it is advisable to undertake control measures commensurate with the extent of damage. No intervention threshold has been established for this pest on okra so far. However, in view of the fact that attacks tend to take place on seedlings that no longer develop as

a result of the stalk or collar being severed, control measures should be considered when 10 to 15% of the seedlings have been damaged. Control is normally not needed after plants are about 25-30 cm tall.

- **Prevention:**

- Proper soil preparation by deep ploughing so as to expose the soil-inhabiting larvae to predation and to desiccation by the sun.
- Flood irrigation kills cutworm caterpillars in the soil.
- If plants damaged by cutworms are found, the cutworms can be located near the damaged plants and destroyed.
- Ashes deter cutworms; they can be spread tickly around plants or mixed with the soil in the planting hole.
- A thin, dry stick inserted at the side of the young plant act as a mechanical barrier, reducing the number of plants cut by cutworms.
- Monitor *Agrotis* spp. populations during okra's period of vegetative growth using boards as traps.
- Conserve natural enemies to avoid cutworm outbreaks. A large number of natural enemies of cutworms have been recorded; the most common are larval parasitoids, mainly parasitic wasps and flies.

- **Plant Protection Products application:** If heavy, widespread infestations occur during periods that are favourable to insect abundance, localised treatment at the foot of the plants can be undertaken using granules insecticides. Alternatively, other insecticides (see annex 1) can be sprayed on the plant's base or collar. In addition, in view of the fact that mature larvae appear to be somewhat resistant to insecticides, bran- or broken rice-based bait mixed with insecticides can be used (30 to 50 kg bait/ha) to control *Agrotis* spp. larvae. As a rule, treatment should be performed in the early evening as soon as symptoms of attack have become perceptible.

#### *Aphis gossypii* Glover (Homoptera: Aphididae)

- **Common name:** Cotton aphid.
- **Distribution:** Warm areas of the world.
- **Description and bio-ecology:** *A. gossypii* is a polyphagous aphid that is found in farming areas. This insect lives in colonies on the lower surface of preferably juvenile, tender leaves or on floral buds. Adult are highly variable in colour ranging from pale yellow to green, dark green or dark grey to black. Apterous (wingless) adults are up to 1.8 mm long and oval-shaped. The antennae are shorter than the body, cornicles are blackish



Respectively, *Aphis gossypii* colony on the underside of a leaf, and symptoms of damage on okra seedlings (Photos, DOUMBIA, 2003)

- and the tail is dark. Alate (winged) adults are approximately 1.4 mm long with a dark grey head and thorax and often a green abdomen. Reproduction occurs exclusively by parthogenesis and viviparity. The development cycle is very short lasting 10 to 12 days at temperatures of 28° to 32° C. A female can produce some 150 to 200 offspring during her lifetime. In any one year, there may be several successive generations. The insect is present the year round during the okra growing period and that of other Malvaceae such as cotton. However, population density is low during periods of heavy rain. These aphids have a symbiotic relationship with ants - the latter provide protection to aphids from their predators, while feeding on the honeydew produced by the aphids.
- **Phenological stages of crop susceptibility:** Aphids attack okra at all stages of development, with a predilection for the juvenile stages.
- **Appropriate periods for intervention:** Intervention must take place as soon as damage due to feeding or the presence of aphid colonies on the lower side of leaves is detected, especially in view of the fact that this insect is a vector for many viral diseases. However, in the event of heavy infestation, the preferred periods of intervention are the seedling and floral bud stages.
- **Other host plants (and adverse previous crops):** Mainly plants in the families of the Malvaceae, Solanaceae Cucurbitaceae and Citrus act as hosts for this aphid and are adverse previous crops for okra culture.
- **Description of symptoms / damage and % of losses:** Symptoms are curling of leaves downwards and blisters. When the attack oc-

curs at the early seedling stage, internode growth is severely impaired causing the whole plant to be stunted. Sooty mould develops on the honeydew produced by aphids thereby diminishing the plant's photosynthetic activity. Aphids cause indirect damage when symptoms of viral diseases such as *Cucumber Mosaic Virus* are perceptible. *Aphis gossypii* is reported to transmit the Yellow Vein Mosaic in okra. In the event of an attack at the early seedling stage, losses may reach 100%, especially if the aphids are carriers of a virus.

- **Conditions conducive to infestation:** The vicinity of wild or cultivated host plants, periods of hot, moist weather, excessive use of pesticides that have destroyed the pest's natural enemies and encouraged resistant strains of *A. gossypii* to develop.
- **Methods of observation and intervention thresholds:** When, at the seedling stage, the first symptoms of an aphid attack are perceptible, or if aphid colonies are seen on the underside of leaves, chemical treatment should be undertaken if there is a risk that plants are infected by viral diseases in the area. If not, control is not advisable until the threshold of 30% infested plants is observed.
- **Prevention:**
  - Do not grow okra in the vicinity of cotton or other wild or cultivated Malvaceae, Solanaceae, Cucurbitaceae and Citrus plants, which are all host plants for *A. gossypii*.
  - Avoid planting okra near an aphid-infested crop or land from which an infested crop has been removed recently.
  - Comply with the okra crop protocol (proper spacing of seeds, suitable manuring plan, effective weed control, especially at the seedling stage) to ensure good growth and vigour of plants.
  - Monitor *A. gossypii* populations during the vegetative growth period of okra using yellow pan traps.
  - Conserve natural enemies. Numerous natural enemies of the cotton are found in okra fields. Among those parasitic wasps and predators such as ladybird beetles, predatory flies, lacewings and hoverflies are the most common natural enemies.
- **Plant Protection Products application:** Applying systemic products (For instance : thiamethoxam, imidacloprid, carbofuran) at the time of seeding to control aphid populations at the seedling stage. If, on the other hand, the risk of *A. gossypii* proliferation occurs during vegetative growth up to the beginning of blossoming, alternate treatments with substances listed in annex 1, may be advisable to reduce aphid populations and restrict the damage. During fruiting, pesticides with low PHI can be used to control aphids. However, active substances must be very conservatively used when there is no indirect aphid damage such as the spread of viral diseases. Use if possible insecticides that are selective in respect of the predators and parasitoids of *A. gossypii*

### *Bemisia tabaci* (Gennadius) (Homoptera: Aleyrodidae)

- **Common name:** Tobacco whitefly, the sweet potato whitefly.
- **Distribution:** Cosmopolitan.
- **Description and bio-ecology:** *B. tabaci* is a widely polyphagous whitefly that is found attacking vegetable crops. Adults are from 0.8 to 1 mm long and their wingspan is 25 mm; males are smaller than females. They have short antennae and their two pairs of wings are white, rounded and held tent-like over the body. Both their wings and body are coated with a powdery white wax. They lay their eggs on the underside of leaves to which they are attached by a short stalk. Nymphs are translucent and yellowish, and have the shape of a flattened, oval capsule laterally fringed with short wax filaments. The first instar is mobile while the following three are stationary and live beneath an irregularly shaped membranous integument. Pupae are light grey and transparent. The adult insect emerges from a T-shaped slit in the integument. The duration of egg incubation and the cycle for the four larval stages depends on ambient temperatures. The insects generally live in colonies on the underside of leaves and adults immediately disperse when disturbed. Adult insects engage in active flight from one plant to another but dispersal over large distances is done by the wind.
- **Phenological stages of crop susceptibility:** Okra is attacked by whiteflies at all stages of development with a predilection for the juvenile



Adult *Bemisia tabaci* (Photos, DOUMBIA, 2003)

stages. Furthermore, attacks by carriers of viruses at an early stage can be a real hazard to seedlings causing growth to stop and thus jeopardising the whole crop.

- **Appropriate periods for intervention:** Steps should be taken as soon as whitefly colonies are seen on a large number of plants, especially at the seedling stage and during dry periods. This is particularly important when symptoms of viral diseases carried by *B. tabaci* such as *Okra Leaf Curl Mosaic Virus* (OLCMV) appear on many of the seedlings. In any case, the preferred period for intervention if heavy infestations occur is from singling to the first harvest.
- **Other host plants (and adverse previous crops):** *B. tabaci* develops on more than 150 species of vegetable crops mainly in the Malvaceae, Solanaceae, Cucurbitaceae and Fabaceae families. Population are also important on cassava, sweet potato and Citrus.
- **Description of symptoms / damage and % of losses:** Direct damage caused by poison injected by *B. tabaci* bites when feeding, giving rise to chlorotic areas on the leaves and sprouts. Severely attacked leaves roll downwards, wither, turn brown and finally abscise as a result of the injection of toxic saliva into cells. Furthermore, the lower leaves become covered with blackish sooty mould on the honeydew excreted by the whiteflies. This in turn diminishes the photosynthetic leaf area and hence the fruit yield. In addition, seedlings may exhibit symptoms of various viral diseases such as *Okra Leaf Curl Mosaic Virus*, *Cotton Yellow Mosaic Virus* or *Hibiscus Yellow Vein Mosaic Virus*. These diseases cause stunting of the plants when attacks occur at an early stage. Direct losses attributable to bites may be in the region of 10 to 20 %. Indirect losses arising from transmission of viral disease can lead to total loss when the attack occurs at the seedling stage and under conducive conditions.
- **Conditions conducive to infestation:** The vicinity of wild or cultivated host plants, periods of dry weather, a humid, shaded and poorly ventilated environment, temperatures from 25° to 30 °C, excessive use of pesticides that has destroyed *B. tabaci*'s natural enemies and encouraged resistant strains to develop.
- **Methods of observation and intervention thresholds:** When, at the seedling stage, the first symptoms of a whitefly attack are perceptible, or if whiteflies colonies are seen on the underside of leaves, chemical treatment is advisable if plants are infected by viral diseases. If not, chemical control should not be implemented until a 30% threshold of infested plants is observed.
- **Prevention:**
  - Do not grow okra in the vicinity of host plants for *B. tabaci*.
  - Comply with the okra crop protocol (proper spacing of seeds, suitable manuring plan, effective weed control, especially at the seedling stage) to ensure good growth and vigour of plants.
  - Monitor whitefly populations during the vegetative growth period of okra using yellow sticky card traps or yellow pan traps containing soapy water.
  - Conserve natural enemies. Whiteflies are mainly attacked by parasitic wasps (e.g. *Eretmocerus* spp. and *Encarsia* spp.) and predators such as phytoseiid mites, lacewings and ladybird beetles.
- **Plant Protection Products application:** Applying systemic products (thiamethoxam, imidacloprid, carbofuran) at the time of seeding can be helpful in controlling whitefly populations at the seedling stage. If, on the other hand, the risk of *B. tabaci* proliferation occurs during vegetative growth up to the beginning of blossoming, alternate treatments with substances listed in annex 1, may be advisable to control the pest. During fruiting, pesticides with low PHI can be used to control whiteflies. However, chemical substances must be very conservatively used when there is no indirect whitefly damage such as the spread of viral diseases. Use if possible insecticides that are selective in respect of the predators and parasitoids of *B. tabaci*.



***Brachytrupes membranaceus* (Drury) (Orthoptera: Gryllidae)**

- **Common name:** Cricket.

- **Distribution:** Tropical Africa.

- **Description and bio-ecology:** *B. membranaceus* is a polyphagous Orthoptera found in farming areas where subsistence and vegetable crops are grown. The adult insect is from 45 to 50 mm long and lives in extensive burrows. Its body is shiny black and the back of the head is of a lighter colour. The hind tibiae are equipped with large spurs. This is a polyphagous species and both larvae and adults feed on plants. The eggs are laid in the burrows which are also where juvenile larvae develop. The larva is similar in shape to the adult but smaller in size with wing pads at the nymphal stage.



Respectively larva and adult specimen of *Brachytrupes membranaceus* and damage on okra seedlings (Photos, DOUMBIA, 2003)

- **Phenological stages of crop susceptibility:** Seeds and seedlings are particularly susceptible to attacks from *B. membranaceus*.

- **Appropriate periods for intervention:** Steps should be taken when extensive characteristic damage has been ascertained on seedlings. When conditions are conducive to pest infestation, it is appropriate to take steps either prior to seeding by treating seeds with chemicals such as Imidacloprid (80 g a.i./100 kg of seeds), or at the time of seeding by depositing Carbaryl pellets in the seed spots (30 kg/ha). If damage is very extensive, treatment by spraying chemical substances may also be performed from germination to singling.

- **Other host plants (and adverse previous crops):** This is a widely polyphagous insect, which attacks a broad range of subsistence and vegetable crops.

- **Description of symptoms / damage:** This insect feeds on juvenile shoots and leaves and hence tends to devour the terminal buds of seedlings and cut their stalks off. Depending on the degree of cricket infestation of the field, many stalks can be seen to be cut, sometimes lying on the ground away from their initial position. In other cases, only the buds are damaged. The extent of the damage and incidence on crop yield depends on the abundance of *B. membranaceus*.

- **Conditions conducive to infestation:** Loose soil that is cool and humus-rich facilitates burrowing and periods of hot, moist weather foster *B. membranaceus* infestation.

- **Methods of observation and intervention thresholds:** At the seedling stage, when initial signs of cricket damage are visible (severed stalks), perform chemical treatments if justified by the number of damaged seedlings. For the time being, no threshold has been specified for this pest in the case of okra culture. However, if attacks kill seedlings as a result of stalks being severed, treatment should be considered when 10 to 15 % of seedlings are harmed.

- **Prevention:**

Deep ploughing (30 to 40 cm) destroys *B. membranaceus* burrows and exposes the larvae buried in the soil.

When possible, flooding the cultivated plots reduces pest populations.

