PIP

GUIDE TO GOOD CROP PROTECTION PRACTICES

FOR CHILLIES (*Capsicum frutescens, Capsicum annuum, Capsicum chinense*) AND SWEET PEPPERS (*Capsicum annuum*)

COLEACP is an interprofessional network promoting sustainable horticultural trade.

The **PIP Programme, implemented by COLEACP**, has two overriding objectives: to enable ACP companies to **comply with European food safety and traceability requirements**; and to consolidate the position of **small-scale producers** in the ACP horticultural export sector.

www.coleacp.org/pip

COLEACP

PIP is financed by the European Development Fund.

The present document was produced with the support of the European Development Fund. The opinions expressed herein represent those of COLEACP/PIP and do not portray the official views of the European Commission.

Programme PIP
COLEACP - UGPIP
Rue du Trône, 98 bte 3 - B-1050 Brussels - Belgium
Tel.: +32 (0)2 508 10 90 - Fax: +32 (0)2 514 06 32

Document drawn up by PIP/MU with the technical collaboration of:

The International Centre of Insect Physiology and Ecology (ICIPE), Plant Health Division/ Horticultural Programme

The International Centre of Insect Physiology and Ecology. P. O. Box 30772-0100, Nairobi, Kenya.

Tel: +254 (0) 20 863 2000

Fax: + 254 (0) 20 863 2001 and 863 2002

Home Page: http//www.icipe.org

Pictures credits:

- Gilles Delhove
- ICIPE : A.M. Varela, B. Nyambo, A.A. Seif

Note

The Guide to Good Plant Protection Practices details all plant protection practices regarding the production of the fruit or vegetables in question and recommends primarily the active substances supported by pesticides manufacturers in the framework of EU Directive 91/414, which must comply with European standards for pesticide residues. Currently, these active substances have not been tested by PIP in ACP countries to check their conformity with European 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.

Table of contents

1. Main pests and diseases

1.1. Importance and impact on yield and quality

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

- the level of economic importance generally observed in ACP countries rated on the following scale: + = low, ++ = average, +++ = high;
- the parts of the plant affected and how they are attacked;
- the resulting types of loss, all of which decrease the yield of marketable fruits 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".

INSECTS						
Extent	Organs attacked		Types of loss			
	Leaves	Fruit	Number of plants	Number of fruits/ plant	Size of fruit	Quality of fruit at maturity
Aphids - *Aphis gossypii, Myzus persicae*						
Aphids cause indirect damage as vectors of important viruses such as alfalfa mosaic, chilli veinal mottle, cucumber mosaic, pepper mottle, pepper severe mosaic, pepper veinal mottle, potato Y and tobacco etch virus. Thes viruses may cause major losses						
+++	Bitten into by adults and larvae		Feeding weaken plants and may cause death of young plants when present in large numbers.	Reduced by weakening of plants and distorted leaves due to high infestations. Reduced by growth of sooty mould, which affects photosynthesis.		High infestation may cause fall off of leaves leading to fruit sun scald in warm weather Honeydew and sooty mould deposits also reduce fruit quality
Cutworms - *Agrotis* spp., *Spodoptera* spp.						
++	Leaves and/or stem are eaten by caterpillars		Plants can be cut off when young so reducing density and harvest	Damage on older plants will affect the growth, but not cause death.		
Fruit flies - *Bactrocera* spp. *Ceratitis* spp.						
all are QO and may lead to rejection of produce in Europe						
+++		Larvae inside		Sharp decrease because attacked fruit can drop.		Maggot-infested peppers are not marketable

INSECTS (continued)						
Extent	Organs attacked		Types of loss			
	Leaves	Fruit	Number of plants	Number of fruits/ plant	Size of fruit	Quality of fruit at maturity
Leafminer fly - *Liriomyza trifolii* QO, *L.huidobrensis, L.bryoniae*						
Feeding and egg laying by adults can serve as entry points for disease-causing organisms such as bacteria and fungi and, in severe attack can kill seedlings.						
+	Bitten into by adults and mined by larvae		Weaken plants and may cause death of young plants when present in large numbers.	Reduced if photosynthesis is significantly slowed due to extensive mining		Causes defoliation, which may lead to fruit sunscald in warm weather.
White flies - *Bemisia tabaci* QO, *Aleurodicus dispersus,Trialeurodes vaporariorum*						
Whiteflies are vectors of viral diseases that may cause major yield losses. This is the main threat to yield posed by whiteflies.						
+++	Bitten into by adults and larvae		May cause death of young plants when present in large numbers.	Reduced if photosynthesis is significantly slowed due to the presence of sooty mould that develops on the honeydew secreted by larvae		Honeydew depreciates market value of fruit
Thrips - *Thrips palmi QO, Frankliniella occidentalis* QO, *Scirtothrips dorsalis, Thrips tabaci*						
Thrips are vectors of the tomato spotted wilt virus (TSWV)						
+++	Eaten by adults and larvae		Heavy infestation can kill the plant	Significant reduction if growth is slowed by severe attacks on young plants particularly in hot weather. When numerous, thrips may cause wilting, distortion of young leaves and shoots, reduction in flower production and flower abortion.		Both nymphs and adults leave scars, deformities. Leaf deformation and defoliation may lead to fruit sunscald in hot weather
Fruit borers – *Helicoverpa armigera* QO; *Spodoptera* spp.						
Mainly on sweet pepper						
++	Eaten by larvae		They may cause flower abortion and falling of young fruits.			Hole and rot in the fruits

MITES

Extent	Organs attacked		Types of loss			
	Leaves	Fruit	Number of plants	Number of fruits/ plant	Size of fruit	Quality of fruit at maturity
Broad mite - *Polyphagotarsonemus latus*						
+++	Eaten by adults and larvae as well as srem and flowers		Severely infested plants may drop the leaves, stop growing and eventually die.	Vegetative growth is inhibited and flower production is reduced. Severely infested fruits fall.		Attacked fruits are deformed and unfit for sale
Red spider mite - *Tetranychus urticae*						
++	Eaten by adults and larvae		Spider mites can kill plants under hot and dry conditions.	May be considerably reduced particular under dry hot conditions due to defoliation of plants		Leaf defoliation may lead to fruit sunscald under dry hot conditions

FUNGI

Extent	Organs attacked		Types of loss			
	Stem	Fruits	Number of plants	Number of fruits/ plant	Size of fruit	Quality of fruit at maturity
Anthracnose - *Colletotrichum* spp.						
+++	Development of mycelium inside the stem	Development of mycelium inside the fruit	Pre-and post emergence damping off killing seedlings.	.		Causes fruit infection rendering them not marketable.
Damping off - Rhizoctonia solani, *Pythium* spp., *Fusarium* spp.						
+	Development of mycelium inside the stem. Soilborne		Death of seedlings prior to and after emergence			
Fusarium wilt - *Fusarium oxysporum* f.sp. *capsici*						
+++	Development of mycelium inside the stem. Soilborne.			Reduced because causes yellowing of foliage and finally wilting of plants.		
Powdery mildew - *Leveillula taurica*						
+++		Presence of the fungus on upper and lower surfaces		Reduced if photosynthesis is significantly slowed due to the presence of the fungus at young crop stage		

BACTERIA

Extent	Organs attacked		Types of loss			
	Stems	Fruits	Number of plants	Number of fruits/ plant	Size of fruit	Quality of fruit at maturity
Bacterial soft rot - *Erwinia carotovora* pv. *carotovora*						
+		The bacteria enter into the fruit by wounds done by insects or after cutting the stem at harvest				Fruit infected often collapse and hang on the plant like a water-filled bag. It can be a destructive post-harvest (market) disease.
Bacterial wilt - *Ralstonia solanacearum* QO						
Before the discovery of resistant varieties, the disease could cause a total loss of the crop.						
++	Bacteria enter in the roots and develop in the stem		Loss of plants at all stages			

NEMATODES

Extent	Organs attacked		Types of loss		
	Roots	Number of plants	Number of fruits/plant	Size of fruit	Quality of fruit at maturity
Root-knot nematode - *Meloidogyne* spp.					
The presence of Meloidogyne favours or aggravates attacks of vascular fungi. Infested plants are very sensitive to drought or irregular irrigation.					
+++	Deformed by galls	Plant will die if attacked at early stage	Significant reduction if growth is slowed by severe attack at early stage		

VIRUSES						
Extent	Organs attacked		Types of loss			
	Leaves	Fruit	Number of plants	Number of fruits/ plant	Size of fruit	Quality of fruit at maturity
Cucumber mosaic (CMV)				*Cucumovirus* (Aphid and mechanically transmitted)		
Potato Y (PVY)				*Potyvirus* (Aphid transmitted)		
Pepper veinal mottle (PeVeMoV)				*Potyvirus* (Aphid transmitted)		
Tobacco mosaic (TMV) and Tomato mosaic (TomMV)				*Tobamovirus* (Mechanically transmitted)		
Tomato spotted wilt (TSWV)				*Tospovirus* (Thrips transmitted)		
Chilli leaf curl (CLCV)				*Geminivirus* (Whitefly transmitted)		
+++	Spreading in the whole plant after inoculation			Significant reduction if infection takes place at early crop stage		

PHYSIOLOGICAL						
Extent	Organs attacked		Types of loss			
	Leaves	Fruit	Number of plants	Number of fruits/ plant	Size of fruit	Quality of fruit at maturity
Blossom-end rot						
+		Due to calcium deficiency and water imbalance				Affected fruits are not marketable.
Sunscald						
+		Due to fruit exposure to direct sunlight and excessive heat				Affected fruits are not marketable.

1.2. Identification and damage

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

INSECT PESTS

Aphids – *Aphis gossypii, Myzus persicae*

Aphids occur in colonies initially around tender plants parts (growing points, young stems and leaves, flower buds) and on the lower leaf surface. When numerous they can be found on all above ground parts of the plant. Feeding by aphids causes distortion (curling, wrinkling or cupping) of young leaves, chlorotic spotting and mottling of older leaves, and may lead to stunting and wilting of plants. Growth of sooty mould on honeydew excreted by aphids can be found on leaves and fruits.

Silver aspect due to honeydew on the upper leaf

Aphids on the underleaf

Cutworms – *Agrotis* spp, *Spodoptera* spp.

Cutworms are the caterpillars of various moths, belonging mostly to the genus *Agrotis*. Moths lay eggs on leaves of grasses, weeds and other plants. Young caterpillars feed on leaves making small holes. After few days they drop to the soil where they live until pupation. Caterpillars remain in the soil during the daytime coming out at night to feed. They cut stems of young seedlings at the level of the soil, causing the seedlings to wilt and die.

Some *Spodoptera* species, in particular *S. litura* and *S. littoralis* act sometimes as cutworms. Caterpillars, in particular under hot conditions, hide during the day in the soil around the base of the plants, and may cut them, especially seedlings, at the base of the stem. At night they climb into plants to feed. They feed mainly on leaves, but also feed on fruits, and are therefore also considered as fruit borers.

Agrotis caterpillars

Fruit flies – *Ceratitis* spp. *Bactrocera* spp.

Fruit fly females lay eggs under the epidermis of the fruit. After emerging from eggs maggots generally move to the core to feed, but they may also feed on the walls of the fruit.

An infested fruit usually has a small dimple where the female fly deposited an egg. As the maggot matures inside the fruit, the fruits turn red prematurely, becoming soft and rotten. Soft spots can often be seen where the maggot has fed on the fruit. When infested fruit is picked, the cap usually separates from the fruit because the maggot has eaten the core. Fruit may drop from the plant.

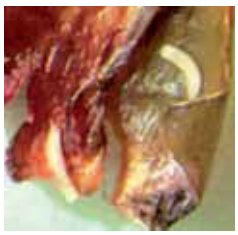
Maggots remain in peppers until fully grown (from 2 to 3 weeks). At this time the maggot leaves the pepper, drops to the soil to pupate.

Sweet peppers fallen on the soil

Rotten sweet pepper fruit

Adult

External symptoms on hot pepper



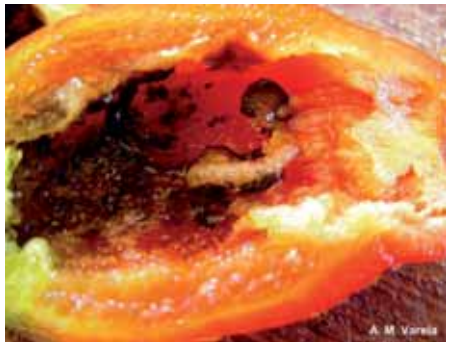
Larvae in hot pepper fruit

Fruit borers – *Helicoverpa* spp., *Spodoptera* spp.

Moths are active at dusk and at night, feeding on nectar and laying eggs on leaves. Caterpillars feed on leaves, flowers and fruits. Although severe leaf damage by feeding of *Helicoverpa* caterpillars may slow plant growth due to reduced leaf area, caterpillar feeding on leaves is usually of not economic importance. The main damage occurs on flowers and fruits. Attack on flower buds results in flower abortion. Caterpillars usually bore holes in fruits, causing extensive damage and promoting decay from secondary infection by diseases.

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

Rotten fruit



Caterpilar inside a fruit

Hole on a sweet pepper fruit

Helicoverpa adult

Helicoverpa caterpillar

Spodoptera caterpilar

Leafminers – *Liriomyza* spp.

Female leafminers make numerous small, whitish punctures on the foliage when feeding and depositing eggs. These punctures can serve as entry points for disease-causing organisms such as bacteria and fungi.

Mines on a leaf

The eggs hatch into tiny yellow maggots that feed on leaf tissues leaving a wandering track in the form of S-shaped mines. Full-grown maggots come out of the mines to pupate in the soil beneath the plants or on the foliage.

Maggots are the most destructive stage. In severe infestation, the leaves might be completely mined, dry and fall off prematurely, causing loss of vigour and turgidity of the plant. This may eventually result in wilting, in particular in warm weather, leading to yield loss, fruit sun scald, or in serious cases death of the plant, especially of young pants.

Thrips – *Frankliniella* spp., *Scirtothrips dorsalis*, *Thrips palmi, Thrips tabaci*

Thrips usually feed on all above ground parts of plants, preferring the underside of young leaves, flowers and fruits. Often they are concealed under the calyx. Female thrips lay eggs in the plant tissue. Pupation takes place in the axils of leaves, in leaf curls, under the calyces of flower and fruits, in the leaf litter or in the soil. Plant damage results from both larvae and adults puncturing leaves and sucking the exuding sap. At the initial stage of infestation leaves have a silvery sheen and show small, dark spots of faecal material on the underside. When the attack increase leaves curl upward, wrinkle and finally dry up. Heavy feeding damage turns leaves, buds and fruits bronze in colour. It may cause wilting, retardation of leaf development and distortion of young shoots resulting in stunted plants.

Thrips larva

Scaring on a fruit

Attack on fruits causes deformation and scarring (manifested as brown lines) of the fruits making them unmarketable.

Thrips can be an important nursery pest since their attack at the seedling and early stages of the crop delays crop development.

White flies – *Aleurodicus dispersus, Bemisia tabaci, Trialeurodes vaporariorum*

Whiteflies damage plants in three ways.

Whitefly immature stages (nymphs) and adults suck sap from leaves. Their feeding, in addition to removing plant nutrients, produces chlorotic spots on infested leaves.

Nymphs excrete a clear sugary liquid known as honeydew, which often completely covers the leaves during heavy infestation. Honeydew supports the growth of a black sooty mould, and as a result the leaves may turn black, affecting photosynthesis.

Whiteflies are vector of important viral diseases.

Aleurodicus dispersus

White flies

MITES

Broad mite – *Polyphagotarsonemus latus*

Broad mites live on the underside of leaves, tender stems, fruits, flower peduncles and flowers. Their feeding produces discoloration, necrosis of tissues and deformation. Initial attack occurs on the stems of terminal shoots and the lower surface of young leaves. Young leaves turn narrow, twisted or crumpled, fail to elongate and finally may wilt and dry, giving the plant a scorched appearance. Older leaves are generally cupped with corky brown areas between the main veins on the lower side of the leaves. The succulent part of the stem of young plants may become slightly swollen, roughened or russeted. The foliage becomes rigid. Attacked fruits become deformed with a cork-like surface or fail to develop. Severely infected fruits fall, and yield is significantly reduced. Symptoms remain for a long period of time after control.

Damage on chilli leaves

Cork-like surface of a fruit

Russeted and deformed leaf

Deformation on young leaves

Spider mites – *Tetranychus* spp.

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

FUNGI

Anthracnose – *Colletotrichum* spp.

It may occur in the field or develop as a post-harvest decay of pepper fruits. It may be expressed as pre–and post-emergence damping-of, dieback of shoots, leaf spots, and fruit rots. Lesions on fruits are sunken and range in colour from buff to salmon colour and often in concentric rings. The worst damage is when fruits are infected.

Damping off – *Rhizoctonia solani / Pythium* spp./ *Fusarium* spp.

Death of seedlings prior to and after emergence. Depicted as irregular patches in nursery beds or scattered areas of the field where directly seeded.

Fusarium wilt – *Fusarium oxysporum* f.sp. *capsici*

Yellowing of foliage followed by a permanent wilt. Vascular tissues are discoloured.

Vascular tissues discoloured

Wilt

Powdery mildew – *Leveillula taurica*

Light chlorotic to bright yellow patches develop on upper side of older leaves. On the lower leaf surfaces a fine talcum-like powder is seen. As the disease progresses shedding of the foliage is a prominent symptom. The white powder can also be observed on young fruits.

Yellow patches on upper side

Fine talcum-like powder on the underside

BACTERIA

Bacterial soft rot – *Erwinia carotovora* pv. *carotovora*

Rot can start as a small spot near the stem and then spreads until the entire fruit collapses into a soft slimy mass. The rotted fruit resembles a sack of liquid retained by the skin.

Rotted fruit (right)

Bacterial wilt – *Ralstonia solanacearum*

A sudden, permanent wilt of the entire plant without yellowing. The vascular tissues are discoloured. Cross sections cut from roots of infected plants produce milky streams of bacterial exudates when suspended in clear water.

Discoloured vascular system

Wilted plant

NEMATODES

Root-knot nematodes – *Meloidogyne incognita*

Stunting and wilting of plants ultimately leading to death despite availability of adequate soil moisture. Roots of affected plants develop galls (knots) that eventually rot. Nematodes aggravate incidence of Fusarium and bacterial wilt.

VIRUSES

Cucumber mosaic (CMV), Potato Y (PVY), Pepper veinal mottle (PeVeMoV), Tobacco mosaic (TMV), Tomato mosaic (TomMV), Tomato spotted wilt (TSWV), Chilli leaf curl (CLCV).

Difficult to diagnose due to overlap in symptomatology, cultivar differences, environmental conditions, host plant nutrition, strain differences and occurrence of virus mixtures. General symptoms constitute mosaic patterns, mottling, leaf deformation, chlorosis, stunting of plants, and spotting and distortion of fruits. Special assay procedures are needed for virus diagnosis. Viruses damage most when infection is initiated at early crop stages. Viruses are a major problem when non-certified or own seed is used.

