

PIP



GUIDE TO GOOD CROP PROTECTION PRACTICES FOR CONVENTIONAL AND ORGANIC WATERMELON (*CITRULLUS LANATUS*) AND BUTTERNUT (*CUCURBITA MOSCHATA*)

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NOTICE

The Guide to Good Plant Protection Practices (fruit or vegetable) details all plant protection practices (for fruits or vegetables). It recommends primarily the active substances supported by pesticides manufacturers in the framework of EU and from 14 June 2011, under the Regulation 1107/2009 replacing the Dir. 91/414/EC and for organic production those allowed for usage by the EU Regulation 2092/91, which must comply with standards for pesticide residues. Currently, these active substances have not been tested by PIP in ACP countries to check their conformity with MRLs. The information given on the active substances suggested is therefore changeable and will be adapted on an ongoing basis in accordance with the new information collected by PIP.

It is, of course, understood that only those products legally registered in their country of application are authorised for use. Growers must therefore check with the local regulatory authorities to see whether the product they wish to use is included on the list of registered products.

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



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1. Main enemies and importance

1.1. Importance of pests and diseases in terms of susceptibility on watermelon and butternut¹

Key:

+ = low
 ++ = average
 +++ = high

PEST / DISEASE	WATERMELON	BUTTERNUT
Chrysomelidae	+	+
African melon ladybird beetle	+	+
Melon moth	+	+
Fruit flies	++	+++
American leafminer	+	+
White flies	+	+
Thrips	+	++
Melon aphids	+++	+++
Red spider mites	++	++
Root-knot nematodes	+++	++
Fusarium wilt	+++	+
Gummy stem blight and black rot	++	++
Anthracnose	++	++
Powdery mildew	+++	+++
Downy mildew	+	+
Damping-off	+	+
Scab	+	+
Angular leaf spot	+	+
Cucumber mosaic virus (CMV) ²	++	++
Watermelon mosaic virus (WMV) ²	+++	+++
Zucchini yellow mosaic virus (ZYMV) ²	++	++

1 - The information in the above table is not related to local occurrence and damage by the specified pests and diseases. It is based on literature on field infestation by pests and infection by diseases (Ref: Annexes: References, websites and Useful documents).

2 - It is virtually impossible to definitely identify individual viral diseases on basis of field symptoms since in most cases they occur in mixtures and share similar symptoms. Their true identity can only be derived from proper immunodiagnostic procedures.

1.2. Extent and impact on the quantity and quality of fruit produced

The main pests and diseases that will be discussed in this guide are listed below. This section presents, for each pest or disease:

- the parts of the plant affected and how they are attacked;
 - the resulting types of loss, all of which decrease the yield of marketable fruit and consequently end up causing a loss of financial income.
- The presence of pests and diseases can reduce yield and cause losses at different levels: fewer plants per hectare, less fruits per plant, smaller-sized fruits, lower quality of fruits.

Quarantine organisms in Europe are followed by the abbreviation "QO".

One should check the status of quarantine organisms on the websites

http://europa.eu/legislation_summaries/food_safety/plant_health_checks/f85001_en.htm and

<http://www.eppo.org/QUARANTINE/quarantine.htm> since regulation can change.

INSECTS					
Organs attacked		Types of losses			
Leaves	Fruits	Number of plants	Number of fruits/plant	Size of fruit	Quality of fruit at maturity
Leaf-eating beetles: <i>Chrysomelidae</i>					
<i>Aulacophora africana</i> , <i>Monolepta</i> spp., <i>Acalymma vittata</i> , <i>Diabrotica undecimpunctata</i> QO, <i>Asbecesta cyanipennis</i> , <i>Asbecesta transversa</i> , <i>Podagrica</i> spp.					
The most significant losses are not related directly to the feeding of the beetles, but to the transmission of bacterial wilt (<i>Erwinia tracheiphila</i>) and Cucumber mosaic virus. Cucumbers and muskmelons appear to be most susceptible to bacterial wilt followed by pumpkin and squash; watermelons can only be infected by artificial inoculation but not in nature					
Leaf perforation by adults Stem near ground and roots can also be attacked by larvae	Perforation of the peel due to feeding by adult beetles	Young plants die if attacked severely			Market value reduced Not acceptable for export
African melon ladybird beetle: <i>Henosepilachna elaterii</i> (= <i>Epilachna chrysomelina</i> = <i>E. elaterii</i>)					
Both adults and larvae feed on leaf surfaces leaving irregular holes	Adults and larvae feed on the peel of the fruits leaving holes	Young plants die if attacked severely			Infested fruits have no commercial value nor export value
Melon moth: <i>Diaphania indica</i> (= <i>Margaronia indica</i> = <i>Palpita indica</i>)					
Larvae feed on the leaves making holes	Larvae also feed on the peel of the fruits		The presence of high number of holes on leaves reduces photosynthesis and growth		Market value reduced Fruits with holes are not acceptable for export
Fruit flies: <i>Dacus vertebratus</i>; <i>Dacus ciliatus</i> QO; <i>Bactrocera cucurbitae</i> QO; <i>Bactrocera invadens</i>; <i>Bactrocera latifrons</i>; <i>Bactrocera zonata</i> QO					
	Maggots feed in fruits		Sharp decrease if fruits attacked at early stage		Fruits rot Infested fruits have no value

INSECTS (CONTINUED)

Organs attacked		Types of losses			
Leaves	Fruits	Number of plants	Number of fruits/plant	Size of fruit	Quality of fruit at maturity
American leafminer: <i>Liriomyza trifolii</i> OQ					
Adults feed on the leaves and lay eggs Emerging larvae mine the leaves			Reduced if photosynthesis is significantly slowed due to severe mining		Fruits may be sunburnt due to defoliation Sunburnt fruits are not marketable
White flies: <i>Bemisia tabaci</i> OQ					
Adults and larvae feed on the leaves			Reduced by less photosynthesis due to the presence of sooty mould that develops on the honeydew secreted by white flies		Honeydew depreciates market value of fruit due to cosmetic value reduction
Thrips: <i>Ceratothripoides cameroni</i>; <i>Frankliniella occidentalis</i> OQ; <i>Thrips</i> sp.					
Adults and larvae feed on leaves, flowers and fruits			Significant reduction under severe infestation on young plants or by flower abortion (less fruits)		Infested fruits are deformed and are not acceptable for export
Melon aphid: <i>Aphis gossypii</i>					
The melon aphid vectors several viruses that can cause a significant yield reduction. A severe viral infection, particularly at early growth stages, can even lead to total crop loss.					
Sap eaten by adults and larvae on the leaf underside			Significant reduction under severe infestation on young plants		
MITES					
Organs attacked		Types of losses			
Leaves	Fruits	Number of plants	Number of fruits/plant	Size of fruit	Quality of fruit at maturity
Red spider mites: <i>Tetranychus urticae</i>					
Feeding by adults and larvae on the leaf underside			Significant reduction under severe infestation on young plants		Severe infestation may cause heavy leaf defoliation thus exposing fruits to sunburn Affected fruits are not acceptable for export

NEMATODES

Organs attacked	Types of losses			
Roots	Number of plants	Number of fruits/plant	Size of fruits	Quality of fruits at maturity
Root-knot nematodes: <i>Meloidogyne</i> spp.				
The presence of <i>Meloidogyne</i> favours and aggravates infection by soil-borne fungi such as <i>Fusarium</i> spp. Infected plants are very sensitive to drought and irregular irrigation.				
Infested roots develop galls and rot under wet condition	Plants will die if severely attacked at early stage	Significant reduction if plants are severely attacked at early stages		

FUNGI

Organs attacked		Types of losses			
Stem	Leaves	Number of plant	Number of fruit/plant	Size of fruits	Quality of fruits at maturity
Fusarium wilt: <i>Fusarium oxysporum</i> f.sp. <i>niveum</i>					
Before the discovery of resistant varieties, the fungus could cause total crop loss.					
Mycelium develop in the stem		Loss of young plants through damping-off, or for older plants through successive wilting		If fruit has formed, it remains small and loose	commercial value
Gummy stem blight and black rot: <i>Didymella bryoniae</i> (= <i>Mycosphaerella citrullina</i>); <i>Phoma cucurbitacearum</i>					
Development of mycelium in stem, leaves and fruits		Loss of plants if infection is severe	Reduction due to leaves loss and infection of crown and runners		Fruits are spotted and rot Infected fruits have no commercial value
Anthracoze: <i>Colletotrichum orbiculare</i> (= <i>C. lagenarium</i>)					
Development of mycelium in stem, leaves and fruits					Although the infection does not reach the flesh, secondary rots may develop causing extensive damage Infected fruits have no commercial value

FUNGI (CONTINUED)

Organs attacked		Types of losses			
Stem	Leaves	Number of plant	Number of fruit/ plant	Size of fruits	Quality of fruits at maturity
Powdery mildew: <i>Sphaerotheca fuliginea</i> ; <i>Erysiphe cichoracearum</i>					
Mycelium develop on upper and lower leaf surfaces and on runners		Premature death of plants under severe infection	Reduced due to loss of foliage		Sunburnt fruits are not acceptable for export and upstream local urban markets
Downy mildew: <i>Pseudoperonospora cubensis</i>					
	Develop on leaves	Premature death of plants under severe infection	Reduced due to loss of foliage		Fruits are seldom affected directly, but may be dwarfed and have poor flavour Such fruits are not acceptable for export markets
Damping-off: <i>Pythium aphanidermatum</i>					
Development of the mycelium in the roots and the collar		Loss of young plants through damping-off			
Scab: <i>Cladosporium cucumerinum</i>					
Develop on leaves, leaf petioles, stems and fruits					Fruits with cavities have no commercial value.

BACTERIA

Organs attacked		Types of losses			
Leaves	Fruits	Number of plants	Number of fruits/plant	Size of fruit	Quality of fruit at maturity
Angular leaf spot: <i>Pseudomonas syringae</i> pv. <i>lachrymans</i>					
Before the discovery of resistant varieties, <i>Pseudomonas syringae</i> pv. <i>lachrymans</i> could cause total crop loss.					
Bacteria develop on stem, leaves and fruits					Fruits rot and have no commercial value

VIRUS

Organs attacked	Types of losses			
Whole plant	Number of plants	Number of fruits/plant	Size of fruits	Quality of fruits at maturity
Cucumber mosaic virus (CMV): <i>Bromoviridae: Cucumovirus</i>				
CMV is transmitted by several species of aphids (e.g. <i>Aphis gossypii</i> , <i>Myzus persicae</i> , etc.) in non-persistent manner. It is also transmitted by striped cucumber beetles (<i>Diabrotica vittata</i>) and 12-spotted cucumber beetles (<i>D. undecimpunctata</i>) by mechanical means in plant sap carried on their mouthparts. CMV is not seed-borne.				
Once transmitted, the virus is spread in the whole plant		Significant reduction if the plants are attacked at early growth stages before flowering.		Deformed or spotted fruits have no commercial value
Watermelon mosaic virus (WMV): Papaya ringspot virus-watermelon strain (PRSV-W)				
Watermelon mosaic virus 2 (WMV-2) (<i>Potyviridae: Potyvirus</i>)				
WMV and ZYMV are transmitted from one plant to another by aphids (e.g. <i>Aphis gossypii</i> , <i>Myzus persicae</i> etc.) and by mechanical inoculation. The transmission mode by aphids is of the non-persistent type: the aphids acquire the virus from an infected plant and then transmit it to a healthy plant with their probing. They can acquire WMV and ZYMV from an infected plant in 10 to 30 seconds and can transmit the virus after feeding for as few as 9 seconds. The viruses are not seed-borne.				
Once transmitted, the virus is spread in the whole plant		Significant reduction of growth if the plants are attacked at early growth stages before flowering		Diseased fruits are not acceptable for export and upstream local urban markets
Zucchini yellow mosaic virus (ZYMV): <i>Potyviridae: Potyvirus</i>				
Once transmitted, the virus is spread in the whole plant		Plant stunting if infection takes place at early growth stages. In this case no fruits are produced		Deformed fruits are not acceptable for export and upstream local urban markets

1.3 Identification and damage

This section provides information and illustrations to help with the identification of the main pests and diseases.

INSECTS

Leaf eating beetles: *Chrysomelidae*

The adult beetles are small, elliptical in shape. Their body length ranges from 3 to 7 mm. Their antennae are usually shorter than the body length. They are often brightly coloured, shiny or metallic. Adults bore small holes in the leaves. Larvae feed on the collar under the surface of the ground, and can even penetrate the main root, often causing death of seedlings.



Aulacophora africana



Monolepta sp.



Diabrotica undecimpunctata



Acalymma vittata

African melon ladybird beetle: *Henosepilachna elaterii* (= *Epilachna chrysomelina*= *E. elaterii*)

Adults are 6-8 mm long, reddish in colour with 12 black spots on wing covers. Larvae are 7-9 mm in length, soft and covered with dark coloured spines. Adults and larvae are often found on the lower surface of leaves. They damage the leaves by "scraping" and devouring the parenchyma and the lower epidermis between the veins, leaving one of the two surfaces intact (often the upper epidermis), as well as the tougher tissues (veins, etc.), in the form of a "window". The affected leaves become translucent, take on a greyish colour and dry up. Young plants can dry up completely and die in cases of severe attack.



Larva



Adult

Melon moth: *Diaphania indica* (= *Margaronia indica* = *Palpita indica*)

Eggs are laid singly or in groups on the underside of leaves. On hatching, the young larvae cluster around the main veins, folding or binding leaves together. The larvae can reach 15 mm long at maturity. They are green with two white longitudinal lines. The caterpillars devour the foliage and eat into or make holes in the peel (rind) of the young fruits. Damage is most serious in the early stages of fruit formation.



Caterpillars

Fruit flies: *Dacus* spp. and *Bactrocera* spp.

The morphology of the various fruit fly species is similar. Adult fruit flies are 4-7 mm long, brightly coloured, usually in brown-yellow patterns. The wings are spotted or banded with yellow and brown margins. The females pierce the skin of very young fruit to lay a dozen or so eggs just beneath the skin. The skin of older fruits is too tough for the insects to pierce. The egg-laying area turns brown, softens and becomes sunken. Eggs are about 1 mm, white, and slender. These are laid, or inserted into fruit in groups of up to 37 eggs. Eggs hatch within 1-2 days into whitish maggots, which feed on the fruit flesh. This causes the fruit to rot. After 4-17 days the maggots leave the fruit, making holes in the skin. They drop to pupate in the soil. The affected part of the fruit becomes soft and colours prematurely. Small fruits are deformed and rot if attacked. They are covered with small tunnels. The holes pierced in the fruit can be places of entry for secondary pathogens (fungi, bacteria).



Damage on fruit of butternut



Dacus sp.



Bactrocera invadens

For more information on fruit flies identification one can consult the web site
<http://www.africamuseum.be/fruitfly/AfroAsia.htm>

American leafminer: *Liriomyza trifolii*

Leafminer adults are small about 2 mm long. They are black and yellow in colour. They have a black thorax with a yellow triangular spot between the base of the wings and the upper part of the thorax is covered with bristles, which give them a gray-silver colour. The head of *L. trifolii* is mainly yellow with only a small black area at the rear edge of the eyes. Females make tiny punctures in the upper side of the leaf when feeding and depositing eggs. These punctures are easily seen in a heavy infestation. Eggs hatch into small yellow maggots and feed on the chlorophyll tissue leaving a linear and irregular pattern (mines) through the leaf with occasional thread-like black frass. Mature maggots may leave the mines and drop to the ground or remain in the mines to pupate. Severe infestation causes defoliation.



Mines on a leaf

White flies: *Bemisia tabaci*

White fly adults have a coating of white, powdery wax on the body and wings. The adults readily fly away when plants are disturbed. The adults are about 1 mm long; males are smaller than females. Eggs are elliptical about 0.2-0.3 mm long, attached vertically to leaf surface by a short stalk, which is inserted into the leaf tissue. Eggs are normally laid in an arc or circle comprising 20-40 eggs on the underside of young leaves. The pupa of *B. tabaci* has an irregular oval shape (drop-like) with oblique sides when viewed laterally. *B. tabaci* is polyphagous. Serious infestations of white fly on young plants can cause the leaves to dry up. The fruit and leaves are contaminated by the secretion of honeydew, on which sooty mould develops, reducing photosynthesis capacity of infested plants.

Thrips: *Ceratothripoides cameroni*; *Frankliniella occidentalis*

Adult thrips measure 0.5-2.0 mm in length, slender and usually winged. The wings are long, narrow and fringed with long hairs and, at rest, are tied dorsally along the body. Depending on the species, their colour varies from pale-yellowish to brownish. Female lays eggs in leaf tissue. The larvae are wingless, inactive and do not feed.

They cause deformations of terminal buds of the plants and stunt their growth. The most serious damage is due to the egg-laying lesions. Feeding cause damages not by the fact of punctures but by deformations due to saliva injected.

The tissues on which the thrips feeds become leaden in appearance and "speckled"; they are severely discoloured, particularly the petals.

Aphids: *Aphis gossypii*

Adult aphids are 1-3 mm long. They are soft-bodied, pear-shaped with a pair of cornicles and a cauda protruding from the abdomen. They may be winged (alate) or wingless. Wingless forms are the most common. Their colour varies widely depending on the host plant, temperature and crowding. Usually they are dark green, almost black while adults produced on overcrowded leaves at high temperatures may be small, less than 1 mm long and very pale yellow. Aphids live in colonies on underside of leaves.

Aphids feed on plant sap using mouthparts called "stylets", which penetrate the intercellular tissues. They can colonise a crop in just a few days. Young shoots and leaves are preferred. After being injected with the aphid's toxic saliva, the leaf or shoot turns yellow, becomes puckered and deformed, curling downward. Shoots are shortened. *A. gossypii* is generally found in large colonies on the lower surface of young leaves or on young shoots. The aphids secrete a sugary substance (honeydew) on which sooty mould develops, reducing the photosynthetic function of the leaves.



Curled leaves

MITES

Red spider mites: *Tetranychus urticae*

Adults rarely exceed a size of 0.5 mm. They are oval in shape with arched back and have eight legs, with the exception of the larval stage, which has six legs. The colour of adults range from yellow-green to brownish red with two black spots on each side of the body. Eggs are spherical, translucent whitish to pinkish in colour; sometimes with a distinct red or pale brown spot. The eggs can only be seen with a magnifying lens. Spider mites live on the underside of leaves and suck out sap by making miniscule holes. They are visible to the naked eye in the form of small red, moving "balls", but their small size makes them difficult to detect until damage is observed. The first sign of spider mite infestation appears on the upper surface of leaves in the form of small yellowish white spots. This is often accompanied by deformation and drying up of the attacked organs. The leaf can also be covered with webbing.



Webbing on a leaf



Symptoms on the upper face of a leaf

NEMATODES

Root-knot nematode: *Meloidogyne* spp.