Monitor *B. membranaceus* populations during the okra vegetative growth period using traps made from tin cans that are buried in the ground so as to be flush with the soil line.

- **Plant Protection Products application:** If major, widespread infestation appears during a period conducive to pest proliferation, spot treatment at the base of plants may be considered using pelleted insecticides. Alternatively, other pesticides (see annex 1) can be sprayed at the base or the collar of the plant. Another way of effectively controlling crickets is to use poisoned bait made from bran or broken rice mixed with insecticides such as carbaryl (25 g a.i./ (10 kg of bran + 8 to 10 l of water + 0.5 kg of sugar)).

**Cosmophila flava** Syn. *Anomis flava* Fabricius (Lepidoptera: Noctuidae)

- **Common name:** Cotton semi-looper.
- **Distribution:** Asia, Africa and South Pacific.
- **Description and bio-ecology:** *Cosmophila flava* is a moth whose wingspan is 30 to 35 mm in adults. It has a light brown body and the forewings have a reniform spot in the middle and wave-shaped lines across them. The outer edge of the forewing also has a wavy line and is dark brown in colour. The hindwing is yellowish brown. Females lay eggs singly or in groups on leaves. Newly hatched larvae are 3 mm long and whitish-creamy coloured, later on becoming pale green. Mature larvae are greenish with a slightly yellow head and have white lines going from the thorax to the tip of the abdomen. Larvae move in a characteristic manner by arching their bodies, which is why they are referred to as loopers. They are highly voracious and preferentially attack juvenile leaves. Pupation occurs either in the soil or in plant litter.
- **Phenological stages of crop susceptibility:** Okra is susceptible to *C. flava* attacks at all stages of development with a predilection for the stages from singling to initial harvests.
- **Appropriate periods for intervention:** Steps should be taken as soon as feeding damage or the presence of many *C. flava* larvae is observed, especially when this occurs between the singling stage and the first harvest of okra pods.
- **Other host plants (and adverse previous crops):** The insect appears to be feed only on plants in the Malvaceae family such as cotton and hibiscus.
- **Description of symptoms / damage:** Larvae feed on leaves, making holes, and sometimes attacked leaves are ripped up, leaving only the midrib and veins. The insect eats all the intermediate tissue mainly on the upper, juvenile leaves. The effects are more spectacular than damaging, as larval populations are most often small, allowing affected plants to recover and produce new leaves. However, intense proliferation of the insect during the rainy season can affect okra pod yield as a result of severe attacks on leaves and, moreover, on flowers, possibly generating significant losses.
- **Conditions conducive to infestation:** The vicinity of wild or cultivated host plants in the Malvaceae family, the rainy season, periods of hot, moist weather foster *C. flava* abundance.
- **Methods of observation and intervention thresholds:** Loopers and feeding damage can be detected by visually inspecting the plants. Outside of the rainy season, the impact of *C. flava* attacks is minor. No intervention threshold has so far been specified for this okra pest. However, if conditions are conducive to heavy infestation by the insect, steps should be taken especially if they occur at susceptible stages of plant development.
- **Prevention:**
  - Do not grow okra in the vicinity of cotton or other wild or cultivated Malvaceae, which are host plants for *C. flava*.
  - In areas where the pest is endemic, avoid overlap between the okra blossoming period and the rainy season.
  - Comply with the okra crop protocol (proper spacing of seeds, suitable manuring plan, effective weed control, especially at the seedling stage) to ensure good growth and vigour of plants.
  - Monitor *C. flava* populations during the vegetative growth period of okra by inspecting plants for loopers and damage.
  - In low populations, the larvae may be hand-picked and destroyed.
- **Plant Protection Products application:** Chemical control is not necessary for this pest unless there is extensive proliferation of insect populations. Alternate use of products listed in annex 1 taking into account PHI in annex 2 can be effective in controlling *C. flava* larvae. However, if treatment is required, pesticides selective in respect of the predators and parasitoids should be preferred (e.g. Bt-based insecticides or neem products).



*Cosmophila flava* larva and feeding damage on okra leaf

***Dysdercus* spp.** (Hemiptera: Pyrrhocoridae)

- **Common name:** Cotton stainers.
- **Distribution:** Tropical regions of the globe.

- **Description and bio-ecology:** Adult *Dysdercus* spp. are elongated, slender and about 1.5 to 2.5 cm long. These bugs are red to reddish-orange. The membranous apical parts of the hemelytron are dark while the basal corium has black spot across it. The insect's abdomen is ringed with red and white. The eggs are laid in moist soil or in crevices in the ground. They hatch in 7-8 days.



Respectively, adults (dorsal and ventral views), larvae and feeding damage by *Dysdercus* spp. on okra pods (Photos, DOUMBIA, 2003)

During initial development stages, the abdomen is bright red and shiny. Its head is black to begin with and gradually turns red over successive moults. Initially, the nymphs are wingless, but wings develop gradually as the nymph grows. The insect's development cycle from the egg stage to adult maturity lasts approximately 6 weeks.

- **Phenological stages of crop susceptibility:** Okra is susceptible from flowering to the end of harvest.
- **Appropriate periods for intervention:** Steps should be taken as soon as the insect is seen in the field, particular when pods are beginning to form.
- **Other host plants (and adverse previous crops):** Wild and cultivated Malvaceae are the major host plants for the insect and hence adverse previous crops for okra culture. Alternate host plants include kenaf, roselle, kapok and baobab. The latter is one of the major hosts of stainer bugs.
- **Description of symptoms / damage and % of losses:** When the insect attacks juvenile fruit, they tend to dry out and end up dropping off. Pods attacked when nearing maturity develop spots at the numerous toxic bite wound locations and dry out. In the case of crops intended for seed production, bitten seeds may lose part of their germination capacity. Furthermore, during moist weather, saprophytic fungi may invade pods through bite wounds thus deteriorating the fruit and intensifying losses. In the case of okra, losses may range from 20 to 50 % and sometimes more when attacks occur during humid weather that fosters development of saprophytic fungi.
- **Conditions conducive to infestation:** The vicinity of wild or cultivated host plants such as cotton, abutilon, hibiscus, and periods of humid weather are conducive to infestation. Infestation is intensified when okra fruiting coincides with the harvesting period for cotton.
- **Methods of observation and intervention thresholds:** Steps should be taken whenever extensive insect abundance is seen during the floral bud stage to prevent impact on marketable fruit yield. No specific intervention threshold has so far been defined for okra. However, during periods of moist weather, large insect populations should not be tolerated on fields cultivated for fruit production because of the risk of saprophytic fungal development that causes fruit decay. In seed production fields, inspections should begin from the floral bud stage to the harvesting of okra pods to avoid impairing seed germination capability due to damage from *Dysdercus* spp. bites.
- **Prevention:**
  - Do not grow okra in the vicinity of cotton or other wild or cultivated Malvaceae, which are host plants for *Dysdercus* spp.
  - In cotton-growing areas in particular, avoid overlap between the okra fruiting period and the cotton-harvesting season.
  - Plough deeply or hoe to expose eggs.
  - Harvest young pods regularly so as to restrict insect damage.
  - Destroy all plants after harvesting.
  - 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 eliminate bugs in 0.25 ha.
  - Monitor populations and feeding damage caused by the insect starting from the floral bud stage.
- **Plant Protection Products application:** Insect attacks occur at a sensitive stage of the okra growing cycle and as such require careful selection of the type of chemical products used. During the okra fruiting period, pods are picked every 2 or 3 days and so only insecticides with short PHIs should be used (see annex 2). Alternate use of active substances listed in annex 1 is advisable to control the pest and restrict damage.

***Earias* spp. (Lepidoptera: Noctuidae)**

- **Common name:** Spiny bollworm or spotted bollworm.
  - **Distribution:** Africa, Asia, Southern Europe and South Pacific.
  - **Description and bio-ecology:** *Earias* spp. are moths which when adult are approximately 12 mm long with a wingspan of about 20 mm. Adults are widely variable in colour depending on the season and species. In *E. biplaga*, forewings are yellowish while in *E. insulana* they are greenish. The female *E. biplaga* has a brown spot in the middle of her forewings. Eggs are deposited singly on the plant. Caterpillars are stocky, spindle-shaped and equipped with fleshy spines all over their bodies with a terminal setum and hairs. Caterpillars vary in colour according to the species. *E. biplaga* caterpillars are brown to reddish-brown. The chrysalis is around 10 mm long and light brown. Pupation occurs either inside the stalk, a shoot or a pod, or else on the ground in a cocoon. Depending on the conditions, pupation lasts from 9 to 16 days. Adults are nocturnal and feed on nectar.
- 
- Earias* spp. larva (Photo, DOUMBIA, 2000)
- **Phenological stages of crop susceptibility:** Okra susceptibility is high from flowering to end of harvest.
  - **Appropriate periods for intervention:** Steps should be taken as soon as large caterpillar populations are seen in the field, particularly when floral buds are forming up to the time of ripening and harvesting of pods.
  - **Other host plants (and adverse previous crops):** Wild and cultivated Malvaceae are the major host plants for the insect and hence adverse previous crops for okra culture.
  - **Description of symptoms / damage and % of losses:** The caterpillars feed on the content of floral buds, flowers and pods of okra plants. These organs are sometimes visibly perforated. On the pods, caterpillars dig entry points that are subsequently invaded by saprophytic fungi. The development of these fungi causes depreciation of the fruit. Juvenile fruit that are attacked by the insect drop off. Heavy attacks can substantially reduce fruit yield (80%), especially during periods of rainy or humid weather that foster development of saprophytic fungi. Spiny bollworm caterpillars may also bore into terminal shoots of young plants, causing death of the tip and subsequent development of side shoots. When podding starts, caterpillars move to the flower buds.
  - **Conditions conducive to infestation:** The vicinity of wild or cultivated host plants such as cotton, abutilon, hibiscus, periods of humid weather, excess nitrogen fertilisation. Infestation is intensified when okra fruiting coincides with the end of the cotton-growing season.
  - **Methods of observation and intervention thresholds:** Steps should be taken to protect plants whenever major insect abundance is seen during the floral bud stage to avoid impact on marketable fruit yield. Pheromone traps can be used to control adult flights. Inspecting the attacked fruit and dissecting them provides an indication of the size of larval population. For this purpose, 50 to 100 plants should be randomly selected. Infestation thresholds from 1.26 % to 25 % can serve as the basis for triggering treatment depending on the season, the crop's development stage and the insect's larval stage.
  - **Prevention:**
    - Do not grow okra in the vicinity of cotton or other wild or cultivated Malvaceae, which are host plants for *Earias* spp.
    - In cotton-growing areas in particular, avoid overlap between the okra fruiting period and the cotton harvest.
    - Destroy and burn all residues of potential *Earias* spp. host plants.
    - Deep plough so as to expose the larvae.
    - Avoid excessive nitrogen fertilisation. High doses of nitrogen fertilisers have been found to increase spiny bollworm infestation.
    - Monitor insect populations and feeding damage as of shortly before the onset the floral bud stage. It is important to detect eggs and caterpillars before they bore into the pods.
    - Hand-pick and destroy eggs and small caterpillars, and damaged tips and pods. This is feasible in small plots.
    - Conserve natural enemies. Egg and larval parasitoids and predators are important natural enemies.

- **Plant Protection Products application:** Insect attacks occur at a sensitive stage of the okra growing cycle, requiring careful selection of the type of chemical products used. During the okra fruiting period, pods are picked every 2 or 3 days and so only insecticides with short PHIs should be used (see annex 2). Alternate use of active substances listed in annex 1 is advisable to control the pest and restrict damage. If chemical treatment is considered necessary, pesticides selective in respect of the predators and parasitoids should be preferred

***Frankliniella* spp.** (Thysanoptera: Thripidae)



Thrips damage on okra pod. Note scarring and pod deformation (Photo: Varela, 2004)



Adult *Frankliniella* thrips yellowish in colour on the right. On the left is a larva (wingless, yellowish) (Photo: Varela, 2004)

- **Common name:** Thrips. *Frankliniella occidentalis* (The western flower thrips), *F. schultzei* (the cotton bud thrips).
- **Distribution:** *Frankliniella occidentalis*: the Americas, Europe, New Zealand, Australia, parts of Asia, and Africa. *Frankliniella schultzei*: sub-Saharan Africa, South and Southeast Asia, The Pacific and Australia.
- **Description and bio-ecology:** Adults of *Frankliniella* thrips are small (0.9-1.4 mm in length) slender, winged and pale brownish yellowish in colour. The wings are long, narrow and fringed with long hairs; at rest the wings are tied dorsally along the body. The female insert 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 have short wing pads, are inactive and do not feed. Juvenil stages are yellowish in colour. 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 lifespan is 2-3 weeks. Thrips migrate actively between different hosts.
- **Phenological stages of crop susceptibility:** Thrips can attack okra in the seedling and early juvenile stages, feeding and laying eggs on the young leaves. However, large numbers of flower and bud thrips are common at the flowering and podding (fruiting) stages of the crop.
- **Appropriate periods for intervention:** Control measures should be undertaken when thrips are detected at the onset of flowering period. *Frankliniella* thrips are usually found in large numbers when it is hot and dry.
- **Other host plants (and adverse previous crops):** *Frankliniella* thrips feed on a wide variety of plants.
- **Description of symptoms / damage:** Thrips feed on the lower surface of the leaves, on flowers and fruits. Damage results from both larvae and adults puncturing the plant tissue and sucking the exuding sap. Attacked plant parts frequently have a silvery sheen and show small dark spots of faecal material. Thrips attack on young plants may delay crop development. Flower thrips feeding on flower buds and flowers may lead to flower abortion or may result in deformed pods. Thrips feeding on pods causes scarring and a rough, silvery texture on the skin reducing the market value. Attacked pods are not fit for export.
- **Conditions conducive to infestation:** the vicinity of wild or cultivated host plants. *Frankliniella* thrips can be found in large numbers when it is hot and dry. In general, thrips numbers tend to be much higher during the hot and dry season.
- **Methods of observation and intervention thresholds:** For early detection of thrips shake the leaves or flowers on a white piece of paper and check for the presence of thrips. No intervention thresholds have been developed for thrips on okra.