Symptoms of virus not identified

Symptoms of virus not identified

Tomato spotted wilt virus

Symptoms of virus not identified

Symptoms of virus not identified

PHYSIOLOGICAL

Blossom-end rot

The rot always occurs at the blossom-end of the fruit. The affected tissue desiccates becoming light brown and leathery in appearance. Affected fruits ripen prematurely. Such fruits are not marketable.

Sunscald

A bleached sunken lesion develops on the exposed side of the fruit to direct sunlight. The affected tissues desiccate and become papery.

1.3. Appearance of pests and diseases in terms of the 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. It is especially during the latter stages that they must be monitored and controlled if necessary. The purpose is to show that the presence of a pest, disease or pathogenic agent is not always harmful to the crop.

Stage	Length of stage [1]	Aphid	Cutworm	Fruit worms	Fruit fly	Leafminers	Thrips	Whitefly	Broad mite	Spider mites
Nursery	4-8 weeks (chillies)	■	■	■			■	■	■	■
From pricking out to flowering	No information available	■	■	■			■	■	■	■
From flowering to first harvest	35 to 50 days[2] 55-60 (chillies)AVRDC	■		■	■	■	■	■	■	■
From first harvest to peak harvest	6-8 weeks (sweet peppers)	■		■	■		■		■	■
From peak to end of harvest				■	■		■			

Stage	Bacterial soft rot	Anthracnose	Bacterial wilt	Damping off	Fusarium wilt	Powdery mildew	Viruses
Seeds	■	■	■	■	■		■
Nursery		■	■	■	■	■	■
From pricking out to flowering		■	■		■	■	■
From flowering to first harvest		■	■		■	■	■
From first harvest to peak harvest	■				■	■	■
From peak to end of harvest	■						

1 Length of stage will vary with mode of production and environmental conditions
2 from flowering to mature green stage

■ 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

1.4. Importance by country – periods of the year and climate conditions favourable to pests and diseases

Key:
0 = no damage
+ = 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.

Aphids – *Aphis gossypii, Myzus persicae*

Favourable conditions: In Kenya, colonies develop rapidly especially in warm humid weather.

Country / Month	1	2	3	4	5	6	7	8	9	10	11	12
Benin	/	/	/	/	/	/	/	/	/	/	/	/
Gambia	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Dominican Republic	/	/	/	/	/	/	/	/	/	/	/	/
Ghana	/	/	/	/	/	/	/	/	/	/	/	/
Kenya	+++	+++	++	+	+	++	++	++	+	+	+	++
Mali	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Senegal	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx
Tanzania	/	/	/	/	/	/	/	/	/	/	/	/
Uganda	+	+	+	+	++	++	++	++	++	++	++	+
Zambia	/	/	/	/	/	/	/	/	/	/	/	/
Zimbabwe	/	/	/	/	/	/	/	/	/	/	/	/

Cutworms – *Agrotis* spp., *Spodoptera* spp.

Favourable conditions: Under dry and warm conditions feeding and development are increased.

Country / Month	1	2	3	4	5	6	7	8	9	10	11	12
Benin	/	/	/	/	/	/	/	/	/	/	/	/
Gambia	/	/	/	/	/	/	/	/	/	/	/	/
Dominican Republic	/	/	/	/	/	/	/	/	/	/	/	/
Ghana	/	/	/	/	/	/	/	/	/	/	/	/
Kenya	++	++	+	+	+	+	+	+	+	+	+	+
Mali	x	x	x	x	x	x	x	x	x	x	x	x
Senegal	x	x	x	x	x	x	x	x	x	x	x	x
Tanzania	/	/	/	/	/	/	/	/	/	/	/	/
Uganda	x	x	x	x	x	x	x	x	x	x	x	x
Zambia	/	/	/	/	/	/	/	/	/	/	/	/
Zimbabwe	/	/	/	/	/	/	/	/	/	/	/	/

Fruit flies – *Ceratitis* spp. *Bactrocera* spp.

Favourable conditions: Fruit flies thrive under humid and hot conditions. The optimum temperatures for development are 26-30 °C.

Country / Month	1	2	3	4	5	6	7	8	9	10	11	12
Benin	/	/	/	/	/	/	/	/	/	/	/	/
Gambia	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Dominican Republic	/	/	/	/	/	/	/	/	/	/	/	/
Ghana	/	/	/	/	/	/	/	/	/	/	/	/
Kenya	/	/	/	/	/	/	/	/	/	/	/	/
Mali	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Senegal	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Tanzania	/	/	/	/	/	/	/	/	/	/	/	/
Uganda	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx
Zambia	/	/	/	/	/	/	/	/	/	/	/	/
Zimbabwe	/	/	/	/	/	/	/	/	/	/	/	/

Fruit borers – *Helicoverpa* spp., *Spodoptera* spp.

Favourable conditions: Generally more prevalent in the dry season. Incidence increases after rains.

Country / Month	1	2	3	4	5	6	7	8	9	10	11	12
Benin	/	/	/	/	/	/	/	/	/	/	/	/
Gambia	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx
Dominican Republic	/	/	/	/	/	/	/	/	/	/	/	/
Ghana	/	/	/	/	/	/	/	/	/	/	/	/
Kenya	++	+	+	+	+	0	0	+	+	+	+	++
Mali	x	x	x	x	x	x	x	x	x	x	x	x
Senegal	+++	+++	+++	+++	+++	++	+	+	+	+	++	+++
Tanzania	/	/	/	/	/	/	/	/	/	/	/	/
Uganda	/	/	/	/	/	/	/	/	/	/	+	/
Zambia	/	/	/	/	/	/	/	/	/	/	/	/
Zimbabwe	/	/	/	/	/	/	/	/	/	/	/	/

Leafminers – *Liriomyza* spp.

Favourable conditions: In Kenya, attack is high during warm or hot periods.

Country / Month	1	2	3	4	5	6	7	8	9	10	11	12
Benin	/	/	/	/	/	/	/	/	/	/	/	/
Gambia	x	x	x	x	x	x	x	x	x	x	x	x
Dominican Republic	/	/	/	/	/	/	/	/	/	/	/	/
Ghana	/	/	/	/	/	/	/	/	/	/	/	/
Kenya	+	+	+	+	+	+	+	+	+	+	+	+
Mali	/	/	/	/	/	/	/	/	/	/	/	/
Senegal	x	x	x	x	x	x	x	x	x	x	x	x
Tanzania	/	/	/	/	/	/	/	/	/	/	/	/
Uganda	/	/	/	/	/	/	/	/	/	/	/	/
Zambia	/	/	/	/	/	/	/	/	/	/	/	/
Zimbabwe	/	/	/	/	/	/	/	/	/	/	/	/

Thrips – *Scirtothrips dorsalis, Thrips palmi, Frankliniella* spp.

Favourable conditions: thrips prefer hot and dry weather. Their numbers are low in the rainy season. However, in Kenya, S. dorsalis can also be an economic pest during the rainy season.

Country / Month	1	2	3	4	5	6	7	8	9	10	11	12
Benin	/	/	/	/	/	/	/	/	/	/	/	/
Gambia	x	x	x	x	x	x	x	x	x	x	x	x
Dominican Republic	/	/	/	/	/	/	/	/	/	/	/	/
Ghana	/	/	/	/	/	/	/	/	/	/	/	/
Kenya	+++	+++	+++	0	0	+	+	++	++	+	+	+
Mali	/	/	/	/	/	/	/	/	/	/	/	/
Senegal	/	/	/	/	/	/	/	/	/	/	/	/
Tanzania	+++	+++	++	+	+	++	+++	+++	+++	+	+	++
Uganda	+	+	+	+	+	+	+	+	+	+	+	+
Zambia	/	/	/	/	/	/	/	/	/	/	/	/
Zimbabwe	/	/	/	/	/	/	/	/	/	/	/	/

White flies – *Bemisia tabaci, Aleurodicus dispersus, Trialeurodes vaporariorum*

Favourable conditions: White fly reproduces more quickly in a humid and sheltered biotope. Dry winds are unfavourable to their multiplication. Bemisia whiteflies are generally more abundant at the beginning of the dry season, with optimal temperatures ranging from 25 to 30°C. T. *vaporariorum* occurs at higher altitudes and cooler places.

Country / Month	1	2	3	4	5	6	7	8	9	10	11	12
Benin	/	/	/	/	/	/	/	/	/	/	/	/
Gambia	x	x	x	x	x	x	x	x	x	x	x	x
Dominican Republic	/	/	/	/	/	/	/	/	/	/	/	/
Ghana	/	/	/	/	/	/	/	/	/	/	/	/
Kenya	+++	+++	+++	+	+	+	+	++	++	++	+	+
Mali	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx
Senegal	+++	+++	+++	+++	+++	++	+	+	+	+	++	+++
Tanzania	/	/	/	/	/	/	/	/	/	/	/	/
Uganda	+	+	+	+	+	+	+	+	+	+	+	+
Zambia	/	/	/	/	/	/	/	/	/	/	/	/
Zimbabwe	/	/	/	/	/	/	/	/	/	/	/	/

Broad mite – *Polyphagotarsonemus latus*

Favourable conditions: Dry, hot weather. Strong rains are unfavourable to this pest.

Country / Month	1	2	3	4	5	6	7	8	9	10	11	12
Benin	/	/	/	/	/	/	/	/	/	/	/	/
Gambia	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx
Dominican Republic	/	/	/	/	/	/	/	/	/	/	/	/
Ghana	/	/	/	/	/	/	/	/	/	/	/	/
Kenya	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Mali	/	/	/	/	/	/	/	/	/	/	/	/
Senegal	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Tanzania	/	/	/	/	/	/	/	/	/	/	/	/
Uganda	/	/	/	/	/	/	/	/	/	/	/	/
Zambia	/	/	/	/	/	/	/	/	/	/	/	/
Zimbabwe	/	/	/	/	/	/	/	/	/	/	/	/

Spider mites – *Tetranychus* spp.

Favourable conditions: Dry, hot weather. They are more prevalent in areas of low humidity. Strong rains are unfavourable to this pest. Wind plays an important role in their dispersal.

Country / Month	1	2	3	4	5	6	7	8	9	10	11	12
Benin	/	/	/	/	/	/	/	/	/	/	/	/
Gambia	x	x	x	x	x	x	x	x	x	x	x	x
Dominican Republic	/	/	/	/	/	/	/	/	/	/	/	/
Ghana	/	/	/	/	/	/	/	/	/	/	/	/
Kenya	+++	+++	+++	0	0	0	+	+	+	+	0	0
Mali	/	/	/	/	/	/	/	/	/	/	/	/
Senegal	x	x	x	x	x	x	x	x	x	x	x	x
Tanzania	/	/	/	/	/	/	/	/	/	/	/	/
Uganda	/	/	/	/	/	/	/	/	/	/	/	/
Zambia	/	/	/	/	/	/	/	/	/	/	/	/
Zimbabwe	/	/	/	/	/	/	/	/	/	/	/	/

Bacterial soft rot – *Erwinia carotovora* pv. *carotovora*

Favourable conditions: Wet warm conditions favour its development. A high incidence of soft rot is frequently associated with harvesting during rains and washing fruit after harvest. It is both seed- and soil-borne.

Country / Month	1	2	3	4	5	6	7	8	9	10	11	12
Benin	/	/	/	/	/	/	/	/	/	/	/	/
Gambia	/	/	/	/	/	/	/	/	/	/	/	/
Dominican Republic	/	/	/	/	/	/	/	/	/	/	/	/
Ghana	/	/	/	/	/	/	/	/	/	/	/	/
Kenya	0	0	+	+	+	0	0	0	0	+	+	0
Mali	/	/	/	/	/	/	/	/	/	/	/	/
Senegal	/	/	/	/	/	/	/	/	/	/	/	/
Tanzania	/	/	/	/	/	/	/	/	/	/	/	/
Uganda	/	/	/	/	/	/	/	/	/	/	/	/
Zambia	/	/	/	/	/	/	/	/	/	/	/	/
Zimbabwe	/	/	/	/	/	/	/	/	/	/	/	/

Bacterial wilt – *Ralstonia solanacearum*

Favourable conditions: High temperatures and wet soil conditions favour its development. Most favourable temperatures are 29.7 to 35.30 C. It could be a major problem in hot areas with relatively high rainfall.

Country / Month	1	2	3	4	5	6	7	8	9	10	11	12
Benin	/	/	/	/	/	/	/	/	/	/	/	/
Gambia	/	/	/	/	/	/	/	/	/	/	/	/
Dominican Republic	/	/	/	/	/	/	/	/	/	/	/	/
Ghana	/	/	/	/	/	/	/	/	/	/	/	/
Kenya	+	+	++	++	++	+	+	+	+	++	++	+
Mali	/	/	/	/	/	/	/	/	/	/	/	/
Senegal	/	/	/	/	/	/	/	/	/	/	/	/
Tanzania	0	0	+	+	+	0	0	0	0	+	+	0
Uganda	0	0	+	+	+	0	0	0	0	+	+	0
Zambia	/	/	/	/	/	/	/	/	/	/	/	/
Zimbabwe	/	/	/	/	/	/	/	/	/	/	/	/

Anthracnose – *Colletotrichum* spp.

Favourable conditions: The optimum and maximum temperatures for diseases development are 27 and 32 ºC, respectively. The fungus causes rapid infection at high relative humidity above 70% - during heavy fog, dew or drizzle.

Country / Month	1	2	3	4	5	6	7	8	9	10	11	12
Benin	/	/	/	/	/	/	/	/	/	/	/	/
Gambia	/	/	/	/	/	/	/	/	/	/	/	/
Dominican Republic	/	/	/	/	/	/	/	/	/	/	/	/
Ghana	/	/	/	/	/	/	/	/	/	/	/	/
Kenya	0	0	+	+++	+++	+	0	0	0	++	+	0
Mali	/	/	/	/	/	/	/	/	/	/	/	/
Senegal	/	/	/	/	/	/	/	/	/	/	/	/
Tanzania	/	/	/	/	/	/	/	/	/	/	/	/
Uganda	/	/	/	/	/	/	/	/	/	/	/	/
Zambia	/	/	/	/	/	/	/	/	/	/	/	/
Zimbabwe	/	/	/	/	/	/	/	/	/	/	/	/

Fusarium wilt – *Fusarium oxysporum* f.sp. *capsici*

Favourable conditions: High temperatures and wet soil conditions favour disease development. The optimum air and soil temperature for disease development is about 280 ºC.

Country / Month	1	2	3	4	5	6	7	8	9	10	11	12
Benin	/	/	/	/	/	/	/	/	/	/	/	/
Gambia	/	/	/	/	/	/	/	/	/	/	/	/
Dominican Republic	/	/	/	/	/	/	/	/	/	/	/	/
Ghana	/	/	/	/	/	/	/	/	/	/	/	/
Kenya	+	+	++	+++	+++	+++	++	+	+	+++	+++	++
Mali	/	/	/	/	/	/	/	/	/	/	/	/
Senegal	/	/	/	/	/	/	/	/	/	/	/	/
Tanzania	0	0	+	+	+	0	0	0	0	+	+	0
Uganda	0	0	+	+	+	0	0	0	0	+	+	0
Zambia	/	/	/	/	/	/	/	/	/	/	/	/
Zimbabwe	/	/	/	/	/	/	/	/	/	/	/	/

Powdery mildew – *Leveillula taurica*

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.

Country / Month	1	2	3	4	5	6	7	8	9	10	11	12
Benin	/	/	/	/	/	/	/	/	/	/	/	/
Gambia	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Dominican Republic	/	/	/	/	/	/	/	/	/	/	/	/
Ghana	/	/	/	/	/	/	/	/	/	/	/	/
Kenya	+++	+++	+	+	+	++	+++	+++	+++	+	+	++
Mali	/	/	/	/	/	/	/	/	/	/	/	/
Senegal	+++	+++	+++	+++	+++	++	+	+	+	+	++	+++
Tanzania	+++	+++	+	+	+	++	+++	+++	+++	+	+	++
Uganda	/	/	/	/	/	/	/	/	/	/	/	/
Zambia	/	/	/	/	/	/	/	/	/	/	/	/
Zimbabwe	/	/	/	/	/	/	/	/	/	/	/	/

Viruses

Favourable conditions: Many pepper viruses are seed transmitted. Furthermore, they are vectored by aphids, leafhoppers, thrips and whiteflies. Apart from primary infection through the seed, secondary spread of the viruses is by insect vectors. Important is vector activity rather than abundance in numbers of the vectors in a crop. For all mentioned insect vectors ideal weather condition is dry season with temperatures ranging between 25 to 30 °C.

Country / Month	1	2	3	4	5	6	7	8	9	10	11	12
Benin	/	/	/	/	/	/	/	/	/	/	/	/
Gambia	/	/	/	/	/	/	/	/	/	/	/	/
Dominican Republic	/	/	/	/	/	/	/	/	/	/	/	/
Ghana	/	/	/	/	/	/	/	/	/	/	/	/
Kenya	+++	+++	++	+	+	++	+++	+++	+++	+	+	++
Mali	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx
Senegal	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx
Tanzania	+	+	+	+	+	+	+	+	+	+	+	+
Uganda	x	x	x	x	x	x	x	x	x	x	x	x
Zambia	/	/	/	/	/	/	/	/	/	/	/	/
Zimbabwe	/	/	/	/	/	/	/	/	/	/	/	/

2. Main control methods

2.1. Introduction

Integrated pest and disease management strategies should be employed to provide maximum protection to the crop protecting the environment and optimising costs. This can be obtained through practicing good agricultural practices aimed at the production of a healthy crop by using appropriate crop husbandry, preventive measures to avoid attack by pests and diseases, and the rational use of pesticides, based on need, to give natural control agents a chance to keep pests below damaging levels.

The principles to manage pests and diseases are:

- Understanding the growth stages of the crop and the occurrence and importance of major pests and diseases related to the different stages. It is also very important to know how both are regulated by environmental factors and the surrounding ecosystem.
- Correct identification of the pest or disease causing damage, the type and extent of the damage, and the stage of the crop.
- Early detection and diagnosis of pests and diseases, which allow for timely interventions. This is done through frequent and regular monitoring of the crop. Before any control measures are taken, regular inspection should be conducted to determine the presence and level of infestation of pests.
- Selection of appropriate control measures when needed
- Proper record keeping (helps to know the history of the land, the effect of previous intervention methods)

2.2. Control methods

1. Good crop husbandry (Proper production practices): provide conditions for growing healthy plants, ensuring good soils, proper irrigation, balanced fertilisation, proper spacing and good nursery management. The right growing conditions for the plants, particularly when they are young, reduce the crop's susceptibility to pest damage, since strong, healthy plants are more likely to withstand pest infestation.

    1.1. Seeds: Cultivation should start with high quality seeds. Good quality seeds are essential to produce healthy vigorous seedlings. Only certified seeds from a reputable seed supplier should be used. The seeds should be free of weeds and have low moisture content. They should have been treated with insecticides and fungicides and stored in a sealed container with a label showing name of variety, germination percentage, date of germination tests and the name of the supplier.