Root-knot nematodes cause the formation of galls on the roots of plants. These irregular swellings, often round-shaped, result from root cell hypertrophy caused by the enzymes secreted by the stylet of nematode larvae. When the galls are opened, small whitish balls, measuring at most 1 mm in diameter, can be seen. These are the female nematodes. The main roots are deformed. The reduction of the secondary root system and the disruption to the conductor vessels and the plant's metabolism hinder the plant's ability to take in water and nutrients. Infested plants are therefore more susceptible to drought, grow more slowly, have fewer and chlorotic leaves, and smaller and fewer fruits. Infested plants die in cases of severe infestation. Nematode infestation can also provide a place of entry for bacteria and fungi present in soil (e.g. *Fusarium* spp.).



Galling on roots

FUNGI

Fusarium wilt: *Fusarium oxysporum* f.sp. *niveum*

When seedlings are invaded, they may damp-off and die. Older susceptible plants wilt initially, occasionally recover at night, but usually wilt quickly and die. Inside wilted stems, the vascular tissue may be discoloured reddish-brown. In wet weather, a white or pinkish fungal growth develops on the surface of dead tissues. In advance stages of the disease, roots may decompose.



Internal browning on a stem



Wilting of watermelon plants due to infection by *Fusarium* wilt

Anthracnose: *Colletotrichum orbiculare* (= *Colletotrichum lagenarium*)

All aboveground plant parts can be affected. Symptoms may develop on seedlings when the disease organism is seed-borne; on such seedlings, cotyledons droop and wilt, and lesions may form on the stem near the ground. Foliage spots begin as small yellowish or water-soaked areas that enlarge rapidly and turn brown on most cucurbits but are black on watermelon. The dry dead tissue breaks and shatters or the whole leaf dies. On muskmelons, petioles are affected. Elongated lesions appear on stems; these, together with foliage destruction, may kill the whole vine. Fruit pedicels can be affected; associated young fruit, especially watermelon fruits, darken, shrivel, and die. Fruit symptoms are most noticeable. Circular, black, sunken cankers appear on fruit. Cankers on watermelon fruit sometimes are up to 0.5 cm in diameter and may be up to 0.6 cm deep. Under humid weather, the centre of the lesions is covered with a gelatinous mass of salmon-coloured spores. The canker does not penetrate the edible flesh, but a melon with a large number of lesions usually is insipid and may be bitter.



Spots on a stem



Lesions on a leaf

Gummy stem blight and black rot: *Didymella bryoniae* (= *Cercopsora citrullina*) *Phoma cucurbitacearum*

Circular to irregular spots on leaves. On centres of the spots pycnidia (fungal fruiting bodies) develop. The spots may tear and drop out giving the leaves a tattered appearance. Crown and runners turn pale-brown and then crack oozing a reddish gum. The affected areas are studded with pycnidia. Runners may be girdled and die. Affected fruits exhibit black, leathery, sunken spots and under moist conditions pycnidia develop at the centres. Gummy exudates usually do not occur on rotted watermelon fruits. Internally, the rind immediately below the point of infection is dark brown to black, becoming progressively lighter towards the edges. Decomposition of the pulp occurs rapidly.

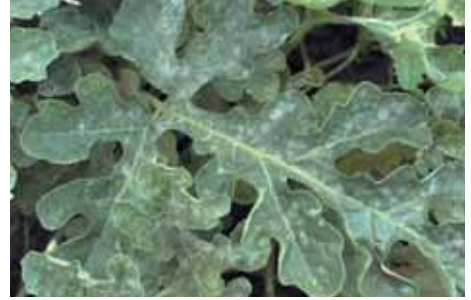
Black rot symptoms frequently develop on stored pumpkins and winter squash. Initially, the affected area is brownish and water soaked. In advanced stages, the rind becomes black and deeply wrinkled. Pycnidia may develop on rotted areas. On butternut squash, a unique superficial symptom appears on the fruit. Large irregular areas of the fruit become bronzed with distinct concentric rings. Affected area may become bleached white.



Symptoms of *Didymella bryoniae*

Powdery mildew: *Erysiphe cichoracearum*; *Sphaerotheca fuliginea*

The first foliar symptom is a whitish talcum-like powdery growth, frequently starting on the shaded undersurface of crown leaves. The areas of white powdery growth may expand and coalesce, eventually covering most of the leaf surface. The affected leaves can wither and die and finally become dry and brittle. Vines exposed when foliage dies may be withered and whitish from sunburning. Secondary effects on fruit include an increase in sunburning, premature ripening, poor flavour and texture. On some watermelon varieties, the fruits can exhibit pimpling or patches of superficial white mould on the fruits.



Whitish spots on the upper face of a watermelon leaf

Downy mildew: *Pseudoperonospora cubensis*

Downy mildew symptoms are variable. Sometimes, the first symptoms on leaves resemble mosaic: pale-green areas separated by islands of darker green. The pale-green areas change to yellow angular spots bounded by leaf veins. During moist weather, the corresponding lower surface is covered with a faint purplish fungus growth. The colour of the fungal growth may range from whitish gray to almost black. The entire affected leaf dies quickly. Fruits are seldom affected directly, but may be dwarfed and have a poor flavour. Under wet conditions infected fruits may be covered with whitish-grey fungal growth.



Lesions on a watermelon leaf



Heavy damage on a watermelon leaf

Damping-off: *Pythium aphanidermatum*

Under wet soil conditions seeds could rot before emergence. Also under wet soil conditions roots can rot. The stem can be infected at the nodes in contact with the ground when the soil is overly wet. The fungus causes soft rot followed by wilting of the stem, and in severe cases death of seedlings.

Scab: *Cladosporium cucumerinum*

The scab fungus may infect any aerial part of the plant. On leaves, water-soaked and light-green spots with a diameter of 3-4 mm are the first symptoms. These spots (often numerous) may appear on or between the veins. Similar and elongated spots may be found on stems and leafstalks. Necrotizing spots become grey and turn from round to angular often with yellowish margins. Dead tissues crack and fall giving the leaves a ragged aspect. When young plants are infected, stem and leaves rot readily. Fruits can be infected at all stages of growth, but they are most susceptible while young. Fruit lesions are grey, slightly sunken. Fruit canker becomes darker with age; collapsed tissue sinks until a pronounced cavity is formed. In moist conditions, a dark-green velvety layer of the fungus grows in the cavity.

BACTERIA

Angular leaf spot: *Pseudomonas syringae* pv. *Lachrymans*

On watermelon, leaf spots begin as small black spots, usually circular and surrounded by a yellow halo. The centre of the leaf spot may be white due to dried bacterial ooze. Lower affected leaf surfaces may appear water-soaked. As spots enlarge, they become irregular in shape and may envelop entire lobes or larger areas of a leaf. Leaves approaching maturity are more susceptible than older leaves. Fruit lesions are smaller than leaf spots and are nearly circular.



Damage on a leaf

VIRUSES

Cucumber mosaic virus (CMV): *Bromoviridae: Cucumovirus*

The plant first presents thinning-out of veins, sometimes with reddish necrotic areas on adult leaves. A pronounced "mosaic" then appears, in the form of mottled shapes of different sizes, dark and light green in colour: foliage growth is stunted and leaves are blistered. Infected plants have slow growth. A dark green marbling against a light green background can be seen on fruits. Infected fruits may exhibit spotting. Infected plants have stunted growth. On young leaves, chlorotic spots appear, forming a more or less pronounced mosaic. Watermelon infected by CMV is less severely stunted and mottled than cucumber and muskmelons.

Watermelon mosaic virus (WMV): *Papaya ringspot virus-watermelon strain (PRSV-W); Watermelon mosaic virus 2 (WMV-2) (Potyviridae: Potyvirus)*

All parts of plants can be affected. On watermelon and muskmelon plants, characteristic symptoms include moderate to severe plant stunting, leaf malformation, blistering, yellow or light-green mottling, and marginal chlorosis. Watermelon fruits on infected vines may be misshapen, dwarfed, mottled or spotted. On winter squash, leaf symptoms range from faint green to a severe chlorotic mottle. Leaves are malformed, puckered or blistered; veins sometimes extend beyond the normal leaf margin. Butternut squash may be stunted and may become bushy while internode expansion is restricted and stunted laterals become prevalent. The most conspicuous symptoms occur on infected fruits. Knobby overgrowths cover the infected fruits, which can be severely distorted.

Zucchini yellow mosaic virus (ZYMV): *Potyviridae: Potyvirus*

ZYMV frequently occurs with other cucurbit viruses. The virus has characteristics very similar to WMV (nonpersistent aphid transmission, etc.), and like WMV its host range is not limited to cucurbits. Muskmelon, watermelon, and squash are severely affected by ZYMV. Foliar symptoms consist of a prominent yellow mosaic, necrosis, distortion, and stunting. Fruits remain small, greatly malformed, and green mottled.



Mosaic pattern on leaves on butternut



Fruit symptoms on butternut

1.4. Appearance of pests and diseases in terms of phenological stage of the plant

The following table shows the stages of cultivation during which crop enemies are potentially present and the stages during which their presence can do the most harm. The purpose is to show that the presence of a pest, disease or pathogenic agent is not always harmful to the crop. It is especially during the latter stages that they must be monitored and controlled if necessary.

Stage	Length of stage	<i>Chrysomelidae</i>	<i>Henosepilachna elaterii</i>	<i>Diaphania</i> spp.	Fruit flies	<i>Liriomyza trifolii</i>	<i>Bemisia tabaci</i>	Thrips	<i>Aphis gossypii</i>	<i>Tetranychus</i> sp.	<i>Meloidogyne</i> spp.	<i>Fusarium oxysporium</i> f. sp. <i>niveum</i>	Gummy stem blight - Anthracnose - Scab	<i>Erysiphe cichoracearum</i> <i>Sphaerotheca fuliginea</i>	<i>Pseudoperonospora cubensis</i>	<i>Pythium aphanidermatum</i>	<i>Pseudomonas syringae</i> pv. <i>Lachrymans</i>	CMV, WMV and ZYMV
Seeds																		
From sowing to emergence	1 week																	
From emergence to flowering	5 weeks																	
From flowering to first harvest	6 - 7 weeks																	
From first harvest to peak of harvest	2 weeks																	
From peak to final harvest	2 weeks																	

- Periods during which pests and pathogenic agents are potentially present
- Periods during which the appearance of large numbers of pests or a serious case of disease can cause the greatest loss

1.5. Extent according to country/time of year and climate conditions favourable to crop enemies

Key:

KEN = Kenya, GAM = Gambia, SEN = Senegal, UGA = Uganda

+ = limited damage

++ = average damage: control necessary

+++ = heavy damage: control essential

X = generally limited damage but evolution of damage level over the year is not known

XX = damage can be average, but evolution of damage level over the year is not known

XXX = damage can be heavy, but evolution of damage level over the year is not known

/ = no information available

N.B. the inventory of pests and diseases has not been conducted exhaustively in all countries. The pest may be present, but has perhaps never been observed in the country on the crop, because it does not cause serious damage

African melon ladybird beetle: *Henosepilachna elaterii*

Favourable conditions: Generally more abundant in rainy season in the Sahel countries.

Month	1	2	3	4	5	6	7	8	9	10	11	12
KEN	X	X	X	X	X	X	X	X	X	X	X	X
GAM	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
SEN	+	+	+	+	+	++	++	++	++	++	+	+
UGA	/	/	/	/	/	/	/	/	/	/	/	/

Melon moth: *Diaphania* spp.

Favourable conditions: Duration of egg, larval and pupal stages decreases with increase of temperature. Optimal temperature range for development is from 25 to 270 C. They like shaded areas.

Month	1	2	3	4	5	6	7	8	9	10	11	12
KEN	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
GAM	X	X	X	X	X	X	X	X	X	X	X	X
SEN	+	+	+	+	+	0	0	0	0	0	0	+
UGA	/	/	/	/	/	/	/	/	/	/	/	/

Fruit flies: *Dacus* spp., *Bactrocera* spp.

Favourable conditions: Fruit flies thrive in hot and humid weather. The optimal temperatures for the development are 26-30 °C.

For additional information on presence of fruits flies in african countries please consult the web site <http://www.africamuseum.be/fruitfly/AfroAsia.htm>

Month	1	2	3	4	5	6	7	8	9	10	11	12
KEN	X	X	X	X	X	X	X	X	X	X	X	X
GAM	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
SEN	+	++	+++	+++	+++	+++	+++	+++	+++	+++	++	+
UGA	/	/	/	/	/	/	/	/	/	/	/	/

American leafminer fly: *Liriomyza trifolii*

Favourable conditions: In the Sahel zone, this pest is more frequent in the dry season. In Kenya, infestation can be heavy in warmer periods (i.e. January-March & October-December).

Month	1	2	3	4	5	6	7	8	9	10	11	12
KEN	++	++	++	+	+	+	+	+	+	+	+	++
GAM	X	X	X	X	X	X	X	X	X	X	X	X
SEN	+	++	++	++	++	+	0	0	0	0	+	+
UGA	/	/	/	/	/	/	/	/	/	/	/	/

White flies: *Bemisia tabaci*

Favourable conditions: High air humidity and high temperature (25-30 °C) favour infestations. Dry winds lower infestations. In Kenya, *Bemisia* is usually more important at the beginning of the dry season.

Month	1	2	3	4	5	6	7	8	9	10	11	12
KEN	+++	+++	+++	+	+	+	+	++	++	++	+	+
GAM	X	X	X	X	X	X	X	X	X	X	X	X
SEN	+	+	+	+	+	0	0	0	0	0	+	+
UGA	+++	+++	+	+	+	++	+++	+++	++	+	+	++

Thrips: *Ceratothripoides cameroni*; *Frankliniella occidentalis*; *Thrips* spp.

Favourable conditions: Thrips infestation develops when weather is hot and dry. Population is usually low in rainy season. In the Sahel zone, during warm and rainy periods, damage is particularly high on watermelon. Serious damage in Senegal, in the Casamance region.

Month	1	2	3	4	5	6	7	8	9	10	11	12
KEN	++	++	+	+	+	+	0	+	+	+	+	++
GAM	/	/	/	/	/	/	/	/	/	/	/	/
SEN	+	+	+	+	+	++	+++	+++	+++	+++	+	+
UGA	/	/	/	/	/	/	/	/	/	/	/	/

Aphids: *Aphis gossypii*

Favourable conditions: *Aphis gossypii* can live in temperatures of up to 30°C and is especially frequent in the warm and dry season. At temperatures of over 30°C its activity is limited.

Month	1	2	3	4	5	6	7	8	9	10	11	12
KEN	+++	+++	++	0	0	+	+	+	+	0	+	+++
GAM	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
SEN	+	++	++	++	++	++	0	0	0	0	0	+
UGA	+++	+++	+	+	+	++	+++	+++	++	+	+	++

Red spider mites: *Tetranychus* sp.

Favourable conditions: Hot, dry weather is conducive to the development of *Tetranychus* spp. They are normally less numerous after rains. They are normally active within a temperature range of 16- 37°C. Wind plays an important role in the dispersal of spider mites.

Month	1	2	3	4	5	6	7	8	9	10	11	12
KEN	+++	+++	++	0	0	+	+	++	++	0	+	+++
GAM	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
SEN	+	+	++	++	++	++	0	0	0	0	+	+
UGA	+++	+++	+	+	+	++	+++	+++	++	+	+	++

Root-knot nematodes: *Meloidogyne* spp.

Favourable conditions: Present throughout the year, but less during the dry season in cool zones. Optimal temperatures are 26 – 28 °C. Light, sandy soils with little organic matter content and warm soil temperatures are highly conducive to nematode development.

Month	1	2	3	4	5	6	7	8	9	10	11	12
KEN	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
GAM	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
SEN	++	++	++	++	++	++	++	++	++	++	++	++
UGA	/	/	/	/	/	/	/	/	/	/	/	/

Fusarium wilt: *Fusarium oxysporum* f.sp. *niveum*

Favourable conditions: Temperatures of between 18 and 23°C and relatively high air humidity are favourable to the development of symptoms of the disease. At temperatures of over 30°C, contaminations are much less severe.

Month	1	2	3	4	5	6	7	8	9	10	11	12
KEN	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
GAM	/	/	/	/	/	/	/	/	/	/	/	/
SEN	+	++	+++	+++	0	0	0	0	0	0	0	+
UGA	/	/	/	/	/	/	/	/	/	/	/	/

Powdery mildew: *Erysiphe cichoracearum*; *Sphaerotheca fuliginea*

Favourable conditions: It is greatly influenced by plant age, humidity, and temperature. Infection can take place at RH as low as 46% though the optimum range is between 50 and 70%. Optimum temperature is 27.4 °C. The disease is most prevalent during dry cool seasons.

Month	1	2	3	4	5	6	7	8	9	10	11	12
KEN	++	++	++	0	0	+	++	++	++	0	+	++
GAM	/	/	/	/	/	/	/	/	/	/	/	/
SEN	+	++	++	++	++	+	0	0	0	0	+	+
UGA	/	/	/	/	/	/	/	/	/	/	/	/

Downy mildew: *Pseudoperonospora cubensis*

Favourable conditions: Cool (18-22°C) and humid weather (watering, dew). Daytime temperatures of 20 to 22°C and a night-time temperature of 15°C are favourable to the disease. It develops ideally during long cool nights with abundant dew.

Month	1	2	3	4	5	6	7	8	9	10	11	12
KEN	0	0	+	+	+	+	0	0	0	+	+	0
GAM	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
SEN	+++	+++	+++	++	++	0	0	0	0	0	++	+++
UGA	/	/	/	/	/	/	/	/	/	/	/	/

Damping-off: *Pythium aphanidermatum*

Favourable conditions: *Pythium* species prefer cool soil temperatures (18 to 24°C) and high soil moisture content.

Month	1	2	3	4	5	6	7	8	9	10	11	12
KEN	X	X	X	X	X	X	X	X	X	X	X	X
GAM	/	/	/	/	/	/	/	/	/	/	/	/
SEN	0	0	+	++	0	0	0	++	++	+	0	+
UGA	/	/	/	/	/	/	/	/	/	/	/	/

Angular leaf spot: *Pseudomonas syringae* pv. *lachrymans*

Favourable conditions: Heavy rains and high humidity with long period of water presence on the leaves. Teeming rains with strong wind. Optimum temperatures are 24 - 28° C.

Month	1	2	3	4	5	6	7	8	9	10	11	12
KEN	0	0	+	+	+	0	0	+	+	+	+	0
GAM	/	/	/	/	/	/	/	/	/	/	/	/
SEN	/	/	/	/	/	/	/	/	/	/	/	/
UGA	/	/	/	/	/	/	/	/	/	/	/	/

Virus diseases: *CMV*; *WMV*; *ZYMV*

Favourable conditions: More abundant in periods favourable to aphids.