- **Prevention:**
  - Conserve natural enemies. Predators in particular (e.g. predatory bugs, predatory mites and predatory thrips) are important in natural control of thrips.
  - Plough and harrow before planting a new okra crop; this helps to reduce subsequent thrips attacks by killing pupae in the soil.
  - Monitor insect population and damage. Pay particular attention at the onset of flower bud formation.
- **Plant Protection Products application:** Thrips are difficult to control with insecticides due to their secretive habits. Some species of *Frankliniella* thrips are known to quickly develop resistance to pesticides. When chemical control is necessary, insecticides should only be used up to the early flowering stage, alternatively only insecticides with short PHIs should be used (see annex 2). Spraying after flowering at a later stage could lead to pesticide residues on the pods.

### *Gryllotalpa* spp. (Orthoptera: Gryllotalpidae)

- **Common name:** Mole-cricket.
- **Distribution:** Africa, Asia, Caribbean and South Pacific.
- **Description and bio-ecology:** Adult specimens are 40 mm long and brown with lighter elytra. Their forelegs are broad and strong and suited to burrowing, which is why they are referred to as digging legs. The insect's prothorax is ovate and partially conceals the head that is equipped with powerful, chewing-type mouthparts. Adults inhabit underground tunnels that they dig. Eggs are deposited inside the tunnel in a chamber, which also accommodates juveniles once they hatch. The insect lives in loose, cool soil where it can dig its tunnels.
- **Phenological stages of crop susceptibility:** The seeding and seedling stages are particularly susceptible to attacks by *Gryllotalpa* spp.
 

Respectively, adult *Gryllotalpa* spp. and okra leaf pieces at the entrance of a burrow (photos, DOUMBIA, 2003)
- **Appropriate periods for intervention:** Seeds, seed spots or seedlings should be treated depending on whether the environment is an endemic one or when weather conditions are conducive to pest damage. This is done by either treating seeds prior to sowing using products such as Imidacloprid (80 g a.i./100 kg of seeds), or at seeding time by depositing Carbaryl pellets (30 kg/ha) in the seed spots. If damage is very extensive, chemical spray treatment can also be conducted after germination and up to singling.
- **Other host plants (and adverse previous crops):** This is a widely polyphagous insect in the same way as *B. membranaceus* and attacks a broad range of vegetable and subsistence crops.
- **Description of symptoms / damage:** Mole-crickets disrupt seedbeds by digging holes and tunnels. Hence seeds either fail to germinate subsequent to attacks or else are moved thereby disrupting crop alignment. Furthermore, attacks on seedlings may sever the stalk at the soil line level. Leaves are often uneven and jagged at the edges. Depending on abundance of *Gryllotalpa* spp., damage may be extensive and jeopardise crop yields.
- **Conditions conducive to infestation:** Loose, cool, humus-rich soil that facilitates burrowing, hot, moist periods of weather.
- **Methods of observation and intervention thresholds:** At the seedling stage when the first symptoms of *Gryllotalpa* spp. attacks are seen (severed tigella, jagged leaves, disruption of seedling alignment), chemical treatment should be undertaken depending on the degree of damage. Just as with *B. membranaceus*, no specific intervention threshold on okra has so far been specified for this pest. However, if attacks cause seedlings to die as a result of their stalks being severed, treatment may be considered when 10 to 15 % of the seedlings are damaged.

- **Prevention:**

Deep ploughing (30 to 40 cm) destroys *Gryllotalpa* spp. burrows and exposes the larvae buried in the soil.

When possible, flooding the cultivated plots contains pest populations.

Monitor *Gryllotalpa* spp. populations during the okra vegetative growth period using traps made from tin cans that are buried in the ground so as to be flush with the soil line.

- **Plant Protection Products application:** If major, widespread infestation appears during a period conducive to pest proliferation, spot treatment at the base of plants may be considered using pelleted insecticides. Alternatively, other insecticides can be sprayed at the base or the collar of the plant (see annex 1). Another way of effectively controlling crickets is to use poisoned bait made from bran or broken rice mixed with insecticides such as carbaryl (25 g a.i./ (10 kg of bran + 8 to 10 l of water + 0.5 kg of sugar)).

***Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae)**

- **Common name:** Cotton bollworm, African bollworm.

- **Distribution:** Africa, Asia, Europe and South Pacific.

- **Description and bio-ecology:** The adult *H. armigera* is 14 to 16 mm long with a wingspan of 30 to 38 mm. It has green eyes and femurs that are thickly covered with setae. Its forewings are greyish-green in males, and greyish-brown, greyish-yellow or pale reddish brown in females. These wings have wavy lines across them, a broad, brown submarginal stripe and a reniform spot of the same colour as the wings. Lines and spots are often more marked in females. Hindwings are pale grey with a blackish or brownish border that extends all the way to the edge of the wing and contains two small lighter spots. Adults are nocturnal and females lay their eggs singly on the upper side of juvenile leaves, often on the floral stalk or the fruit. After three to five days of incubation, the young larvae hatch reaching a size of 40 mm by the time pupation is imminent. Larvae are generally variable in colour from pale green, yellow, pink, brown and black, giving the impression that different species are involved. However, a broad lateral band of pale colour above the spiracles is almost always visible together with a dark dorsal stripe lengthwise, which is useful for identification purposes. At the end of its development cycle, the caterpillar burrows into the soil to a depth of approximately 5 cm to pupate. The larval cycle lasts between 15 and 35 days while pupation lasts from 15 to 25 days depending on ambient conditions.



Dorsal and lateral view of adult *Helicoverpa armigera* larva (Photo, DOUMBIA, 2000)

- **Phenological stages of crop susceptibility:** Okra is susceptible during the period from flowering to end of harvest.
- **Appropriate periods for intervention:** Steps should be taken as soon as large populations of caterpillars are seen in the field, especially when floral buds are forming until fruit ripening and harvest.
- **Other host plants (and adverse previous crops):** *H. armigera* is a widely polyphagous species that lives at the expense of many host plant species belonging mainly to the Malvaceae, Solanaceae, Fabaceae, Cucurbitaceae, Brassicaceae, Liliaceae and Poaceae families, which are therefore adverse previous crops for okra culture.
- **Description of symptoms / damage and % of losses:** Caterpillars attack floral buds, flowers and pods. They make large holes in the leaves, eat into floral buds and perforate pods producing cavities of various sizes. Saprophytic fungi invade the fruit through these holes causing them to depreciate. Attacks on juvenile fruit cause them to drop. Heavy attacks may substantially reduce fruit yield (80%), particularly during periods of rainy or humid weather that foster development of saprophytic fungi.
- **Conditions conducive to infestation:** The vicinity of wild or cultivated host plants, periods of hot, moist weather foster *H. armigera* infestation. Infestation is intensified when okra fruiting coincides with the end of the cotton-growing season.

- **Methods of observation and intervention thresholds:** Steps should be taken to protect plants whenever major insect abundance is seen during the floral bud stage to avoid impact on the marketable fruit yield. Pheromone traps can be used to monitor adult. Inspecting the attacked fruit and dissecting them provides an indication of the size of larval population. In this case, larva or attacked plants can be counted in the same ways as for *Earias* spp. on cotton. For this purpose, 50 to 100 plants should be randomly selected. Infestation thresholds from 1.26 % to 25 % can serve as the basis for triggering treatment depending on the season, the plant's development stage and the insect's larval stage.
- **Prevention:**
  - Do not grow okra in the vicinity of other *H. armigera* host plants.
  - Avoid overlap between the okra fruiting period and the cotton harvest, especially in major cotton-growing areas.
  - Destroy and burn all debris of potential *H. armigera* host plants.
  - Deep plough so as to expose the pupae.
  - Harvest young pods regularly so as to restrict insect damage.
  - Monitor populations and feeding damage caused by the insect starting from the floral bud stage. 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.
  - Monitor moth populations using traps.
  - Hand-pick and destroy eggs and small caterpillars. This is feasible when the numbers are low.
  - Conserve natural enemies. 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.
- **Plant Protection Products application:** Insect attacks occur at a sensitive stage of the okra growing cycle and as such requires careful selection of the type of chemical products used. During the okra fruiting period, pods are picked every 2 or 3 days and so only insecticides with short PHIs should be used (annex 2). Alternate use of active substances listed in annexe 1 is advisable to control the pest and restrict damage. If chemical treatment is considered necessary, pesticides selective in respect of the predators and parasitoids should be preferred. (e.g. Bt-based pesticides or some plant extracts such as neem products).

***Jacobiasca lybica* (de Bergevin) (Homoptera: Cicadellidae)**



Respectively larvae, exuvia and adult specimens of *Jacobiasca lybica* on the lower surface of okra leaf, and leaf symptoms and damage from the insect (Photos, DOUMBIA, 2003)

- **Common name:** Leafhopper or jassid.
- **Distribution:** Africa, South America, Asia and southern Europe.
- **Description and bio-ecology:** *Jacobiasca lybica* is a Homoptera in the family of the Cicadellidae. Adults are between 2.5 and 3 mm long. It is a lively, light to yellowish green insect, which hops or flies whenever there is any disturbance in its immediate vicinity. It can be carried by the wind over large distances. The egg stage lasts from 6 to 10 days and the larval stage (similar to the adult) lasts from 8 to 16 days. Nymphs move sideways. During the daytime, they lie on the underside of the leaves sheltered from the sunlight and make their way to the upper side at night.
- **Phenological stages of crop susceptibility:** Okra is attacked at all stages of development by jassids, but susceptibility is greater in the juvenile stages.



- **Appropriate periods for intervention:** Steps should be taken as soon as feeding damage or the presence of insects is observed in the field, especially at the seedling stage. It is essential to take steps if populations or feeding damage become abundant, especially between the singling stage and the first harvest of okra pods (10 to 45 days after seeding).
- **Other host plants (and adverse previous crops):** Malvaceae, Cucurbitaceae, tomato, sweet pepper and eggplant are hosts for leafhoppers and therefore adverse previous crops for okra culture.
- **Description of symptoms / damage:** To begin with, leaves yellow starting from the edges. Then the edges become brown or red and discolouring extends to the intertrial area of the leaves. These symptoms are caused by injection of poisonous saliva by the leafhoppers during sucking. Severe attacks at the seedling stage prevent the plant from developing properly and jeopardise fruiting.
- **Conditions conducive to infestation:** The vicinity of wild or cultivated host plants, periods of hot, humid weather, and excessive nitrogen fertilisation favour infestation.
- **Methods of observation and intervention thresholds:** At the seedling stage, when initial signs of jassid damage are visible (severed stalks?), perform chemical treatments when populations are large or if leaf discolouring is apparent in the field. There is no need for urgent intervention after okra fruiting. No specific intervention threshold has been defined for this insect. In Senegal the threshold is 1 jassid per leaf until the first harvest. Then 5 insects per leaf until the period of maximum of harvest. After the peak of harvesting it is not considered useful to treat against jassid.
- **Prevention:**
  - Do not grow okra in the vicinity of Malvaceae, tomato, sweet pepper or eggplant, which are host plants for jassids.
  - Comply with the okra crop protocol (proper spacing of seeds, suitable manuring plan, effective weed control, especially at the seedling stage) to ensure good growth and vigour of plants.
  - Monitor jassid populations and feeding damage during the vegetative growth period of okra by inspecting plants.
- **Plant Protection Products application:** If infestation becomes apparent between the seedling stage and the beginning of blossoming, alternate use of active substances listed in annex 1 may be effective in controlling the pest and restricting damage. Intervals between spraying treatments depending on insect abundance may be 15 days. During the fruiting period, it is usually not useful to perform treatments, as the impact is much less serious at this stage.

### *Lagria villosa* (Fabricius) (Coleoptera: Tenebrionidae)

- **Common name:** Lagriid beetle
- **Distribution:** Africa and South America.
- **Description and bio-ecology:** *Lagria villosa* is a polyphagous beetle found in vegetable and subsistence crop growing areas. Adults are between 10 and 14 mm long and elongate in shape. Their elytra are shiny olive green to metallic blue, with a darker head and pronotum. The antennae are well articulated and progressively widen going from base to tip. The larvae live on the ground where they feed on decaying plant material.
- **Phenological stages of crop susceptibility:** Okra is susceptible to *L. villosa* attack at all stages of development but particularly from singling to the first okra pod harvest.
- **Appropriate periods for intervention:** When justified, steps should be taken between singling and the first harvest, especially when those stages coincide with the rainy season, which is conducive to extensive proliferation of *L. villosa*.
- **Other host plants (and adverse previous crops):** Wild and cultivated Malvaceae, bean, soya, maize, pineapple and other vegetable crops serve as hosts for *L. villosa*.