    1.2. Soils: Capsicums thrive in well drained, aerate, light to medium soils. Soils with high humus content will greatly increase yield and lengthen the cropping period (chillies). Peppers are tolerant of slightly acidic soils but a pH of 5.5-6.6 is preferable.

    1.3. Irrigation: The correct availability of water is essential for optimum plant growth and yield. A water deficit may result in bud and flower abortion, and too much water will cause root rotting. Erratic watering causes physiological disorders in the fruits. The amount of water required by the crop will vary by locality, soil type, and crop stage. The soil moisture content can be gauged by taking a handful of soil from the bottom of a 15-cm deep hole and squeezing it; if it holds together when you release your grip, then there is sufficient soil moisture. If the soil crumbles, then is time to irrigate. When choosing the irrigation system the existing or expected pest and disease problems should be considered. In areas prone to foliar bacterial diseases avoid overhead irrigation, use furrow or drip irrigation; where soil-borne diseases (e.g. bacterial wilt, *Fusarium* wilt or *Verticillium* wilt) are rampant avoid furrow irrigation, use over-head or drip irrigation. Drip irrigation is the choice system where both soil-borne and foliar diseases are prevalent. Overhead irrigation discourages pests such as aphids, mites, thrips and whiteflies. However, avoid evening overhead irrigation as wet leaves and fruits promote disease development, especially at night.

1.4. Fertilisation: Peppers require high fertility in the early stages of growth and side dressings later on. Fertiliser needs will depend on the soil and stage of the crop. A soil analysis is needed to determine the needs of fertiliser. The amount of fertiliser to be applied can be calculated based on the target yield and residual nutrients in the soil. Hot peppers have greater demands for fertiliser than sweet peppers.
The recommended blanket rates for mineral fertilisers, subjected to adjustment based on the results of soil analysis, for hot pepper are 400-600 kg NPK/ha in a 4-1-3 N:P:K proportion.

Recommendations for sweet peppers (AVRDC):

- Forty percent of the N should be applied as basal fertiliser before transplanting. The remaining 60% should be side-dressed in three equal amounts at 2,3 and 6 weeks after transplanting. Fifty percent of the P and K should be applied as basal fertiliser, and the remaining 50% should be addressed at 4 weeks after transplanting.

A suggested schedule of fertiliser application for the Caribbean is as follows:

- First application: 1/3 of the total requirement of NPK (170 kg/ha) broadcasted evenly over the field just before ridging.
- Second application (after transplanting). Seedlings are fertigated with a water soluble fertiliser (liquid urea at 11.25 l/ha), potassium nitrate (56 kg/ha) and 85% phosphoric acid at 2.5 l/ha)
- The remaining 2/3 of the requirement of NPK fertiliser (340 kg/ha) can then be applied as a side dressing at the appearance of the first flower buds.
- Finally fertigation as explained above should be done after the first and all subsequent pickings.

Recommendation for chillies in Kenya:

- At transplanting a phosphate fertiliser (e.g. triple superphosphate) at a rate of 60 to 115 kg/ha depending on soil fertility. Manure can be applied at a rate of 15t /ha
- Top dressing: First and second moths after transplanting. Calcium ammonium nitrate (100kg/ha) for acidic soils or ammonium sulphate nitrate (100kg/ha) for alkaline soils.
- Foliar feeds with magnesium are desirable on alkaline soils.

Recommendation for sweet peppers in Tanzania (Lesotho):

- Before planting add a teaspoon of NPK per planting hole.
- Top dress at flowering with a teaspoon (100kg/ha) of CAN (calcium ammonium nitrate)or SA (sulphate of ammonia) and repeat 4 weeks later.

These recommendations should be fine tuned for every location and variety. Application of too much nitrogenous fertiliser should be avoided as it may make the plants more attractive to aphids.

1.5. Plant spacing: The spacing recommended for each variety should be followed. Spacing may also depend on the irrigation system used. Dense planting creates a microclimate that is conducive to the development of foliar diseases.

1.6. Pruning: Prevent sweet pepper plants from being overloaded with fruits. Remove routinely all fruits that set at the first bifurcation node, and all leaves and branches below the first bifurcation node. This will promote vigorous plant growth and reduce the spread of foliar diseases.

2. Sanitation: crop residues (roots, stems, leaves and fruits) and weeds are sources of pests and diseases and should be destroyed. Crop residues can be composted, buried, or burned. Weeds, in addition to compete for nutrients, can act as host for pests (cutworms, mites, thrips, whiteflies, leafminers) and harbour viruses and other diseases. Removal and elimination of infested fruit helps to reduce build up of fruit worms and fruit flies. Rotting peppers attract fruit flies

   2.1. If there is a disease or pest outbreak in one part of the field or one field, work in other healthy areas/fields of the field before working on the affected area/field.

   2.2. To restrict the spread of tobamoviruses (tobacco mosaic virus, tomato mosaic virus, and pepper mild mottle virus) dip your tools in milk or in a 3% (w/v) solution of trisodium phospate (TSP) before handling plants.

3. Crop arrangement: There are many alternate vegetable hosts for pests and diseases attacking peppers; therefore care must be taken with rotations and arrangements of fields so as not to allow infestation of new crops from old infested ones.

   3.1. Neighbouring crops: avoid planting near an infested/infected crop or on land from which an infested/infected crop has been removed recently

   3.2. Mixed cropping may help reduce pest infestation if the right mixture of crops is selected. Avoid overlapping of solaneceous crops (capsicum, eggplant, potatoes, tobacco, tomatoes) since they share similar complex of pests and diseases. Onion and garlic are recommended as intercrop to manage thrips on sweet peppers in Tanzania. Intercropping with marigold is reported to reduce nematodes.

   3.3. Crop rotation: Do not continuously plant chillies or peppers, on the same land or after other crops, which belong to the same family (Solaneceae) such as tomatoes, potatoes, and eggplants. Good rotation crops include brassicas, onions, cereals, legumes, lettuce, fodder grass, baby corn, rice or cucurbits. Rotation with French beans or coriander is reported to reduce incidence of bacterial wilt disease in India. Crop rotation with cereals is reported to reduce nematodes.

   3.4. Trap plants can be used to deviate attack from the main crop to other plants that are preferred by the pest. For example cotton is used as trap crop for aphids. The trap plants should be regularly monitored and the pest destroyed (manually or by application of pesticides).

   3.5. Planting barrier crops or windbreaks may help to avoid/delay infestations from neighbouring crops.

4. Resistant and tolerant varieties: Many varieties carry resistance to one or more pests and diseases. In particular, the bird pepper types are reported to be disease-resistant. The Caribbean Agricultural Research and Development Centre (CARDI) has a research programme for production of new and improved varieties of hot pepper for the Caribbean.

5. Pest and disease avoidance: Pests and diseases can be avoided by planting the crop when the pest pressure is lowest. Some growers avoid planting chillies during the rainy season since the plants are prone to many diseases.

6. Biological control: through conservation, augmentation and importation of natural enemies.

7. Mechanical control

7.1. Mass trapping helps to control pests such as leafminers and whiteflies, when present in low numbers especially in protected cultivation (plastic tunnels and houses, screenhouses and glasshouses). Yellow traps attract aphids, leafminers, fruit flies (pepper maggot), whiteflies, and thrips. Thrips are also attracted by blue and white traps. Sticky traps may not be practical options in dusty conditions where the sticky surface may be covered with dust, or when the surface quickly gets covered with large number of insects. Water traps are an alternative to sticky traps.

7.2. Mulching, in addition to control weeds and conserve soil moisture, helps to control pests such as aphids and whiteflies. Reflective plastic mulch repels aphids as long as 50% of the surface area is reflective. Even black mulch has been shown to reduce aphid numbers compared with bare-ground crops. Colour mulching in particular yellow have given significant reduction of whiteflies, and increase of yields as long as the plants are young and the plastic film is not covered by the plants.

7.3. Insect proof nets are used for protection of seedlings in the nursery and in crops grown in a protected environment, in particular from whiteflies, aphids and thrips. Preventing physical contact of these insects with the plant helps to avoid/reduce the transmission of viruses and delay their spread

7.4. Overhead irrigation and strong rainfall discourage aphids, thrips, mites, whiteflies and powdery mildew.

7.5. Hand picking and destruction of eggs and small caterpillars is feasible when their numbers are low.

7.6. Soil cultivation: Ploughing kills stages of insect pests that occur in the soil, such as cutworms, pupae of leafminers, thrips, fruit worms and fruit flies, and root knot nematodes.

7.7. Soil sterilisation: Helps to minimise the incidence of nematodes and soil-borne diseases.

7.7.1. Steaming: The soil/growing medium can be sterilised by using steam. This is a feasible practice for the seedbed and for crops grown in protected environments (greenhouse, glasshouses).

7.7.2. Solarisation: After irrigation, the soil is covered with a clear or transparent polyethylene sheet for 2-3 months, depending on the intensity of sunshine. It reduces soil borne diseases, nematodes and pests occurring in the soil. Its success depends on adequate sunshine, good land preparation and fallowing for up to 6 weeks. It is more suitable for nursery beds and small plots.

8. Use of selective pesticides:

8.1. Microbiological pesticides: The bacterium *Bacillus thuringiensis* as commercial product is widely used alone or in combination with natural enemies for control of fruitworms and other caterpillars. The insect pathogenic fungus *Verticillium lecanii* (Zimmenn) formulated as wettable powder is used for control of whiteflies.

8.2. Botanical insecticides, such as neem products provide good control of leafminers, fruit borers, aphids, whiteflies, nematodes, and some fungal diseases, and usually are not or only slightly harmful to natural enemies.

8.3. Spraying with a soap and water solution helps to wash off the aphids and is reported to control whiteflies and thrips. The amount of soap needed depends on the soap type. Using strong soaps or high concentrations of soft soaps can scorch leaves. Whenever possible use soft soaps made from potash. The concentration should not exceed 1 part of soap to 20 parts of water. It is best to initially experiment on small plots to find the right concentration.

8.4. Growth regulators have shown good potential for control of the whiteflies and leafminers in IPM programmes. They typically do not kill adult insects, including natural enemies, and can sometimes be used in conjunction with natural enemies.

2.3. Pest management strategy with relation to the phenological stages of the crop

Nursery stage

Start a crop with healthy, vigorous seedlings free from pests and diseases.

- Site nursery far away from vegetable or ornamental crops to minimise spread of pests and diseases from old to new crops.
- Do not use sites for nursery that have previously been under vegetables (especially solanaceous crops) or from which infested crops have been removed recently.
- Prepare seedbed properly. Only sterilised potting medium should be used. Hence a commercial potting mixture is recommended. Alternatively, use forest topsoil mixed with compost or decomposed manure. Burn plant trash on seedbed surface for 30 minutes and after cooling mix soil with equal amount of compost or with decomposed manure at a rate of 2 to 3 kg/sq m. In semi-arid areas soil solarisation of seedbed could be done.
- Assure good drainage of the seedbed. Raised beds (10 cm) are recommended to allow good drainage. This is very important to control/avoid soil borne diseases.
- Use certified disease-free seed of high yielding and resistant/tolerant varieties to diseases whenever available.
- Observe proper plant density in the nursery sites. The seeds should be sown 1.3 cm deep at a distant of 3 to 5 cm from each other. (Recommendation for chillies in Kenya).
- Irrigate seedbed regularly, but avoid over watering as it can induce damping-off diseases; do not water late in the afternoon because extended wetness of leaf surfaces is conducive to foliar diseases.
- Observe proper fertilisation in the nursery sites. Nutrients can be supplied through slow release fertilisers mixed in the planting mixture. After emergence the seedlings should be fertilised weekly with a water-soluble fertiliser containing nitrogen, phosphorus and potassium with micronutrients. (Recommendations for chillies in the Caribbean)
- After sowing, shade should be erected to protect the seedlings from excessive rain and sun. Before transplanting harden the seedlings slightly by gradually reducing the shade and watering.
- Monitor regularly by inspecting the crop and by using traps (pheromone traps, yellow sticky traps, water traps, suction traps) for early detection of potential pests and diseases. The most important pests in this stage are cutworms, aphids, whiteflies and thrips.
- Cover young seedlings with insect-proof netting, or sow them inside a screenhouse in areas where virus diseases are endemic to restrict infestation by vectors of virus diseases such as aphids, thrips and whiteflies. Where netting is not viable, spray seedling with appropriate insecticides at recommended doses for control of insect vectors.
- Use mulch. It reduces water evaporation and has a repellent effect on aphids, in particular reflective plastic mulch.
- Remove weak and unhealthy looking seedlings.
- Keep the seedbed and its surroundings free of weeds that can act as host for pests and reservoirs for diseases.
- Take interventions based on crop scouting data

Transplanting

- Avoid transplanting during long rains (wet weather) to minimise incidence and severity of diseases.
- Avoid transplanting seedlings in a field next to or near an old crop of chilli or a crop belonging to the Solanaceae family (e.g. tomato, eggplant) and ornamentals, particularly if this is infested as pests could spread from the old to the new crop.
- Avoid transplanting near an infested crop or on land from which an infested crop has been removed recently. Ensure that transplanting fields have not been under solanaceous crops for at least three years.
- Avoid transplanting in a land with a history of serious soil borne problems.
- Always ensure that a new field is sited up hill particularly where surface irrigation is used in areas with a history of soil borne diseases.
- Plant new fields upwind in order to minimise the spread of pests carried by wind such as aphids, spider mites and thrips.
- Select land with well drained, aerate, light to medium soils. Soils with high humus content will greatly increase yield and lengthen the cropping period. The desirable pH is 5.8 to 6.8.
- Whenever possible plant trap crops along field borders (e.g. beans and cotton) before transplanting.

- Transplant only robust, healthy seedlings. Chilli seedlings are ready for transplanting when they are 5-10 cm high after 3 to 4 weeks in the nursery. (Recommendation in Kenya). Sweet peppers seedlings should be transplanted 5-8 weeks after sowing when seedlings are 10-15 cm tall or when they have developed at least 4 true leaves. (Recommendation in Tanzania)
- Observe recommended plant spacing according to variety. Avoid overcrowding of plants.
- Transplant in well-prepared soil. Ploughing and harrowing expose cutworms and pupal stages of fruit worms, leafminers and thrips to sunshine and to predators.
- Remove weeds before transplanting. Weeds may attract pests such as cutworm moths.
- Transplant preferably late in the afternoon when air and soil temperatures are receding. This is particularly important in dry/hot months in order to avoid wilting of seedlings due to transplanting stress.
- Irrigate (surface) immediately after transplanting
- Observe proper fertilisation after transplanting, according to the soil characteristics.
- After transplanting the seedlings can be drenched with appropriate insecticide/ fungicide combination. This treatment protects the seedlings from fungal root rots, from insect vectors of viral diseases.
- The irrigation system should be put in place before the seedlings are transplanted.

Field stage

- Keep the field weed-free. Weeds, in addition to compete for nutrients, are potential alternative hosts of many diseases and pests.
- Apply mulching (organic or plastic) to retain soil moisture to protect fruits from water splashes and debris and to deter pests such as aphids and whiteflies.
- Observe proper fertilization according to the soil characteristics. Apply optimal dose of nitrogen fertiliser. An excess of nitrogen is generally conducive to many pests and diseases.
- Irrigate the field regularly (one to two times per week) according to need. In dry, hot weather, it is recommended to irrigate every two days. A water deficit may result in bud and flower abortion, and too much water will cause rot rotting. Choose an appropriate irrigation system in relation to existing or expected pest and disease problems.
- Do not work in fields when plants are wet since it will facilitate spread of diseases, particularly bacterial diseases.
- Inspect plants for insects and diseases regularly and keep records of pest infestation throughout the development of the crop. Take interventions based on monitoring data. Ensure proper identification of pests and diseases before taking any intervention measure.
- Remove from field virus and bacteria infected plants.
- Watch early in the season for pests and diseases such as aphids, leafminers, mites, thrips, whiteflies and viral diseases. At beginning of fruit set concentrate on pests and diseases that damage fruits.
- Avoid pesticide use after fruit setting. If pesticide application is necessary consider the pre-harvest intervals when selecting the pesticide.
- Conserve natural enemies by using selective pesticides and/or application techniques that are safe to natural enemies and bees. Prefer selective pesticides or pesticides with short persistence so that not all life stages of natural enemies are affected (and so that natural enemies can be reintroduced shortly after application).
- Avoid damaging fruit when harvesting.
- Sweet peppers: Remove routinely all fruits that set at the first bifurcation node, and all leaves and branches below the first bifurcation node.
- In areas prone to tobamoviruses dip your hands and tools in milk before handling plants to avoid mechanical transmission of the diseases. In particular dip knives routinely in a 3% (w/v) solution of trisodium phospate (TSP) or milk at harvesting
- Uproot the crop and remove crop residues from field after last harvesting, since these maybe a source of pests and diseases.
- Practice proper crop rotation (4 to 5 years). Do not grow chillies or peppers after the same crop or other related crops such as other solanaceous crops (eggplant, potatoes, tobacco, tomatoes). Avoid overlapping of these crops. Good rotation crops include brassicas, onions, cereals, legumes, lettuce, fodder grass, rice, baby corn or cucurbits. Do not plant peppers after sweet potatoes due to allelopathic effects.
- Ensure that farm implements are washed prior to be used in another field.
- Keep records of all farm undertakings. It is important to know the history of the land when deciding on the crop arrangement and on the effect of measures used.

2.4. Pest growth cycle or disease cycle and position of control methods and factors influencing development

Based on the stages of development of each pest or disease on peppers, 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 plant's development cycle.

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 return to part 1.2 of this guide.

The control methods for pests or 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.