Month	1	2	3	4	5	6	7	8	9	10	11	12
KEN	+++	+++	++	+	+	+	+	++	++	++	++	+++
GAM	/	/	/	/	/	/	/	/	/	/	/	/
SEN	+	++	++	++	++	++	0	0	0	0	0	+
UGA	/	/	/	/	/	/	/	/	/	/	/	/

Minor diseases and pests

	Chrysomelidae	Anthraxnose <i>Colletotrichum orbiculare</i>	Gummy stem blight <i>Didymella bryoniae</i>	Scab <i>Cladosporium cucumerinum</i>
Favourable conditions	/	A high RH ($\geq 95\%$) and temperatures at about 25°C are very favourable conditions for disease development.	Heavy rains and high humidity with long period of water presence on the leaves. Optimal temperatures (20 to 28° C)	Heavy rains and high humidity with long period of water presence on the leaves. Optimal temperatures (18° C)
KEN	X	/	X	/
GAM	/	/	/	/
SEN	/	/	/	/
UGA	/	/	/	/

2. Main control methods

2.1. Introduction

General points on combating plant pests and diseases:

Successful production requires an integrated approach to managing pests and diseases. An important part of this approach involves a number of preventative strategies that minimise the likelihood of occurrence and when infection occurs, its severity. When these measures are implemented adequately, pest and disease problems will not reach economic thresholds.

A range of preventative measures are important to minimise susceptibility to pest and disease pressures. Some key preventative measures are as follows:

- **Location/regional occurrence** - Understanding the prevalence, timing and severity of specific pests or diseases for a given location is very important and can have a significant impact on production costs and reliability of production. One has to consider location, its microclimate and soils.
- **Surrounding land use** - Neglected farms or poorly managed surrounding properties can be a constant source for new outbreaks of pests or diseases, and infestation of properly managed fields.
- **Variety** - Selection of plant material with resistance characteristics should be used wherever possible. Selecting varieties that are well suited to the local growing conditions will ensure healthy growth and resilience to problems.
- **Healthy crop** - Emphasis on maintaining healthy crop that is naturally able to cope with minor pest or disease problems is important. The foundation for healthy crop is healthy seeds and a healthy soil. Ensure certified disease-free seeds are used. *If the seeds are pink, red, green or blue, they have been treated with fungicides and cannot be used for organic production.* Healthy soil is achieved by creating a biologically active soil with adequate organic matter and nutrient cycling (mulch) to balance the chemical, biological and physical condition of the soil.
- **Biodiversity** - Farm floor management that involves a mix of plant species and mowing at the right time to encourage beneficial insects such as predators, parasitoids and pollinators (which like flowers). Windbreaks and shelterbelts can also be designed to encourage biodiversity.
- **Hygiene** - Vigilant and thorough farm hygiene is very important. Removal of infected fruit and other plant tissues can reduce the severity of subsequent problems.
- **Rapid decomposition** - Infected plant material – as a source of future inoculum – can be reduced by rapid decomposition assisted with mulch from the farm floor.

As a result, when the right varieties of cucurbits are planted in the right location, and taken care of as above, pests and diseases will rarely pose problems.

However, this does not mean that pests and diseases will not occur. Proper identification, regular monitoring and (preparation for) timely intervention are essential for a sustainable production of high quality fruit.

Chemical products are one way of combating pests and diseases. They should be used along with other methods such as the choice of resistant varieties, good agricultural practices, etc. For example, tilling the soil after harvest helps destroy some of the pests whose development includes a stage in the ground (e.g. *Aulacophora* eggs, larvae and pupae, *Dacus* pupae, etc.).

The destruction of plants and crop residues eliminates certain pests and diseases remaining in or on the plant (e.g. *Aulacophora* larvae, *Henosepilachna* pupae, *Dacus* maggots and pupae, *Liriomyza*, white fly larvae, disease inoculum, etc.).

In the case of PPP, for repeated applications to combat pests with short life-cycles and closely spaced generations (aphids, whitefly, mites), it is important to alternate active substances with different modes of action, in order to minimise the risks of resistance.

Selective products should be used wherever possible to limit the negative impact on auxiliary insects.

Similarly, in case of application during the flowering period, products that are detrimental to pollinators such as bees must not be used.

Only products registered for the crop and for a specific use should be sprayed.

2.2. Pest or disease cycle; positioning of control methods and factors influencing the development of the cycle

Based on the stages of development of each pest or disease, the following are the applicable control methods, as well as the effects of natural factors other than those related to climate, which are described in Part 1.4. of this guide. The control methods are then positioned in terms of the development cycle of the plant.

N.B.: The illustrations of the cycles represent the different stages of development, but in no case should these illustrations be used to identify pests or diseases. For identification, please refer to part 1.2 of this guide.

The control methods for pests and diseases whose cycle is not illustrated are presented in a table.

The second column of the table shows what actions should be taken to control the different stages of development of the pest or the disease shown in the first column.

In the second column, actions that can be referred to as "cultivation practices" are shown in green boxes, and actions that can be referred to as "application of plant protection products", in pink boxes.

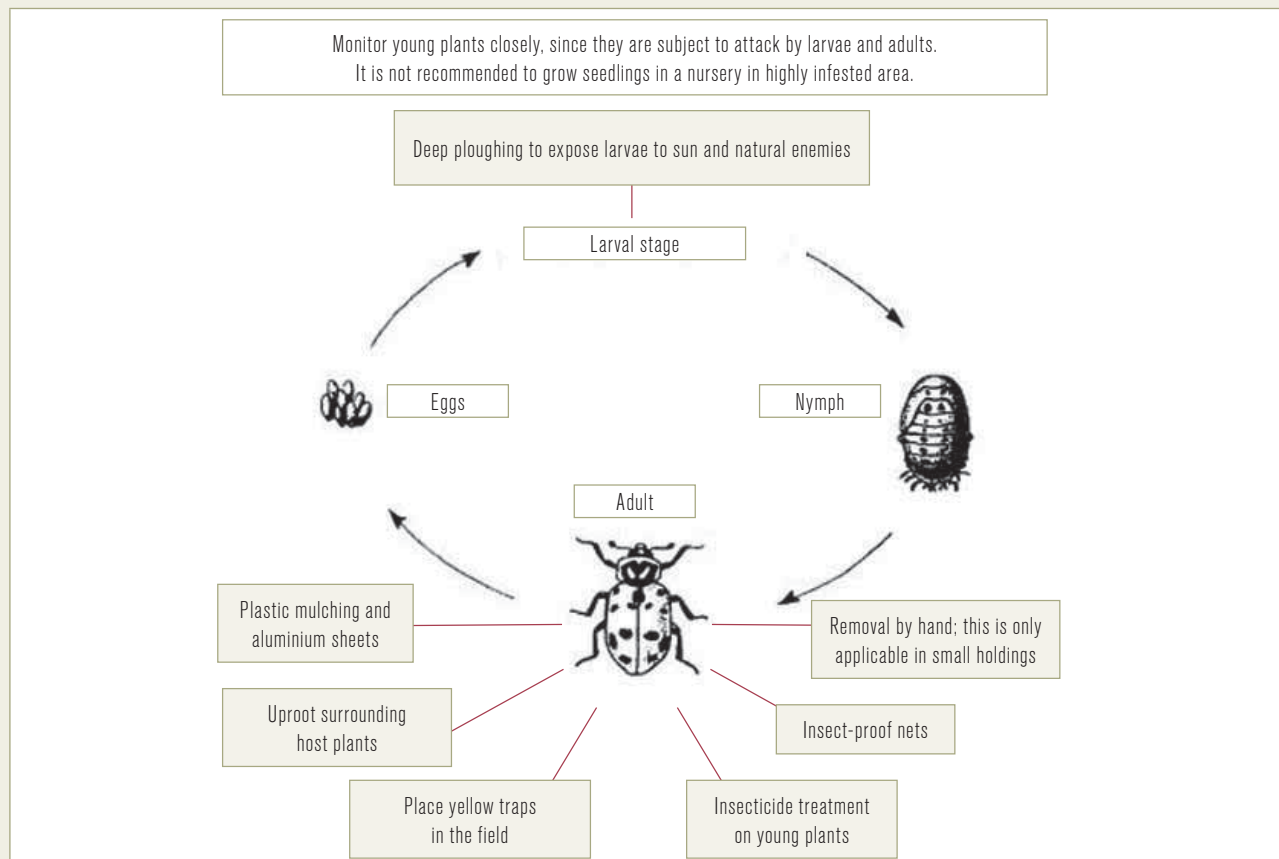
Cultivation practices

Application of plant protection product

The third column shows the cultivation stage during which these actions should be taken.

CHRYSOMELIDAE

Positioning of control methods in terms of the development stage of the pest



Positioning of control methods in terms of the development cycle of the plant

Nursery

- Uproot all old cucurbits and weeds neighbouring the nursery.
- Use a physical protection (insects-proof nets where viable) from emergence to young plant stage.
- Removal of adult beetles by hand.
- Insecticide treatment for serious outbreaks.

Field

During the production cycle, and particularly in the growth stage

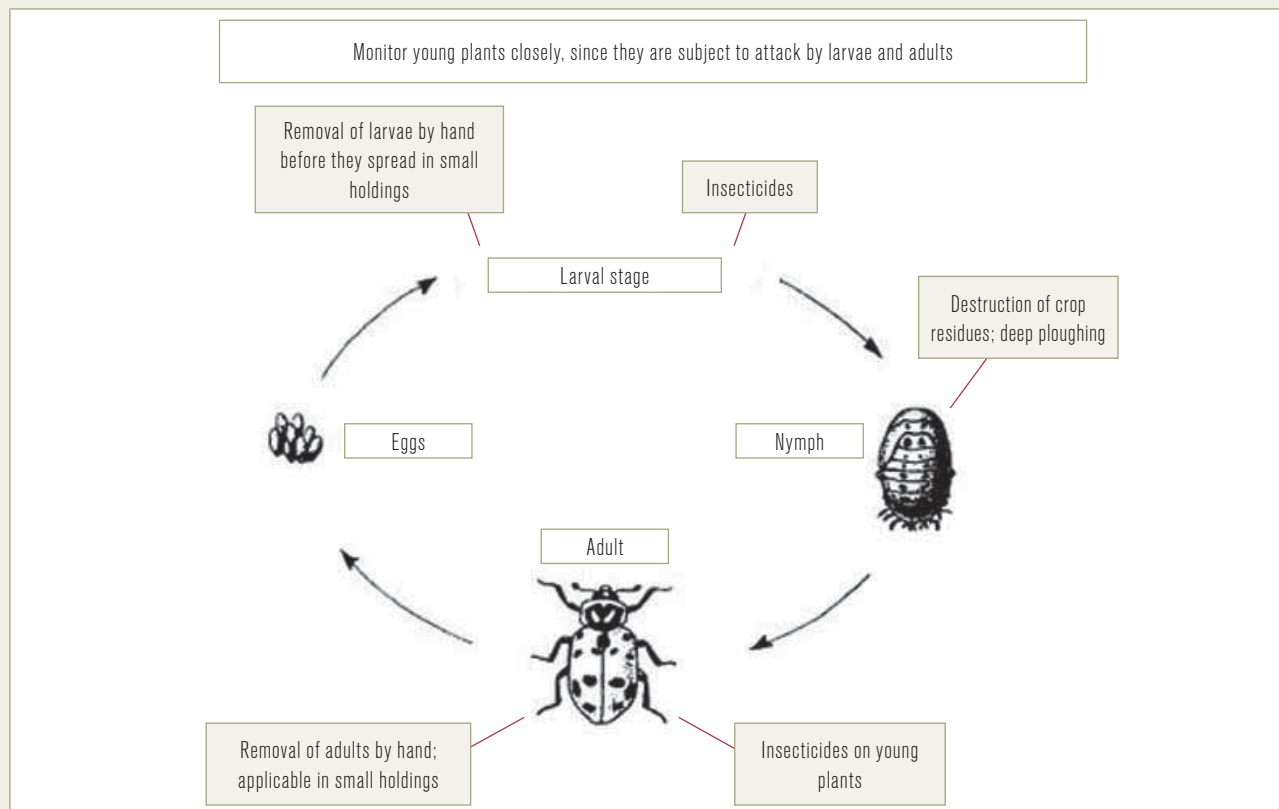
- Uproot wild cucurbits which represent a source of infestation or disease inoculum.
- Removal of adult beetles by hand on crops on small holdings. Since Chrysomelidae prefer shaded areas, inspect the underleaf and the base of plants.
- Insecticide treatment on young plants in case of serious outbreak.
- Plastic mulching and aluminium sheets where financially viable. Light reflection repels adult beetles.

After the final harvest

- Bury deeply crop residues. Larvae will not survive in the soil.

AFRICAN MELON LADYBIRD BEETLE: *HENOSEPILOCHNA ELATERII*

Positioning of control methods in terms of the development cycle of the pest



Positioning of control methods in terms of the development cycle of the plant

Nursery

- Removal of larvae and adults by hand in small holdings.
- Insecticide treatment in case of serious outbreak.

Field

During the production cycle, and particularly in the growth stage

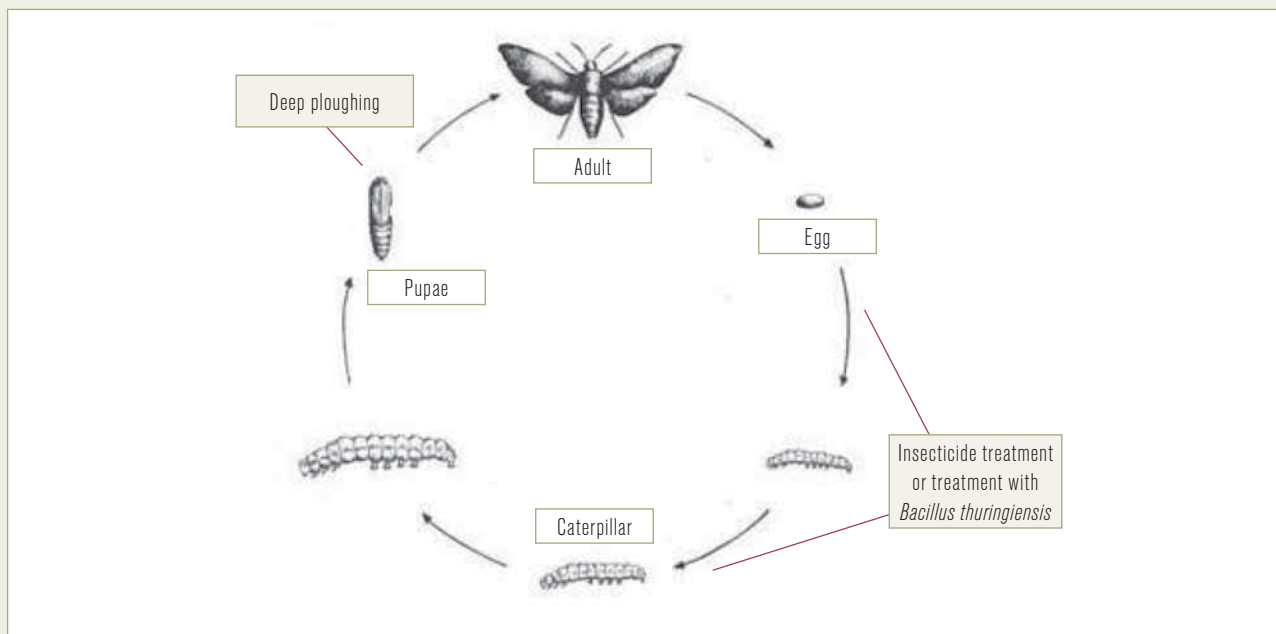
- Removal of larvae and adults by hand in small holdings.
- Insecticide on young plants in case of serious outbreak. In organic culture use botanicals.

After the final harvest

- Destruction of crop residues.

MELON MOTH: *DIAPHANIA* SPP.

Positioning of control methods in terms of the development cycle of the pest



Positioning of control methods in terms of the development cycle of the plant

Field

During the development cycle

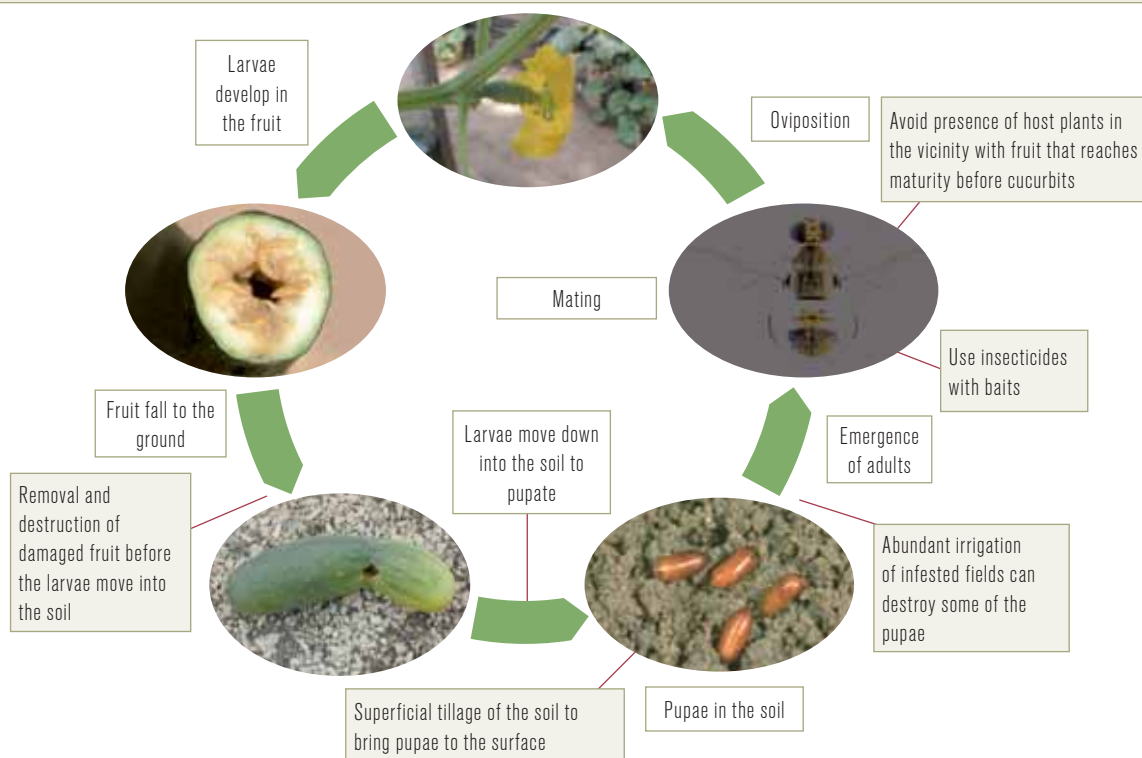
Monitoring young plants allows early detection of attacks, which generally may require a single application of insecticide in case of heavy infestation.