Adult specimen of *Lagria villosa* (Cliché, DOUMBIA, 2000)

- **Description of symptoms / damage:** Holes of variable size appear on the lamina as a result of the insect feeding on the foliar tissue. The economic impact of *L. villosa* is minor because it is not voracious and is rarely abundant on okra except in the rainy season. Additionally, the impact of attacks is offset by production of new leaves.
- **Conditions conducive to infestation:** The vicinity of wild or cultivated plant hosts, and periods of hot, humid weather are conducive to infestation.
- **Methods of observation and intervention thresholds:** The pest can be detected by visual inspection because of its highly visible colouring. No specific intervention threshold has been defined for this okra pest whose impact is generally low.
- **Prevention:**
  - Do not grow okra in the vicinity of host plants for *L. villosa*.
  - Comply with the okra crop protocol (proper spacing of seeds, suitable manuring plan, effective weed control, especially at the seedling stage) to ensure good growth and vigour of plants.
  - Monitor *L. villosa* populations during the vegetative growth period of okra by inspecting plants.
- **Plant Protection Products application:** as a general rule, there is no justification for chemical treatment against *L. villosa* considering its low economic incidence on okra culture. If chemical treatment is necessary due to heavy proliferation of the insect, the alternate use of products listed in annex 1 may be effective in controlling *L. villosa* populations and restricting damage.

*Liriomyza trifolii* (Burgess), *Liriomyza huidobrensis* (Blanchard), *Liriomyza sativae* (Blanchard) (Diptera : Agromyzidae)

- **Common name:** Leafminers.
- **Distribution:** Cosmopolitan.
- **Description and bio-ecology:** *Liriomyza trifolii* is a polyphagous insect found in vegetable crop growing areas. The adult insect is a fly, from 1.5 to 2.3 mm long and has a black dorsum with one large yellow spot and two small yellow spots just behind the thorax. The sides are whitish-yellow. The abdomen of adults is black, narrow and covered with long setae; wings are transparent and densely pubescent. Females are very active at daytime and oviposit below the foliar epidermis through an ovipositor. The larvae hatch within 2 to 5 days, are yellow and are equipped with a discernible black claw. The larvae dig twisting tunnels as they feed on the foliar parenchyma. Following larval development, pupation occurs outside those tunnels on the leaves or in the upper layers of the soil.
- **Phenological stages of crop susceptibility:** Okra is liable to attack from leaf miners at all stages of development, but with a predilection for the juvenile stages (from emergence to the first harvest of okra pods).
- **Appropriate periods for intervention:** Steps should be taken as soon as feeding damage by adults occurs (tiny whitish dots on the leaf lamina) or larval tunnels are seen particularly between germination and floral bud initiation.
- **Other host plants (and adverse previous crops):** Plants in the families of the Malvaceae, Solanaceae, Cucurbitaceae, and Fabaceae are hosts for *L. trifolii* and as such adverse previous crops for okra culture.
- **Description of symptoms / damage:** Symptoms are visible on leaves in the form of whitish wavy lines, which are the tunnels, dug by the larvae. In addition, feeding damage by adults appear on lamina as numerous tiny whitish spots. Leaves that have been attacked by larvae then become necrotic when the larvae emerge and large portions turn brown thereby reducing photosynthetic activity. In the rainy season, saprophytic fungi may invade the damaged leaves. If attacks occur early in the rainy season, losses can be significant.
- **Conditions conducive to infestation:** The vicinity of wild or cultivated host plants, periods of humid weather, shading, excessive use of pesticides that has destroyed leafminer natural enemies favour infestation.



Symptoms of attack by leaf miner (*Liriomyza* spp.) larvae on okra leaves (Photo, DOUMBIA, 2003)

- **Methods of observation and intervention thresholds:** Visual inspection is enough to ascertain the presence of leafminers and extent of damage on plants. For the time being, no specific intervention threshold has been defined for this pest on okra.
- **Prevention:**
  - Do not grow okra in the vicinity of wild or cultivated Malvaceae, or Solanaceae, Cucurbitaceae, Fabaceae, which are host plants for *L. trifolii*.
  - Destroy and burn post-harvest plant residues.
  - Plough the soil prior to seeding to destroy pupae.
  - Comply with the okra crop protocol (proper spacing of seeds, suitable manuring plan, effective weed control, especially at the seedling stage) to ensure good growth and vigour of plants.
  - Reduce areas of shade during hot, sunny periods.
  - Monitor leafminer populations during the vegetative growth period of okra by inspecting plants for damage from adult feeding and for larval tunnels on leaves.
  - Conserve natural enemies. Leafminers are normally controlled by naturally occurring larval parasitoids, but use of insecticides for control of leafminers or other pests disrupts the natural control of leafminers.
- **Plant Protection Products application:** If necessary, use only insecticides that are selective with regard to the predators and parasitoids of leafminer. Lyriomiza leafminers rapidly develop resistance to insecticides. If infestation is apparent from the seedling stage to floral bud initiation, alternate use of active substances listed in annex 1 may be effective in controlling damage.

#### *Mylabris* spp. (Coleoptera: Meloidae)

- **Common name:** Blister beetles, flower beetles.
- **Distribution:** Cosmopolitan.
- **Description and bio-ecology:** *Mylabris* spp. are polyphagous beetles found in vegetable and subsistence crop growing areas. Adults have a cylindrical, elongate shape and are soft with black elytra with yellow to yellowish orange spots across them. The head is clearly distinguishable from the prothorax. Adult size varies from 12 to 16 mm. Females lays eggs in clusters on the ground. These hatch in about two weeks depending on ambient conditions. Larval development is highly complex. The larvae inhabit the soil and are predators of Orthoptera eggs, while adults are phytophagous and feed on the leaves and floral organs of plants.
- **Phenological stages of crop susceptibility:** The crop is susceptible to blister beetle attacks from floral buds initiation to pod harvest.
- **Appropriate periods for intervention:** Steps should be taken as soon as feeding damage by adults is seen on the leaves and floral organs when the pest is abundant. The blossoming period is particularly important inasmuch as destruction of flowers jeopardises fruit yield.
- **Other host plants (and adverse previous crops):** Plants in the Malvaceae, Solanaceae, and Fabaceae families are hosts for blister beetles and hence adverse previous crops for okra culture.
- **Description of symptoms / damage:** Symptoms are visible on the leaves in the form of holes on the lamina. On floral organs, the petals, stamen and pistil are all devoured. This gives rise to varying degrees of seed abortion. As a result, losses may be extensive depending on the severity of pest infestation.
- **Conditions conducive to infestation:** The vicinity of wild or cultivated plant hosts, and periods of hot, humid weather are conducive to *Mylabris* spp. infestation.
- **Methods of observation and intervention thresholds:** Insects and the damage they cause on floral organs can very easily be detected by visually inspecting okra plants during their growing season, particularly at blossoming. No specific intervention threshold has so far been defined for this pest on okra. Nonetheless, no more than 10 to 15 % of plants showing symptoms should be tolerated to avoid jeopardising fruit yield.



A number of *Mylabris* spp. specimens (Photo, DOUMBIA, 2000)

- **Prevention:**

- Do not grow okra in the vicinity of other wild or cultivated Malvaceae, or of Solanaceae and Fabaceae that are host plants for blister beetles.
- Comply with the okra crop protocol (proper spacing of seeds, suitable manuring plan, effective weed control, especially at the seedling stage) to ensure good growth and vigour of plants.
- In the case of small populations, pick off adults by hand. However, care should be taken when hand-picking the beetles, 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 grasshopper's eggs.
- Monitor blister beetle populations during the blossoming stage of okra by visually inspecting plants.

- **Plant Protection Products application:** If chemical control is necessary, the alternate use of products listed in annex 1 is advisable to control blister beetle populations and restrict damage.

***Nisotra* spp.** (Coleoptera: Chrysomelidae)

- **Common name:** Flea beetles.

- **Distribution:** Africa, Asia.

- **Description and bio-ecology:** *Nisotra* spp. are polyphagous chrysomelid beetles found on farms growing vegetable and subsistence crops. The adult is 3 mm long and has shorter, oval elytra that are metallic blue. The head and pronotum are rust-coloured. They have well-developed, spring-like muscles in their enlarged hind legs that enable them to jump long distances when disturbed. These insects generally gather in large numbers on one plant, often assembling on the lower surface of one leaf. They are found all year round when food is abundant. Eggs are laid on the soil close to the host plants. Larvae hatch in the soil; they are whitish, very small and have tiny legs and a dark head. They feed on roots and plant debris. Pupation takes place in the soil.



Adult specimens of *Nisotra* spp. (Photo, DELHOVE, 2002)

- **Phenological stages of crop susceptibility:** Okra is attacked by *Nisotra* spp. at all stages of development.
- **Appropriate periods for intervention:** Steps should be taken as soon as feeding damage by adults or the presence of *Nisotra* spp. is seen in the field, especially at the seedling stage and during hot, moist weather. As the insect also attacks pods, interventions may also take place during fruiting and are particularly useful because damage at this stage depreciates the fruit's market value.
- **Other host plants (and adverse previous crops):** Malvaceae are flea beetle hosts and as such adverse previous crops for okra culture.
- **Description of symptoms / damage and % of losses:** Numerous tiny holes appear on the leaves and diminish the leaf area. *Nisotra* spp. also attack juvenile pods and perforate them. These feeding sites are then invaded by saprophytic fungi. Young seedlings are the most vulnerable. Heavy insect attacks at the initial stages of the growing season can seriously jeopardise okra yield entailing losses of 30 to 70 %.
- **Conditions conducive to infestation:** The vicinity of wild or cultivated host plants, periods of hot, moist weather, soil that is light, crusted or poor in organic material, excessive nitrogen fertilisation favour infestation.
- **Methods of observation and intervention thresholds:** *Nisotra* spp. can be detected by visual inspection of the field or yellow pan traps. Additionally, their presence is apparent from feeding damage on leaves. Frequent monitoring is important as flea beetles are very mobile and disperse readily, thus, they can rapidly invade a field. Monitoring should be done at least three times per week during the seedling stage, and twice per week in later stages. No specific intervention threshold for this pest on okra has so far been defined. Nonetheless, considering that saprophytic fungi are liable to develop in moist weather, treatment may be undertaken when 15 to 20 % of plants are damaged. In dry periods, a higher threshold can be considered because the plants are approaching the blossoming stage. At the fruiting stage, an even lower threshold can be considered depending on insect abundance.

- **Prevention:**
  - Do not grow okra in the vicinity of other Malvaceae, which are host plants for *Nisotra* spp.
  - In the dry season prior to seeding, deep plough (30 to 40 cm) so as to expose the insect's soil-inhabiting larvae to drying out and predation.
  - Comply with the okra crop protocol (proper spacing of seeds, suitable manuring plan, effective weed control, especially at the seedling stage) to ensure good growth and vigour of plants.
  - Weed in and around fields, this may help to eliminate *Nisotra* spp. shelters and breeding grounds.
  - Monitor *Nisotra* spp. populations during the vegetative growth period of okra by inspecting plants and with yellow pan traps.
- **Plant Protection Products application:** Alternate use of active substances listed in annex 1 is advisable to control *Nisotra* spp. attacks. During the fruiting period, in view of the risk of chemical residues, pesticides with low PHI should be preferred for flea beetle control.

*Oxycarenus hyalinipennis* (Costa) (Heteroptera: Lygaeidae)

- **Common name:** Cotton seed bug.
- **Distribution:** Africa, South America, Asia, southern Europe.
- **Description and bio-ecology:** *O. hyalinipennis* is a Heteroptera pest for plants in the Malvaceae family. The size of an adult insect is approximately 4 to 5 mm. This is a small, narrow, flattened bug with a black body and translucent wings. The female oviposits singly or in small groups inside open okra pods. Nymphs hatch in 4 days and resemble adults although they are smaller and do not have wings. At all stages of development, the insect feeds by sucking various organs, with a preference for seeds.
- **Phenological stages of crop susceptibility:** The plant is most susceptible to *O. hyalinipennis* when fruit is ripe.
- **Appropriate periods for intervention:** In the case of okra intended for local consumption or for export, there is no need for intervention. However, for seed production, the appropriate period for intervention is when pods are approaching maturity because the insect causes loss of seed germination capability.
- **Other host plants (and adverse previous crops):** Plants in the Malvaceae family are the main hosts for *O. hyalinipennis* and hence adverse previous crops for okra culture.
- **Description of symptoms / damage:** Symptoms are visible in seed production fields on fruit whose seeds are attacked by *O. hyalinipennis* during the ripening process. The seeds are often wrinkled and have tiny brown or blackish dots, which are the insect bite wounds. These bites diminish the germination capacity of the damaged seeds. In the case of seed production crops, losses may be considerable.
- **Conditions conducive to infestation:** The vicinity of wild or cultivated host plants, and periods of hot, moist weather favour infestation.
- **Methods of observation and intervention thresholds:** *O. hyalinipennis* can be detected by careful inspection of fruit during the fruiting stage as they near maturity or when pods open in the case of seed production. Groups of bugs are usually found between flowers buds, flowers and pods. No intervention threshold has been specified for this pest on okra. However, in the case of seed production, efforts should be made to avoid heavy insect infestation so as not to produce seeds that are unable to germinate.
- **Prevention:**
  - Do not grow okra in the vicinity of other wild or cultivated Malvaceae, which are host plants for *O. hyalinipennis*.
  - Harvest okra pods prior to their opening in seed production crops.
  - Visually inspect plants in seed-growing fields to monitor *O. hyalinipennis* populations during fruiting and as fruit near maturity.
- **Plant Protection Products application:** For crops intended for local consumption or export, there is no need for treatment. However, for seed production purposes, treatment may be necessary in the case of heavy infestation by *O. hyalinipennis*. If necessary, alternate use of products listed in annex 1 can be effective in controlling the pest and restricting damage.