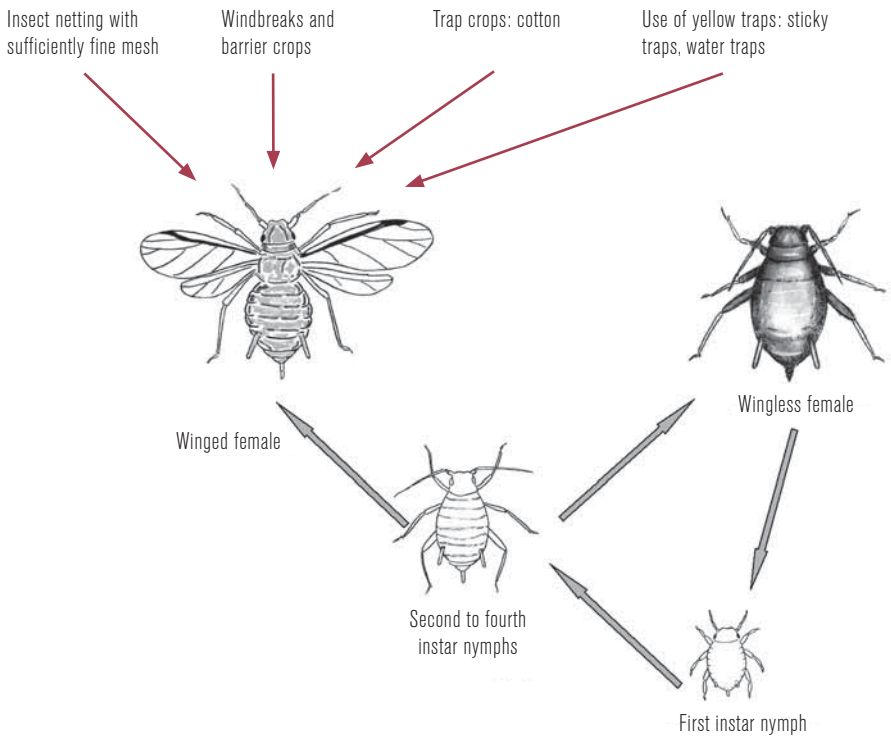
In the second column, actions that can be referred to as "cultivation practices" are shown in green boxes, and actions that can be referred to as "application of plant protection products", in orange boxes

- Cultivation practices
- Application of plant protection product

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

APHIDS - *Aphis gossypii, Myzus persicae*

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



To control all stages

- Natural heavens to encourage natural enemies e.g. beetles and hoverflies, *Aphidius*
- Use of selective insecticides: soap solutions, neem products
- Sprinkler irrigation, strong rain
- Natural enemies: Parasitic wasps, predators (ladybird beetles, hoverflies, lacewings)
- Control ants in the field, as these will disrupt natural enemy activities

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

Nursery

- Insect netting with sufficiently fine mesh can prevent the presence of adults on the plants.
- Treatment with selective insecticides as soon as attacks have been detected on young plants.

Field

Throughout the production cycle

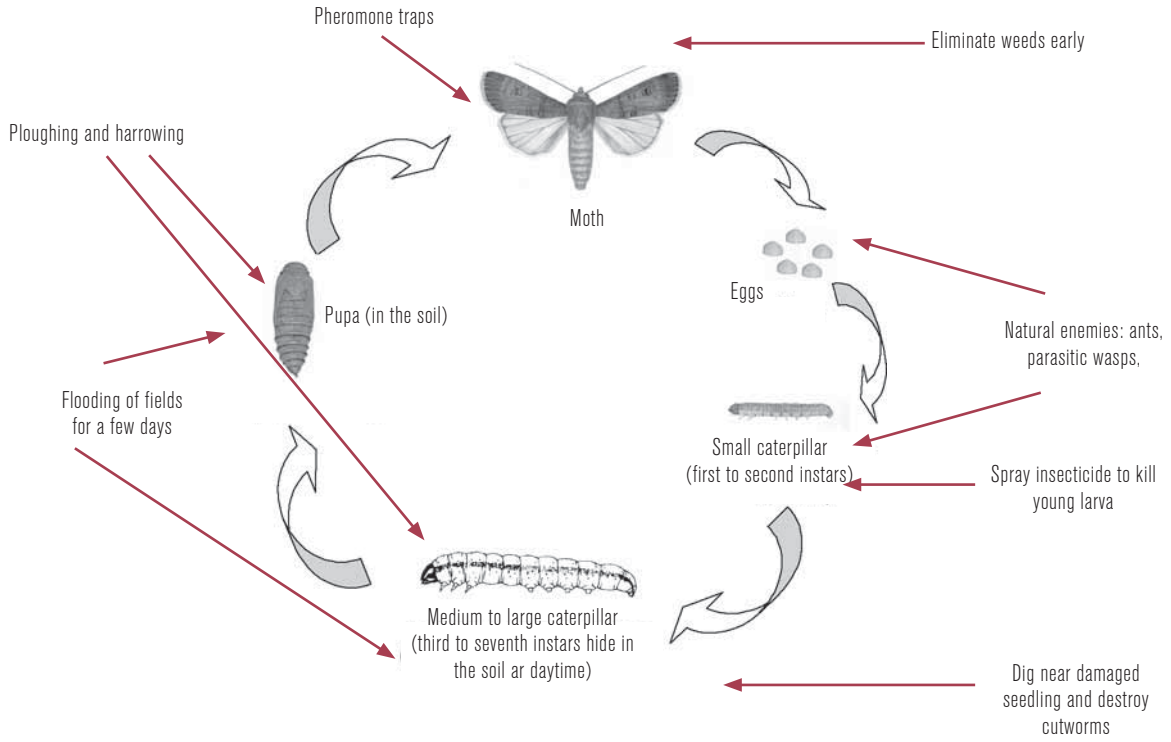
- Sprinkler irrigation or sustained rain can reduce infestation washing-off aphids.
- Install yellow traps in the plot to monitor the population level and to reduce infestation somewhat; it is imperative to detect attacks at the earliest stage of cultivation to limit the risks of early transmission of viruses or direct damage by large populations of aphids.
- Treatment with a selective insecticide upon detection of attacks on young plants.

After the final harvest

- Pull up the plants as soon as they have stopped producing.

CUTWORMS – *Agrotis* spp., *Spodoptera* spp.

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

At field preparation

- Ploughing and harrowing to expose larva and pupae to sun and natural enemies.
- Flooding of fields for a few days before transplanting to kill larvae and pupae.
- Eliminate weeds.

During first weeks

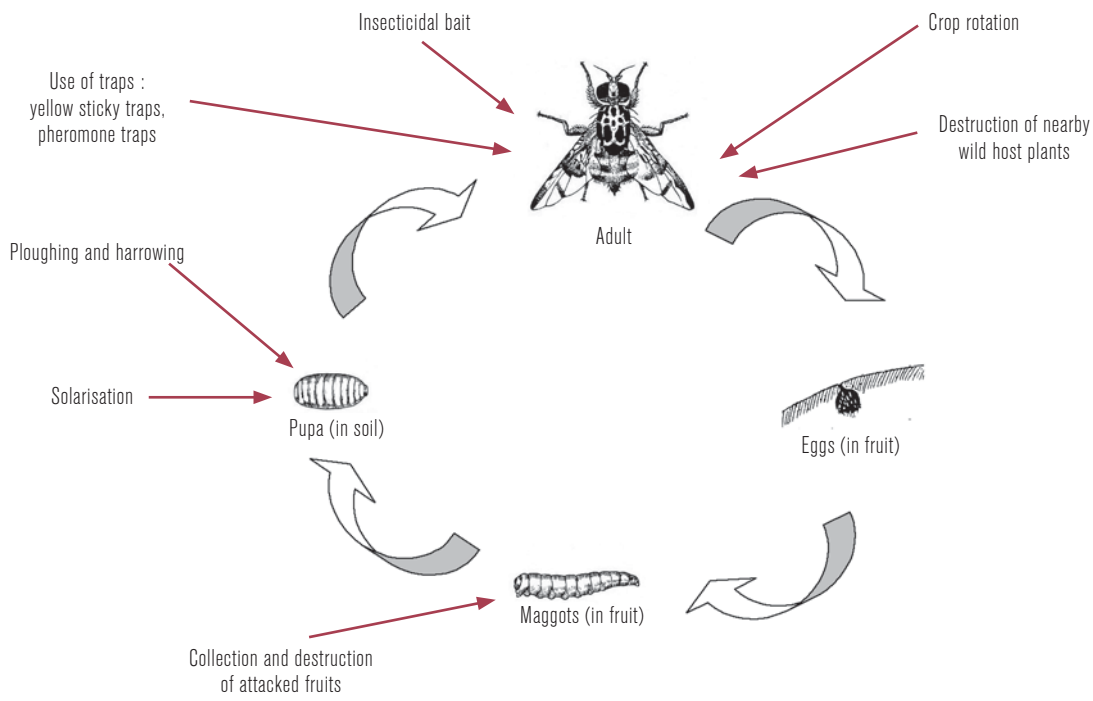
- Spray insecticide to kill young larva.
- Dig near damaged seedling and destroy cutworms.
- Avoid treatments destructive to natural enemies.

During all plant cycle

- Weed control in the field and around the margins is important to suppress population build up on alternative host sites.

FRUIT FLIES - *Bactrocera* spp. *Ceratitis* spp., *Zonosemata electa*

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

Throughout the production cycle

- Destruction of nearby wild plants which can be important reservoirs of infestation.

From the first settings

- Trapping with yellow sticky panels or pheromones placed on the plot to monitor evolution and reduce the population of adult flies.
- Insecticide treatment

From the first harvest

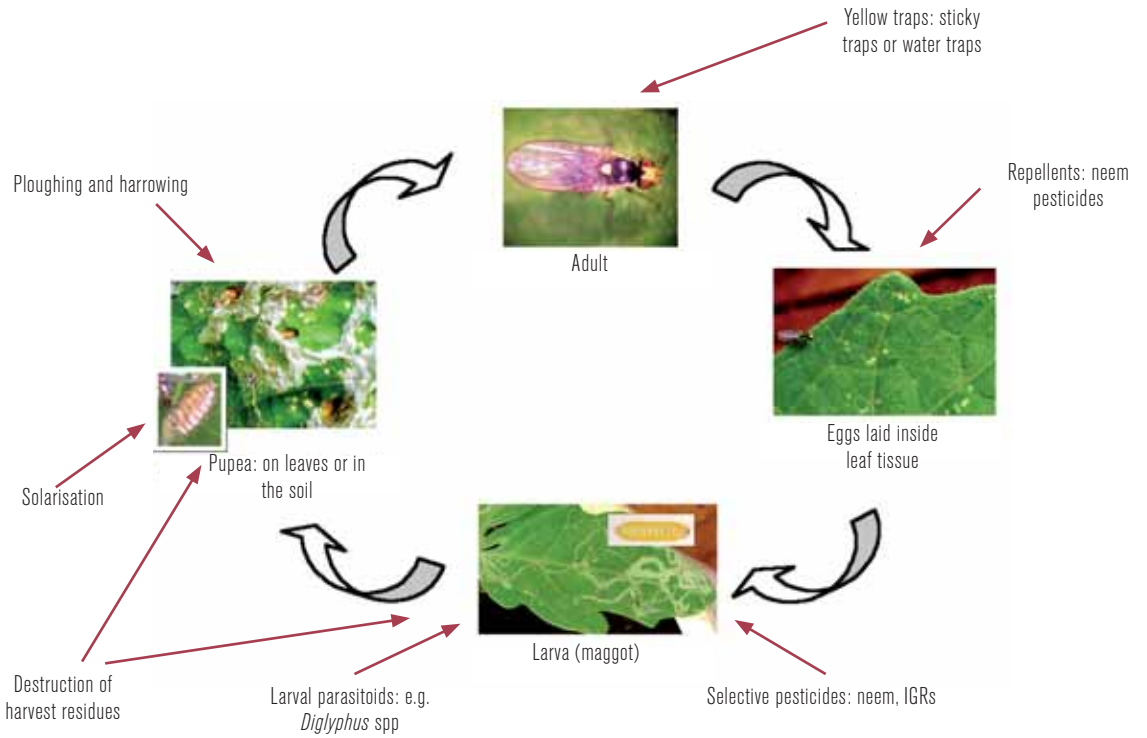
- Removal and destruction of damaged fruit through crushing and deep burial (60-90 cm) or burning.

After the final harvest

- Superficial tillage of the soil can bring the pupae to the surface and expose them to predators, parasites and sunshine.

LEAFMINER FLY - *Liriomyza trifolii, L.huidobrensis, L.bryoniae*

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

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

During the production cycle

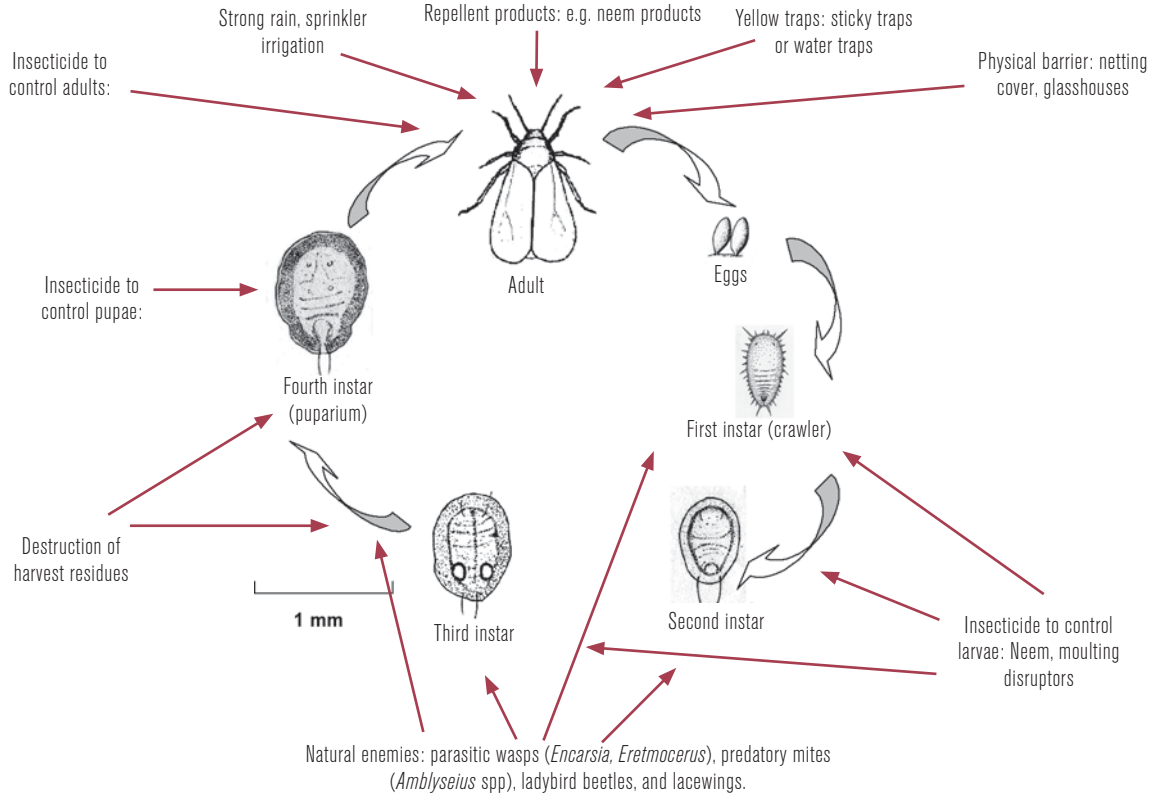
- Trapping with yellow sticky or water traps placed on the plot to monitor evolution and reduce the population of adult flies.
- Treatment with selective or repellent (to protect natural enemies), contact (to control the adults), translaminar or systemic insecticides (to kill larvae) used alternately (to limit risks of resistance) in case of serious outbreak.

After the final harvest

- Superficial tillage of the soil can bring the pupae to the surface and expose them to predators, parasites and sunshine.
- Destruction of harvest residues.

WHITE FLIES - *Bemisia tabaci, Aleurodicus dispersus,Trialeurodes vaporariorum*

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

- Protective netting.
- Insecticides if necessary.

Field

<u>During the production cycle</u>

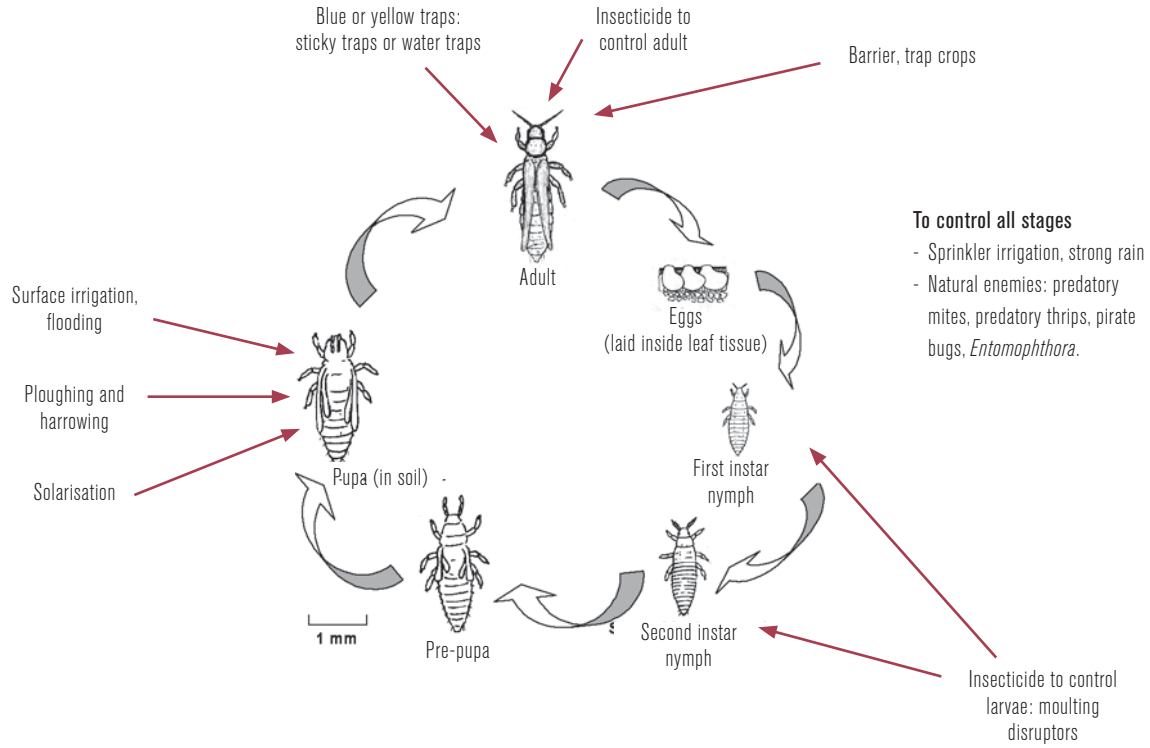
- Yellow traps: sticky traps or water traps.
- Sprinkler irrigation or strong rain will limit the spread of the pest.
- Systemic insecticides to control the pupae (puparium): soap, oils.
- Selective insecticides (to limit the negative impact on natural enemies) used alternately (to limit the risks of resistance) to control adults.
- Natural enemies: *Encarsia formosa*...

<u>After the final harvest</u>

Destruction of harvest residues to prevent buil up and spreading.

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

- Protect seedlings with insect netting, because young plants are sensitive to attacks by thrips.
- Spray insecticides if needed.