After the final harvest

Deep ploughing to kill last stage of larvae and pupae.

FRUIT FLY: *DACUS* SPP.; *BACTROCERA* SPP.

Positioning of control methods in terms of the development cycle of the pest



N.B. Cycle on cucumber is similar on other cucurbits

Positioning of control methods in terms of the development cycle of the plant

Field

Throughout the production cycle

- Destruction of nearby wild cucurbits which can be important reservoirs of infestation.
- Avoid presence of host plants in the vicinity with fruit that reaches maturity before cucurbits.

From the first settings

- Trapping with attractant to monitor evolution and reduce the population of adult flies.
- Use insecticides with food baits (e.g. protein hydrolytes, yeast products).

From the first harvest

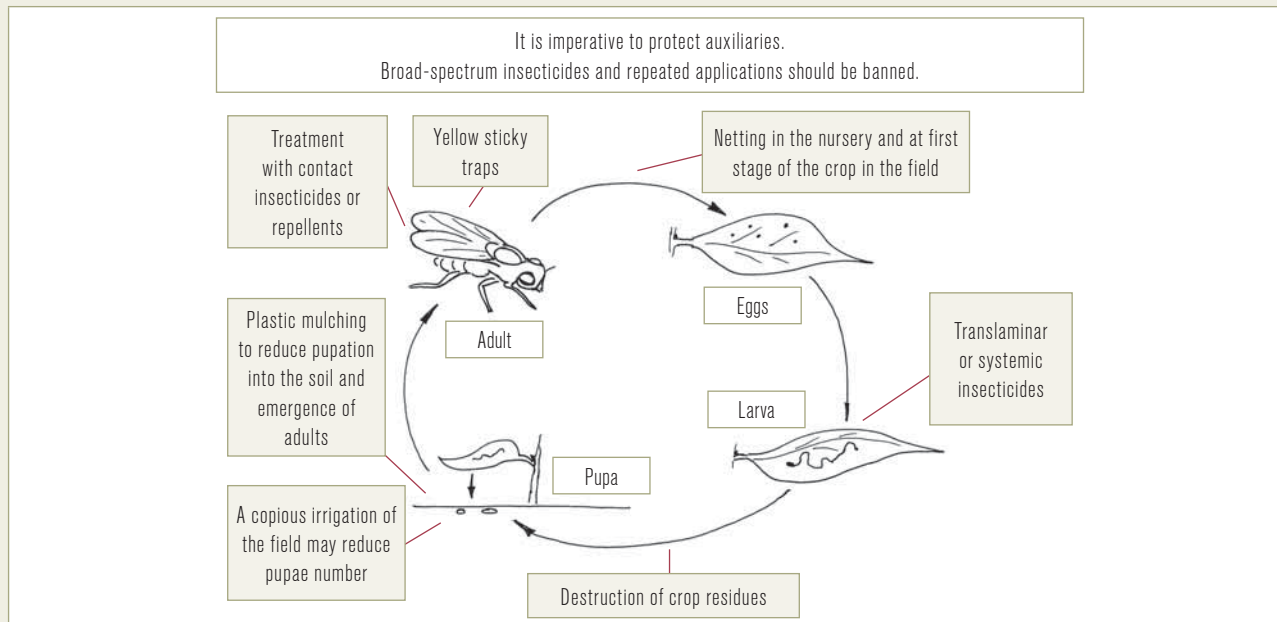
- Removal and destruction of damaged fruit through crushing and deep burial (60-90 cm) or burning.
- Use of lime during burial of damaged fruits to kill emerging larvae.

After the final harvest

- Abundant irrigation of infested fields can destroy some of the pupae.
- Superficial tillage of the soil can bring the pupae to the surface and expose them to predators, parasites and sunshine.

AMERICAN LEAFMINER FLY: *LIRIOMYZA TRIFOLII*

Positioning of control methods in terms of the development cycle of the pest



Positioning of control methods in terms of the development cycle of the plant

Nursery

- Cover with a net to avoid infestation by adults and oviposition into the leaves.
- Treatment with selective (to protect natural enemies), contact (to control the adults), translaminar or systemic insecticides (to kill larvae) used alternately (to limit risks of resistance) in case of serious outbreak.

Field

At field setting

- Cover the crop at early stages with a net to avoid infestation by adults and oviposition.
- Choose a field isolated from other crops susceptible to leafminers.
- Flood the field to destroy the pupae in the soil.
- Provide a plastic mulching to reduce pupation into the soil and emergence of adults.

During the production cycle

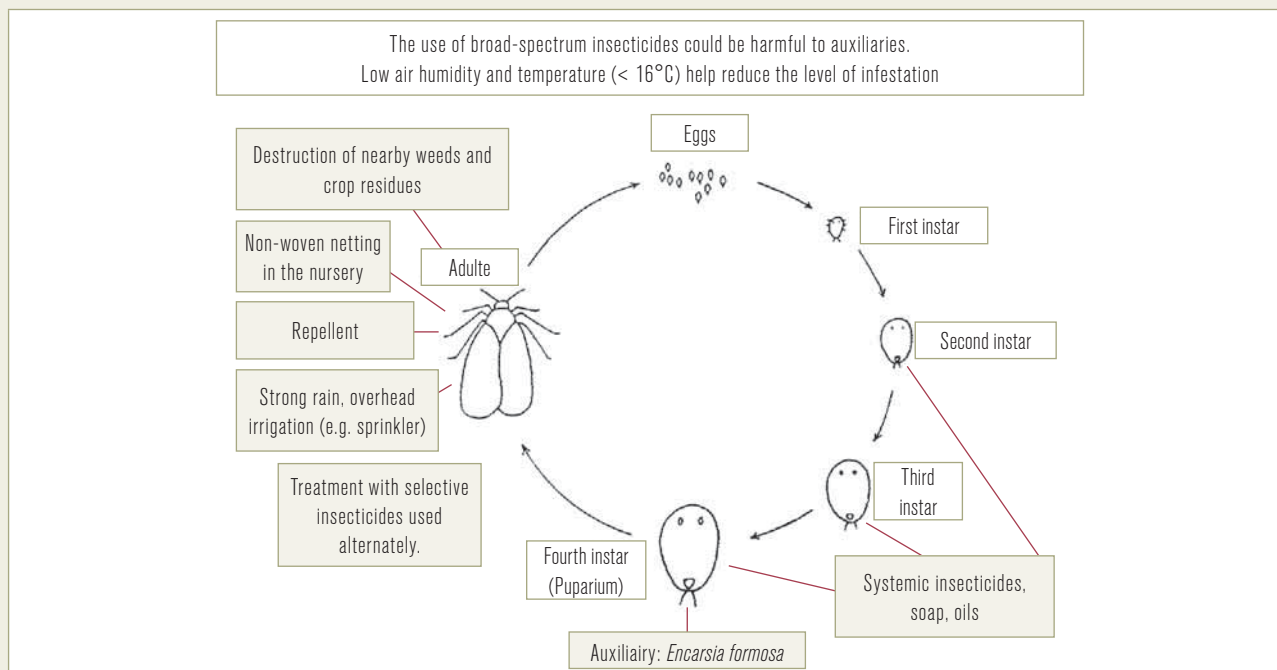
- Treatment with selective (to protect auxiliaries), contact (to control the adults), translaminar or systemic insecticides (to kill larvae) or repellents used alternately (to limit risks of resistance) in case of serious outbreak.
- Use yellow sticky traps to reduce adult population.

After the final harvest

- Destruction of crop residues.

WHITE FLIES: *BEMISIA TABACI*

Positioning of control methods in terms of the development cycle of the pest



Positioning of control methods in terms of the development cycle of the pest

Nursery

- Control of weeds (host plants for whiteflies) to minimise sources of infestation.
- Protective netting.
- Auxiliary: *Encarsia formosa* (in greenhouse).

Field

During the production cycle

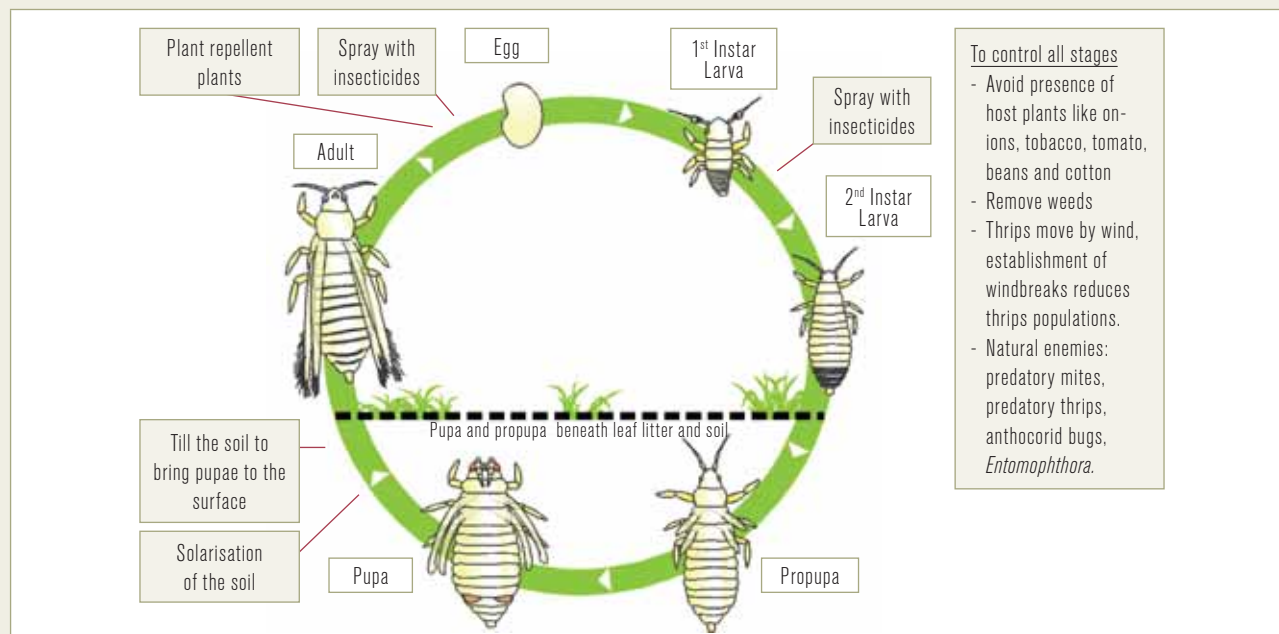
- Control of weeds (host plants for whiteflies) to minimise sources of infestation.
- Sprinkler irrigation or strong rain will limit the spread of the pest.
- Systemic insecticides to control the pupae, soap, oils.
- Selective insecticides (to limit the negative impact on auxiliaries) used alternately (to limit the risks of resistance) to control adults. Note that synthetic products are not allowed in organic production.
- Auxiliary: *Encarsia formosa* (in greenhouse).

After the final harvest

- Destruction of crop residues.

THRIPS

Positioning of control methods in terms of the development cycle of the pest



Positioning of control methods in terms of the development cycle of the plant

Nursery

- Thrips move by wind, establishment of windbreaks reduces thrips populations.
- Avoid presence of host plants like cotton, tobacco, tomato etc.
- Spray insecticides if thrips detected in the nursery.

Field

At field preparation

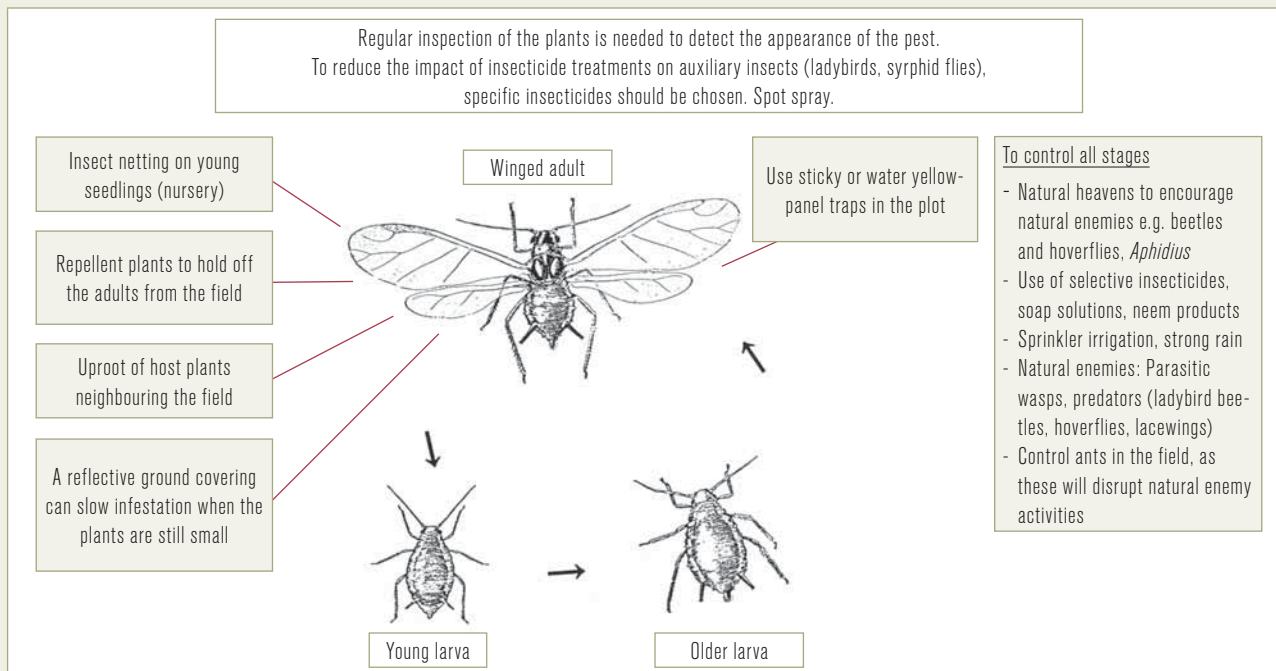
- Plough and harrow before transplanting. Solarisation can kill pupae in the soil from previously infested crops.
- Plants that have a natural repellent to thrips are citronella and pyrethrum. Plant these near the cucurbit plots.

At all stages

- Remove weeds to minimise migration of thrips.
- If absolutely necessary, spot spray repellent or biological insecticides but caution about their impact on the thrips' natural enemies.
- Try to enhance presence of natural enemies, particularly predators, are important in natural control of thrips. Main natural enemies include predatory bugs, predatory mites and predatory thrips.

MELON APHID: *APHIS GOSSYPII*

Positioning of control methods in terms of the development cycle of the pest



Positioning of control methods in terms of the development cycle of the plant

Nursery

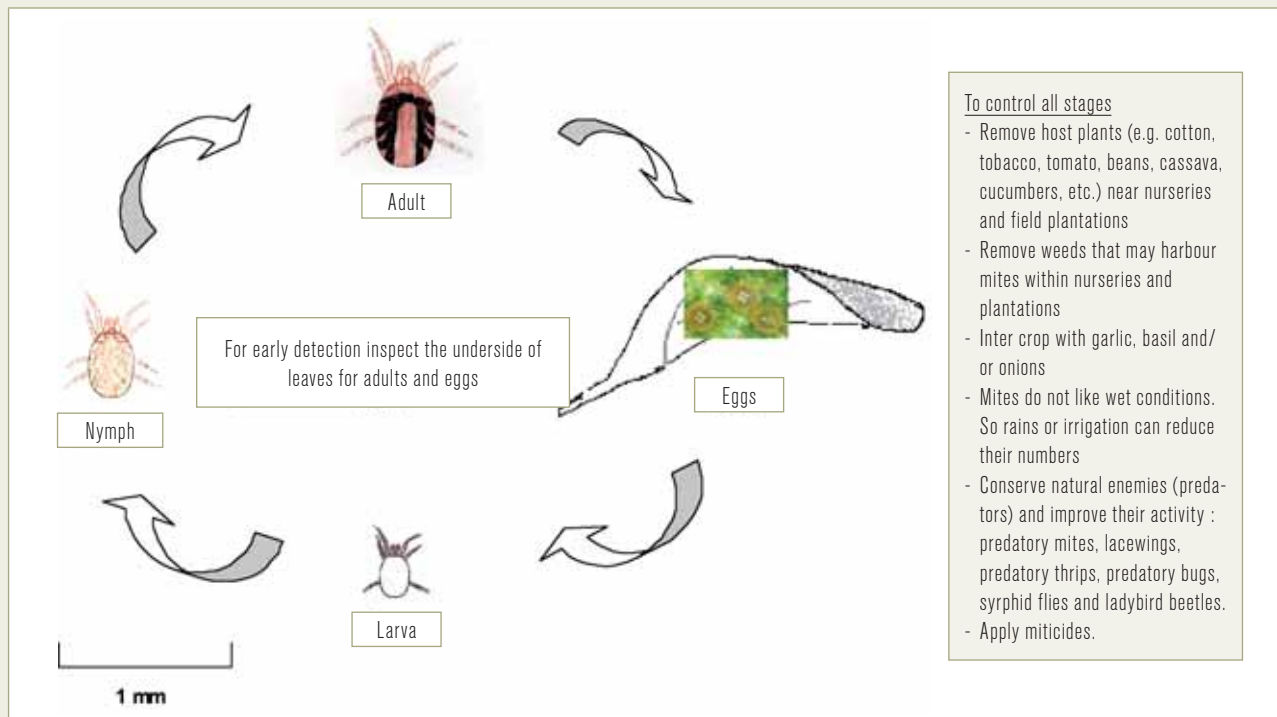
- Young plants in the nursery are vulnerable to attacks by aphids. The elimination of volunteer cucurbits and weeds around the nursery is advisable.
- Treatment with selective insecticides as soon as attacks have been detected on young plants.

Field

- Sprinkler irrigation or sustained rain can reduce infestation.
- Use well-balanced fertilisation, because an excess of nitrogen predisposes the plants to attacks by aphids.
- Install yellow traps in plots to monitor the population level and to reduce infestation; it is imperative to detect attacks at the earliest stage of cultivation to limit the risks of early transmission of viruses (CMV, etc.) or direct damage by large populations of aphids.
- Treatment with a selective insecticide upon detection of attacks on young plants.
- Destroy plants heavily infested.
- Certain plants are repellents to aphids (e.g. marigolds); they can be planted near the crops.
- Reflecting mulch can reduce infestation at early stages of the plants.

RED SPIDER MITES: *TETRANYCHUS* SP.