Adult specimen of *Oxycarenus hyalinipennis*  
(Cliché, DOUMBIA, 2003)

***Pachnoda* spp. (Coleoptera: Scarabaeidae)**

- **Common name:** Cetonid.
- **Distribution:** Cosmopolitan.
- **Description and bio-ecology:** *Pachnoda* spp. is a beetle pest for many plant species. Adults are large and bulky, 20 to 25 mm long. They are black with either a lateral yellow stripe going around the body or orangey-yellow stripes across the elytra. Larvae are most often soil-inhabiting and feed on roots.
- **Phenological stages of crop susceptibility:** Okra is attacked by *Pachnoda* spp. at all stages of development.
- **Appropriate periods for intervention:** Steps should be taken as soon as feeding damage by adults is seen on the leaves, stalks and juvenile pods, especially following the first rains when the pest tends to proliferate.
- **Other host plants (and adverse previous crops):** *Pachnoda* spp. attack a large variety of plant species, as it is widely polyphagous.
- **Description of symptoms / damage:** Adult insects attack leaves and stalks as well as young okra pods. Damage to leaves and stalks causes abnormal growth of the plant and deformities. Young pods that are attacked are often invaded by saprophytic fungi and eventually drop off. Following the first rains, fields may become heavily infested by the insect leading to significant losses in crop.
- **Conditions conducive to infestation:** The vicinity of wild or cultivated host plants, and periods of hot, moist weather, especially the rainy season are conducive to infestation.
- **Methods of observation and intervention thresholds:** These large, bulky beetles are easily seen during the okra growing season by inspecting the plants. No specific intervention threshold has been defined for this pest on okra. However, heavy infestation following the beginning of the rainy season does require intervention, particularly if okra is at the fruiting stage.
- **Prevention:**
  - Do not grow okra in the vicinity of host plants for *Pachnoda* spp.
  - In the dry season prior to seeding, deep plough so as to expose the soil-inhabiting larvae and nymphs.
  - Comply with the okra crop protocol (proper spacing of seeds, suitable manuring plan, effective weed control, especially at the seedling stage) to ensure good growth and vigour of plants.
  - On small plots, manually pick off the specimens as soon as they are seen.
  - Monitor *Pachnoda* spp. populations during okra's growth cycle by inspecting plants.
- **Plant Protection Products application:** In the event of heavy *Pachnoda* spp. infestations, especially during the rainy season, insecticides may be used on okra depending on its stage of development. If infestation occurs, insecticides listed in annex 1 can be used to control *Pachnoda* spp taking into account PHI in annex 2.



Adult specimens of two *Pachnoda* spp. (Photo, DOUMBIA, 2000)

***Podagrica* spp. (Coleoptera: Chrysomelidae)**

- **Common name:** Flea beetles.
- **Distribution:** Africa, Asia and southern Europe.
- **Description and bio-ecology:** Adult insects are 3 to 4 mm long and light brown apart from the head and thorax that are dark brown. The adults are tiny have well-developed, spring-like muscles in their enlarged hind legs that enable them to jump long distances when disturbed. They generally live on the plant in large numbers, assembling on the lower side of a single leaf. They are found all year round when food is abundant. When food is scarce, adults take shelter in crevices in the soil. Eggs are deposited in the soil close to the host plants. Pupation takes place in the soil and the life cycle lasts 1 month on average.



Respectively, *Podagrica* spp. adults and damage on okra leaf and fruit  
(Photos, DOUMBIA, 2003)

- **Phenological stages of crop susceptibility:** Okra is susceptible to chrysomelid attack at all stages of development.
- **Appropriate periods for intervention:** Steps should be taken as soon as feeding damage or insects are seen in the field, especially at the seedling stage and in periods of hot, moist weather. Treatment can be implemented during the fruiting stage as insect damage depreciates fruit value. Some species of flea beetles such as *P. sjostedti*, *P. uniforma* and *P. decolorata* are reported as vectors of the okra mosaic virus in West Africa. *Podagrica* is one of the vectors of *Cotton Yellow Mosaic Virus* and if symptoms of this viral disease appear, steps should immediately be taken against the insect.
- **Other host plants (and adverse previous crops):** Malvaceae are hosts for chrysomelids and adverse previous crops for okra culture. The insect often develops on eggplant.
- **Description of symptoms / damage and % of losses:** Numerous tiny holes appear on the leaves and diminish the leaf area. *Podagrica* spp. also attack juvenile pods and perforate them. These feeding sites are then invaded by saprophytic fungi. Heavy *Podagrica* attacks at the initial stages of the growing season can seriously jeopardise okra yield with losses of 30 to 70 %. Indirect damage such as Cotton Yellow Mosaic Virus may considerably reduce yield.
- **Conditions conducive to infestation:** The vicinity of wild or cultivated host plants, periods of hot, moist weather, soil that is light, crusted or poor in organic material, and excessive nitrogen fertilisation favour infestation.
- **Methods of observation and intervention thresholds:** Frequent monitoring is important as flea beetles are very mobile and disperse readily, thus, they can rapidly invade a field. Monitoring should be done at least three times per week during the seedling stage, and twice per week in later stages. At the seedling stage, when the first symptoms of chrysomelid attacks are observed, chemical treatment should be undertaken if plants are seen to be affected by viral disease. Furthermore, considering that saprophytic fungal are liable to develop during humid weather, treatment may be undertaken when 15 to 20 % of the plants are damaged. In the dry season, the threshold can be higher when plants are nearing the flowering stage. Nonetheless, no overall threshold has been defined for this pest as its impact varies depending on the season, the stage in the plant's development cycle and the insect's status as carrier of viral disease.
- **Prevention:**
  - Do not grow okra in the vicinity of other Malvaceae or eggplant which are host plants for *Podagrica* spp.
  - In the dry season prior to seeding, deep plough so as to expose the soil-inhabiting larvae to drying-out and predation.
  - Comply with the okra crop protocol (proper spacing of seeds, suitable manuring plan, effective weed control, especially at the seedling stage) to ensure good growth and vigour of plants.
  - On small plots, manually pick off the specimens as soon as they are seen.
  - Monitor *Podagrica* spp. populations during okra's growth cycle by inspecting plants and using yellow pan traps.
- **Plant Protection Products application:** Alternate use of active substances listed in annex 1 is advisable to control *Podagrica* spp. attacks. During the fruiting period, in view of the risk of chemical residues, pesticides with low PHI should be used to control the chrysomelids. However, use of pesticides should be highly conservative unless *Podagrica* causes indirect damage such as spreading viral disease.

***Pseudococcus* spp.** (Homoptera: Pseudococcidae)

- **Common name:** Mealybugs.
- **Distribution:** Cosmopolitan.
- **Description and bio-ecology:** *Pseudococcus* spp. are polyphagous mealybugs found in vegetable and subsistence crop growing areas. Mealybugs live in colonies on the lower surface of preferably young, tender leaves, or on the floral buds. Adult females are pinkish and 1 to 3 mm long. Their body is covered with a fairly dense, cotton-like white secretion. The males are also pinkish in colour but smaller than females (1.5 mm). Eggs are deposited in clusters and when larvae hatch they wander for some time before settling on the plant. There is a symbiotic relationship between these mealybugs and ants – the ants protect the caterpillars and in return the latter produce honeydew that serves to feed ant larvae. In this way, ants help disseminate caterpillars in search of suitable hosts.
- **Phenological stages of crop susceptibility:** Okra is susceptible to mealybugs attack at all stages of development, with a predilection for the juvenile stages.
- **Appropriate periods for intervention:** Steps should be taken as soon as feeding damage or colonies are found on the lower surface of juvenile leaves or on floral buds so as to avoid insect dissemination, prevent growth disruption and diminished yields.
- **Other host plants (and adverse previous crops):** Plants in the Malvaceae, Solanaceae, Fabaceae, Bromeliaceae and Euphorbiaceae families are hosts for caterpillars and hence adverse previous crops for okra culture.
- **Description of symptoms / damage:** Symptoms occur as deformity and stunting of terminal shoots. Internodes are shortened and in extreme cases the plant withers and dies. Furthermore, the leaves located beneath the mealybugs colonies are covered with sooty mould thereby diminishing photosynthetic activity. Severe attacks interfere with plant growth and lead to substantial decreases in yield.
- **Conditions conducive to infestation:** The vicinity of wild or cultivated host plants, periods of hot, sunny weather, the presence of ants, and excessive use of pesticides that has destroyed the mealybug's natural enemies favour infestation.
- **Methods of observation and intervention thresholds:** The extent of mealybug attacks in okra fields can be assessed by visually inspecting the underside of the plant's leaves and looking for sooty mould. Chemical treatment should be undertaken as soon as the first symptoms of mealybug attacks are seen when conditions are conducive to pest proliferation (presence of ants, hot, sunny weather). No threshold has been defined for this pest on okra.
- **Prevention:**
  - Do not grow okra in the vicinity of host plants for *Pseudococcus* spp.
  - Comply with the okra crop protocol (proper spacing of seeds, suitable manuring plan, effective weed control, especially at the seedling stage) to ensure good growth and vigour of plants.
  - Control ants by ploughing up nests to destroy them.
  - Rapidly remove the affected plants before infestation becomes widespread.
  - Monitor *Pseudococcus* spp. populations during okra's growth cycle by inspecting plants.
  - Conserve natural enemies.
- **Plant Protection Products application:** If infestation occurs between singling and flowering, treatment with active substances listed in annex 1 may be effective in controlling caterpillar populations. On the other hand, if there is a risk of *Pseudococcus* spp. infestation from flowering to harvest, pesticides used must be limited to those with short PHI (2 days).



Adult specimens and larvae of *Pseudococcus* spp.  
(Photo, DOUMBIA, 2003)



### *Spodoptera* spp. (Lepidoptera: Noctuidae)

- **Common name:** Armyworms.

- **Distribution:** Cosmopolitan.



*Spodoptera* spp. larvae respectively on okra leaves and pods (Photos, DOUMBIA, 2003)

- **Description and bio-ecology:** *Spodoptera* spp. are polyphagous Lepidoptera found in vegetable and subsistence crop farming areas. The adult insect is a moth that can be up to 45 mm long in certain species with a wingspan of 30 to 40 mm. Forewings are narrow and vary in colour according to species. Wing markings are characteristic of these species. The forewings sometimes have several cross-, length-wise and oblique stripes on the upper part and seven narrow longitudinal stripes on the lower part in the case of *S. littoralis*. In *S. litura*, wings are marked with numerous lighter spots and lines. Adults are nocturnal and they deposit their eggs in clusters of several hundreds arranged in several layers as sticky masses covered with setae, hairs or scales from the female abdomen depending on the species. Larvae hatch after three or four days and their colour varies with age and according to species. There are three longitudinal lines on larvae, i.e. one middle one and two lateral. On each side above these lateral lines there is a dark band. The larval cycle can last three weeks and mature larvae may be up to 40 mm long. Pupation occurs underground at a depth of 3 or 4 cm and lasts one to two weeks.

- **Phenological stages of crop susceptibility:** Okra is attacked by *Spodoptera* spp. at all stages of development, with a predilection for juvenile stages.

- **Appropriate periods for intervention:** Steps should be taken as soon as feeding damage by juvenile larvae, which chew exclusively on the parenchyma of the lower surface of leaves, is visible. Treatment against older larvae is not always successful as they are more resistant to toxic chemicals. In addition, if attacks occur at an early stage on seedlings during a rainy period, treatment may be effective in restricting damage.

- **Other host plants (and adverse previous crops):** *Spodoptera* spp. are widely polyphagous moths that attack several species of plants belonging mainly to the Malvaceae, Solanaceae, Poaceae, Alliaceae, Fabaceae, and Brassicaceae families, which are hosts for the pest and hence adverse previous crops for okra culture.

- **Description of symptoms / damage:** Juvenile larvae attack the plant by scratching the parenchyma on the underside of leaves which then show through as yellow spots on the upper side. As for older larvae, they devour the entire leaf leading to complete defoliation. Caterpillars also attack the floral buds and open flowers as well as pods. Damage can be very extensive depending on the size of larval populations.

- **Conditions conducive to infestation:** The vicinity of wild or cultivated host plants, periods of hot, moist weather, loose, relatively dry soil that provides shelter to larvae and pupation sites, and excessive use of pesticides that has destroyed the insect's natural enemies (braconid, ichneumonid wasps, tachinid flies) favour infestation.

- **Methods of observation and intervention thresholds:** *Spodoptera* spp. can be very quickly detected by carefully inspecting the plants. In addition, pheromone traps can also be used to assess adult populations but involve a cost. No specific intervention threshold has been defined for okra. However, it is advisable to take steps while populations of young larvae are small and the plant is juvenile to avoid jeopardising the crop.

- **Prevention:**

- Do not grow okra in the vicinity of other wild or cultivated host plants for *Spodoptera* spp.
- Shallow plough so as to expose larvae and caterpillars to predation.
- Comply with the okra crop protocol (proper spacing of seeds, suitable manuring plan, effective weed control, especially at the seedling stage) to ensure good growth and vigour of plants.
- Manually pick off and incinerate egg clusters and young caterpillars while they are still assembled when small plots are involved.
- Monitor *Spodoptera* spp. populations during the okra growing season by visual inspection or using pheromone traps.
- Conserve natural enemies.

- **Plant Protection Products application:** Alternate use of products listed in annex 1 is advisable to control *Spodoptera* spp. larvae. However, if chemical treatment is necessary, selective insecticides with regard to the predators and parasitoids of *Spodoptera* spp. should be preferred.