Field

During the production cycle

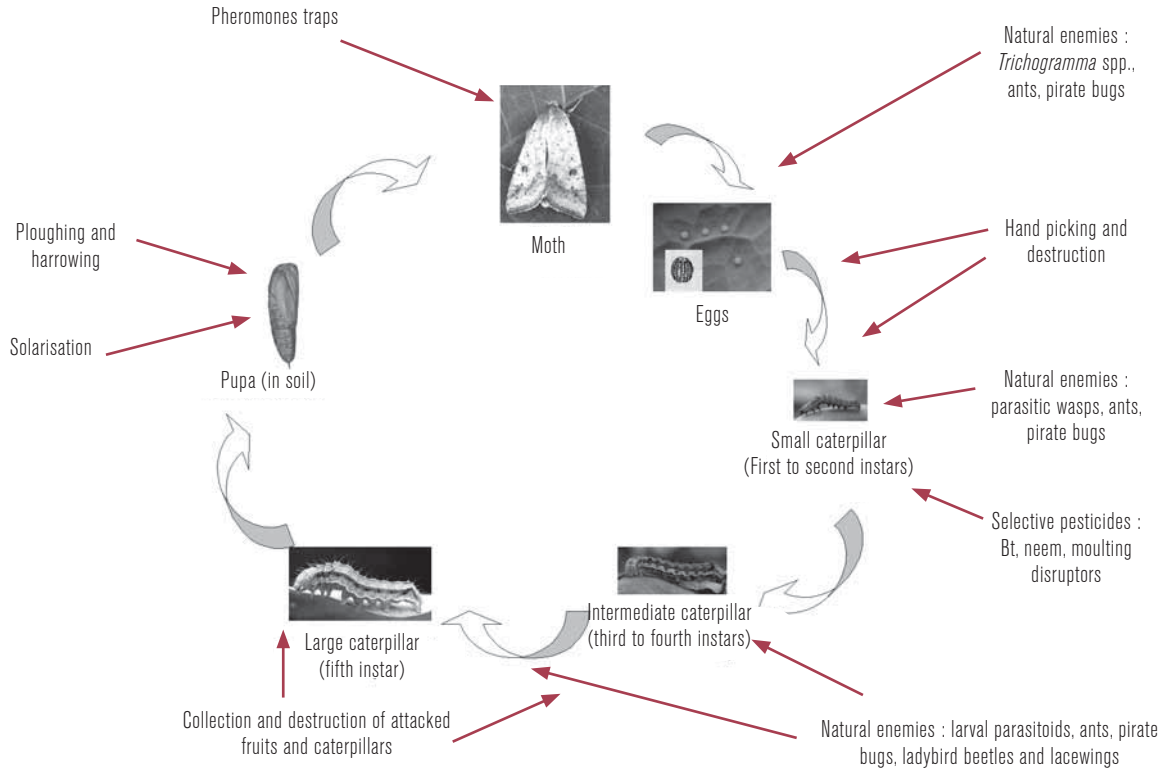
- Insecticids as needed.
- Blue or yellow traps: sticky traps or water traps.
- Sprinkler irrigation will wash-off thrips from the plants.

After the final harvest

Till the soil to bring the pupae to the surface; they will be killed by the heat of the sun or by natural enemies or flood the plot to kill yhe pupae.

FRUIT BORERS – *Helicoverpa armigera; Spodoptera* 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

Throughout the production cycle

- Pheromone traps to monitor population of the insect.

From the first settings

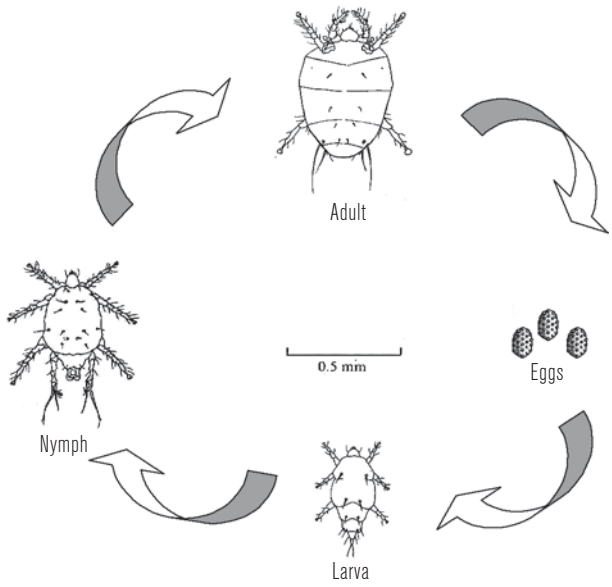
- Hand picking and destruction of attacked fruits and caterpillars through crushing and deep burial (60-90 cm) or burning.
- Insecticides treatment.

After the final harvest

- Ploughing and harrowing of the soil can bring the pupae to the surface and expose them to predators, parasites and sunshine.
- Solarisation of the soil can kill paupae.

Broad mite – *Polyphagotarsonemus latus*

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



To control all stages

- Encourage and release natural enemies such as predatory mites *Amblyseius*
- Apply specific acaricides to control larva, nymph and adult (someone are also ovicide)
- Remove and destroy trash from field, after harvest, immediately to avoid build up of populations in the field

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

During all plant cycle

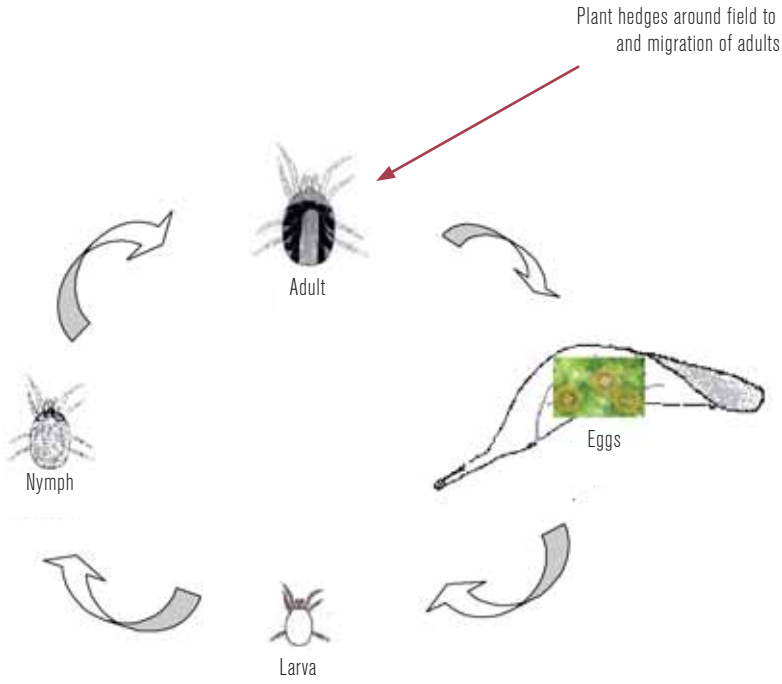
- Applying overhead irrigation on a regular basis will wash off a significant number of mites.
- Predatory mites, such as *Amblyseius* can be used to suppress populations.
- Apply acaricides during early development of populations, before malformation appear on the plant.

After last harvesting

- Remove and destroy trash from field, after harvest, immediately to avoid build up of populations in the field.

RED SPIDER MITE - *Tetranychus urticae*

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



To control all stages

- Encourage and release natural enemies such as predatory mites
- Apply specific acaricides to control larva, nymph and adult (someone are also ovicide)
- Apply products such as starch, milk and oil to suppress mite populations
- Dowse dirt track with water
- Apply overhead irrigation to increase microclimate humidity
- Remove and destroy trash from field, after harvest, immediately to avoid build up of populations in the field

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

At field preparation

- Where practical, hedges can be planted around the field to help reduce dust and adults reaching the crop.

During all plant cycle

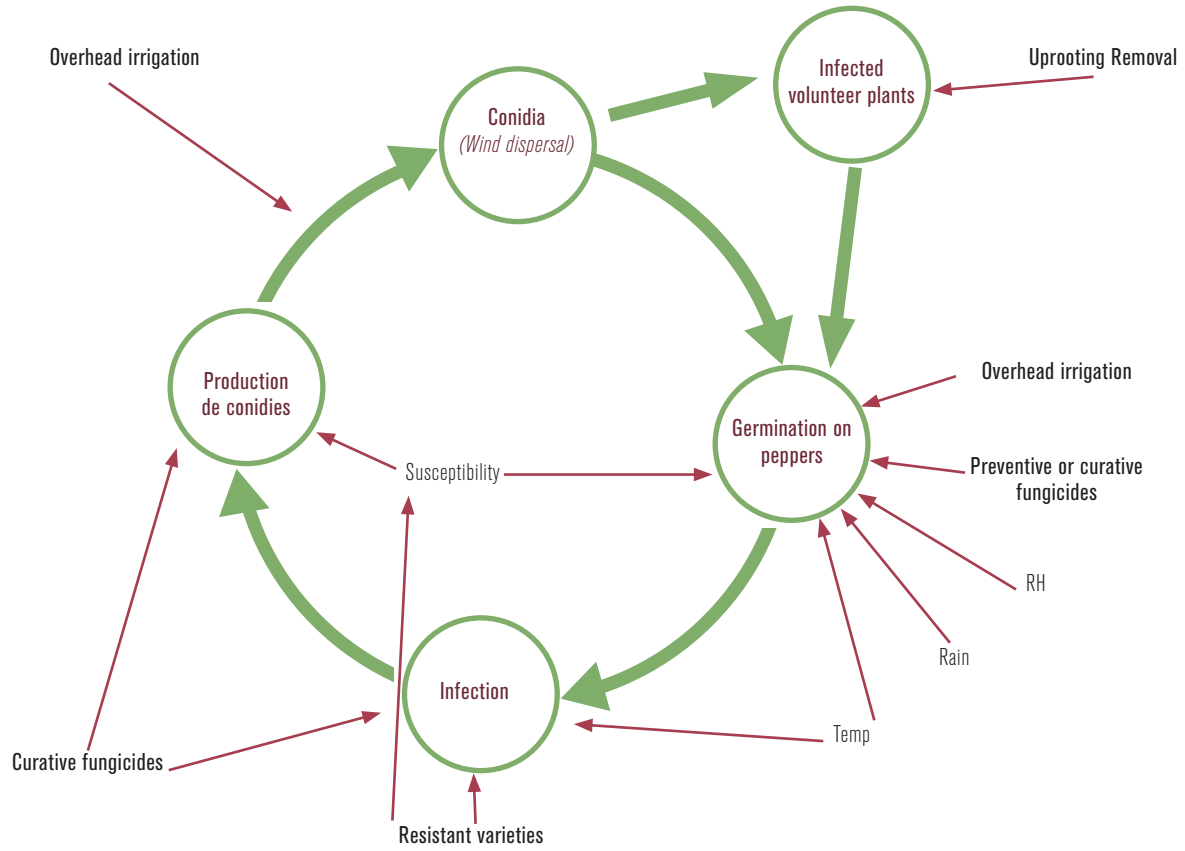
- Red spider mites thrive in dry conditions. Applying overhead irrigation on a regular basis will increase the microclimate humidity. This will lead to an unfavourable environment for mite development. The application of overhead also washes off a significant number of mites.
- Dust from farm tracks can get blown onto the webbing created by mites, further protecting them from pesticide control. In addition the photosynthetic capability of the plant is reduced. Any road close to the crop should be dowsed in water on a regular basis to reduce dust.
- Natural enemies like predatory mites, pirate bugs and predatory beetles can suppress populations.
- Products such as starch, milk and oil can be used as sprays to help suppress mite populations.
- Apply acaricides during early development of populations, before webbing formation.

After last harvesting

- Remove and destroy trash from field, after harvest, immediately to avoid build up of populations in the field.

Powdery mildew – *Leveillula taurica*

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



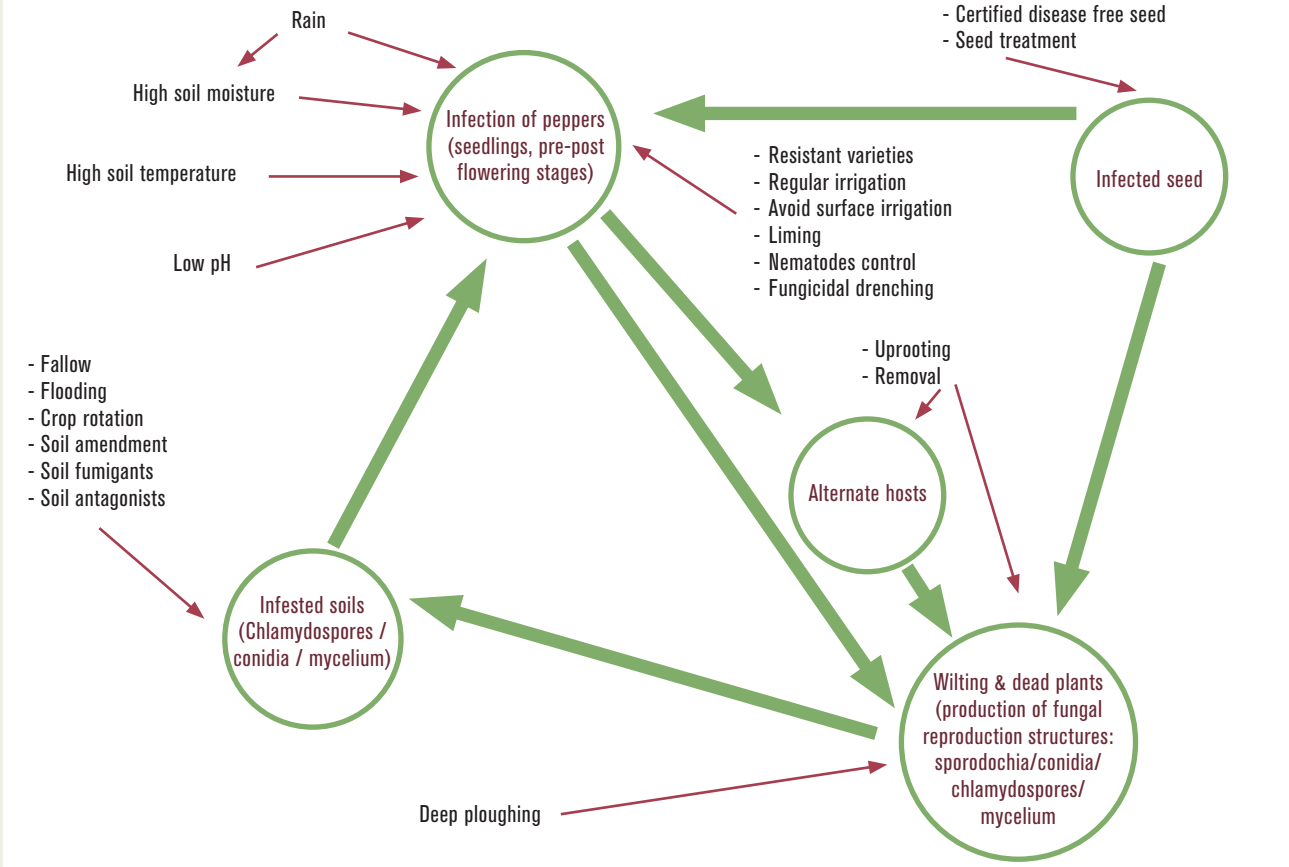
Positioning of control methods in terms of the development cycle of the plant

Action	Cultivation stages									
	Nursery substrate and environment preparation	Sowing	Nursery	Choice of piece of land	Field preparation	Transplanting	From transplanting to first harvest	From first harvesting to peak of harvesting	From peak of harvesting to end	After last harvesting
Overhead irrigation will wash spores off plant.			X			X	X	X	X	
Apply fungicides to prevent germination of spores.			X			X	X	X	X	
Apply fungicides to prevent mycelium development			X			X	X	X	X	
Remove solanacae weeds from within and around field		X	X	X	X	X	X	X		
Use resistant varieties		X								

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

Fusarium wilt - *Fusarium oxysporum* f.sp. *capsici*

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



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

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
Raising and maintaining the soil pH to 6.0 – 7.0 by liming helps limit the disease.				X	X					
The plant roots need to be kept free of attack from nematodes whose bites represent places of entry for fungi.	X		X				X			
The growing of peppers on plots where water stagnates, in overly damp or very heavy soil should be avoided, to help keep the plant collar dry.				X	X					
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 harvest residues so that they decompose completely.										X
Use of long rotation periods (3 to 4 years).				X	X					
Flooding can reduce inoculum in the soil				X	X					
Use certified seed free from disease		X								
Use resistant varieties		X								
Treat seeds		X								
Soil fumigants to destroy inoculum in the soil	X				X					
Use of antagonist to reduce inoculum in the soil					X					
Fungicidal drenching (low efficacy)	X				X					

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

Damping off											
Natural factors favourable to the fungus - Serious in heavy, poorly drained soils, with high pH.											
Development stage of the fungus	**Action**	**Cultivation stages**									
		Nursery substrate and environment preparation	Sowing	Nursery	Choice of piece of land	Field preparation	Transplanting	From transplanting to first harvest	From first harvesting to peak of harvesting	From peak of harvesting to end	After last harvesting
Germination on pepper plant	Avoid wounding roots and collar			X			X				
	Seedbed conditions should not be too moist	X		X							
	Regulate irrigation programme to avoid overwatering							X			
	Use of organic material to improve soil structure and pH			X		X					
	Avoid water logging areas when planting.				X	X	X				
	Apply fungicides as seed treatment to prevent germination		X								
Development in pepper plant	Apply fungicides to prevent mycelium development	X		X			X				
Development on crop or weeds	Remove and destroy Solanceae weeds from within and around fields.		X	X		X	X	X	X	X	
	Remove and destroy infected plants.			X			X				
Conservation in the soil	Use clean and/or sterile soil or potting media.	X			X						
	Steam, heat (65°C for 30 minutes) and solar treatment of soil and growing media will help to kill the disease	X				X					
	Composted bark increases the air filled porosity of media, releases inhibitors as it decomposes, and allows antagonistic soil fungi such as *Trichoderma* sp. to build up	X				X					
	Media used for seedlings ideally should not be reused, and seedling trays should be sterilised before reuse. Ideally trays should kept off the ground both when stored and in use	X									

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

Bacterial Wilt - *Ralstonia solanacearum*

Natural factors favourable to the disease

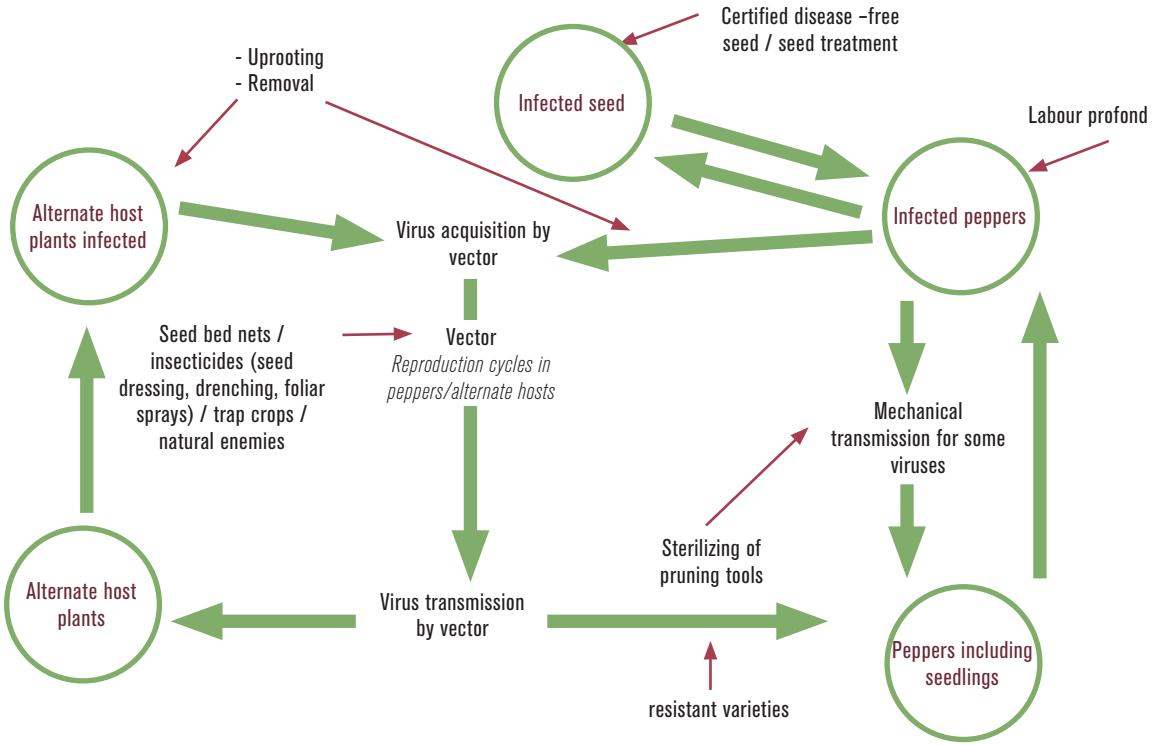
- Prevalent in sandy, loam and clay soils. Optimal development at temperatures 35 – 37°C.