Positioning of control methods in terms of the development cycle of the pest



Positioning of control methods in terms of the development cycle of the plant

At all stages

- Maintain good biological control by conserving natural enemies.
- Use sprinkler irrigation in nurseries and in the field.
- Controlling dust, which improves predator activity, is critical for maintaining biological control when mites are a problem. Planting hedges along roads reduced dust drift onto crops. Make vehicles drive slowly in the vicinity of the farms. Wet dirt roads to prevent airborne dust.
- Spraying the underside of leaves with a forceful stream of water can reduce mite populations on the crop. Adding soap will be more effective.
- To minimise initial infestation, avoid drought and other stress. Appropriate irrigation frequency and amounts will reduce the adverse impact of mite feeding.
- Good sanitation practices (i.e., elimination of favoured weed species) and removal of alternative host plants (e.g. ornamental plants and vegetable crops like tomato) that act as mite reservoirs are useful cultural control practices.

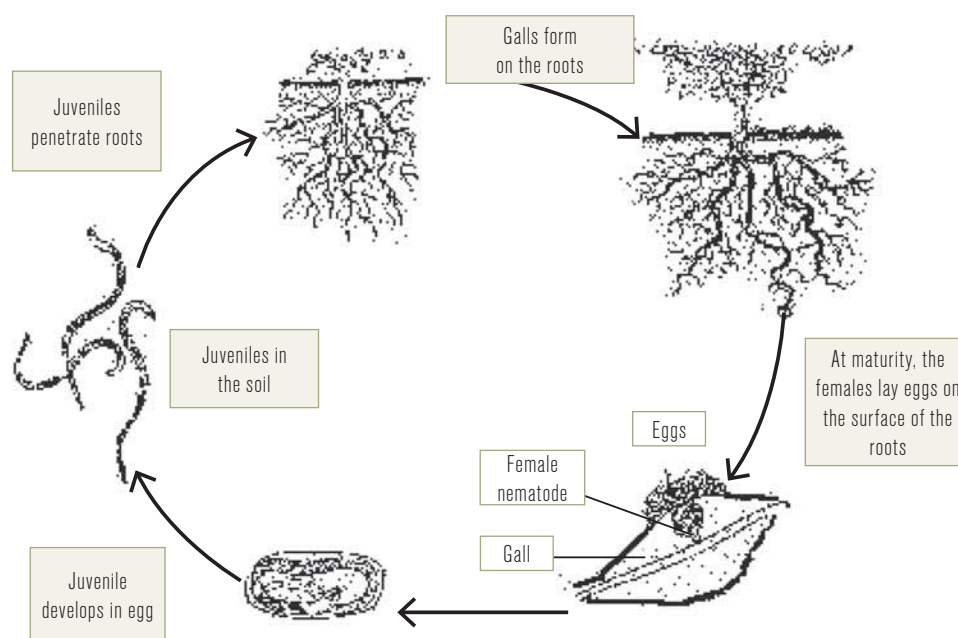
ROOT KNOT NEMATODE (*MELOIDOGYNE* SPP.)

Natural factors favourable to the pest

- Significant presence in sandy, light soils without excessive water.
- In the young larval stage, the nematode is an aquatic animal that moves in water in the ground. Nematodes therefore spread more easily in damp and light soils.

Major elements of the control strategy:

- Apart from the use of tolerant or resistant varieties, cultivation practices and field hygiene are the best ways of limiting damage from nematodes.
- Light soils should be avoided. Clayey soils are preferable, in particular vertisol soils.



Development cycle of root-knot nematode

Actions that can be used to control the pest are shown in the following table.

Development stages of the pest	Action	Cultivation stages									
		Preparation of substrate and nursery environment	Sowing	Nursery	Choice of parcel	Preparation of parcel	Planting	From planting to first harvest	From first harvest to peak of harvest	From peak to final harvest	After final harvest
Mobile phase in the ground	Disinfection of the substratum or the soil (solarisation, heat treatment)	X				X					
	Prolonged flooding of the ground results in a significant reduction of infestation by killing larvae and adults				X	X					
	The addition of organic matter (thoroughly decomposed compost, plant slurry) has a depressive effect on nematodes The decomposed organic matter activates antagonists				X	X					
	The planting of marigolds and crotalaria intercropped throughout the plot can reduce the infestation rates as a result of their nematicidal action					X	X				
Penetration and development in the plant	Localised treatment of the soil in the field (planting hole, strip) with a nematicide can prove necessary in severely infested ground					X	X	X			
Conservation in the ground	Working shrimp compost into the ground can limit the impact of the infestation					X					
Transport through water or displaced soil	Transferring soil from an infested area should be avoided					X	X				
	The disinfection of work tools limits the contamination of the ground by soiled material					X	X				
Multiplication on another crop or on weeds	The use of adequate rotation, avoidance of the use of plots where crops susceptible to nematodes have been grown (tomato, okra, tobacco, etc.) and rotation of less susceptible vegetable species (onions, sweet potato, etc.) help limit the extent of damage caused by nematodes				X	X					
	The use of plants that trap nematodes (groundnut) in crop rotation limits infestations. Likewise, intercropping with grasses can help reduce the level of infestation				X	X					

X = action to be taken at the cultivation stage shown in the corresponding column.

FUSARIUM WILT: *FUSARIUM OXYSPORIUM* F. SP. NIVEUM

Natural factors favourable to the fungus

- Humid soil, high level of organic matter.

Major elements of the control strategy:

- The pathogen survives in the soil in the saprophyte state on plant debris.
- Cultivation methods alone, such as the use of long rotation periods (3 to 4, or even 8 years) with crops other than cucurbits, can reduce the impact of the disease.
- The use of resistant varieties and of healthy seeds is strongly recommended.
- Use plants grafted onto resistant rootstock.
- Fungicide treatments are generally ineffective.
- Application of antagonist micro-organisms (e.g. *Trichoderma* spp.) helps to suppress *Fusarium* population.

Development stage of the fungus	Action	Cultivation stages									
		Preparation of substrate and nursery environment	Sowing	Nursery	Choice of parcel	Preparation of parcel	Planting	From planting to first harvest	From first harvest to peak of harvest	From peak to final harvest	After final harvest
Germination on the plant	Raising and maintaining the soil pH to 6.0 – 7.0 by liming helps limit the disease				X	X					
	The plant stems need to be kept free of attack from insects whose bites are entry points for fungi and bacteria	X		X				X			
	The growing of cucurbits on plots where water stagnates, in overly damp or very heavy soil should be avoided, to help keep the plant collar dry				X	X					
	Use plants grafted onto resistant rootstock	X	X	X			X				
Development in the plant	Excessive nitrogen fertilising is to be avoided. Sufficient application of calcium and potassium seems to reduce attacks					X	X	X			
Conservation in the ground	The destruction of diseased plants and the elimination of plant debris reduce the inoculum in the soil							X	X	X	X
	Deep tillage of the soil is necessary to bury crop residues so that they decompose completely										X
	The nursery soil can be disinfected through solarisation), or the application of damp heat (60°C)	X									
Transport through water or displaced soil	Caution is needed to keep from contaminating disinfected plots with agricultural material or contaminated soil					X	X				
	The disinfection of tools (bleach) limits the propagation of the disease			X		X	X				
Multiplication on another crop or on weeds	Use of long rotation periods (3 to 4 years)				X	X					

X = action to be taken at the cultivation stage shown in the corresponding column

GUMMY STEM BLIGHT AND BLACK ROT: *DIDYMELLA BRYONIAE*

Major elements of the control strategy:

- A long rotation (at least 2 years) with non-cucurbit crops.
- Good sanitation in the field is the best preventive control. Conditions conducive to the pathogen development should be avoided.
- An accurate monitoring of leaves is necessary to detect early infection and start sprayings on time.
- Avoid building of high humidity in the field.

Development stage of the fungus	Action	Cultivation stages										
		Preparation of substrate and nursery environment	Sowing	Nursery	Choice of parcel	Preparation of parcel	Planting	From planting to first harvest	From first harvest to peak of harvest	From peak to final harvest	After final harvest	
Germination on the plant	Seeds should be healthy and disinfected		X									
	Use of variety resistant to <i>Didium</i> limit infection by <i>Dydymella</i>		X									
	Disinfect soils and destroy infected plants	X										
	Select a piece of land exposed to the sun all the day round and a well drained soil				X	X						
	Plant in lines parallel to prevailing winds to favour air movement, avoid shading by windbreaks				X	X	X					
	Observe recommended plant spacing, avoid high density					X	X					
	Avoid water on foliage during irrigation; bring water at the base of young plants; avoid sprinkler irrigation or irrigate early in the morning to ensure drying of water on leaves; in case of dew during dry season, sprinkler irrigation should be done after evaporation of the dew						X	X	X	X		
	When climate conditions are favourable to the fungus, spraying of fungicides should be done in the few hours following a sprinkler irrigation, taking care to cover the undersides of leaves				X				X	X		
Development in the plant	Fungicides application as described above			X				X	X			
Production of spores	Destroy all plants after last harvest									X	X	
Dissemination of spores	Avoid walking through the plots when the plants are wet							X	X			
	Control aphids and beetles to reduce spreading of the disease							X	X			
	The disinfection of tools (bleach) limits the propagation of the disease							X	X			
	Mulching reduces splashing of water that facilitates disease spread							X	X			
	When the disease break out, sprinkler irrigation should be avoided to reduce spores dissemination							X	X			
Multiplication on another crop or on weeds	Clean up the area surrounding the nursery and field (the fungus spores survive on wild cucurbits)						X	X	X	X		

X = action to be taken at the cultivation stage shown in the corresponding column

ANTHRACNOSE: COLLETOTRICHUM ORBICULARE

Major elements of the control strategy:

- Use resistant varieties.
- Use healthy seeds, certified and treated (Thiram, captan). However, treated seeds are not acceptable in organic culture.
- Practise rotation (2 to 3 years) with crops other than cucurbits, tobacco, peppers and tomato.

Development stage of the fungus	Action	Cultivation stages									
		Preparation of substrate and nursery environment	Sowing	Nursery	Choice of parcel	Preparation of parcel	Planting	From planting to first harvest	From first harvest to peak of harvest	From peak to final harvest	After final harvest
Germination on the plant	Disinfect soil and destroy infected plants	X									
	Select a piece of land exposed to the sun all the day round and a well drained soil				X	X					
	Plant in lines parallel to prevailing winds to favour air movement, avoid shading by windbreaks				X	X	X				
	Observe recommended plant spacing; avoid high density planting					X	X				
	Avoid water on foliage during irrigation; irrigate at the base of young plants; avoid sprinkler irrigation or irrigate early in the morning to ensure drying of water on leaves; in case of dew during dry season, sprinkler irrigation should be done after evaporation of the dew					X	X	X	X		
	Lift up stems before they touch the soil. Avoid contact of fruits with the soil								X	X	
	When climate conditions are favourable to the fungus, spraying of fungicides should be done in the few hours following a sprinkler irrigation, taking care to cover the under leaf			X				X	X		
Development in the plant	Fungicides application as described above			X				X	X		
	Pull out infected leaves and destroy them outside the field			X				X			
	Fertilising young plants with manure can reduce impact of the disease	X									
Production of spores	Destroy all plants after last harvest									X	X
Dissemination of spores	Avoid walking through the plots when the plants are wet							X	X		
	Control insects as some may carry the fungus							X	X		
	The disinfection of tools (bleach) limits the propagation of the disease							X	X		
	Mulching reduce splashing of water that facilitates disease spread							X	X		
	When the disease breakout, sprinkler irrigation should be avoided to reduce spores dissemination							X	X		
Multiplication on another crop or on weeds	Clean up the area surrounding the nursery and field (the fungus spores survive on wild cucurbits)						X	X	X	X	

X = action to be taken at the cultivation stage shown in the corresponding column

POWDERY MILDEW: *ERYSIPHE CICHORACEARUM*; *SPHAEROTHECA FULIGINEA*

Natural factors favourable to the fungus

- Plant susceptibility increases with age.

Major elements of the control strategy:

- Close weekly monitoring of the crop when conditions are favourable for development of the disease.
- The elimination of plant debris at the end of a growing season.
- Use resistant or tolerant varieties.
- Promote a vigorous growing but without excess on nitrogen.

Development stage of the fungus	Action	Cultivation stages									
		Preparation of substrate and nursery environment	Sowing	Nursery	Choice of parcel	Preparation of parcel	Planting	From planting to first harvest	From first harvest to peak of harvest	From peak to final harvest	After final harvest
Germination on the plant	Fungicide treatments are applied, alternating active substances from different families and with different types of action (to avoid the rapid appearance of resistant fungus strains) when conditions are favourable for development of the disease. Synthetic products are not acceptable in organic culture							X	X		
Development in the plant								X	X		
Production of spores	Crop residues must be removed and destroyed								X	X	X
Spores carried by the wind	Avoid sowing near an older crop affected by powdery mildew	X			X						
Multiplication on another crop or on weeds	Clean up the area surrounding the plot to limit infection, because the fungus spores survive on wild cucurbits and other plants	X				X	X	X	X	X	

X = action to be taken at the cultivation stage shown in the corresponding column

DOWNY MILDEW: *PSEUDOPERONOSPORA CUBENSIS*

Major elements of the control strategy:

- Use of resistant varieties where these exist.
- Good hygiene in the field is the best preventive measure. It should be done to discourage the creation of ideal conditions for the fungus.
- Careful inspection of leaves allows detection of an infection from the start and intervention as soon as symptoms appear.
- Be careful not to keep the crop too damp.

Development stage of the fungus	Action	Cultivation stages									
		Preparation of substrate and nursery environment	Sowing	Nursery	Choice of parcel	Preparation of parcel	Planting	From planting to first harvest	From first harvest to peak of harvest	From peak to final harvest	After final harvest
Germination on the plant	Choose a plot exposed to sunlight all day long and with well-drained soil				X	X					
	Plant rows parallel to the direction of the dominant winds to encourage the circulation of air and to avoid shading windbreaks				X	X	X				
	Plant at proper spacing and avoid overly dense planting					X	X				
	Avoid wetting leaves during irrigation; irrigate around the base of young plants; avoid sprinkler irrigation or use it early in the morning to give leaves time to dry; in dry season when dew is present, sprinkler watering should not be used until the dew has evaporated					X	X	X	X	X	
	For intensive cultivation in climate conditions favourable to the disease, fungicide treatments should be used. Be sure to cover the underside of leaves completely; treatments should be applied within a few hours following sprinkler irrigation.			X				X	X	X	
Development on the plant	Fungicide treatments, as described above			X			X	X	X		
Production of spores	Destroy foliage and debris from affected plots after the final harvest								X	X	
Dissemination of spores	Avoid planting in the vicinity of cucurbit crops						X	X	X		
	Avoid walking through the plots when the plants are wet				X						
Multiplication on another crop or on weeds	Clean up the area surrounding the nursery and field (the fungus spores survive on wild cucurbits)					X	X	X	X		

X = action to be taken at the cultivation stage shown in the corresponding column

DAMPING-OFF: *PYTHIUM APHANIDERMATUM*

Major elements of the control strategy:

- Only proper hygiene in the field and appropriate cultivation methods can lessen the impact of the disease. Encourage vigorous growth.
- Avoid over-watering the nurseries and dense planting.

Development stage of the fungus	Action	Cultivation stages									
		Preparation of substrate and nursery environment	Sowing	Nursery	Choice of parcel	Preparation of parcel	Planting	From planting to first harvest	From first harvest to peak of harvest	From peak to final harvest	After final harvest
Germination on the plant	Use treated seeds for the protection of seedlings from the start. Note: treated seeds with fungicides are not acceptable in organic culture.		X								
	Avoid damp plots and excessive watering; encourage good drainage			X	X	X	X	X			
	Plant on mounds to facilitate the elimination of excess water				X	X					
	Avoid excessive dampness of soil at night			X			X	X			
Development in the plant	Apply specific and systemic fungicides by watering around the base of the plant (possibly using a drip irrigation system).						X	X			
Production of spores	Pull up and burn diseased plants							X	X	X	X
Conservation in the soil	Deep tillage is necessary to bury crop residues so that they decompose completely					X					X
Spores carried by water	Avoid irrigating with water from infected plots					X	X	X			
	Avoid transferring soil from infected plots					X	X	X			
Multiplication on another crop or on weeds	Rotation is advised but is not very effective because the fungus remains in the soil as a saprophyte, living on plant debris				X	X					

X = action to be taken at the cultivation stage shown in the corresponding column

SCAB: *CLADOSPORIUM CUCUMERINUM*

Major elements of the control strategy:

- Practise a rotation (2 to 3 years) with crops other than cucurbits.
- Good hygiene in the field is the best preventive measure. It should be done to discourage the creation of ideal conditions for the fungus.
- Be careful not to keep the crop too damp.
- Avoid poorly drained soils.

Development stage of the fungus	Action	Cultivation stages											
		Preparation of substrate and nursery environment	Sowing	Nursery	Choice of parcel	Preparation of parcel	Planting	From planting to first harvest	From first harvest to peak of harvest	From peak to final harvest	After final harvest		
Germination on the plant	Seeds should be healthy and disinfected		X										
	Use resistant varieties where available		X										
	Choose a plot exposed to sunlight all day long and with well-drained soil				X	X							
	Plant rows parallel to the direction of the dominant winds to encourage the circulation of air and to avoid shading by windbreaks				X	X	X						
	Plant at proper spacing and avoid overly dense planting					X	X						
	Avoid wetting leaves during irrigation; water around the base of young plants; avoid sprinkler irrigation or use it early in the morning to give leaves time to dry; in dry season when dew is present, sprinkler watering should not be used until the dew has evaporated					X	X	X	X				
	For intensive cultivation in climate conditions favourable to the disease, fungicide treatments should be used. Be sure to cover the underside of leaves completely; treatments should be applied within a few hours following sprinkler irrigation				X				X	X			
Development in the plant	Fungicide treatments, as described above			X					X	X			
Production of spores	Destroy foliage and debris from affected plots after the final harvest								X	X	X	X	
Dissemination of spores	Avoid walking through the plots when the plants are wet								X	X			
Multiplication on another crop or on weeds	Clean up the area surrounding the nursery and field (the fungus spores survive on wild cucurbits)							X	X	X	X		

X = action to be taken at the cultivation stage shown in the corresponding column

ANGULAR LEAF SPOT: *PSEUDOMONAS SYRINGAE* PV. *LACHRYMANS*

Major elements of the control strategy:

- Rotation every three to four years, because the bacteria survives in the soil.
- Use resistant varieties where these exist.
- Use healthy seeds.
- Avoid prolonged presence of water on leaves.