***Sylepta derogata* (Fabricius) (Lepidoptera: Pyralidae)**

- **Common name:** Leafroller.
- **Distribution:** Cosmopolitan.
- **Description and bio-ecology:** *Sylepta derogata* is a Lepidoptera in the Pyralidae family. Adult wingspan is between 30 and 40 mm with creamy coloured wings spotted with complex, brown or black lines. The head and thorax of adults are spotted with black. Leaf rollers are translucent green with black legs and head. The female oviposits on the lower surface of leaves and the larvae hatch in 3 days. Older larvae cut out pieces in leaves, which they then roll to take shelter in and feed on. Pupation occurs either in the rolled leaves on the plant or in plant debris on the ground.
- **Phenological stages of crop susceptibility:** Okra is susceptible from the singling stage (10 to 14 days post-seeding) to the first harvests (45 to 55 days post-seeding), i.e., during the plant's vegetative growth.
- **Appropriate periods for intervention:** Steps should be taken as soon as damage by insects is seen in the field, especially at the seedling stage. If populations are large, particularly in the period from singling to the first okra pod harvest, it is essential to intervene failing which damage will be considerable.
- **Other host plants (and adverse previous crops):** Malvaceae are hosts for the *Sylepta* leafroller and hence adverse previous crops for okra culture.
- **Description of symptoms / damage:** Pieces of okra leaves are cut out and rolled by the leaf rollers where they hide. In many cases, when many leaves are affected, the leaf area and hence photosynthetic activity are diminished. In the event of heavy attacks, plant growth may be hindered.
- **Conditions conducive to infestation:** Shading and moisture may foster infestation together with the presence of wild or cultivated host plants in the vicinity of okra and periods of humid weather. In Côte d'Ivoire, *S. derogata* proliferation occurs during the rainy seasons.
- **Methods of observation and intervention thresholds:** At the seedling stage, as soon as the first signs of leaf roller attack appear (missing pieces, rolled leaves), chemical treatment should be undertaken if damage is very extensive. In many cases, heavy infestation at the beginning of the growing season will require treatment to avoid a sharp drop in fruit yield. No clearly defined threshold has been set out for this pest on okra.
- **Prevention:**
  - Do not grow okra in the vicinity of other Malvaceae which are host plants for okra leaf rollers.
  - Comply with the okra crop protocol (proper spacing of seeds, suitable manuring plan, effective weed control, especially at the seedling stage) to ensure good growth and vigour of plants.
  - Monitor leaf roller populations during the vegetative growth period of okra by inspecting plants.
  - Remove and destroy eggs, caterpillars and rolled leaves.
  - Conserve natural enemies. Leafrollers are attacked by parasitic wasps. Spiders and praying mantis are also important natural enemies of leafrollers.
- **Plant Protection Products application:** Alternate use of products listed in annex 1 is advisable to control *Spodoptera* spp. larvae.



Respectively *Sylepta derogata* larvae and damage on okra leaf (Photos, DOUMBIA, 2003)

### *Okra white grubs* (Coleoptera: Scarabeidae)

White grubs are the larvae of various species of beetles in the Scarabeidae family that inhabit the soil and feed on plant material. The few species found in Africa on okra are *Schizonycha* sp., *Heteroligus* sp., *Heteronychus* sp., and *Dryctes* sp.



White grub larvae and symptoms due to damage on whole okra plants and on the root system (Photos, DOUMBIA, 2003)

- **Distribution:** Cosmopolitan.
- **Description and bio-ecology:** White grubs are the larvae of widely polyphagous beetles found in farming areas. The antennae of adults generally end in a highly characteristic mass made of three to seven enlarged, mobile lamellate segments. They vary in size from 10 to 20 mm. Adults generally oviposit in the soil or on decaying plant material at the end of the dry season. The larvae hatch at the beginning of the rainy season. They are C-shaped and have three pairs of well-developed thoracic legs. They vary in size from 20 to 30 mm depending on the species. The head-capsule of the larva is highly chitinised and yellowish-orange in colour, while the rest of the body is whitish. The larva has a chewing-type mouthpart equipped with heavy-duty components. Larvae and adults most often inhabit the soil where they feed on plant debris and the roots of cultivated plants. Pupation occurs in the soil and the new adults usually hatch at the beginning of the dry season. The life cycle can last approximately one year.
- **Phenological stages of crop susceptibility:** The stage of highest susceptibility of okra to white grubs is considered to be from emergence to the initiation of floral buds.
- **Appropriate periods for intervention:** Steps should be taken as soon as damage by larvae is seen on plant roots (wilting), especially when this occurs between emergence and blossoming. Furthermore, it may be useful to treat when these stages coincide with the beginning of the rainy season to limit the impact of attacks.
- **Other host plants (and adverse previous crops):** White grubs are widely polyphagous insects that attack a large variety of vegetable and subsistence crops.
- **Description of symptoms / damage:** Visible symptoms range from wilting to lodging of affected plants. Initial signs give the impression of a water deficit. However, upon inspection, an uprooted plant is found to have no secondary roots and bites on the taproot. Often, symptoms appear in the field in patches. When extremely high larval density occurs at the beginning of the rainy season in a very humus-rich, moist soil, considerable losses may be generated.
- **Conditions conducive to infestation:** The vicinity of wild or cultivated host plants, periods of hot, moist weather, humus-rich soils, recently cleared plots with inadequate stump removal, and presence of decaying plant material or incompletely decomposed wood chip-based compost are conducive to infestation.
- **Methods of observation and intervention thresholds:** At the seedling stage, when the first signs of wilting appear giving the impression of a water deficit, uproot the plants and inspect the root system. If there are bites in several places and no secondary roots, white grub attack may be involved. This can very easily be checked by digging down a few centimetres at the position from which the plant has just been uprooted. No intervention threshold has so far been established for this pest on okra. However, in view of the fact that white grub attacks more often than not cause the seedling to die, a threshold of 10 to 15 % wilted plants prior to blossoming can be considered a reasonable intervention threshold.
- **Prevention:**
  - Deep plough so as to expose the soil-inhabiting larvae and nymphs to predation.
  - Only use well-decomposed, mature compost.
  - Remove all old stumps from the fields as they serve as ovipositing sites for adults.
  - Monitor white grub attacks by visually inspecting fields for symptoms.
- **Chemical control:** If major, widespread infestations occur during the period that is conducive to pest proliferation, spot treatment at the base of plants using pelleted insecticides is advisable to reduce the impact of the white grubs. Additionally, during the growing season, spraying insecticides (see annex 1) on the base or collar of the plants can be helpful in containing damage.

***Xanthodes graellsii*** (Feisthamel) (Lepidoptera: Noctuidae)

- **Common name:** Cotton worm.
- **Distribution:** Africa, Asia.
- **Description and bio-ecology:** *Xanthodes graellsii* is a moth that feeds only on plants in the Malvaceae family and more specifically on the genera *Gossypium* and *Hibiscus*. Adults are approximately 18 mm long and have a wingspan of 40 mm. Adult insects have yellow wings. In females, these have a large brown stripe extending from the middle to the outer edge of the wing, and several small brown dots below that stripe. The hindwings are pearl grey with yellow front and lateral borders. In males, the yellow wings have no stripes or dots. Females deposit their eggs singly on the lower surface of leaves. These hatch after a week producing juvenile larvae. The caterpillar is generally green with a bright yellow stripe down the middle of its back and one additional one on each side as well as a black half-circle on nearly all of its segments. The half-circles in the middle portion of the body contain a black spot while the last segments have only a number of vertically aligned spots. The caterpillar's whole body is covered with long white hairs. It can be up to 40 mm long when fully developed. Pupation takes place in the soil and lasts some two weeks.
- **Phenological stages of crop susceptibility:** Okra is susceptible to attack by *X. graellsii* at all stages of development, with a predilection for the juvenile stages.
- **Appropriate periods for intervention:** Intervention should take place between singling and the first harvest as soon as feeding damage is seen.
- **Other host plants (and adverse previous crops):** *X. graellsii* feeds only on plants in the Malvaceae family.
- **Description of symptoms / damage:** The caterpillars are phyllophagous and symptoms are visible on leaves, which are devoured or from which large pieces have been cut out. Damage is generally minor as this pest is not usually very abundant in okra fields.
- **Conditions conducive to infestation:** The vicinity of wild or cultivated host plants, and periods of hot, moist weather favour infestation.
- **Methods of observation and intervention thresholds:** *X. graellsii* caterpillars can very easily be detected by visual inspection because of their recognisable colour and markings. No intervention threshold has been defined for this pest, which in any case causes little economic damage. However, if there is a massive proliferation of caterpillar populations at the seedling stage, intervention may be necessary to restrict damage.
- **Prevention :**
  - Do not grow okra in the vicinity of cotton or other Malvaceae which are host plants for *X. graellsii*.
  - Deep plough so as to expose nymphs to predation.
  - Comply with the okra crop protocol (proper spacing of, suitable manuring plan, effective weed control, especially at the seedling stage) to ensure good growth and vigour of plants.
  - Monitor *X. graellsii* populations during the vegetative growth period of okra by inspecting plants.
  - Manually pick off the first larvae seen in the fields so as to contain the damage.
- **Plant Protection Products application:** Generally speaking, chemical control is rarely needed for *X. graellsii* as population density tends to be low and it is rarely harmful. In addition, manually picking off the insects as soon as infestation appears is more than adequate for controlling pest damage on small plots in peasant holdings. However, for large plots that produce okra for export, heavy caterpillar infestation at the seedling stage often requires treatment to control *X. graellsii* larvae.



Respectively *Xanthodes graellsii* larvae and feeding damage on leaf and adult specimen on okra leaf (Photos, DOUMBIA, 2003)

***Zonocerus variegatus*** (Linnaeus) (Orthoptera: Acrididae)

- **Common name:** Variegated cricket.

- **Distribution:** Sub-Saharan Africa.

- **Description and bio-ecology:** *Z. variegatus* is a polyphagous cricket found in vegetable and subsistence crop farming areas. Adult insects are approximately 40 mm long and yellowish-green and black with a few reddish spots on the head, legs and abdomen. Males tend to be smaller than females. Females oviposit in the soil close to areas of vegetation at the end of the rainy season. Larvae usually hatch at the end of the dry season or with the first rains in mid-April in humid areas. Juvenile larvae are black, spotted with yellow. The larval cycle lasts approximately 3 to 4 months. Adults and larvae live in groups and feed together on plant material. The insect is often present all year round in humid areas, with low densities during the hot, dry periods.



Adult specimen of *Zonocerus variegatus* (Photo, DOUMBIA, 2003)

- **Phenological stages of crop susceptibility:** Okra is liable to be attacked by the variegated cricket at all stages of development.

- **Appropriate periods for intervention:** Steps should be taken as soon as crickets are seen, particularly if dense populations are found at the beginning of the rainy season when okra is in the juvenile stage. Furthermore, the adult population that is alive during the dry season also attacks off-season okra. It may be useful to take steps in that period.

- **Other host plants (and adverse previous crops):** *Z. variegatus* is widely polyphagous and attacks a large variety of both cultivated and wild plants.

- **Description of symptoms / damage:** In the case of juvenile larvae, the upper surfaces of damaged leaves appear eroded. Adults feed on the entire leaf leading to defoliation of the plants. Additionally, when massive infestations occur, the entire plant may be devoured right down to the root at soil line level. Losses entailed may be considerable.

- **Conditions conducive to infestation:** Periods of hot, moist weather, off-season cultivation, and excessive use of pesticides that has destroyed the natural enemies of *Z. variegatus* favour infestation.

- **Methods of observation and intervention thresholds:** *Z. variegatus* can very easily be detected by visual inspection of the plots. No intervention threshold has been defined for this pest on okra. However, attacks that follow hatching of juvenile larvae after the first rainfall may be harmful to the crop if plants are juvenile. In this case, the pest should be controlled to restrict damage.

- **Prevention:**

- Deep plough at the beginning and end of the dry season to expose the soil-inhabiting eggs and nymphs to drying-out and predation.
- Damage can be contained on small surface areas by manually picking off specimens very early in the morning when they are relatively inactive.
- Using plant traps such as *Chromolaena odoratum* or *Ageratum conyzoides* is helpful as the insects can then be picked off and put into bags to be destroyed.
- Comply with the okra crop protocol (proper spacing of seeds, suitable manuring plan, effective weed control, especially at the seedling stage) to ensure good growth and vigour of plants.
- Monitor *Z. variegatus* populations during the okra growing season by inspecting the plants.

- **Plant Protection Products application:** If crickets invade juvenile plants, alternate use of active substances listed in annex 1 can be effective in controlling the variegated cricket.

Table below is a summary of the main insect pests for okra and the associated phenological stages of the plant.