Development stage of the bacteria	Action	Cultivation stages									
		Nursery substrate and environment preparation	Sowing	Nursery	Choice of piece of land	Field preparation	Transplanting	From transplanting to first harvest	From first harvesting to peak of harvesting	From peak of harvesting to end	After last harvesting
Infection on pepper plant	Avoid damage to roots during transplanting and weeding.						X	X	X		
	Do not use uncertified seed		X								
Development in pepper plant	Mulch crop to help suppress disease						X				
Transport by equipment or water	Avoid contaminated water. If solanacae plants are grown up river and irrigation water is taken from the river, samples should be tested regularly. If contaminated treat with peroxygen or chlorine dioxide.			X			X	X	X	X	
	Regularly clean and disinfect all machinery and equipment.					X					
	Avoid waterlogging from irrigation			X	X	X	X	X	X	X	
	Intercrop with maize, beans and other non-host plants will reduce spread of inoculum					X					
Development on crop or weeds	Remove solanacae weeds from within and around field to reduce secondary infection from alternative hosts.					X	X	X	X	X	
Conservation in the soil	Carry out a good crop rotation which avoids repeated plantings of solanacae crops on the same piece of land				X						
	Crop trash should be removed from the field and destroyed immediately after harvest										X

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

LES VIRUS

Positioning of control methods in terms of the development cycle of the disease and their vectors



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

Action	Cultivation stages									
	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	After final harvest
Use resistant or tolerant varieties if available		X								
Use certified-free seeds		X								
Avoid the presence of vectors by protecting the crop with non-woven netting until flowering.	X		X			X				
Plant trap crops to reduce vectors population					X	X				
Destroy infected plants and crop residues. Deep ploughing.										
Use pesticides not harmful to natural enemies of the vectors							X	X	X	X
It is advisable not to plant peppers near crops already infected with viral diseases of the peppers .							X	X	X	
Weed the area surrounding the field properly.				X	X	X				
Sterilize tools if the crop must be pruned							X	X	X	
Insecticides (seed dressing / drenching / foliar sprays) to reduce vectors population							X	X	X	
Insecticides (seed dressing / drenching / foliar sprays) to reduce vectors population		X	X				X			

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

2.5. Cultivar resistance or tolerance

Company/seed source	Cultivar	Resistance or tolerance										
		Aphids	BLS	Mildew	Fusarium	Oidium	PCR	CMV	PMV	PYV	TEV	TMV
Associated Seed Growers, (USA)	Texas Resistant No.1	X		X								
Baumaux (France)	F1 Bastion, F1 Tucan , F1 Fidji, F1 Brennus, F1 Galick, F1 Cyrano, F1 Figaro, F1 Sugar, F1 Zecchino				X	X						
Information from New England. No source of seeds given	Boynton Bell (GSP), X3R Camelot (GSP), Commandant (GSP)		X									X
	X3R Wizard (GSP), Enterprise (GSP), Yorktown (GSP), Brigadier (GSP), Pageant (YSP)		X									
	Paladin (GSP), Conquest (GSP)						X					
	New Ave (GSP), North Star (GSP), Karma (GSP), Merlin (GSP), Vivaldi (GSP), Melody (RSP)											X
	Emerald Isle (GSP)						X	X		X		
	Aristotle (GSP)		X				X					
	King Arthur (RSP), Orobelle (YSP)									X		X
	Admiral (YSP)		X							X		X
Asgrow Seed Co Tracy, CA (USA); Harris-Moran Seed Co Salinis, CA (USA), Petoseed Co., Inc. (Saticoy, CA (USA)	Keystone Resistant Giant #3 (SP)1, Mercury (SP)											X
A. R. C. O. Seed Co, Inc. El Centro, CA (USA)	Tambell 2 (SP)								X	X	X	X
Walter Baxter Seed Co. Welasco, TX, USA	Grande Rio 66 (SP)											X
Otis S. Twilley Seed Co. Trevose, PA (USA)	Purple Belle (SP), Mexi Bell (HP)											X
	Summer Sweet # 820 (SP)									X		X

BLS: Bacterial leaf spot (*Xanthomonas*); PCR: *Phytophthora* crown rot; CMV: Cucumber Mosaic Virus; PMV: Pepper Mosaic Virus; 4 PYV: Potato Y Virus; TEV: Tobacco Etch Virus; TMV: Tobacco Mosaic Virus
GSP= green sweet pepper, RSP= red sweet pepper, YSP= yellow sweet pepper, SP= sweet pepper HP= hot pepper

2.6. Use of natural enemies:

Insect and mi te pests of chillies and sweet pepper are naturally attacked by a variety of natural enemies including parasitoids, predators and micro-organisms (fungus, virus, bacteria). Although they cannot always prevent economic damage by pests and diseases they are important in their management, and therefore they should be conserved. In some cases where locally occurring natural enemies do not give satisfactory control, commercially produced natural enemies may be released.

Main natural enemies of major pests of chillies and peppers:

Aphids are naturally controlled by parasitic wasps; predators such as ladybird beetles, rove beetles, hoverflies, cecidomyiid flies, anthocorid bugs, spiders and lacewings; and fungal diseases. The parasitic wasps *Aphidius* spp are common in Kenya, and help to maintain aphids under control provided compatible pesticides are used for control of aphids or other pests. These parasitic wasps are also commercially available.

Whiteflies are mainly attacked by parasitic wasps (*Eretmocerus* spp. and *Encarsia* spp.), which are widely used at a commercial level in several crops. Predators such as phytoseiid mites (*Amblyseius* spp. and *Typhlodromus* spp.), ladybird beetles and lacewings (*Chrysopa* spp.) are also important natural enemies of whiteflies. Most of these natural enemies are commercially available and are widely used particularly in protected cultivation.

Caterpillars, and in particular the fruit worms have a wide variety of natural enemies, the main ones being egg parasitoids (e.g. *Trichogramma* wasps), larval parasitoids and predators such as anthocorid (pirate) bugs, ants, lacewings and ladybird beetles. These natural enemies are usually common in the fields. They are also commercially available. Augmentative releases of *Trichogramma* spp. alone and in combination with applications of *B. thuringiensis,* are used for the management of fruit worms in several crops worldwide.

Leafminers are normally controlled to satisfactory levels by naturally occurring larval parasitoids, provided persistent broad-spectrum pesticides are not used. One of the most important is the parasitic wasp *Diglyphus isaea* Walker. This parasitoid is commercially available and some growers (in Kenya) are rearing them for management of leafminers on several crops including chillies. The parasitic wasps *Dacnusa sibirica* and *Opius pallipes* are used fro control of leafminers on Solanaceous crops in glasshouses in Europe.

Thrips are attacked by a number of predators and some parasitoids. Predators, in particular predatory mites (*Amblyseius cucumeris, A. degenerans*), pirate bugs (*Orius* spp.) parasitoids (e.g. *Ceranisus menes*) and predatory thrips are important in natural control of thrips. Fungal diseases such as *Entomophthora* can occasionally wipe out thrips populations.

A number of predators are known to feed on spider mites. These include predatory mites, staphilinidae beetles, ladybird beetles, lacewings, predatory thrips, anthocorid or pirate bugs, mired bugs and cecydomyiid and syrphid flies. Among them the predatory mites *Phytoseiulus persimiles* and *Amblyseius andersonii* have been widely used mainly in greenhouse crops. In most cases, naturally occurring predators are capable of controlling infestation of the two-spotted spider mite provided broad-spectrum insecticides are not applied and the crop is irrigated properly.

Broad mites are attacked by predatory mites. *Phytoseiulus persimilis* is not very much attracted to broad mites. *Amblyseius* spp are better predators of broad mites. In particular *A. californicus* is used for control of broad mites in different parts of the world.

Selective measures can be used for encouragement of natural enemies. They can be attracted to crops by growing / conserving plants that are attractive to them, by overlapping of different crops on adjacent plots or by intercropping. For instance, the numbers of anthocorid (pirate) bugs, which are important predators of eggs of fruit worms, thrips, mites, small caterpillars, usually build up after plants start to flower. These predatory bugs could be attracted early to the crop by planting plants which early and distinct flowering as intercrop or on adjacent plots. Hedges of perennial pigeon peas reportedly encourage predatory mites.

A number of natural enemies, in particular of moth eggs, aphids, leafminers, thrips, mites and whiteflies, are commercially available, and are used for artificial augmentation, in particular in protected cultivation (glass or greenhouses, plastic houses). Releases, particularly early on in mixed cropping system, may be effective, but repetitive releases may be needed. Control is satisfactory provided that sufficient natural enemies are released in good time, and that no detrimental pesticides are used. The timing of introductions of natural enemies can be determined by monitoring the presence of the pests.

When pesticide application is necessary it is important to choose insecticides and methods of application that are not damaging to biological control agents. The active substances used should be safe to natural enemies and bees, or have a short persistence so that not all life stages of natural enemies are affected (and so that natural enemies can be reintroduced shortly after application). Selective application techniques such as seed dressing and drenching of systemic pesticides in the seedbed safeguard natural enemies. Dusting, blanket application and the use of a wetter or a spreader generally are detrimental to natural enemies and should be avoided.

Soil borne diseases (e.g. *Fusarium* wilt) can be controlled with antagonist microorgansms such as *Trichoderma* fungi that compete with the disease-causing fungi. *Trichoderma* is available as a commercial product.

Antagonisitc microorganisms commercially available for control of nematodes include *Paecilomyces lilacinus* and *Poconia chlamydosporia*

3. Crop monitoring and intervention thresholds

3.1. Introduction

Crop monitoring involves gathering and recording information about a crop. Constant monitoring of arthropod pests, diseases and nutritional disorders is essential to detect a problem in the crop early and to take action before serious damage occurs. For example, early detection of eggs or caterpillars of fruit worms before they bore into the fruits is important. Once the caterpillars have entered the fruit they are difficult to control and by then they have caused damage. It also involves checking for presence and abundance of natural enemies. This information is important when deciding on interventions.

Monitoring helps to reduce the use of preventative tactics and aids in the assessment of previous interventions. It must be frequent and regular. The crop should be scouted at least twice a week. If possible, scouting should be done daily during the most sensitive stages of the crop, such as nursery and from the beginning of flowering till last harvest.

Growers of hot and sweet peppers for export are exposed to season long pest pressure with a very low (near zero) tolerance for pest and disease damage. Economic thresholds are generally not available for major pests and diseases of peppers. A few available economic thresholds for some insect pests are given below. They are meant as guides; locally established thresholds should be used / calculated. In case of diseases there are no thresholds per se. Preventive interventions must be taken on basis of weather conditions prevalent that could be conducive to disease development and / or on expression of initial disease symptoms. Expertise is needed to detect the initial symptoms. When a disease is observed, curative interventions would be required. Where virus diseases are concerned, infected plants when observed must be uprooted to stop further spread particularly if they are vector associated.

3.2. Monitoring methods

Crop monitoring methods include plant sampling (scouting) and use of insect traps and indicator plants.

Traps reduce crop inspection time considerably and lead to timely interventions. Yellow sticky traps and water traps are useful to detect leafminers, fruit flies (pepper maggot), whiteflies, and thrips. Blue traps are used for detection of thrips. Bait traps are used for monitoring fruit flies. Pheromone traps are specific traps and are commonly used to monitor fruit flies, and moths such as fruitworms and cutworms.

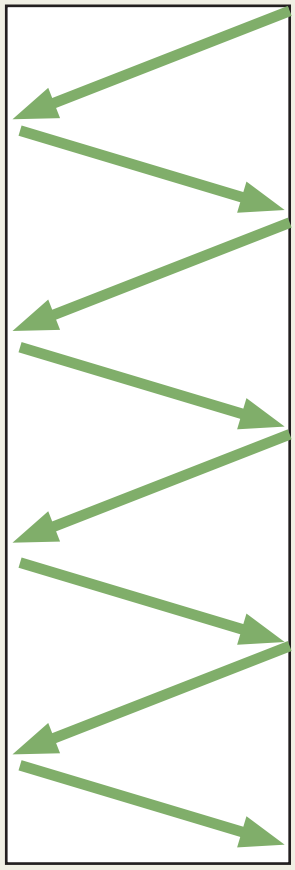
Baiting of yellow traps with a vial of ammonia is recommended to monitor the pepper maggot in New England, USA). At least one trap per acre should be placed around field margins. Traps are more reliable when hung about 20 feet high.

Sticky traps can be made by painting a small board (yellow or blue), and coating it with a commercial product (e.g. Tanglefoote) or with mineral oil, petroleum jelly or grease. The number of traps per area depends on the stage of the crop. A recommendation from India for field-grown peppers in India is to set yellow traps at 10 traps per ha.

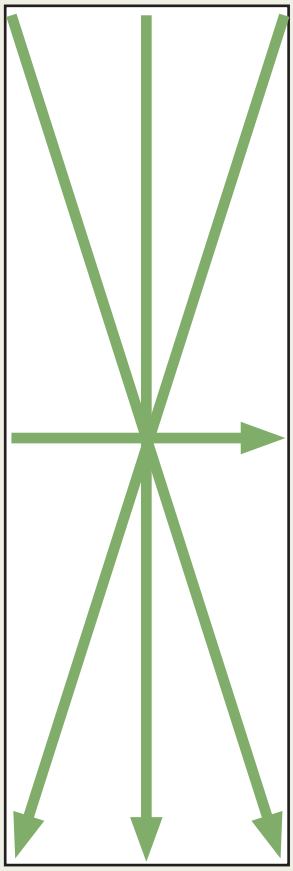
To scout a crop the farmer surveys the crop area to get an overview of the major problems and the general condition of the crop. This is followed by methodical inspection of the crop, picking plants at random at sampling sites and filling observations in a prepared inspection sheet. Different sampling sites should be chosen each time the crop is inspected. The number of sampling sites on each stretch will depend on the size of the field. The number of plants to be inspected on each site will depend on the size of the plants, the crop and spacing. For sweet peppers, it has been recommended to check 60 plants chosen randomly in 0.1 ha (AVRDC). For a smallholder plot, 10 sites per farm unit and 10 plants per sampling site should be adequate. While carrying out random sampling, the grower should be alert to unusual problems and conditions in the rest of the field.

Sampling patterns vary, depending on farm size and crop. Examples include zigzag, multi-bisectoral and 'W' patterns as shown below

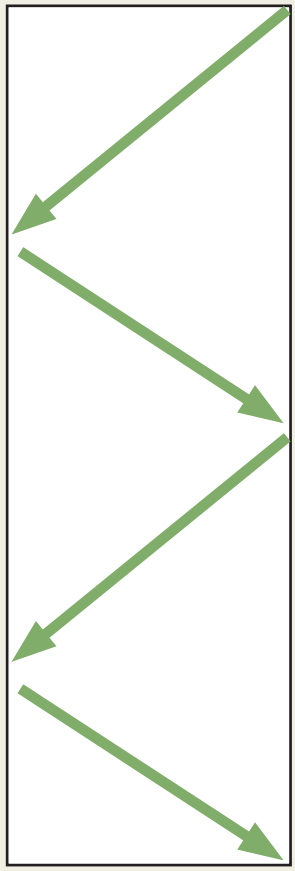
Examples of scouting patterns



Zigzag pattern



Multi-bisectoral pattern



'W' pattern

Scouting involves thorough inspection of the sample plant from soil and roots to the top of the newest shoot, carefully checking both the upper and under sides of leaves, flowers and fruits. Check for incidence and severity of pests and diseases and any other abnormality in the crop. Check for presence and abundance of natural enemies.

In the nursery attention should be given to pests such as cutworms, aphids, whiteflies and thrips, and damping off. At transplanting watch for cutworms, and white grubs, which may cut the seedlings. In the field, watch early in the season for pests and diseases such as aphids, leafminers, mites, thrips, and whiteflies, and viral diseases. At the beginning of fruit set concentrate on pests and diseases that damage fruits. It is important to detect mites, thrips, fruit worms and fruit flies in early stages of development. They are a greater problem than foliar feeders because damage to fruits or blossoms directly affects the marketable part of the plant. Control may be necessary if moderate damage is observed.

Scouting guide for main pests and diseases of hot and sweet peppers:

Cutworms:

Cutworms are caterpillars of moths. Moths are about 2 cm long, grey-brown in colour. The forewings have dark brown margins in from of rings and lines. Caterpillars are grey, greenish-brown to brown in colour with a smooth skin. They normally curl-up when disturbed. Caterpillars feed at night and hide in the soil during the day. Scout for seedlings cut off at the base of the stem. Check for cutworms in the soil near the damaged plants.

Check field for cutworms before transplanting or before plants emerge when direct sowing is done. If pheromone traps are used to monitor appearance of moths check them regularly.

Threshold for peppers in New England, USA: Treat if 1% or more of seedling stems are cut.

Aphids:

Aphids are soft-bodied, small (1-3 mm long) insects. The body is oval to pear-shaped with long antenna and usually a pair of cornicles (horns) towards the posterior end of the body. They can be wingless or winged. For early detection check for winged aphids, which start new colonies on young shoots. Check for small colonies on young leaves and shoots. When the numbers are high the plant maybe covered with honeydew and black sooty mould. Check also for the presence of natural enemies. Parasitised aphids, known as mummies, are easily recognised, as they turn hard, and brown in colour. Larvae and adults of ladybird beetles, lacewings and hoverflies are normally found within or near the colony of aphids.