Development stage of the bacteria	Action	Cultivation stages									
		Preparation of substrate and nursery environment	Sowing	Nursery	Choice of parcel	Preparation of parcel	Planting	From planting to first harvest	From first harvest to peak of harvest	From peak to final harvest	After final harvest
Germination on the plant	Avoid excessively damp ground and excessive watering; encourage good drainage				X	X		X	X		
	It is preferable to use drip irrigation				X	X					
	Avoid excessive dampness of leaves at night							X	X	X	
	Apply copper-based products as soon as attacks are detected. Consult certification body on the use copper in organic culture. Repeated application may not be allowed							X	X		
Dissemination	Destroy infected plants and crop residues							X	X	X	X
Conservation in the soil	Use rotation every 3 to 4 years because the bacteria survive in the soil				X						
Transported through water or displaced soil	For irrigation, avoid using surface water near neighbouring cucurbits crops			X	X	X	X	X	X		
	Avoid transferring soil from infected plots					X	X	X	X		
	Disinfect tools	X		X		X	X	X	X		
Multiplication on another crop or on weeds	Use rotation every 3 to 4 years without cucurbits				X	X					

X = action to be taken at the cultivation stage shown in the corresponding column

VIRUS DISEASES: CMV, WMV AND ZYMV

Major elements of the control strategy:

- Because viral diseases are transmitted primarily by insects (aphids), it is important to control the vectors of viruses (see controlling aphids) on young plants.
- The use of tolerant varieties (where these exist) is recommended.
- CMV is capable of surviving on a large number of cultivated or wild host plants, and in particular, on many commercial vegetable crops.

Stage of the disease cycle and/or vector to be controlled	Action	Cultivation stages									
		Preparation of substrate and nursery environment	Sowing	Nursery	Choice of parcel	Preparation of parcel	Planting	From planting to first harvest	From first harvest to peak of harvest	From peak to final harvest	After final harvest
Inoculation in the plant	Avoid the presence of vectors by protecting the crop with non-woven netting until flowering	X		X			X				
	Watch for the appearance of aphids (vectors) and control them until the fruits are formed, during the first stages of growth.			X				X			
Development in the plant	Use all means to speed up development young plants (watering, manure, etc.) and to get them through the susceptible stage as quickly as possible						X	X			
Absorption by a vector	Destroy infected plants and crop residues							X	X	X	X
Displacement of the vector of the virus	The planting of dense rows of maize, every 3 to 5 m, is said to slow the spread of the virus. The maize is sown before the cucurbits so that it will have grown to at least 50 cm when the crop is planted. But ensure the maize is free of aphids				X	X	X	X	X		
	Mulching the soil with plastic sheeting limits aphid infestation					X	X	X			
Multiplication on another crop or on weeds	It is advisable not to plant cucurbits near crops already infected with this viral disease. Weed the area surrounding the field properly				X	X	X	X	X		

X = action to be taken at the cultivation stage shown in the corresponding column

2.3. Resistant or tolerant varieties

Watermelon and butternut varieties

Varieties	Resistance or tolerance						
	Viruses	Anthracnose	Fusarium wilt	Angular leaf spot	Downy mildew	Powdery mildew	Gummy stem blight
Watermelon							
Athens Premium		X	X				
Calhoun Grey			X				
Carman		X	X				
Carson		X	X				
Celebration		X	X				
Charleston Grey ¹			X				
Crimson Delight		X	X				
Crimson Sweet ¹		X	X				
Crimson Tide		X	X				
F1 California							X
F1 Bengal Tiger		X	X				
F1 Big Guy			X				
F1 Boxer			X				
F1 Midnight		X	X				
F1 Red Baby							X
F1 Sucrose		X	X				
F1 Sweet Dragon		X	X				
F1 Sweet Sensation			X				
F1 Sweet Yellow	X	X	X				
F1 Zebra Golden			X				
Royal Jubilee			X				
Royal Majesty			X				
Royal Star			X				
Royal Sweet			X				
Ruby			X				
Sugar Baby ¹		X					
Sukari F1 ¹		X	X				
Sunday Special ¹		X	X				
Sweet Favorite		X	X				
Tiger Baby			X				
Viking Premium		X	X				
Vista		X	X				
Zuri Fl ¹		X	X				
Butternut							
Betternut 401						X	
Bugle						X	
Early Butternut F1 ¹						X	
Ultra F1 ¹			X			X	
Waltham ¹						X	

¹ Available in Kenya

2.4. Importance and use of natural enemies

One of the most important goals in sustainable agricultural production and, particularly in organic culture, is the achievement of healthy plants by encouraging an ecological balance between pests and beneficial species. Natural enemies should be encouraged by providing conducive habitats (flowers, humidity). Natural enemies such as ladybird beetles, lacewings, predatory bugs, predatory flies, predatory mites and parasitoids can play the role of auxiliaries, preventing and limiting population explosion of pests. Some of these natural enemies are commercially produced. For example, in Kenya, the listed below biological agents are commercially available:

<i>Aphidius transscapicus</i>	<i>Encarsia formosa</i>
<i>Beauveria bassiana</i>	<i>Phytoseiulus persimilis</i>
<i>Bacillus thuringiensis</i>	<i>Trichoderma asperellum</i>
<i>Trichogrammatoidea nr lutea</i>	<i>Trichoderma spp.</i>
<i>Diglyphus isaea</i>	<i>Paecilomyces lilacinus</i>
<i>Amblyseius californicus</i>	<i>Pochonia chlamydosporia</i>
<i>Orius jeanneli</i>	

In conventional production systems caution should be taken to minimally disrupt the natural enemies. This can be done by avoiding as much as possible the use of broad-spectrum active substances and preference given to selective products.

Fruit flies (*Dacus* spp; *Bactrocera* spp.)

Fruit flies have several predators. Braconid wasps are egg parasites. Ants and ground beetles feed on the maggots present on the ground. Spiders, different flies and birds eat the adult flies.

- **Description of braconid wasps:**

Adult wasps are tiny, about 2.5 mm in size, slender black or brown with threadlike waists.

Female wasps lay eggs into the eggs of hosts' pests.

- **Conservation**

Adult braconids feed on nectar, honeydew, or pollen before laying eggs. Dill, yarrow, zinnia, clover, alfalfa, parsley, cosmos, sunflower, and marigold are flowering crops that attract the native braconid populations and provide good habitats for them.

Thrips (*Ceratothripoides cameroni* ; *Frankliniella occidentalis* ; *Thrips* spp.)

Natural enemies, particularly predators, are important in natural control of thrips. Main natural enemies include predatory bugs (*Orius* spp. and *Antho-coris* spp.), predatory mites and predatory thrips.

The naturally occurring predaceous thrips, *Franklinothrips orizabensis* and *F. vespiformis*, are important biological control agent that responds in large numbers to the presence of thrips populations.

The larval stage of this predators are easily identified by the red band on the abdomen. The adult thrips is black in colour, has a thin waist and legs which have white bands a mimic to ants.

Red spider mites (*Tetranychus* spp.)

A number of natural enemies (predators) are known to feed on spider mites. These include predatory mites, small staphylinid beetles, ladybird beetles, lacewings, predatory thrips, anthocorid bugs, mirid bugs, and cecidomyiid and syrphid flies.

Predaceous mites include *Amblyseius (Neoseiulus) californicus*, *Euseius hibisci*, *Galendromus annectens*, and *G. helveolus*. *Black hunter thrips (Leptothrips mali)*, *sixspotted thrips (Scolothrips sexmaculatus)*, *brown lacewings (Hemerobius spp.)* and green lacewings (*Chrysopa* and *Chrysoperla* spp.), a predatory midge (*Feltiella* sp., *Cecidomyiidae*), a rove beetle (*Oligota oviformis*, *Staphylinidae*), and the spider mite destroyer lady beetle (*Stethorus picipes*) are other common predators.

Ladybird beetles: They lay yellow to orange in colour eggs. The eggs are elongated and are laid in groups on the underside of leaves near aphid colonies. Newly hatched larvae are soft-bodied and usually long and thin in shape. Their colour varies from black to dark brown with various types of markings. They are less than 4 mm long. Adults are oval to hemispherical and strongly convex with short legs and short antennae. Most species are brightly coloured. When disturbed, some of them emit a strong smelling yellow liquid as a protection against other predators. Their colours vary from red, orange, steel blue, yellow-brown, or yellow elytra, frequently spotted or striped with black. They feed on pollen, nectar, water, and honeydew but aphids or other prey are necessary for egg production.

Ladybird beetles are found in most agricultural and garden habitats. These beetles are attracted by the flowers of the *Cruciferae* and *Compositae* family. Planting these flowers around the fields or even within the fields will attract the beetles. Their presence indicates that natural biological control is occurring. It is important to maintain habitats planted with several flowering crops. These give the ladybird beetles varied food sources. When food is not available, they tend to eat each other.

Lacewings: The wings of the adults are greenish (green lacewings - *Chrysopa* and *Chrysoperla* spp.) or brownish (brown lacewings - *Hemerobius* spp.) and all are semi-transparent. The eggs are laid at the end of tiny stalks, usually on foliage. The larvae have long, sickle-shaped mouth parts. The pupae are whitish and spherical and can be confused with spider mite egg sacs. Conservation of these and other natural enemies is important in management of whiteflies.

Whiteflies (*Bemisia tabaci*)

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

Aphids (*Aphis gossypii*)

The adults and larvae of most ladybird beetles (*Cheilomenes* spp., *Coccinella* spp., *Cryptolaemus montrouzieri*, *Hippodamia* spp.) are important predators of aphids. Other predators include green lacewings (*Chrysoperla carnea*, *C. rufilibris*) and predatory bugs (*Orius* spp. and *Anthocoris* spp.). Also parasitic wasps (*Aphidius colemani*, *Aphelinus abdominalis*, *Diaeretiella rapae*) play an important role in control of aphids.

Leafminers (*Liriomyza* spp.)

Leafminers are normally controlled by naturally occurring larval parasitoids (*Diglyphus isaea*; *Dacnusa sibirica*) and entomopathogenic nematodes (*Steinernema feltiae*; *Heterorhabditis megidis*). These natural enemies are also commercially produced.

Melon worm (*Diaphania* spp.)

Several parasitoids have been reported in the management of melon worm. These include *Apanteles taragamae* (on larvae); *Argyrophylax proclinata* (on larvae); *Chelonus* spp. (on eggs); *Elasmus brevicornis* (on larvae); *Eurytoma braconidis* (on larvae); *Phanerotoma hendecasisella* (on larvae); *Trathala flavo-orbitalis* (on larvae); *Trichogramma chilonis* (on eggs); and *Trichogramma confusum* (on eggs). Bacterial pathogen (*Bacillus thuringiensis*) is also widely used in the control of melon worm larvae.

Root-knot nematodes (*Meloidogyne* spp.)

A number of antagonist micro-organisms are used in the control of root-knot nematodes. They include *Hirsutella rhossiliensis*, *Paecilomyces lilacinus*, *Pasteuria penetrans*, *Pochonia chlamdosporia* and *Xenorhabdus nematophilus*.

Fusarium wilt (*Fusarium oxysporium*)

Commercial formulations of *Trichoderma asperellum* and *Trichoderma* spp. for control of Fusarium wilt are available in international markets and also in Kenya.

3. Monitoring the phytosanitary state of the crop and intervention thresholds

Crop monitoring should be carried out each week or more frequently where practicable in order to detect a problem in a crop early and to take action before serious damage occurs. The frequency of monitoring should be increased when there are favourable conditions for the development of the pest or disease (e.g. warm, humid weather for fungal diseases).

Monitoring can be carried by walking through the crop and stopping 10-20 times picking plants at random to examine the leaves / flowers / fruits / roots for pests, diseases and natural enemies. Observations should be recorded. Even if pests are present, there may be no need to spray. If their number has not increased since the previous monitoring it means that natural regulatory processes such as natural enemies or host plant resistance are preventing them multiplying to damaging numbers. In case of diseases, it may be necessary to take intervention measures when initial symptoms appear on the crop and when weather conditions are favourable for their development. In addition to physical check of plants, insect traps and indicator plants may also be employed in crop monitoring.

For fruit flies, the EU regulation 2092/91 on organic agriculture allows the usage of parapheromones for the monitoring of fruit flies. However, food attractants are still the most common monitoring tools. Trapping techniques can be utilized to reduce natural pesticide use by improving timing of sprays as a result of better monitoring of pest populations.

In general, intervention thresholds are established taking into consideration the species of pest and the local conditions. It means that from one country to another, even from one production site to another, threshold levels will be different. In most of Africa, threshold values have not yet been established. Nevertheless, careful monitoring is still recommended as pest population dynamics need to be monitored. It is very valuable to know and analyse the evolution of the pressure and to take action when a sudden increase in number is noted.

Below is a monitoring guideline for cucurbits with non-edible peel.

Pest/disease monitored	When?	Frequency	Where?	How?	Sampling
Fruit flies	First flowering, fruit to end harvest	Weekly	Fruits	Traps & physical check on fruits	4 traps per ha
Leaf eating beetles	Nursery and young plants in the field	Weekly	Nursery & in the field ; edges of the field and shaded areas	Check for leaf perforation	General field inspection
African melon ladybird beetle	Nursery and young plants in the field. Rainy season	Weekly	Nursery and in the field	Check for leaf perforation	General field inspection
Melon worm	Nursery & field. Warm season	Weekly	Leaves & fruits. Shaded areas	Devoured leaves & holes in the fruit rind.	General field inspection
Melon aphid	Nursery & field. Warm dry season	Weekly	Lower sides of young leaves	Puckered, thickened, crumpled leaves	General field inspection
American leafminer	Nursery & field. Dry season	Weekly	Leaves	Check for leaf mines	General field inspection
Whiteflies	During hot, dry weather. Nursery & field	Weekly	Lower surface of young leaves	Check visually for eggs and adults, and for presence of honeydew. Yellow sticky traps	General field inspection
Thrips	Seedlings and mature plants. Hot, dry weather	Weekly	Inflorescences; Underside of leaves	Tapping leaves and flowers over a white sheet. Yellow, blue or white sticky traps in the field	General field inspection
Mites	Nursery & field. Dry hot periods	Weekly	Concentrate on plot borders near dirt roads	Check old leaves ; Small moving red dots underleaf ; webbing	General field inspection
Root-knot nematodes	Nursery and in the field	Weekly	Yellowing of leaves; wilting of plants	Check for galling of the roots	General field inspection
Damping-off	Nursery and in the field. Excess moisture in the soil	Weekly	Seedlings in nursery and transplants in the field	Poor stand; rotting of stems at soil level covered with whitish mycelial growth.	General field inspection
Gummy stem blight and black rot	Field plants. Wet cool weather	Weekly	Leaves, crown, runners & fruit	Brown spots with pycnidia at their centres. Crowns & runners with reddish ooze. Black sunken spots on fruits	General field inspection
Fusarium wilt	Nursery & field. Warm weather	Weekly	Nursery & field	Plants yellow & wilt. Internal stem & root tissues turn brownish.	General field inspection
Downy mildew	Seedlings and mature plants. Humid weather	Weekly	Leaves	Brown angular leaf spots ; faint purplish growth underleaf	General field inspection
Powdery mildew	Seedlings and mature plants. Dry weather	Weekly	Inflorescences and leaves.	White powdery growth on leaf surfaces	General field inspection
Anthraxnose	Seedlings & field. Warm humid weather	Weekly	Leaves & fruits	Brown round leaf spots. Circular, black, sunken spots on fruits covered with salmon-coloured spores	General field inspection
Scab	Field plants. Wet cool weather	Weekly	Leaves & fruits	Grey leaf spots. Cankerous cavities on fruits	General field inspection
Angular leaf spot	Field plants. Wet warm weather	Weekly	Leaves & fruits	Black spots with white centres (bacterial exudation)	General field inspection
Viral diseases	Seedlings and mature plants. Hot, dry periods	Weekly	Leaves, vines and fruit.	Mosaic patterns on leaves, deformed leaves, fruit spotting, and presence of insect vectors	General field inspection

4. Active substances and treatment recommendations

Introduction

For each pest or disease, proposals of the strategy for the use of Plant Protection Products (PPP) are indicated below.

A list of active substances is suggested for each pest or disease. When available, the critical GAP is also given.

The PHIs (Pre-Harvest Intervals) are also indicated for:

- either to comply to the European MRL (for foodstuffs exported to EU) ;
- or to comply to the Codex MRL (for foodstuffs marketed in countries which refer to the Codex MRLs) ;
- or to produce without quantifiable residues and so respond to « 0 » residues requirements of some private standards.

Any change in one or more elements of these GAPs (increase in the doses, frequency of application and number of applications, last application before harvest not respecting the recommended pre-harvest interval) can result in residues in excess of the MRL in force. These GAPs does not represent a treatment calendar to be applied as such. In practice, the frequency of treatments must take account locally of the severity of attacks and the real risks of damage

PIP quarterly updates on its website a compilation of the GAPs (Good Agricultural Practice) taking into account modifications of EU and Codex MRLs.

Some GAP (highlighted with yellow boxes in the tables thereafter) was tested by PIP in melons in 2009/10 under tropical conditions in Senegal. It is justified to use the melon data, because in the group "cucurbits - inedible peel" melons are the major crops. That means extrapolations from melon residue data is in principle possible to the whole group "cucurbits - inedible peel" including water melons and butternut.

The list of active substances proposed has been drawn up taking into account the products used by ACP producers and the products registered in ACP countries. It is nevertheless worth noting that there are very few PPP registered on this crop in ACP countries and that not all the ACP producers contacted provided information on the PPP used. The active substances are classified by resistance risk group (classification and codes of FRAC - Fungicide Resistance Action Committee - <http://www.frac.info/frac/index.htm> and IRAC - Insecticide Resistance Action Committee - <http://www.irac-online.org/>). In practice, it is important to alternate active substances belonging to different groups.

The most appropriate development stages of the crop (green boxes) for the application of each active substance are also suggested, taking into account the pre-harvest interval to be respected so as to comply with MRLs, the modes of action of the active substances and the effects on natural enemies.

Since cucurbits depend on bees for pollination, it is recommended that the use of insecticides be kept to a strict minimum during the flowering period.

Other PPPs not shown in the following tables can be effective, for example, neem extract (to control aphids, white flies, beetles, nematodes, etc.), wood ash (to combat aphids, etc.) and soap solutions (to control spider mites, aphids, etc.). The effectiveness of this type of PPP depends in large measure on the origin of the raw materials used, so efficacy needs to be checked locally. These PPPs offer possible treatment of pests and diseases in organic production. Prior to any usage, the producer should check with his/her certification body that such usage is allowed.

Commercial soap-based PPPs (to control aphids, spider mites, whitefly, etc.) also exist and are not listed in the following tables because they pose no problems in terms of residues.

Very often, organic farmers in ACP countries use farm-made botanical extracts of which the exact concentration in active ingredients is not known, and likely fluctuates considerably. In most of the cases, the active ingredients of plant extracts degrade very quickly. This has the advantage that they do not leave residues. The Pre-Harvest Interval (PHI) is then set at the minimum (2 days) and residues are hardly a problem even when a Maximum Residue Level (MRL) is set at Limit of Quantification (LOQ).

Indications on how to prepare the farm-made products are given after the tables of products.