**Table 6 – Main insect pests of okra and associated stages of crop development**

Species	Extent of damage according to stage			
	Seedbed	From emergence to singling	From singling to first harvest	Harvest
<i>Acrosternum acutum</i>			+	++
<i>Agrotis</i> spp.	++	+++	+	
<i>Aphis gossypii</i>		+	+++	+++
<i>Bemisia tabaci</i>		+	+++	+
<i>B. membranaceus</i>		++		
<i>Cosmophila flava</i>			++	
<i>Dysdercus</i> spp.				+++
<i>Earias</i> spp.			++	+++
<i>Frankliniella</i> spp.			++	+++
<i>Gryllotalpa</i> spp.		++		
<i>Helicoverpa armigera</i>			+	+++
<i>Jacobiasca lybica</i>			+++	
<i>Lagria villosa</i>			++	+
<i>Liriomyza trifolii</i>		++	++	
<i>Mylabris</i> spp.			++	++
<i>Nisotra</i> spp.		+	+++	++
<i>Oxycarenus hyalinipennis</i>				++
<i>Pachnoda</i> spp.			+	+++
<i>Podagrica</i> spp.		+	+++	++
<i>Pseudococcus</i> spp.		+	++	+
<i>Spodoptera</i> spp.			++	
<i>Sylepta derogata</i>			+++	
White grubs	++	+++	+	
<i>Xanthodes graellsii</i>			+++	
<i>Zonocerus variegatus</i>			++	

+: minor ++: moderate +++: major

## NEMATODES

Okra is liable to be attacked by several species of nematodes such as the *Pratylenchus* spp., *Meloidogyne* spp. The most common species in okra culture with spectacular symptoms is *Meloidogyne* spp. which is dealt with in our analysis of nematodes on okra.

### *Meloidogyne* spp. (Nematoda: Meloidogynidae)

- **Common name:** Root-knot nematode.
- **Distribution:** Cosmopolitan.
- **Description and bio-ecology:** Root-knot nematodes of the genus *Meloidogyne* are tiny, wire-like worms. Males are from 1 to 2 mm long and are free-ranging in the soil. As for females, they are pear-shaped, less than 1 mm long and live attached to roots. Eggs are deposited as a gelatinous mass secreted by the female. The second instar penetrates into the roots and become established close to the vascular area. After usually 4 instars, male individuals move away from the roots, while females sedentarise on the root tissue. The life cycle lasts from 4 to 6 weeks depending on ambient conditions.
- **Phenological stages of crop susceptibility:** Okra is susceptible to *Meloidogyne* spp. attacks at all stages of development, but particularly in the period from singling to the first pod harvest.
- **Appropriate periods for intervention:** Steps should be taken as soon as nematode damage is detected by inspecting the root system of plants that are stunted or give signs of suffering from water deficit, especially during the period of highest susceptibility.
- **Other host plants (and adverse previous crops):** Extreme differences in host range occur between species within the genus *Meloidogyne*. Generally speaking plants in the families of the Malvaceae, Solanaceae, Cucurbitaceae, Fabaceae, Apiaceae and Asteraceae are hosts for *Meloidogyne* spp. and hence adverse previous crops for okra culture. Banana and papaya are also host plants.
- **Description of symptoms / damage:** Symptoms are visible as the formation of galls on okra roots, impaired development of new roots and stunting of affected plants. Plants often display signs of water deficit even when water is plentiful. Attacks at an early stage cause seedlings to wither and lead to considerable loss.
- **Conditions conducive to infestation:** Light, sandy soils with little organic matter content and optimal soil temperatures of 26 to 28 °C are highly conducive to the development of *Meloidogyne* spp. Furthermore, the presence of wild or cultivated host plants in the vicinity of okra, accidental or intentional transport of infested soil (earth that adheres to boots and to implements) are all conducive to infestation by *Meloidogyne* spp.
- **Methods of observation and intervention thresholds:** If, at the seedling stage, some plants appear to be growing slowly or display signs of water deficit, uproot several specimens and look for the typical gall produced by attacks from *Meloidogyne* spp. If galls are seen on the roots, take steps depending on the number of affected plants. No specific intervention threshold has been defined for *Meloidogyne* spp. on okra.
- **Prevention:**
  - Do not grow okra in the vicinity or after plants host for the same species of *Meloidogyne* than okra.
  - Grow resistant varieties where available.
  - Avoid or reduce transportation of soil or material from infested areas to newly planted okra plots.



Okra root-gall (symptoms of attack by *Meloidogyne* spp.) (Photo, DOUMBIA, 2003)

- Comply with the okra crop protocol (proper spacing of seeds, suitable manuring plan, effective weed control, especially at the seedling stage) to ensure good growth and vigour of plants. Rotate okra with crops that are either tolerant or resistant. Examples of tolerant crops include brassicas, chilli pepper, radish, sweet potato, and turnip. Nematode resistant crops include cassava, garlic, leek, maize, millet, onion, shallots, sorghum, sweet corn and grasses.
  - Application of appropriate amounts of organic matter (1 to 2.5 kg per seed spot) is helpful in controlling *Meloidogyne* spp.
  - For off-season crops on bottomland, flooding plots contributes to killing large numbers of larval and adult *Meloidogyne* spp.
  - Solarisation in dry weather for 15 days fumigates the soil.
  - Bare fallow in the dry season reduces nematode populations.
  - The use of controlled fallow based on non-host or antagonist plants for *Meloidogyne* spp. such as wheat, sunnhemp, Chromolaena, sesame, marigold.
  - After harvest, uproot entire plants and destroy crop debris. Tops can be composted but infested roots should be burnt since nematodes may survive the relatively low heat of the compost heap.
  - Regularly inspect plots for symptoms.
- **Plant Protection Products application:** If nematode problems become apparent in a given area, nematicides can be incorporated into the soil prior to establishing the crop. In this case, substances such as pelleted Cadusafos (50 kg/ha) or Carbofuran (20 to 60 kg/ha) may be used to prevent *Meloidogyne* spp. infestation.

**Table 7 - Root-knot nematodes for okra and associated stages of crop development**

Species	Extent of damage depending on stage			
	Seedbed	From emergence to singling	From singling to first harvest	Harvest
<i>Meloidogyne</i> spp.	++	++	+++	+

+: minor ++: moderate +++: major



## MITES

There are two major species of mites that affect okra - *Tetranychus* spp. and *Polyphagotarsonemus latus* which are examined below.

***Tetranychus* spp. (Acari: Tetranychidae)**

- **Common name:** Spider mites. *Tetranychus urticae* (The two-spotted or common spider mite); *T. loubardini* (the crimson spider mite).
- **Distribution:** 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.
- **Description and bio-ecology:** The okra red spider mite is polyphagous and attacks more than 100 species of plants in various botanical families. They are tiny (about 0.5 mm long), oval in shape with an arched back and eight pair of legs, except in the larval stage when they have six. 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. Adults weave a network of fine webs to which sand, earth and dust adhere to giving the leaf a dusty, grimy appearance. They look like tiny moving dots on the leaves. They tend to proliferate in hot, dry weather and egg incubation lasts only ten days in favourable conditions.
- **Phenological stages of crop susceptibility:** Okra is susceptible to *Tetranychus* spp. attack at all stages of development.
- **Appropriate periods for intervention:** Steps should be taken as soon as feeding damage by mites is seen. This arises in the form of small white dots that may cover the whole foliar lamina making the leaf look yellowish-white and dry. If symptoms appear on many plants in hot, dry weather, steps should immediately be taken to restrict mite damage.
- **Other host plants (and adverse previous crops):** More than a hundred cultivated plant species are hosts for spider mites, in particular in the Malvaceae, Solanaceae, Cucurbitaceae and Fabaceae families. Papaya is also an important host.
- **Description of symptoms / damage:** Symptoms appear as tiny white dots on the foliar lamina that spread to cover the entire surface of the leaves, which turns yellow-white or a reddish bronze colour as infestations become heavy. The leaves curl up under severe attack, dry out and are shed, leading to plant defoliation. In hot, dry weather, damage may be extensive, especially on plots producing off-season okra.
- **Conditions conducive to infestation:** Evidence of mite attack is most often seen during hot, dry weather, which is conducive to the development of *Tetranychus* spp. In addition, the vicinity of wild or cultivated host plants also encourages *Tetranychus* spp. infestation.
- **Methods of observation and intervention thresholds:** Plants should be monitored for symptoms of *Tetranychus* spp. attacks during periods of hot, dry weather by examining the lower surface of leaves where mites are concealed. No specific intervention threshold has been defined for *Tetranychus* spp. on okra.
- **Prevention:**
  - Do not grow okra in the vicinity of other host plants.
  - Comply with the okra crop protocol (proper spacing of seeds, suitable manuring plan, effective weed control, especially at the seedling stage) to ensure good growth and vigour of plants.
  - Regularly inspect plots for symptoms.
  - Conserve natural enemies. A number of predators are known to feed on spider mites (e.g. predatory mites, predatory thrips, ladybird beetles). In many cases, natural occurring predators are capable of controlling infestations of the two-spotted spider mite. Provided broad-spectrum pesticides are not used and the crop is irrigated properly.



*Tetranychus* sp. on leaf (Photo, DOUMBIA, 2003)

- **Plant Protection Products application:** Chemical control is necessary when symptoms are found on many plants but only in hot, dry weather as moist weather does not foster mite proliferation. When treatment is found to be necessary, active substances listed in annex 1 can be used to prevent *Tetranychus* spp. infestation. Avoid using of broad-spectrum insecticides, since they eliminate natural enemies; moreover, some insecticides can enhance spider mite reproduction. Their use may lead to mite outbreaks. Spider mites rapidly develop resistance to pesticides. Rotation of acaricides with different chemical active ingredients is essential to avoid or delay development of resistance. Spot spraying of localised infestation usually controls initial infestations.

***Polyphagotarsonemus latus* (Bank) (Acari: Tarsonemidae)**

- **Common name:** Broad mite.
- **Distribution:** Cosmopolitan.
- **Description and bio-ecology:** Broad mites are polyphagous mites that attack vegetable and subsistence crops. They are small, yellow translucent spiders found on the lower surface of leaves. Male spiders are stocky with long legs, the fourth of which carries a tubercle instead of a claw. They live in colonies on the underside of leaves and are dispersed by the wind or by debris of infested plants. Eggs are laid on the lower side of leaves, on juvenile shoots, pods, floral stalks and flowers. The life cycle is extremely short and in favourable conditions for the pest – overcast, humid weather – may take just one week.
- **Phenological stages of crop susceptibility:** Okra is susceptible to *P. latus* attack at all stages of development.
- **Appropriate periods for intervention:** Steps should be taken as soon as feeding damage by broad mites is seen, particularly in overcast, humid weather. The vegetative growing phase from singling to floral bud initiation is a particularly susceptible period during which treatment can be useful in the event of heavy broad mite infestation.
- **Other host plants (and adverse previous crops):** More than a hundred plant species serve as hosts for broad mites, specifically plants in the Malvaceae, Solanaceae, Cucurbitaceae, Fabaceae, Brassicaceae, Araceae, Sterculiaceae, Anacardiaceae and Euphorbiaceae families.
- **Description of symptoms / damage and % of losses:** On juvenile leaves and terminal buds, symptoms show as downward curling of leaves, deformity with hard, protruding ribs that have a bronzed appearance. In the event of heavy attacks, juvenile shoot growth may be stopped. Mature leaves turn brown or necrotic areas appear on the lower part of the leaf whose edges gradually curl downwards. Later on, uneven tears appear in places on the leaves. Early attacks may jeopardise the development of the plant, preventing growth and reducing flowering. The losses thus entailed may reach 20 to 50 %.
- **Conditions conducive to infestation:** Evidence of broad mite attacks most often occur during overcast, humid weather which is conducive to *P.latus* development. Furthermore, the vicinity of wild or cultivated host plants also encourages *P.latus* infestation.
- **Methods of observation and intervention thresholds:** In periods of overcast, humid weather, plants should be visually inspected for symptoms of *P.latus* attack by examining the lower surface of leaves where the broad mites are hidden. No specific intervention threshold has been defined for *P.latus* on okra.
- **Prevention:**
  - Do not grow okra in the vicinity of other host plants.
  - Reduce or remove areas of shading in okra fields.
  - Comply with the okra crop protocol (proper spacing of seeds, suitable manuring plan, effective weed control, especially at the seedling stage) to ensure good growth and vigour of plants.
  - Regularly inspect plots for symptoms, particularly in overcast, humid weather.



Symptoms of attack on juvenile leaves by *Polyphagotarsonemus latus* (photo, DOUMBIA, 2003)

- **Plant Protection Products application:** Chemical treatment may be necessary when many plants show symptoms during overcast, humid weather, since hot, dry weather and very rainy conditions do not foster broad mite development. If treatment is necessary, alternate use of active substances listed in annex 1 can be effective in preventing *P. latus* infestation.

Table below is a summary of the main mite pests for okra and the associated stages of plant development

**Table 8 - Main mite pests for okra and associated stages of crop development**

Species	Extent of damage depending on stage			
	Seedbed	From emergence to singling	From singling to first harvest	Harvest
<i>Tetranychus</i> spp.		+	+++	+
<i>Polyphagotarsonemus latus</i>		++	+++	+

+: minor ++: moderate +++: major

# Annex 1: Known registrations in ACP countries and efficacy of active substances

Tables below give known registrations in ACP countries. Efficacy given is based on existing registrations, documents on okra production and information from pesticides companies.