Recommendation for scouting in Wisconsin, USA: check leaves from the mid to lower half of 25 plants per sample site. Count the total number of aphids. Treat if you find more than 50 wingless aphids per 25 plants early in the season or 100 per 25 plants late in the season. Monitor whether numbers are increasing or decreasing over time.

Threshold for peppers in New England, USA: Treat if aphid numbers exceed 10 per leaf prior to fruit set and 5 per leaf after fruit set.

Fruit flies:

Monitor fruits for egg-laying scars (dimples or small white specks in the middle of a shallow indented area on the surface of the fruit). Check appearance of flies on traps. Fruit flies are 4-7 mm long, brightly coloured, usually in brown-yellow-black patterns. The wings are spotted or banded with yellow or brown margins.

Threshold in New England, USA: Treat when first flies are captured or when egg-laying scars are detected.

Fruit worms:

For early detection scout for eggs and small caterpillars especially on young leaves, flower buds and shoots. Once the caterpillars get into the flowers and fruits they are well protected and damage has been done. Helicoverpa moths lay single eggs while *Spodoptera* moths lay eggs in groups (masses) covered with scales or hairs on the lower leaf surfaces or on the structures of greenhouses. The colour of the caterpillars is very variable. *Helicoverpa* young caterpillars are olive green to reddish brown, have a dark head and coarse black hairs that gives them a spiny appearance. Older caterpillars are olive green or dark grey or brown with alternating light and dark stripes running lengthwise on the body and two typical side stripes. They may reach 3-5 cm when fully grown. *Spodoptera* caterpillars vary from green, yellowish white to brown and have lines along the body or dark spots on the dorsal side, according to the species. The size of the mature caterpillars varies from 3 to 4.5 cm long depending on the species.

If pheromone traps are used to monitor appearance of moths, check them regularly. Helicoverpa moths are about 1.5 cm long, yellowish brown in colour, with greyish wavy lines and a dark mark on each forewing. *Spodoptera* littoralis moths are about 2 cm long, brown in colour with a large number of pale yellow lines across the forewings. S. exigua are smaller (1.2 cm), brownish-grey with two small spots on the forewings.

Threshold in India for H. armiguera on peppers: 8 to 10 moths per day per trap. One egg / caterpillar per plant, or one damaged fruit per plant.

Leafminers:
For early detection check the upper surface of young leaves for punctures made by adults while feeding and laying eggs. The adult leafminer is a tiny (2-3mm long) blackish yellow fly. Check for presence of mines on leaves. Mines in young leaves indicate recent attacks. Check mines for presence of parasitised maggots (dark in colour in contrast to yellow colour of healthy maggots). Check yellow traps (sticky or water traps) for presence of leafminer flies and parasitic wasps such as *Diglyphus*.

Thrips:
Adult thrips are small (0.5-2.0 mm), slender and usually winged. The wings are long and narrow, fringed with long hairs, and at rest lie over the body. Thrips vary in colour from black or brown to yellow or yellowish-orange. Eggs are laid inside the plant tissue. Immature thrips are wingless and usually green in colour. For early detection check the underside of leaves, the apices of young fruits and shake flowers on a white piece of paper and look for the thrips. Check the underside of leaves for a silvery sheen and/or small, dark spots of faecal material. The upper side of older leaves turns brown. Monitor adult thrips by hanging coloured (blue, yellow or white) sticky or water traps in the nursery or field. Check traps regularly. Check for natural enemies. Pirate (*Orius*) bugs are commonly found in the flowers when thrips are present.

Threshold in India for peppers: 6 thrips per leaf or 10% affected plants.

Whiteflies:
For early detection check the underside of young leaves for presence of adults and eggs. Whitefly adults resemble very small moths (about 1 mm long), are white in colour. They are often found in groups on the lower leaf surface and readily fly away when the plant is shaken. Eggs are elliptical, about 0.2 to 0.3 mm long, attached vertically to the leaf surface. They are normally laid in an arc or circle on the underside of young leaves. The young stages or nymphs are scale-like in shape, greenish in colour and are covered or surrounded by wax. They are found on the underside of intermediate-aged and old leaves. They do not move. When they are many the plant may be partially or completely covered by sooty mould. Check yellow traps if used.

Broad mites:
Broad mites are very small (0.1-0.2 mm long) and cannot be seen with the naked eye, and are difficult to detect with a hand lens. For early detection check for symptoms such as necrosis on the lower leaf surfaces, deformation (elongation and curling) of young leaves.

Spider mites:
Check plants at the edges of the field as mites can be dispersed by wind and infestation start in patches often on plants along the border. To detect early infestation look out for white speckling (clusters of yellow-white spots) of the upper leaf surface and check lower surface of leaves mainly along the main veins for presence of eggs and mites. Mites are tiny (about 0.5 mm long) oval in shape with an arched back and have eight legs, except in the larval stage when they have six legs. The colour of the adult mite varies from yellowish green, brownish red to dark red according to the species. The eggs, which look like a droplet of water, can be seen only with a hand lens. A magnifying lens will also be handy to determine if they are alive. This is particular important to determine if an intervention (e.g. spraying with acaricides) has been successful.

Diseases: Early symptoms of the major diseases:

Damping-off: Seedlings fail to emerge (pre-emergence damping-off), small seedlings collapse (post-emergence damping-off) or seedlings are stunted (root rot and collar rot). Seedbeds affected appear patchy. In the field, seedling diseases are conduced by cold, wet periods.

Anthracnose: Small tan flecks develop on cotyledon leaves shortly after emergence. Spots on leaves and fruits are small, sunken with dark fungal spores on them, and a characteristic concentric ring (target-shaped) appearance. The fungus causes rapid infection only during heavy fog, dew or drizzle. The disease is most serious on ripe fruits.

Powdery mildew: On the upper leaf surface, chlorotic blotches or yellow spots, which may become necrotic are symptomatic. On the lower leaf surface, a white to grey powdery growth may develop. Warm temperatures and high relative humidity favour the disease.

Fusarium wilt: The first visible symptom is drooping of the lower leaves. Later, younger shoots turn yellow, die and turn brown. Invaded roots become soft and develop a water-soaked appearance. Sliced roots exhibit a reddish brown colour in the wood. The disease is favoured by warm temperatures and high soil moisture and thus particularly serious in poorly drained soils.

Bacterial spot: Leaf spots first appear as small, circular, pale green pimples that are raised on the under surface of the leaf while the top surface of the spot may be depressed slightly. On older leaves, spots often are first dark green and water-soaked. Fruit spots are circular, initially green but become brown and raised with a cracked, roughened and wart-like surface (scabby appearance). Warm temperatures and high relative humidity with free moisture on leaves favour disease development.

Bacterial soft rot: Rot symptoms usually start as a sunken area, either from the peduncle or around a skin puncture. The rot spreads rapidly until the entire fruit collapses into a soft slimy mass (resembling a sack of liquid retained by the skin). When the skin breaks the contents flow out. It is most destructive market disease. Warm temperatures and high moisture favour disease development.

Bacterial wilt: First symptom is drooping of all leaves resembling symptoms of soil moisture deficiency. This is particularly conspicuous when it is hot. Drooping of leaves is followed by a sudden, permanent wilt of the entire plant with no leaf yellowing or browning. Roots of infected plants are discoloured. Cross sections cut from lower stems and roots of infected plants exude milky streams of bacteria from the vascular system when suspended in water. Warm temperatures and high soil moisture favour disease development.

Root-knot nematodes: Aboveground symptoms may include stunting, drooping of leaves, lack of vigour and wilting of plants. Roots of affected plants develop small knots or galls. Severely affected roots rot. Root-knot nematodes are most damaging in sandy soils and in warm climates.

Virus diseases: It is nearly impossible to identify specific pepper viruses on the basis of symptoms observed on pepper plants and fruits in the field. Symptoms include mosaic patterns, mottling, leaf deformation (including small-sized leaves), leaf curling, chlorosis, stunting (dwarfing) of plants when plants are attacked at early growth stages, and spotting (including ring spots), line patterns and distortion of fruits. Since many of the pepper viruses are transmitted by pests (aphids, leaf hoppers, mites, thrips and whiteflies), it is important to check for these pests during scouting. Most viruses are serious in arid and semiarid areas where high temperatures prevail.

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 which allows compliance with European MRLs currently in force is also shown, or the highest national MRL when no harmonised European MRL exists. 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. At this stage, however, it is worth noting that no tests have been carried out in ACP production environments to check compliance of MRLs with the GAPs indicated. 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

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 and in Europe. It is nevertheless worth noting that not all the ACP producers contacted provided information on the PPP used. The products mentioned by producers have been underlined in the tables. The active substances are classified by resistance risk group (FRAC and IRAC classification and codes). 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 (melons are harvested around twice a week), the modes of action of the active substances and the effects on natural enemies.

Notes:

- Use pesticides as a last resort and based on need.
- Observe pre-harvest intervals (PHI)
- Whenever possible do not use pesticides in toxicity classes 1a, 1b and 2.
  The WHO Recommended Classification of Pesticides by Hazard http://www.who.int/ipcs/publications/pesticides_hazard/en/ is as follow:
  - Class 1a : extremely hazardous
  - Class 1b : highly hazardous
  - Class II : moderately hazardous
  - Class III : slightly hazardous
  - Unlikely to present acute hazard in normal use (Table 5)
- Whenever possible, select pesticides that are compatible with, or are known to have minimal detrimental effect on natural enemies.

Aphids

Strategy: Decision on spraying should be based on regular scouting of the crop. Spray only when aphid colonies begin to build up to high numbers. In areas with a history of virus transmitted by aphids, spraying of seedlings in the nursery and young plants in the field may help to reduce spread of viruses. Low infestations should be dealt with spot treatment (spraying only infested plants). Blanket spraying should be carried out only for heavy infestation, since frequent and inappropriate use of pesticides may result in elimination of natural enemies. Great care must be taken in pesticide use. Spray effectiveness may vary depending upon the species present. Several aphid species, in particular *Aphis gossypii* and *Myzus* persicae easily develop resistance to certain groups of pesticides (e.g. *pirimicarb* or *organophosphorus* compounds). Therefore product choice and rotation of pesticides is very important to minimise or delay development of resistance. Preventive application and application of lower than recommended dosages should be avoided since they too may lead to resistance. Systemic and foliar insecticides provide good control. Products with a purely physical, such as starch-based preparations or fatty acids, may be useful for management of resistant aphids. Treat at five to seven day interval. Coverage of lower leaf surface is important.

Active substance (WHO toxicity class)	Recommended GAP*				Proposed application period					
	Dode g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)	Sowing	Nursery	Planting to flowering	Flowering to first harvest	First harvest to peak of harvest	Peak to end of harvests
Group 1 – Organophosphates and carbamates										
acephate (III)	375	3	15	21		■	■			
carbofuran (Ib)	/	One at planting	n.a.	At planting		■	■			
chlorpyriphos-methyl	680	1	n.a.	5		■	■	■		
diazinon (II)	/	/	/	14		■	■	■		
dimethoate (II)	/	/	14	14		■	■	■		
fenitrothion (II)	/	/	14	7		■	■	■		
heptenophos [18] (Ib)	/	/	/	/		■				
malathion (III)	/	/	14	7		■	■	■		
methomyl (Ia)	/	/	/	3		■	■	■	■	
oxamyl (Ib)	/	/	/	21		■	■	■		
pirimicarb [18] (II)	500	2	7	3		■	■	■	■	
pirimiphos-methyl (III)	/	/	14	7		■	■	■		
Group 4 – Nicotinic Acetylcholine receptor agonists/antagonists										
acetamiprid	25	2	7	7		■	■	■		
imidacloprid (II)	/	/	/	3	■	■	■	■	■	
thiacloprid (II)	/	/	/	3		■	■	■	■	
thiamethoxam [16] (III)	100	2	7	3	■	■	■	■	■	
Group 3 – Pyrethroids (sodium channel modulator)										
alpha cypermethrin (II)	30	1	n.a.	7		■	■	■		
bifentrin [16] (II)	5 - 20	2	7	5		■	■	■		
cyfluthrin (I)	/	/	/	7		■	■	■		
cypermethrin (II)	/	/	14	15		■	■	■		
etofenprox (Table 5)	/	/	/	7		■	■	■		
fenvalerate (II)	/	/	7	7		■	■	■		
lambda-cyhalothrin [16] (II)	12.5	2	7	3		■	■	■	■	
permethrin 20 (II)	/	/	/	/		■	■	■	■	■
pyrethrins [16] (Table 5)	/	/	/	2		■	■	■	■	■
Group 18 – Ecdysone aganists/moulting disruptors										
azadirachtin [16.18] (Table 5)	/	/	/	2		■	■	■	■	■
Group 2 – Organochlorins and fiproles										
endosulfan [20] (II)	/	/	/	/		■	■			
pymétrozine (III)	100 to 450	3	7	3		■	■	■	■	
Not classified										
insecticidal soap [16]	/	/	/	2		■	■	■	■	■
Natural pyrethrum and garlic [16]	/	/	/	2		■	■	■	■	■
petroleum oil [16]	/	/	/	2		■	■	■	■	■

[16] Growers, Kenya; [18] Gambia (growers); [20] Uganda (growers).

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

/ elements of the recommended GAP not available

n.a. : not applicable

Cutworms

Strategy: Young caterpillars (first and second instars) can be found on the canopy and can be easily controlled with insecticides. This is particularly effective when treatments are based on information from pheromone traps. When treatment of older caterpillars (hiding in the soil at daytime) is necessary, the amount of insecticide applied can be minimised by banding the insecticide over the rows rather than broadcasting, by drenching around the base of each plants in the evening, and by using baits mixed with insecticides. Baits are more effective when other food is limited. In case of widespread outbreaks place baits in fields before transplanting or before plants emerge when direct sowing is done.

Active substance (WHO toxicity class)	Recommended GAP*				Proposed application period					
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)	Sowing	Nursery	Planting to flowering	Flowering to first harvest	First harvest to peak of harvest	Peak to end of harvests
Group 18 – Ecdysone aganists/moulting disruptors										
azadirachtin (Table 5)	/	/	/	2						
tebufenozide (Table 5)	/	/	/	7						
Group 3 – Pyrethroids (sodium channel modulator)										
beta-cyfluthrin (II)	/	/	/	3						
bifenthrin [16] (II)	/	/	/	5						
cypermethrin (II)	/	/	/	15						
deltamethrin (II)	7.5	2	7	7						
fluvalinate (II)	/	/	/	/						
lambda-cyhalothrin [16] (II)	12.5	2	7	3						
permethrin [20] (II)	/	/	/	3						
pyrethrin (Table 5)	/	/	/	2						
zeta-cypermethrin (II)	/	/	/	/						
Group 1 – Organophosphates and carbamates										
carbaryl (II)	/	/	/	/						
chlorpyriphos-ethyl (II)	/	At planting	-	At planting						
fenitrothion (II)	/	/	14	7						
malathion (III)	/	/	14	7						
methomyl (Ia)	/	/	/	3						
Group 5 – Spynosines										
spinosad (III)	144	3	7	3						
Group 11 – Microbial disruptors of insect midgut membranes										
Bt (Table 5)	/	/	/	2						

[16] Growers, Kenya, [20] Uganda (growers).

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

/ elements of the recommended GAP not available

n.a.: non applicable

Fruit borers

Strategy: Early detection of eggs or caterpillars before they bore into the fruits is important. Pesticide use may be needed in severe infestation. A number of insecticides afford good control of the fruit worms. However, selective pesticides, which preserve natural enemies, should be preferred. For example, pesticides based on *Bacillus thuringiensis* (Bt) or some plant-based extracts such as neem products can be used with minimal negative effects on natural enemies. Use a knapsack sprayer fitted with a fine/medium hollow cone nozzle. *Helicoverpa* spp. (e.g. the African bollworm) can develop resistance to pesticides quickly. Therefore care should be taken to rotate pesticides.

Active substance (WHO toxicity class)	Recommended GAP*				Proposed application period					
	(WHO toxicity class)	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)	Sowing	Nursery	Planting to flowering	Flowering to first harvest	First harvest to peak of harvest	Peak to end of harvests
Group 18 – Ecdysone aganists/moulting disruptors										
azadirachtine (Table 5)	/	/	/	2			■	■	■	■
tebufenozide (Table 5)	/	/	/	7			■	■		
methoxyfenozide	/	/	/	/			■			
Group 11 – Microbial disruptors of insect midgut membranes										
Bt (Table 5)	/	/	/	2			■	■	■	■
Group 3 – Pyrethroids (sodium channel modulator)										
beta-cyfluthrin [16] (II)	/	/	/	7			■	■		
bifentrin [16] (II)	/	/	/	5			■	■		
cypermethrin (II)	75	/	/	15			■	■		
deltamethrin [16, 18] (II)	12.5	/	/	3			■	■		
esfenvalerate (II)	/	/	/	7			■	■		
fenvalerate (II)	/	/	/	7			■	■		
lamba cyhalothrin [16] (II)	12.5	2	7	3			■	■	■	
natural pyrethrum + garlic [16]	/	/	/	2			■	■	■	■
permethrin (II)	/	/	/	3			■	■	■	
pyrethrins (Table 5)	/	/	/	2			■	■	■	■
Group 1 – Organophosphates and carbamates										
carbaryl (II)	/	/	/	7			■	■		
Group 15 - Benzoylureas										
diflubenzuron (tableau 5)	/	/	/	/						
Group 2 – Organochlorins and fiproles										
endosulfan[20] (II)	/	/	/	/						
Group 22 – Voltage-dependent sodium channel blockers										
indoxacarbe	/	/	/	/						
Not classified										
huile de pétrole[16]	/	/	/	2			■	■	■	■
Group 5 – Spynosines										
spinosad (III)	144	3	7	3			■	■	■	■

Growers, Kenya; [17] India; [18] Gambia (growers); [20] Uganda (growers).

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

/ elements of the recommended GAP not available

Fruit flies

Strategy: Timely application is essential. Insecticides should be applied when flies appear or when egg-laying marks are detected and repeated at an interval of five to eight days weekly as indicated by trap collections.

Active substance (WHO toxicity class)	Recommended GAP*				Proposed application period					
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)	Sowing	Nursery	Planting to flowering	Flowering to first harvest	First harvest to peak of harvest	Peak to end of harvests
Group 1 – Organophosphates and carbamates										
acephate (III)	375	3	15	21				■		
dimethoate (II)	/	/	/	14				■		
malathion (III)	/	/	7	7				■		
Group 3 – Pyrethroids (sodium channel modulator)										
bifenthrin (II)	/	/	7	5				■	■	■
deltamethrin [18] (II)	17.5	/	/	3				■	■	■
fenvalerate [20]	/	/	/	/						
Group 2 – Organochlorins and fiproles										
endosulfan (II)	/	/	/	/						

[18] Gambia (growers), [20] Uganda (growers).

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

/ elements of the recommended GAP not available

Leafminers

Strategy: *Liriomyza* leafminers are difficult to control with insecticides due to their feeding habit and their enormous capacity to develop resistance to insecticides. In addition, the use of broad-spectrum pesticides disrupts their control by natural enemies. When spraying is necessary select translaminar or systemic pesticides. Choose selective pesticides to conserve natural enemies. Neem-based pesticides and insect growth regulators are recommended for their control. Rotate pesticides regularly. Use a knapsack sprayer fitted with a fine/medium hollow cone nozzle.