Leaf-eating beetles: *Aulacophora Africana*, *Monolepta spp.*, *Acalymma vittat*, *Diabrotica undecimpunctata*, *Asbecesta cyanipennis*, *Asbecesta transversa*, *Podagrica spp.*

Strategy: In case of severe infestations on large surfaces, one or two applications of a pyrethroid insecticide can be enough to keep attacks under control. During the flowering period, it is important to use insecticides that are not toxic to pollinating insects. The underside of leaves must be carefully treated to reach the larvae found there.

African melon ladybird beetle: *Henosepilachna elaterii*

Strategy: Insecticide treatments are rarely necessary, except in cases of severe infestation.

Active substance	Recommended GAP*						Proposed application period						
	Dose g /ha	Maximum number of applications	Minimum interval between applications (days)	Pre-harvest interval (days)			Preparation of soil	Sowing	Nursery	Transplant to flowering	Flowering to first harvest	First harvest to peak harvest	Peak to final harvest
				EU MRL	CODEX MRL	LOQ							
Group 3 – Pyrethroids (sodium channel modulators)													
Alpha-Cypermethrin	10	/	/	7	/	/							
Bifenthrin	40	2	/	3	3	3							
Deltamethrin	12.5	2	7	3	3	3							
Lambda-cyhalothrin	12.5	2	7	3	3	3							
Cypermethrin	40 - 50	/	/	/	/	/							

* The elements of the recommended GAP shown here allow to comply with the European MRL, the Codex MRL or the LOQ (see part 6 of this guide).
/ elements of the recommended GAP not available

Fruit flies: *Dacus spp.*; *Bactrocera spp.*

Strategy: Insecticide treatments do not reach eggs or larvae inside the fruit, or pupae. They should target adults only, to prevent egg-laying in fruits at the susceptible stage (8-10 cm in diameter). To improve their effectiveness, bait (protein hydrolysate, sugar water) can be added to the insecticide mixtures, which will be sprayed in a steady stream on nurse crops near the melon crop. Insecticides are applied to the crop itself from the start of flowering or setting at intervals of one week in cases of severe infestation. They are continued until the majority of the fruit has made it through the susceptible stage of 8 to 10 cm in diameter. It is essential to use insecticides that are not toxic to pollinating insects.

Active substance	Recommended GAP*						Proposed application period						
	Dose g /ha	Maximum number of applications	Minimum interval between applications (days)	Pre-harvest interval (days)			Preparation of soil	Sowing	Nursery	Transplant to flowering	Flowering to first harvest	First harvest to peak harvest	Peak to final harvest
				EU MRL	CODEX MRL	LOQ							
Group 3 – Pyrethroids (sodium channel modulators)													
Bifenthrin	50	2	/	7	7	7							
Deltamethrin	12.5	2	7	3	3	3							
Lambda-cyhalothrin	12.5	2	7	3	3	3							
Group 5 – Spinosines													
Spinosad	144	4	7	3	3	3							

Spinosad used to control fruit fly should be applied in spot treatment on maize as a trap crop. Since the product is applied on maize, there is no pre-harvest interval to be observed for the crop.

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/ elements of the recommended GAP not available

American leafminer fly: *Liriomyza trifolii*

Strategy: Broad-spectrum insecticides (pyrethroids), used at regular intervals to control other pests, can destroy auxiliaries and provoke explosions in the population of American leafminer fly. In case of serious infestations, detected by the presence of numerous feeding bites and tunnels, only selective insecticides (cyromazine, etc.) or acaricide-insecticides (abamectin) should be used. Treatment at the start of growth can be enough to control the pest throughout the cultivation period. Plants must be completely free of this pest when they leave the nursery.

Active substance	Recommended GAP*						Proposed application period						
	Dose g /ha	Maximum number of applications	Minimum interval between applications (days)	Pre-harvest interval (days)			Preparation of soil	Sowing	Nursery	Transplant to flowering	Flowering to first harvest	First harvest to peak harvest	Peak to final harvest
				EU MRL	CODEX MRL	LOQ							
Group 18													
Cyromazine	300	3	7	Water-melon 3 Butter-nut >21	>21	>21							
Group 6 – Avermectins													
Abamectin	9	4	7	3	3	3							

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/ elements of the recommended GAP not available

Whitefly: *Bemisia tabaci*

Strategy: Plants must be kept free of the pest in the nursery and during the early stages of their development. When the plants are older, treatments can generally be staggered over longer intervals.

A selective insecticide spares auxiliaries and is compatible with biological control. The same is true for insecticides with translaminar action that is limited to biting and sucking insects. Applications should cover the underside of leaves thoroughly to reach adults and pupae. Broad-spectrum insecticides could be harmful to auxiliaries. The flowering period requires the use of insecticides that are not toxic to pollinating insects.

Active substance	Recommended GAP*						Proposed application period						
	Dose g /ha	Maximum number of applications	Minimum interval between applications (days)	Pre-harvest interval (days)			Preparation of soil	Sowing	Nursery	Transplant to flowering	Flowering to first harvest	First harvest to peak harvest	Peak to final harvest
				EU MRL	CODEX MRL	LOQ							
Group 3 – Pyrethroids													
Bifenthrin	50 to 100	2	/	5	5	5							
Etofenprox	/	/	/	/	/	/							
Group 4 – Nicotinic Acetylcholine receptor agonists/antagonists													
Acetamiprid	30	2	7	7	/	/							
Imidacloprid	100	2	7	3	3	3							
Thiamethoxam	100	2	7	3	3	3							
Group 18 – Ecdysone agonist/moulting disruptors													
Azadirachtin	/	/	/	2	/	/							
Group 23 – Inhibitors of lipid synthesis													
Spiromesifen	/	2	7	3	/	/							
Group 9													
Pymetrozine	200	3	7	3	/	/							
Group 7 – Juvenile hormone mimics													
Pyriproxyfen	/	/	/	/	/	/							

* The elements of the recommended GAP shown here allow to comply with the European MRL, the Codex MRL or the LOQ (see part 6 of this guide).

/ elements of the recommended GAP not available

Thrips: *Ceratothripoides cameroni*; *Frankliniella occidentalis*; *Thrips* sp.

Strategy: Interventions must begin in the nursery and be continued on young plants. Avoid wherever possible repeated use of broad-spectrum insecticides (pyrethroids), which are harmful to auxiliaries. The flowering period requires the use of insecticides that are not toxic to pollinating insects.

Active substance	Recommended GAP*						Proposed application period						
	Dose g /ha	Maximum number of applications	Minimum interval between applications (days)	Pre-harvest interval (days)			Preparation of soil	Sowing	Nursery	Transplant to flowering	Flowering to first harvest	First harvest to peak harvest	Peak to final harvest
				EU MRL	CODEX MRL	LOQ							
Group 6 : Avermectins													
Abamectine	22.5	4	7	3	3	3							
Group 3 : Pyrethroids													
Acrinathrin	71,25	/	/	3	/	/							
Deltamethrin	12.5	2	7	3	3	3							
Lambda-cyhalothrin	12.5	2	7	3	3	3							
Bifenthrin	15 to 25	2	/	5	5	5							
Pyrethrin	100	/	/	2	/	/							
Group 1 - Organophosphates and carbamates													
Formetanate	500	/	/	7	/	/							
Methomyl	200	/	/	7	/	/							
Group 4 - Nicotinic acetylcholine receptor agonists/antagonists													
Imidacloprid	100	2	7	3	3	3							
Thiamethoxam	100	2	7	3	3	3							
Group 5 - Spinosines													
Spinosad	144	4	7	3	3	3							
Group 18 - Ecdysone agonist/moulting disruptors													
Azadirachtine	/	/	/	2	/	/							

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/ elements of the recommended GAP not available

Webworm: *Diaphania (Margaronia) indica*

Strategy: Inspection of young plants allows early detection of the first attacks, which, in case of a significant infestation, generally necessitate only a single application of a pyrethroid insecticide. Interventions are sometimes necessary to protect fruit.

Active substance	Recommended GAP*						Proposed application period						
	Dose g /ha	Maximum number of applications	Minimum Interval between applications (days)	Pre-harvest interval (days)			Preparation of soil	Sowing	Nursery	Transplant to flowering	Flowering to first harvest	First harvest to peak harvest	Peak to final harvest
				EU MRL	CODEX MRL	LOQ							
Group 3 – Pyrethroids													
Alpha-cypermethrin	10	1	/	7	/	/							
Bifenthrin	10	2	/	3	3	3							
Deltamethrin	12.5	2	7	3	3	3							
Esfenvalerate	12.5	/	/	/	/	/							
Lambda-cyhalothrin	12.5	2	7	3	3	3							
Group 5 – Spinosines													
Spinosad	144	4	7	3	3	3							

* The elements of the recommended GAP shown here allow to comply with the European MRL, the Codex MRL or the LOQ (see part 6 of this guide).

/ elements of the recommended GAP not available

Aphids: *Aphis gossypii*

Strategy: Localised treatments must begin as soon as the first signs of infestation have been detected to keep the population of aphids at an economically acceptable level. To lessen the impact of insecticide treatments on auxiliary insects (beetles, syrphus flies), specific insecticides (aphicides) should be chosen (pirimicarb, pymetrozine...). Pymetrozine provides translaminar and fast action, leading to an immediate halt of feeding. It is recommended to alternate insecticides with different modes of action to limit the risk of resistance. Be sure to wet the underside of leaves thoroughly to reach the aphids. The flowering period requires the use of insecticides that are not toxic to pollinating insects.

Active substance	Recommended GAP*						Proposed application period						
	Dose g /ha	Maximum number of applications	Minimum interval between applications (days)	Pre-harvest interval (days)			Preparation of soil	Sowing	Nursery	Transplant to flowering	Flowering to first harvest	First harvest to peak harvest	Peak to final harvest
				EU MRL	CODEX MRL	LOQ							
Group 9													
Pymetrozine	100	3	7	3	/	/							
Group 1 : Organophosphates and carbamates													
Pirimicarb	50	2	7	3	/	/							
Methomyl	300	/	/	7	7	/							
Group 4: Nicotinic acetylcholine receptor agonists/antagonists													
Imidacloprid	100	2	7	3	3	3							
Thiamethoxam	100	2	7	3	3	3							
Acetamiprid	30	2	7	3	/	/							
Thiacloprid	96	2	/	Watermelon 3 Butternut >21	/	/							
Group 3 - Pyrethroids													
Bifenthrin	15	2	/	3	3	3							
Lambda-cyhalothrin	12.5	2	7	3	3	3							
Tau-fluvalinate	48	/	/	3	3	3							

* The elements of the recommended GAP shown here allow to comply with the European MRL, the Codex MRL or the LOQ (see part 6 of this guide).

/ elements of the recommended GAP not available

Red spider mites: *Tetranychus* spp.

Strategy: Red spider mites are polyphagous pests that are harmful at every stage of their development (larvae, pupae and adults). Selective acaricides should be used, with an alternation to limit risks of resistance and to minimise the negative impact on auxiliaries, including predator mites.

As soon as the first symptoms have been detected, and if the attack starts to spread, treatments should be envisaged, either with specific acaricides having ovicide and/or larvicide action, or with insecticides having an acaricide effect (abamectin, pyrethroids with acaricide action). Pyrethroids with acaricide action can control most insects present at the time of treatment. Certain fungicides (sulphur) used to control powdery mildew slow the development of spider mites. However, sulphur is harmful to predatory mites.

For repeated applications, it is advisable to alternate the use of active substances with different types of action to minimise the development of resistance.

To the extent that attacks are limited in space (dust-covered plants beside paths), it is sometimes possible and useful to concentrate applications on the infested areas.

Active substance	Recommended GAP*						Proposed application period						
	Dose g /ha	Maximum number of applications	Minimum Interval between applications (days)	Pre-harvest interval (days)			Preparation of soil	Sowing	Nursery	Transplant to flowering	Flowering to first harvest	First harvest to peak harvest	Peak to final harvest
				EU MRL	CODEX MRL	LOQ							
Group 6 - Avermectins													
Abamectin	9	4	7	3	/	/							
Group 3 - Pyrethroids													
Acrinathrin	6	/	/	3	/	/							
Bifenthrin	60	2	/	7	7	7							
Group 10													
Clofentezine	200	/	/	3	/	/							
Hexythiazox	50	/	/	3	/	/							
Group 12													
Fenbutatin-oxid	495	2	/	3	3	3							
Not classified													
Sulphur	3600	7	7	Not required									
Group 21													
Tebufenpyrad	/	/	/	/	/	/							
Group 23 - Inhibitors of lipid synthesis													
Spiromesifen	/	2	7	3	/	/							

* The elements of the recommended GAP shown here allow to comply with the European MRL, the Codex MRL or the LOQ (see part 6 of this guide).

/ elements of the recommended GAP not available

Root-knot nematodes: *Meloidogyne* spp.

Strategy: In case of absolute necessity, nematicides which are often expensive and toxic, can be applied at sowing, on the strips or in pockets, avoiding generalised application.

Active substance	Recommended GAP*						Proposed application period						
	Dose g /ha	Maximum number of applications	Minimum Interval between applications (days)	Pre-harvest interval (days)			Preparation of soil	Sowing	Nursery	Transplant to flowering	Flowering to first harvest	First harvest to peak harvest	Peak to final harvest
				EU MRL	CODEX MRL	LOQ							
Group 1 - Organophosphates and carbamates													
Oxamyl	/	/	/	/	/	/							
Ethoprofos	/	/	/	/	/	/							

* The elements of the recommended GAP shown here allow to comply with the European MRL, the Codex MRL or the LOQ (see part 6 of this guide).
/ elements of the recommended GAP not available

Powdery mildew: *Erysiphe cichoracearum*; *Sphaerotheca fuliginea*

Strategy: As soon as symptoms appear or as soon as fruit has formed during the period favourable to the disease, fungicides, triazole, strobilurin or pyrimidine, should be used. Only authorised products should be used, in the recommended doses and observing the pre-harvest interval. Treatments must be repeated at intervals of seven to 14 days depending on the product and the climate conditions. Fungicide treatments should alternate active substances with different families and types of action to avoid the rapid development of strains of resistant fungi. Wettable sulphur, for preventive use, must not be used at temperatures of over 28°C (phytotoxicity).

Active substance	Recommended GAP*						Proposed application period						
	Dose g /ha	Maximum number of applications	Minimum interval between applications (days)	Pre-harvest interval (days)			Preparation of soil	Sowing	Nursery	Transplant to flowering	Flowering to first harvest	First harvest to peak harvest	Peak to final harvest
				EU MRL	CODEX MRL	LOQ							
Group 11 : QoI fungicides													
Azoxystrobin	200	3	7	3	3	/							
Boscalid	80	3	7	3	/	/							
Kresoxim-methyl	40	3	10	3	/	/							
Pyraclostrobin	100	3	7	3	/	/							
Trifloxystrobin	/	2	7	Watermelon 3 Butternut >21	/	/							
Group 8: hydroxy-(2-amino-)pyrimidines													
Bupirimate	50	/	/	8	/	/							
Group 3: DMI - fungicides													
Myclobutanil	75	3	10	3	3	3							
Penconazole	50	4	10	14	/	/							
Tetraconazole	/	/	/	7	7	7							
Triadimenol	125	2	21	7	/	/							
Imazalil	/	/	/	/	/	/							
Group M: Multisite activity													
Sulphur	3600	7	7	Not required									
Group 1: MBC fungicides													
Thiophanate-methyl	360	3	10	3	10	10							
Not classified													
Potassium hydrogen carbonate	/	/	/	Not required									

* The elements of the recommended GAP shown here allow to comply with the European MRL, the Codex MRL or the LOQ (see part 6 of this guide).
/ elements of the recommended GAP not available

Scab: *Cladosporium cucumerinum*

Strategy: Seed treatment (e.g. thiram). Spray with fungicides when weather conditions are favourable for disease development and / or when first symptoms appear.

Active substance	Recommended GAP*						Proposed application period						
	Dose g /ha	Maximum number of applications	Minimum interval between applications (days)	Pre-harvest interval (days)			Preparation of soil	Sowing	Nursery	Transplant to flowering	Flowering to first harvest	First harvest to peak harvest	Peak to final harvest
				EU MRL	CODEX MRL	LOQ							
Group 11 : QoI fungicides													
Azoxystrobin	200	3	10	3	3	/							
Pyraclostrobin	100	3	7	3	/	/							
Boscalid	100	3	7	3	/	/							
Group M: Multisite activity													
Thiram	/	/	/	/	/	/							
Captan	/	/	/	/	/	/							
Chlorothalonil	1500	4	7	3	3	3							
Mancozeb	1600	4	7	3	>21	> 21							
Maneb	1500	/	/	3	>21	> 21							
Tolyfluanide	750	6	7	3	/	/							

* The elements of the recommended GAP shown here allow to comply with the European MRL, the Codex MRL or the LOQ (see part 6 of this guide).
/ elements of the recommended GAP not available

Anthracnose: *Colletotrichum orbiculare*

Strategy: Seed treatment (e.g. thiram). Fungicide applications to control scab are usually effective against anthracnose (refer to scab)

Gummy stem blight and black rot: *Didymella bryoniae*; *Phoma cucurbitacearum*

Strategy: Seed treatment (e.g. thiram). Fungicide applications to control scab are usually effective against gummy stem blight and black rot (refer to scab).

Fusarium wilt: *Fusarium oxysporum f.sp.niveum*

Strategy: The use of resistant varieties can reduce the impact of the disease. Liming of the soil and soil application of antagonistic micro-organism such as *Trichoderma* spp. suppress the development of Fusarium wilt. Disinfection of tools (bleach) limits the propagation of the disease.

Downy mildew: *Pseudoperonospora cubensis*

Strategy: In the case of intensive cultivation in climatic conditions favourable to the disease, fungicide treatments will be applied starting in the nursery, wetting the underside of the leaves thoroughly and applying the treatment within a few hours of a sprinkler irrigation. As preventive treatment and during low-risk periods, dithiocarbamate (maneb, mancozeb, etc.) or chlorothalonil should be applied weekly or twice a week in case of abundant dew. As soon as the first symptoms appear and during high-risk periods, phenylamide (metalaxyl-M), strobilurins (azoxystrobin) and triazole (myclobutanil) provide good control of the disease. They should be used only every 10 days because they are more persistent. The same active substance should not be used more than twice on a plot.