**Remarks:** This information should be tallied with the legislation in force locally in each area of production.

Fungicides												
Active substances	Azoxystrobin	Carberdazim	Chlorothalonil	Difenoconazole*	Iprodione	Mancozeb	Maneb	Metaxyl-M*	Copper	Sulfur	Thiophanate-methyl	Thiram*
Registration in ACP countries												
Côte d'Ivoire		**	**		**	**	**	**	**		**	
Ghana						**	**					
Jamaica						**						
Kenya	**	**	**	**	**	**		**	**	**	**	**
Tanzania	**	**	**	**	**	**		**	**	**	**	**
Efficacy												
Damping-off: <i>Pythium</i> spp., <i>Rhizoctonia solani</i> , <i>Sclerotium rolfsii</i>				✓	✓			✓	✓			✓
<i>Cercospora malayensis</i>		✓	✓		✓	✓	✓		✓		✓	
<i>Cercospora abelmoschii</i>		✓	✓		✓	✓	✓		✓		✓	
<i>Erysiphe cichoracearum</i>	✓	✓								✓	✓	
<i>Xanthomonas axonopodis</i> pv. <i>malvacearum</i>									✓			
Miticides												
Active substances	Abamectin		Bifenthrin		Sulfur							
Registration in ACP countries			KEN** TAN**		KEN** TAN**							
<i>Polyphagotarsonemus latus</i>	✓		✓		✓							
<i>Tetranychus</i> spp.	✓		✓		✓							

\*: Active substances used in granules formulation at sowing of for seeds application

\*\* : Registered on vegetables

\*\*\* : Registered on various crops

CIV = Côte d'Ivoire ; GHA = Ghana ; JAM = Jamaica ; KEN = Kenya ; TAN = Tanzania

Insecticides																		
Active substances	Abamectin	Azadirachtin (Neem)	Bacillus thuringiensis	Beta-cyfluthrin	Bifenthrin	Cadusaphos*	Carbofuran*	Carbosulfan*	Chlorpyrifos-ethyl*	Cypermethrin	Deltamethrin	Diazinon	Dimethoate	Imidacloprid	Lambda-cyhalothrin	Malathion	Spinosad	Thiamethoxam
<b>Registration in ACP countries</b>																		
CILLS															**			
Côte d'Ivoire						**			**	**		**		**	**			
Ghana						***		**		**	**			***				
Jamaica									0	**	**			**	**	**		
Kenya	**	**	**	**	**	***	**	***	**	**	**	**	**	**	**	**	**	**
Tanzania	**	**	**	**	**	***	**		**	**	**	**	**	**	**	**	**	
<b>Efficacy</b>																		
<i>Acrosternum acutum</i>		✓		✓	✓					✓	✓		✓		✓		✓	
<i>Agrotis</i> spp.				✓	✓		✓	✓	✓	✓	✓		✓		✓	✓		
<i>Aphis gossypii</i>		✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓			✓
<i>Bemisia tabaci</i>		✓		✓	✓	✓	✓	✓		✓	✓		✓	✓	✓		✓	✓
<i>Brachytripes membranaceus</i>				✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓			
<i>Cosmophila flava</i>		✓	✓	✓	✓					✓	✓				✓		✓	
<i>Dysdercus</i> spp.		✓		✓	✓					✓	✓		✓		✓			
<i>Earias</i> spp.		✓	✓	✓	✓					✓	✓				✓		✓	
<i>Frankliniella</i> spp.																		✓
<i>Gryllotalpa</i> spp.				✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		
<i>Helicoverpa armigera</i>		✓	✓	✓	✓					✓	✓				✓		✓	
<i>Jacobiasca lybica</i>		✓		✓	✓			✓		✓	✓		✓		✓			
<i>Lagria villosa</i>		✓		✓	✓					✓	✓		✓		✓			
<i>Liriomyza trifolii</i>	✓	✓																✓
<i>Mylabris</i> spp.		✓		✓	✓					✓	✓	✓	✓		✓			
<i>Nisotra</i> spp.		✓		✓	✓					✓	✓		✓		✓		✓	
<i>Oxycarenus hyalinipennis</i>		✓		✓	✓					✓	✓		✓		✓			
<i>Pachnoda</i> spp.		✓		✓	✓					✓	✓	✓	✓		✓			
<i>Podagrica</i> spp.		✓		✓	✓					✓	✓		✓		✓		✓	
<i>Pseudococcus</i> spp.												✓	✓	✓				
<i>Spodoptera</i> spp.		✓	✓	✓	✓			✓		✓	✓				✓		✓	
<i>Sylepta derogata</i>		✓	✓	✓	✓					✓	✓				✓		✓	
White grub				✓	✓			✓	✓	✓	✓				✓			
<i>Xanthodes graellsii</i>		✓	✓	✓	✓					✓	✓				✓		✓	
<i>Zonocerus variegatus</i>		✓		✓	✓					✓	✓	✓			✓			

\*: Active substances used in granules formulation at sowing of for seeds application

\*\* : Registered on vegetables

\*\*\* : Registered on various crops

0 : Registered on okra

CIV = Côte d'Ivoire ; GHA = Ghana ; JAM = Jamaica ; KEN = Kenya ; TAN = Tanzania

## Annex 2: Residues results on pesticides tested by PIP in Côte d'Ivoire

Residues trials have been undertaken in Côte d'Ivoire in 2004. Tables below give the synthesis of the results and advices on the use of active substances to comply with the current MRL European regulation (updates September 2008).

Information in the table are as follow :

- **Column 1 – Active substance** : Name of the active substance.
- **Column 2 – EU Status**: Status of the active substance in Directive 91/414.
- **Column 3 – Current MRL** : Existing MRL in Europe.
- **Column 4, 5 and 6 – GAP tested** :  
 Good Agricultural Practices (GAP) tested in the trials (active substance dose, number of applications and interval between applications) are indicated in these columns.
- **Column 7 – PHI (days) tested that comply with current MRL and highest residue value detected (mg/kg)**: In this column one can find if the Pre-Harvest Intervals (PHIs) tested comply with the current MRL.

The grower must first and foremost follow the instructions (doses, interval between treatments, number of applications and Pre-Harvest Interval) provided on the labels of locally authorised products. Following such instructions, however, does not necessarily guarantee compliance with MRLs currently in force in the European Union countries. To comply with European regulations on pesticide residues, it is recommended to producer use pesticides only within the limits of the Good Agricultural Practices tested by the PIP. Any change to one or more elements of these GAPs (dose increase, frequency of application and number of applications, final application closer to harvest than the recommended Pre-Harvest Interval) may result in a failure to remain below the MRL.

### Note on European MRL harmonisation:

The DG for Health and Consumers (DG SANCO) has undertaken an MRL harmonisation process on the European level and has established a new EC MRL regime under EC Regulation 396/2005 and its annexes, which was published afterward as separate Regulations.

A list of national MRL was gathered by DG SANCO in June 2005 and submitted to EFSA (European Food Safety Authority) for verification and approval. When no specific MRL exists for a crop, a default MRL is set at 0,01 mg/kg. These default EU MRLs as well as the EU MRLs based on measured residues could only be set after the publication of Annex I to the Regulation, establishing the list of food and feed products (Regulation (EC) No 178/2006 of 1st February 2006).

Towards the end of 2007 EFSA submitted the conclusion report of the MRL evaluation and recommendation to the Commission for final decision on the setting of harmonised EU MRLs.

These EU MRLs are listed in the annexes ,II,III and IV of the EC Regulation which were established by the Regulation (EC) No 149/2008 of 29 January 2008. The annexes were updated for the first time in March 2008 and the MRLs were entered into force on September 1st, 2008 and are available on the website [http://ec.europa.eu/sanco\\_pesticides/public/index.cfm](http://ec.europa.eu/sanco_pesticides/public/index.cfm)

Remark. *Bacillus thuringiensis* and azadiachtin have not been tested for residues since the first one has no MRL need and the second one, on the basis of trials implemented on French beans, have no detectable residues until a PHI of 1 day. Iprodione has not been tested since phytosanitary company expected to provide samples has not shown an interest for the trial.

### INSECTICIDES, NEMATOCIDES AND MITICIDES

Active substance	EU DIR 91/414 status	EU MRL	GAP tested			PHI tested that comply with current MRL (highest residues value (ppm) observed at this PHI)
			Dose g/ha	Number of applications	Interval between applications	
Abamectin	Notified List 3A	0.01	10	2	14	7 (<0.01)
Beta-cyfluthrin***	Annex 1	0.02	9	3	14	7 (<0.01)
Bifenthrin	Notified List 3A	0.2	40	2	7	2 (0.11)
Cadusaphos	Withdrawn	0.01	750	1	/	*
Carbofuran	Withdrawn	0.02	750	1	/	*
Carbosulfan	Withdrawn	0.05	750	1	/	*
Chlorpyrifos-ethyl	Annex 1	0.5	750	1	/	*
Cypermethrin	Annex 1	0.5	50	2	14	7 (<0.05)
Deltamethrin	Annex 1	0.3	12.5	1	/	2 (0.05)
Diazinon	Withdrawn	0.01	250	1	/	At thinning (<0.01)
Dimethoate	Annex 1	0.02	800	2	14	14 (0.02)
Imidacloprid***	Notified List 3A	0.5	20	3	14	2 (0.03)
L-Cyhalothrin	Annex 1	0.1	25	1	/	2 (0.02)
Malathion	Withdrawn	0.02	750	1	/	2 (<0.01)
Spinosad	Annex 1	1	160	2	14	2 (0.61)
Thiamethoxam	Annex 1	0.05	100	3	14	7 (<0.01)
			**	1	/	*

/ : not applicable

\*: application only on seeds, at sowing or at emergence

\*\* : APRON STAR 42 WS = 250 g/100 kg of seeds with 850 to 1,850 ml of water

\*\*\* : applied with a commercial product at 45 g/l for beta-cyfluthrin and 100 g/l for imidacloprid

## FUNGICIDES

Active substance	EU DIR 91/414 status	EU MRL	GAP tested			PHI tested that comply with current MRL (highest residues value (ppm) observed at this PHI)
			Dose g/ha	Number of applications	Interval between applications	
Azoxystrobin	Annex 1	2	150	3	7	2 (0.48)
Carbendazim	Annex 1	2	600	1	/	2 (1.69)
Chlorothalonil	Annex 1	2	1,000	2	14	2 (1.02)
Copper	Notified List 3A	5	2,500	1	/	*
Difenoconazole	Notified List 3B	0.05	**	1	/	*
Maneb	Annex 1	0.5	2,000	2	14	7 (0.14)
Mancozeb	Annex 1	0.5	2,000	2	14	7 (0.13)
Metalaxyl-M	Annex 1	0.05	**	1	/	*
Sulfur	Notified List 4H	50	6,000	2	14	2 (233)***
Thiophanate-methyl	Annex 1	1	490	2	7	2 (0.87)
Thiram	Annex 1	0.1	500	1	/	*

/ : not applicable

\* : application only on seeds, at sowing or at emergence

\*\* : APRON STAR 42 WS = 250 g/100 kg of seeds with 850 to 1,850 ml of water

\*\*\* : values observed in treated plots are the same than in control plots but above the 50 ppm of the MRL because okra is naturally reach in sulfur (more or less 230 ppm). Therefore it is obvious that sulfur applications don't release residues.



## Annex 3: Useful documents and web sites on okra

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CAB International (2006): Crop Protection Compendium. 2006 Edition. Wallingford, UK.

<http://www.cabi.org/>

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

Infonet-Biovision (2007): Okra datasheet

<http://www.infonet-biovision.org>

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## CROP PRODUCTION PROTOCOLS

Avocado (*Persea americana*)  
French bean (*Phaseolus vulgaris*)  
Okra (*Abelmoschus esculentus*)  
Passion fruit (*Passiflora edulis*)  
Pineapple Cayenne (*Ananas comosus*)  
Pineapple MD2 (*Ananas comosus*)  
Mango (*Mangifera indica*)  
Papaya (*Carica papaya*)  
Pea (*Pisum sativum*)  
Cherry tomato (*Lycopersicon esculentum*)

## GUIDES TO GOOD PLANT PROTECTION PRACTICES

Amaranth (*Amaranthus* spp.)  
Baby carrot (*Daucus carota*)  
Baby and sweet corn (*Zea mays*)  
Baby Leek (*Allium porrum*)  
Baby pak choy (*Brassica campestris* var. *chinensis*), baby cauliflower (*Brassica oleracea* var. *botrytis*), baby broccoli and sprouting broccoli (*Brassica oleracea* var. *italica*) and head cabbages (*Brassica oleracea* var. *capitata* and var. *sabauda*)  
Banana (*Musa* spp. – plantain (*matoke*), apple banana, red banana, baby banana and other ethnics bananas)  
Cassava (*Manihot esculenta*)  
Chillies (*Capsicum frutescens*, *Capsicum annum*, *Capsicum chinense*) and sweet peppers (*Capsicum annum*)  
Citrus (*Citrus* sp.)  
Coconut (*Cocos nucifera*)  
Cucumber (*Cucumis sativus*), zucchini and pattypan (*Cucurbita pepo*) and other cucurbitaceae with edible peel of the genus *Momordica*, *Benincasa*, *Luffa*, *Lagenaria*, *Trichosanthes*, *Sechium* and *Coccinia*  
Dasheen (*Colocasia esculenta*) and macabo (*Xanthosoma sagittifolium*)  
Eggplants (*Solanum melongena*, *Solanum aethiopicum*, *Solanum macrocarpon*)  
Garlic, onions, shallots (*Allium sativum*, *Allium cepa*, *Allium ascalonicum*)  
Ginger (*Zingiber officinale*)  
Guava (*Psidium catteyanum*)  
Lettuce (*Lactuca sativa*), spinach (*Spinacia oleracea* and *Basella alba*), leafy brassica (*Brassica* spp.)  
Lychee (*Litchi chinensis*)  
Melon (*Cucumis melo*)  
Organic Avocado (*Persea americana*)  
Organic Mango (*Mangifera indica*)  
Organic Papaya (*Carica papaya*)  
Organic Pineapple (*Ananas comosus*)  
Potato (*Solanum tuberosum*)  
Sweet potato (*Ipomea batatas*)  
Tamarillo (*Solanum betaceum*)  
Water melon (*Citrullus lanatus*) and butternut (*Cucurbita moschata*)  
Yam (*Dioscorea* spp.)