Active substance	Recommended GAP*						Proposed application period						
	Dose g /ha	Maximum number of applications	Minimum Interval between applications (days)	Pre-harvest interval (days)			Preparation of soil	Sowing	Nursery	Transplant to flowering	Flowering to first harvest	First harvest to peak harvest	Peak to final harvest
				EU MRL	CODEX MRL	LOQ							
Group 11: QoI fungicides													
Azoxystrobin	200	3	10	3	/	/							
Famoxadone	1125	3	8	/	/	/							
Group M: Multisite activity													
Chlorothalonil	1500	4	7	3	>21	>21							
Copper	/	/	/	20	/	/							
Mancozeb	1600	4	7	3	>21	>21							
Maneb	1600	/	/	3	>21	> 21							
Propineb	2000	/	7	Water-melon 3 But-ternut >21	/	/							
Tolyfluanid	1250	3	/	14	/	/							
Group 33: Phosphonates													
Fosetyl-Al	3000	4	/	7	/	/							
Group U: risk of resistance unknown													
Iprovalicarb	/	/	/	/	/	/							
Group 27: Cyanoacetamide-oximes													
Cymoxanil	150	3	8	/	/	/							
Group 4: PhenylAmide fungicides													
Metalaxyl-M	180	3	10	Water-melon 7 But-ternut >21	/	/							
Group 28: Carbamates													
Propamocarb-HCl	1125	2	7	20	20	/							

* The elements of the recommended GAP shown here allow to comply with the European MRL, the Codex MRL or the LOQ (see part 6 of this guide).

/ elements of the recommended GAP not available

Damping-off: *Pythium aphanidermatum*

Strategy: Apply preferably as a preventive treatment in the nursery substratum or at the foot of plants in the field.

Active substance	Recommended GAP*						Proposed application period						
	Dose g /ha	Maximum number of applications	Minimum Interval between applications (days)	Pre-harvest interval (days)			Preparation of soil	Sowing	Nursery	Transplant to flowering	Flowering to first harvest	First harvest to peak harvest	Peak to final harvest
				EU MRL	CODEX MRL	LOQ							
Group 28: carbamates													
Propamocarb HCl	See below			20	20	/							
<p>The usual doses are as follows for a commercial product at 722 g/l: In the field: Preventive use: 100 ml/plant of a 0.1% mixture, used to water the base of the plant or for drip watering, 1-2 applications at an interval of 14 days – Curative use: 100-150 ml/plant (200 ml to control <i>Pythium aphanidermatum</i>) of a 0.1% concentration, used to water the base of the plant or for drip watering, 1-2 applications at an interval of 7 days. In the nursery : 5 l/m² of a 0.1% mixture, on the mounds or the seedbed.</p>													
Group 4: PhenylAmide fungicides													
Metalaxyl-M	180	3	10	Water-melon 7 But-ternut >21	/	/							

Angular leaf spot: *Pseudomonas syringae* pv. *lachrymans*

Strategy: When detected at an early stage, the disease can be kept fairly well under control using applications of copper.

Active substance	Recommended GAP*						Proposed application period						
	Dose g /ha	Maximum number of applications	Minimum Interval between applications (days)	Pre-harvest interval (days)			Preparation of soil	Sowing	Nursery	Transplant to flowering	Flowering to first harvest	First harvest to peak harvest	Peak to final harvest
				EU MRL	CODEX MRL	LOQ							
Copper	800	/	/	20	/	/							

Virus diseases: CMV; WMV; ZYMV

Strategy: Because viral diseases are transmitted primarily by insects (aphids), the vectors of viruses need to be controlled (see controlling aphids) on young plants.

* The elements of the recommended GAP shown here allow to comply with the European MRL, the Codex MRL or the LOQ (see part 6 of this guide).
/ elements of the recommended GAP not available

Sources of GAP validated by PIP melon trials (boxes highlighted in yellow in previous pages)

Active substance	Commercial product	Manufacturer	Trials	
			Year	Country
Chlorothalonil	Bravo 500 SC	Syngenta	2010	Senegal
Cyromazine	Trigard 75 WP	Syngenta	2010	Senegal
Deltamethrin	DECIS 25 EC	Bayer	2010	Senegal
Imidacloprid	Confidor 200 SL	Bayer	2010	Senegal
Lambda-Cyhalothrin	Karate 5 SC	Syngenta	2010	Senegal
Mancozeb	Dithane M 45	Dow	2010	Senegal
Myclobutanil	Systhane 240 EC	Dow	2010	Senegal
Spinosad	Laser 480 SC	Dow	2010	Senegal
Thiamethoxam	Actara 25 WG	Syngenta	2010	Senegal
Thiophanate-methyl	Topsin M 50 SC	Bayer	2010	Senegal

Note : GAPs indicated in previous pages are those corresponding to the PPPs listed above. User of this information should check if the product used is equivalent (same concentration and same type of formulation) to the reference product. If it is not the case, the indicated GAP could not be adequate.

Preparation and direction for use of “farm-made” concoctions:

Usage of neem tree (*Azadirachta indica*, family Meliaceae) extracts for spot spraying treatments. To control webworm, aphid, thrips, whiteflies . . . The effective ingredients are present in all parts of the tree but are most highly concentrated in the seeds. The insect controlling substances are primarily azadirachtin A and B. In addition, neem contains a number of other substances such as Salannin and Meliantriol, which have primarily repellent effects, and Nimbin/Nimbidin, which seem to have antiviral effects. Some substances support each other, thus creating synergistic effects. Neem seeds should be dried well so that they do not produce the toxic aflatoxins which impair their pest control properties and which are highly toxic to humans. When harvesting neem seeds, care must be taken that the fruit colour is neither greenish-yellow nor brownish-yellow but plain absolute yellow. Greenish yellow fruits are not fully mature and are low in azadirachtin content. For the collection of the fruits, spread a plastic or cloth under the tree. Thus they do not come in contact with the soil and the danger of fungus attack and aflatoxin development is reduced. After collection, the fruit pulp should be removed. The seeds are then dried for one day in the sun, and the following three days in the shade, during which they are regularly stirred. Stored neem kernels should be kept in well aerated containers or jute bags to prevent mould, which would reduce effectiveness and produces the highly toxin aflatoxin.

Seeds between 3 and 9 months after harvest have the highest quantity of azadirachtin. Germination of neem seeds will decrease about one month after harvest and if exposed to temperatures higher than 45°C.

Characteristics

- Only seeds which are green inside have a high azadirachtin content. If they are brown inside, they should be discarded.
- The pulp of the fruits has no insect control properties and should be removed.
- Azadirachtin is highly sensitive to ultraviolet light. Therefore spraying in the evening is highly recommended. Spraying also should be done immediately after the preparation is prepared.
- Degradation in 24 hours, no risk of residues.

Dosage recommendations:

- For seeds: per ha, about 30 g of azadirachtin is required. In neem seeds, contents between 2 and 9 mg/g can be found. (5 to 10 kg of seeds/ha)
- For usage of pounded neem leaves: concentration 100g/L.
- The solution should be left for decantation one day and then sprayed immediately after filtration on targeted pest.

Fatty acids of potassium salts: Active ingredient present in soft soap. To control aphids, whiteflies, thrips, mites, powdery mildew.

Take only the soft soap used for washing dishes and not washing powders since these can harm plants. Be careful with soap as it can be phytotoxic when too concentrated. First trial on a few trees is recommended before larger scale treatment.

Ginger, garlic, and chilli extracts to control fruit flies, thrips, whiteflies: Soak 50 g of peeled garlic overnight in 10 ml mineral oil. Combine garlic, 25 g of green chillies, and 25 g of ginger. Add 50 ml of water to the mixture. Grind them. Add 3 litres of water. The taste of garlic will remain on sprayed plants for one month after spraying so it may be best to avoid spraying near harvest time.

Extracts of marigold (*Tagetes* spp.) to control whiteflies: Crush large quantities of fresh flowers (roots and leaves can be added) and put this in water. Leave this for 5 to 7 days while stirring daily. Filter the mixture using a cloth. Dilute the mixture and add liquid soap (use soft soap used for washing dishes and not washing powders since these can harm plants). Preventative this should be applied once a week.

Citrus oil to control aphids, white flies: Homemade citrus oil can be made by soaking citrus peelings in an equal amount of water for 10 days to two weeks. Adding garlic-pepper tea makes the spray even more powerful. It will also kill beneficials so don't use unless pests are a problem. Possible phytotoxicity.

Wood ash to control powdery mildew, aphids: A heaped tablespoon of wood ash is stirred vigorously into one litre of water and left to stand over for one night, then strained and mixed with a cup of sour milk or buttermilk. Before spraying, this mixture is diluted three times with water. Always try out on a few trees the strength of dilution as it differs per crop to find the most effective dilution.

5. Existing registrations in ACP countries

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

For **Senegal** and **The Gambia**, none of the active substances listed in this Guide have CSP registration.

Registration in Uganda:

Data not available

For organic production

As the market of approved pesticides for ACP organic producers is very small, plant protection products specific to organic cucurbits are rarely developed. Even when an organic pesticide is registered in the producing country, it is for general use, and there are no specific recommendations for cucurbits.

Registration of active ingredients is not required for the "farm concoctions" made out of plant extracts. In all the ACP countries surveyed, there is no legislation for such products. It is not written that it is allowed to use them either, they are just not mentioned and accepted as long as they do not leave residues.

Registration of insecticides, acaricides and nematocides in Kenya

Active substance	Type of registration	Target pest											
		<i>Aulocophora africana</i>	<i>Henosepilachna elaterii</i>	<i>Dacus</i> spp. <i>Bactrocera</i> spp.	<i>Liriomyza trifolii</i>	<i>Acalymma vittata</i>	<i>Bemisia tabaci</i>	<i>Ceratitrioides cameroni</i> , <i>Thrips</i> sp. <i>Frankliniella occidentalis</i>	<i>Diaphania</i> spp.	<i>Aphis gossypii</i>	Leaf-eating beetles	<i>Tetranychus</i> sp.	<i>Meloidogyne</i> spp.
Azadiractin	cucurbits	X	X		X	X	X	X		X	X		
Bifenthrin	vegetables											X	
Cyromazine	Horticultural crops				X								
Ethoprophos	vegetables												X
Lambda-cyhalothrin	vegetables	X	X			X				X	X		
Pirimicarb	vegetables									X			
Spinosad	vegetables				X			X	X				
Sulphur	vegetables											X	

Registration of fungicides in Kenya

Active substance	Type of registration	Target disease								
		<i>Fusarium</i> sp.	<i>Colletotricum orbiculare</i>	<i>Didymella bryoniae</i>	<i>Erysiphe cichoracearum</i> <i>Sphaerotheca fuliginea</i>	<i>Pseudoperonospora cubensis</i>	<i>Pythium</i> sp.	<i>Cercospora citrullina</i>	<i>Cladosporium cucumerinum</i>	<i>Pseudomonas syringae</i> pv. <i>lachrymans</i>
Bupirimate	horticultural crops				X					
Copper	cucurbits		X							X
Famoxadone + Cymoxanil	cucurbits				X					
Fosetyl-Aluminium	vegetables					X				
Mancozeb	cucurbits					X				
Metalaxyl-M + Mancozeb	vegetables					X				
Propineb + Cymoxanil	vegetables		X			X				
Propineb	vegetables		X			X				
Sulphur	vegetables				X					
Triadimefon	vegetables				X					

6. European regulations and pesticide residues

Status of the active substances in Directive 91/414, European MRLs and Codex MRLs. Updated in December 2010.

Caution: The information contained in this table is subject to change by future amendment in regulations.

Active substance	Status DIR 91/414	European MRL on watermelon	European MRL on others cucurbits with non edible peel (butternut)	Codex MRL on cucurbits *
Abamectin	Annex 1	0.01	0.01	/
Acetamiprid	Annex 1	0.01	0.01	/
Acrinathrin	Not included*	0.1	0.1	/
Alpha-cypermethrin	Annex 1	0.2	0.2	0.07
Azadiracthin	Not included*	1	1	/
Azoxystrobine	Annex 1	1	1	1
<i>Bacillus thuringiensis</i>	Annex 1	No MRL required		/
Bifenthrin	Not included*	0.05	0.05	/
Boscalid	Annex 1	0.5	0.5	/
Bupirimate	Not included*	0.2	0.2	/
Captan	Annex 1	0.02	0.02	/
Chlorothalonil	Annex 1	1	1	/
Clofentezine	Annex 1	0.02	0.02	/
Copper	Annex 1	5	5	/
Cymoxanil	Annex 1	0.1	0.1	/
Cypermethrin	Annex 1	0.2	0.2	/
Cyromazine	Annex 1	0.3	0.05	/
Deltamethrin	Annex 1	0.2	0.2	0.2
Esfenvalerate	Annex 1	0.02	0.02	/
Etofenprox	Annex 1	0.5	0.01	/
Ethoprophos	Annex 1	0.02	0.02	/
Famoxadone	Annex 1	0.02	0.02	/
Fenbutatin oxyde	Not included*	0.05	0.05	/
Formetanate	Annex 1	0.05	0.2	/
Fosetyl-AI	Annex 1	75	75	/
Hexythiazox	Not included*	0.5	0.5	/
Imazalil	Annex 1	0.05	0.05	/
Imidacloprid	Annex 1	0.2	0.1	/
Indoxacarbe	Annex 1	0.1	0.1	/
Iprovalicarbe	Annex 1	0.2	0.05	/
Kresoxym-methyl	Annex 1	0.2	0.2	/
Lambda-cyhalothrin	Annex 1	0.05	0.05	0.05
Mancozeb	Annex 1	1	1	/

Active substance	Status DIR 91/414	European MRL on watermelon	European MRL on others cucurbits with non edible peel (butternut)	Codex MRL on cucurbits *
Maneb	Annex 1	1	1	/
Mefenoxam (Metalaxyl-M)	Annex 1	0.2	0.05	/
Methomyl	Annex 1	0.1	0.1	0.1
Myclobutanil	Not included*	0.2	0.2	/
Oxamyl	Annex 1	0.01	0.01	/
Penconazole	Annex 1	0.1	0.1	/
Potassium hydrogen carbonate	Annex 1	No MRL required		/
Propamocarb HCl	Annex 1	5	10	5
Propineb	Annex 1	1	0.5	/
Pymetrozine	Annex 1	0.2	0.2	/
Pyraclostrobin	Annex 1	0.5	0.5	/
Pyrethrin	Annex 1	1	1	/
Pirimicarb	Annex 1	1	1	/
Pyriproxyfen	Annex 1	0.05	0.05	/
Spinosad	Annex 1	1	1	0.2
Spiromesifen	Pending	0.3	0.3	/
Sulfur	Annex 1	Not required		
Tau fluvalinate	Not included*	0.01	0.01	/
Tebuconazole	Annex 1	0.5	0.05	/
Tetraconazole	Annex 1	0.05	0.05	/
Thiacloprid	Annex 1	0.2	0.02	/
Thiamethoxam	Annex 1	0.2	0.1	/
Thiophanate-methyl	Annex 1	0.3	0.3	/
Thiram	Annex 1	0.1	0.1	/
Tolyfluanide	Annex 1	0.3	0.3	/
Triadimenol	Annex 1	0.2	0.2	0.2
Trifloxystrobin	Annex 1	0.2	0.02	0.3

* Not included in Annex 1 for the time being and the EU Member States have the possibility to maintain authorisations until 31 December 2011
/ no fixed MRL – to be considered LOQ as default LMR

Note on the status of active substances in EU

Before a Plant Protection Product can be marketed in EU, its active substance must be approved by the European Commission. Directive 91/414/EEC provides a comprehensive list (Annex I) of active substances that can be incorporated in plant protection products. This Directive and its amendments are available on: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31991L0414:EN:NOT>

The status of active substances can be checked on the following web site: http://ec.europa.eu/sanco_pesticides/public/index.cfm.

Regulation (EC) No 1107/2009 concerning the placing on the market of plant protection products replaces Directive 91/414/EEC from June 14, 2011. http://europa.eu/legislation_summaries/food_safety/plant_health_checks/sa0016_en.htm

It should be noted that if an active substance is not registered in the EU it can still be used in the ACP countries in food items exported to Europe, provided the residue complies with the EU MRL.

Note on MRLs:

The quantities of pesticide residues found in food must be safe for consumers and remain as low as possible.

The maximum residue limit (MRL) is the maximum concentration of pesticide residue legally permitted in or on food or feed.

MRLs in the EU

Pursuant to Regulation (EC) No 396/2005 harmonized Community MRLs have been established.

The European Commission (EC) sets MRLs applying to foodstuffs marketed in the territories of the EU countries, either produced in the EU or in third countries.

Annex I to the Regulation contains the list of crops (Regulation (EC) 178/2006) on which MRLs are assigned, Annexes II and III contain the MRLs: temporary MRLs can be found in Annex III, final MRLs in Annex II. Substances for which an MRL is not required are listed in Annex IV (Regulation (EC) 149/2008). When there is no specific MRL for a substance / crop a default MRL, usually set at 0.01 mg/kg, is applied.

When establishing an MRL, the EU takes into account the Codex MRL if it is set for the same agricultural practices and it passes the dietary risk assessment. Where appropriate Codex MRLs exist, the import tolerance will be set at this level.

EU harmonized MRLs came into force on 1 September 2008 and are published in the MRL database on the website of the Commission http://ec.europa.eu/sanco_pesticides/public/index.cfm

See also the leaflet "New pesticide residues in food" http://ec.europa.eu/food/plant/protection/pesticides/explanation_pesticide_residues.pdf

How are MRLs applied and monitored in EU?

- Operators, traders and importers are responsible for food safety, and therefore for compliance with MRLs.
- The Member State authorities are responsible for monitoring and enforcement of MRLs.
- To ensure the effective and uniform application of these limits, the Commission has established a multiannual Community monitoring program, defining for each Member State the main combinations of crops and pesticides to be monitored and the minimum number of samples to be taken. Member States must report results to the Commission, which published an annual report. At present the reports are published by the European Food Safety Authority (EFSA) <http://www.efsa.europa.eu/en/scdocs.htm>
- In case of detection of pesticide residue levels posing a risk to consumers, information is transmitted through the Rapid Alert System for Food and Feed (RASFF) and appropriate measures are taken to protect the consumer. The database is accessible on http://ec.europa.eu/food/food/rapidalert/rasff_portal_database_en.htm and RASFF publishes an annual report http://ec.europa.eu/food/food/rapidalert/index_en.htm.
- PIP monthly updates on its website a summary of RASFF notification for fruit and vegetable imports from ACP countries.

MRLs in ACP countries – Codex

The Codex Alimentarius Commission was established in 1961 by the Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) with the objective to develop an international food code and food standards. Membership of the Codex Alimentarius Commission is open to all Member Nations and Associate Members of FAO and WHO. More than 180 countries and the European Community are members of the Codex Alimentarius Commission.

The Joint FAO/WHO Meetings on Pesticide Residues (JMPR) is not officially part of the Codex Alimentarius Commission structure, but provide independent scientific expert advice to the Commission and its specialist Committee on Pesticide Residues for the establishment of Codex Maximum Residue Limits, Codex MRLs for pesticides which are recognized by most of the member countries and widely used, especially by countries that have no own system for evaluating and setting MRLs.

The Codex MRL database can be found on the web site: <http://www.codexalimentarius.net/pestres/data/index.html?lang=en>.

ANNEXES

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- <http://www.fermedesaintemarthe.com/>
- <http://www.sunseeds.com/>

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.)