Active substance (WHO toxicity class)	Recommended GAP*				Proposed application period					
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)	Sowing	Nursery	Planting to flowering	Flowering to first harvest	First harvest to peak of harvest	Peak to end of harvests
Group 6 - Avermectins										
abamectin (III)	21.6	2	15	3		■	■	■	■	
Group 18 – Ecdysone aganists/moulting disruptors										
azadirachtin (Table 5)	/	/	/	2		■	■	■	■	■
Group 17										
cyromazine (III)	225	4	7	14		■	■	■		
Group 1 – Organophosphates and carbamates										
oxamyl (Ib)	/	/	/	7						
Not classified										
soap concentrate	/	/	/	2		■	■	■	■	■
Group 5 – Spynosines										
spinosad (III)	144	3	7	3		■	■	■	■	

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

/ elements of the recommended GAP not available

Thrips

Strategy: Thrips are difficult to control with insecticides due to their secretive habits. However, thrips usually emerge from the flowers or under the leaves early in the morning or late afternoon, and at this time they are more exposed to pesticides. Therefore pesticide application should be done at this time of the day. Some thrips species, in particular *Frankliniella occidentalis* rapidly develop resistance to pesticides. Pyrethroids are often ineffective against the western flower thrips. The onion thrips can be controlled with broad-spectrum pyrethroids, but since these do not control eggs and the pupae in the soil, repeated applications are needed to achieve satisfactory control. However, their use should be avoided or minimised due to the adverse effect on natural enemies. Where Tomato Spotted Wilt Virus is prevalent, thrips need to be controlled in the nursery and after transplanting, since this virus may cause significant losses in plants infected at the seedling stage.

Active substance (WHO toxicity class)	Recommended GAP*				Proposed application period					
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)	Sowing	Nursery	Planting to flowering	Flowering to first harvest	First harvest to peak of harvest	Peak to end of harvests
Group 6 - Avermectins										
abamectin (III)	21.6	2	15	3		■	■	■	■	
Group 1 – Organophosphates and carbamates										
acephate (III)	375	3	15	21		■	■			
dimethoate (II)	/	/	/	/		■				
malathion (III)	/	/	/	7		■	■	■		
methomyl (Ia)	/	/	/	3		■	■	■		
oxamyl (Ib)	/	/	/	/		■				
Group 18 – Ecdysone aganists/moulting disruptors										
azadirachtin [16] (Tab. 5)	/	/	/	2		■	■	■		
Group 3 – Pyrethroids (sodium channel modulator)										
acrinathrin (Tab. 5)	70	/	/	3		■	■	■	■	
alpha cypermethrin [16] (II)	30	1	n.a.	7		■	■	■		
bifentrin [16, 19] (II)	/	/	/	5		■	■	■	■	
cyfluthrin (II)	/	/	/	7		■	■	■		
etofenprox (Table 5)	/	/	/	7		■	■	■		
deltamethrin [16] (II)	/	/	/	3		■	■	■	■	
lambda-cyhalothrin [16] (II)	12.5	2	7	3		■	■	■	■	
natural pyrethrum and garlic [16]	/	/	/	2		■	■	■	■	■
Group 2 – Organochlorins and fiproles										
endosulfan [20] (II)	/	/	/	/		■				
fipronil (II)	/	/	/	/		■				
Group 4 – Nicotinic Acetylcholine receptor agonists/antagonists										
imidacloprid (II)	/	/	/	3		■	■	■		
thiacloprid (II)	/	/	/	3		■	■	■		
thiametoxam [16] (III)	100	2	7	3		■	■	■	■	
Not classified										
petroleum oil [16]	/	/	/	2		■	■	■	■	■
Group 5 – Spynosines										
spinosad [19] (III)	96	3	7	3		■	■	■	■	
Group 15 - Benzoylureas										
lufenuron	100	3	7	7		■	■	■		

[16] Kenya (growers); [19] Tanzania (growers); [20] Uganda (growers)

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

/ elements of the recommended GAP not available

n.a. : not applicable

Whiteflies

Strategy: Low populations of whiteflies do not cause heavy direct plant damage and therefore do not justify chemical intervention. However, even small numbers of whiteflies may need to be controlled if there is transmission of viral diseases. Whiteflies rapidly develop resistance to many insecticides, and resurgence of populations is common. When chemical treatment is needed, it is essential to carefully choose a proper product and an appropriate application method. Rotation of group of pesticides is essential to minimise or delay the development of resistance. Systemic pesticides give best results. Some insecticides reduce whitefly populations to a great extent but are not effective in reducing the transmission and spread of viruses. Combinations of mineral oils and some insecticides give rapid control of whitefly adults, suppressing virus transmission. If the pesticides used are effective only against adult whiteflies repeated treatment (rotating pesticides) every 3–5 days would be necessary for several weeks before control can be achieved.

Active substance (WHO toxicity class)	Recommended GAP*				Proposed application period					
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)	Sowing	Nursery	Planting to flowering	Flowering to first harvest	First harvest to peak of harvest	Peak to end of harvests
Group 18 – Ecdysone aganists/moulting disruptors										
azadirachtin (Tab. 5)	/	/	/	2		■	■	■	■	■
Group 3 – Pyrethroids (sodium channel modulator)										
bifenthrin [15, 16] (II)	20 - 40	2	/	14		■	■	■	■	
cypermethrin (II)	/	/	/	15		■	■	■		
deltamethrin (II)	/	/	/	/		■	■			
pyrethrin [16] (Tab. 5)	/	/	/	/		■	■			
Group 16										
buprofezin (Tab. 5)	132	/	/	7		■	■	■		
Not classified										
"Detergent" [16]	/	/	/	/		■	■			
fatty acids	/	/	/	/		■	■			
insecticidal soaps	/	/	/	2		■	■	■	■	■
mineral oil [16]	/	/	/	2		■	■	■	■	■
Group 1 – Organophosphates and carbamates										
diazinon (II)	/	/	/	/		■				
malathion (III)	/	/	/	7		■	■	■		
methomyl [16] (Ia)	450	/	/	3		■	■	■		
Group 4 – Nicotinic Acetylcholine receptor agonists/antagonists										
acetamiprid	25	2	7	7		■	■			
imidacloprid (II)	/	/	/	3	■	■	■	■		
thiacloprid (II)	/	/	/	3		■	■	■		
thiamethoxam 16 (III)	100	2	7	3		■	■	■	■	
thiocyclam hydrogenoxalate [16] (II)	500	3	7	7		■	■	■		
Group 9										
pymetrozine (III)	100 à 450	3	7	3		■	■	■	■	

[16] Kenya (Growers)

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

/ elements of the recommended GAP not available

Broad mites

Strategy: The application of acaricides should begin as soon as the first symptoms appear. Two to three applications will be made at intervals of 5 to 7 days. The development of the pest must be monitored and action taken if necessary up until the peak of the harvest period. Good coverage of the plant, including the underside of the leaves is essential for successful control of mites. Broad mite adults are highly susceptible to most acaricides, but eggs and nymphs are much more difficult to control. At these stages emulsion of petroleum oils could be used.

Active substance (WHO toxicity class)	Recommended GAP*				Proposed application period					
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)	Sowing	Nursery	Planting to flowering	Flowering to first harvest	First harvest to peak of harvest	Peak to end of harvests
Group 6 - Avermectins										
abamectine (III)	21.6	2	15	3	■	■	■	■	■	
Not classified										
garlic [16]	/	/	/	2	■	■	■	■	■	
petroleum oil [16]	/	/	/	2	■	■	■	■	■	
Group UN: mode of action unknown										
dicofol (III)	480	/	14	15	■	■	■	■		
Group 12										
propargite [16] (III)	/	/	/	/	■					
tetradifon [16] (Tab. 5)	/	/	/	/	■					
cyhexatrin	/	/	/	/	■					

Kenya (Growers).

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

/ elements of the recommended GAP not available

Spider mites

Strategy: Spider mites rapidly develop resistance to pesticides, particularly when these are used for several consecutive seasons. When spraying, rotation of acaricides with different active ingredients is essential to avoid or delay development of resistance. Preventive application or application of lower than recommended dosages should be avoided since it may cause development of resistance.

The indiscriminate use of broad-spectrum insecticides eliminates natural enemies, and some insecticides can enhance spider mite reproduction. Their use may lead to mite outbreaks. When chemical intervention is necessary, it is important to avoid using broad-spectrum insecticides. Spot spraying of localised infestations usually controls initial infestation of mites. Good coverage of the plant, including the underside of the leaves, with the spray at small droplet size is essential for successful control of mites.

Active substance (WHO toxicity class)	Recommended GAP*				Proposed application period					
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)	Sowing	Nursery	Planting to flowering	Flowering to first harvest	First harvest to peak of harvest	Peak to end of harvests
Group 6 - Avermectins										
abamectine (III)	21.6	2	15	3		■	■	■	■	
Group 3 – Pyrethroids (sodium channel modulator)										
acrinathrim (Tab. 5)	60	/	/	/		■				
bifenthrin [16] (II)	40 - 80	2	/	5		■	■	■		
fenpropathrin (II)	/	/	/	/		■	■			
Group 19 – Octopaminergic agonists										
amitraze (III)	400	2	14	30		■	■			

Group 12										
cyhexatin (III)	/	/	/	/						
fenbutatin-oxide (Tab. 5)	500	3	14	3						
tetradifon [16] (Tab. 5)	/	/	14	/						
propargite [16] (III)	/	/	/	/						
Group UN: mode of action unknown										
dicofol [18] (III)	480	/	14	15						
Group 21										
fenazaquin (II)	/	/	/	/						
tebufenpyrad (III)	100 à 195	1	n.a.	14						
Group 10										
hexythiazox (Tab. 5)	50	/	/	/						
clofentezine (Tab. 5)	/	/	/	/						
Not classified										
Petroleum oil [16]	/	/	/	2						
Garlic [16]	/	/	/	2						
sulfur [18] (Tab. 5)	/	/	10	5						

Kenya (Growers); [18] Gambia (growers); [20] Uganda (growers).
* The elements of the recommended GAP shown here allow to comply with the harmonised European MRL or the highest national MRL (see part 6 of this guide).
/ elements of the recommended GAP not available

Bacterial soft rot

Strategy: Spray the crop with a copper-based product at the first appearance of symptoms.

Active substance (WHO toxicity class)	Recommended GAP*				Proposed application period					
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)	Sowing	Nursery	Planting to flowering	Flowering to first harvest	First harvest to peak of harvest	Peak to end of harvests
copper hydroxide [19] (III)	/	/	/	3						

[19] Tanzania (growers)
* The elements of the recommended GAP shown here allow to comply with the harmonised European MRL or the highest national MRL (see part 6 of this guide).
/ elements of the recommended GAP not available

Fusarium wilt

Strategy: Treat soil with permitted fumigants before transplanting or with antagonists such as Trichoderma before or at transplanting time.

Active substance (WHO toxicity class)	Recommended GAP*				Proposed application period					
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)	Sowing	Nursery	Planting to flowering	Flowering to first harvest	First harvest to peak of harvest	Peak to end of harvests
dazomet [16]	/	/	/	/						
Trichoderma [16]	/	/	/	/						

[16] Kenya (EAG); [19] Tanzania (growers).
* The elements of the recommended GAP shown here allow to comply with the harmonised European MRL or the highest national MRL (see part 6 of this guide).
/ elements of the recommended GAP not available

Anthrachnose

Strategy: Treat with permitted fungicides on observance of first symptoms. Frequency and interval of application depend on weather conditions (the wetter the weather, the shorter the interval and higher the frequency of application).

Active substance (WHO toxicity class)	Recommended GAP*				Proposed application period					
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)	Sowing	Nursery	Planting to flowering	Flowering to first harvest	First harvest to peak of harvest	Peak to end of harvests
Group 11 : QoI fungicides										
azoxystrobin (Tab. 5)	200	3	7	3		■	■	■	■	
Group 1: MBC fungicides										
benomyl (Tab. 5)	/	/	14	14		■	■	■		
carbendazim (Tab. 5)	/	/	14	14		■	■	■		
thiophanate methyl (Tab. 5)	/	/	14	14		■	■	■		
Group M: Multisite activity										
propineb (Tab. 5)	/	/	14	14		■	■	■		
chlorothalonil (Tab. 5)	1,875	4	7	10		■	■	■		
mancozeb (Tab. 5)	1,600	4	7	3		■	■	■	■	
dithianon (III)	1,875 to 3,750	/	/	14		■	■	■		
metiram (Tab. 5)	/	/	14	14		■	■	■		
Group 3: DMI - fungicides										
triforine (Tab. 5)	/	/	14	14		■	■	■		

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

Powdery mildew

Strategy: Basically based on taking interventions when favourable conditions prevail or on observance of initial disease symptoms. There is no need of fungicide application during wet weather.

Active substance (WHO toxicity class)	Recommended GAP*				Proposed application period					
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)	Sowing	Nursery	Planting to flowering	Flowering to first harvest	First harvest to peak of harvest	Peak to end of harvests
Group 11 : QoI fungicides										
azoxystrobin [16] (Tab. 5)	200	3	7	3		■	■	■	■	
trifloxystrobin	/	/	/	/		■	■			
kresoxim methyl [16] (III)	/	/	/	/		■	■			
Group 8: hydroxy-(2-amino-)pyrimidines										
bupirimate (Tab. 5)	/	/	7	14		■	■	■		
Not classified										
garlic [16]	/	/	/	2		■	■	■	■	■
Group M: Multisite activity										
sulphur [16, 18, 19] (Tab. 5)	3,600	4	10	5		■	■	■		
copper oxychloride (III)	/	/	21	14		■	■	■		
Group 1: MBC fungicides										
thiophanate methyl (Tab. 5)	/	/	7	14		■	■	■		
benomyl (Tab. 5)	/	/	7	14		■	■	■		

Group 3: DMI - fungicides										
triamidefon [16] (III)	/	/	7	14						
triforine (Tab. 5)	/	/	7	14						
mycobutanil	/	/	/	/						
difenoconazole [16, 19]	125	3	8	14						
tebuconazole [16] (II)	/	/	/	/						
bitertanol [16] (Tab. 5)	/	/	10	14						
hexaconazole (Tab. 5)	/	/	7	7						

[16] Kenya Growers; [18] Gambia (growers), [19] Tanzania (growers)
* The elements of the recommended GAP shown here allow to comply with the harmonised European MRL or the highest national MRL (see part 6 of this guide).
/ elements of the recommended GAP not available

Nematodes

Strategy: Treat with nematicides where permitted by local regulations. Application is done at planting.

Active substance (WHO toxicity class)	Recommended GAP*				Proposed application period					
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)	Sowing	Nursery	Planting to flowering	Flowering to first harvest	First harvest to peak of harvest	Peak to end of harvests
Group 18 – Ecdysone aganists/moulting disruptors										
azadirachtine [16] (IV)	/	/	/	2						
Group 1 – Organophosphates and carbamates										
carbofuran (Ib)	/	Once at planting	n.a.	At planting						
ethoprophos (Ia)	/	/	/	/						
oxamyl (Ib)	/	/	/	/						

[16] Kenya Growers
* The elements of the recommended GAP shown here allow to comply with the harmonised European MRL or the highest national MRL (see part 6 of this guide).
/ elements of the recommended GAP not available
n.a. : non applicable

5. Existing registrations in ACP countries

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

For CILSS countries, the registrations issued by the Sahel Pesticides Committee (CSP) apply. The only existing registration for use on melon is that of a commercial product based on lambda-cyhalothrin.

For the Dominican Republic, we currently have no information on existing registrations.

Insecticides registered in Zambia

Zambia does not have an official Pesticide Control board. Any pesticide that is registered in a reputable country is permitted for use in Zambia under that registration.

5.1. Registration of fungicides and nematocides in Kenya

Active substance	Type of registration	Targeted diseases								
		Bacterial diseases	Antrachnose	Damping off	Fusarium wilt	Leaf spots	Phytophthora	Powdery mildew	Viral diseases	Nematodes
Azadiractin	Vegetables									X
Bupirimate	Horticultural crops							X		
Carbofuran	Vegetables									X
Carboxin + thiram	Vegetables			X						
Chlorothalonil	Vegetables		X	X		X	X			
Copper hydroxide	Vegetables	X	X	X		X	X			
Copper oxychloride	Vegetables	X	X	X		X	X	X		
Cuprous oxide	Vegetables	X	X	X		X	X			
Dazomet	Horticultural crops			X	X					X
Difenoconazole			X					X		
Ethoprophos	Vegetables									X
Fosetyl-aluminium	Vegetables						X			
Iprodione	Vegetables			X		X				
Mancozeb	Vegetables		X	X		X	X			
Metalaxyl + Mancozeb	Vegetables		X	X		X	X			
Metiram complex	Vegetables		X	X		X	X			
Propamocarb-hydrochloride	Horticultural crops			X						
Propineb	Vegetables		X	X		X	X			
Propineb + Cymoxanil	Vegetables		X	X		X	X			
Pyrazophos	Vegetables							X		
Quintozene	Horticultural crops			X						
Sulphur	Vegetables							X		
Tebuconazole	Vegetables		X	X		X	X	X		
Thiophanate methyl	Vegetables		X			X		X		
Triadimefon	Vegetables							X		
Triforine	Horticultural crops		X			X	X			

5.2. Registration of insecticides and acaricides in Kenya

Active substance	Type of registration	Targeted pests							
		Aphids	Cutworms	Fruit worms	Fruit flies	Leafminers	Thrips	Whiteflies	Mites
Abamectin	Vegetables					X	X		X
Acephate	Vegetables	X					X	X	
Alpha Cypermethrin	Vegetables	X	X	X			X		
Amitraz	Vegetables							X	X
Aphidius transcapicus	Vegetables	X							
Azadiractin	Vegetables	X	X			X	X	X	
Bacillus thuringiensis var. *kurstaki*	Vegetables			X					
Beta-Cyfluthrin	Vegetables	X	X	X			X		
Bifenthrin	Vegetables	X		X	X		X	X	X
Buprofezin	Vegetables							X	
Carbofuran	Vegetables		X						
Chlorpyrifos	Horticultural crops		X	X					
Cypermethrin	Horticultural crops	X	X	X	X	X	X	X	
Cyromazine	Vegetables					X			
Deltamethrin	Vegetables	X	X	X	X	X	X	X	
Diazinon	Vegetables	X	X			X			X
Dicofol	Vegetables								X
Diglyphus isaea	Vegetables					X			
Dimethoate	Horticultural crops	X	X	X	X	X	X	X	X
Encarsia formosa	Vegetables							X	
Endosulfan	Vegetables	X	X	X	X	X	X	X	
Fenthion	Vegetables	X		X	X				
Fipronil	Vegetables						X		
Imidacloprid	Vegetables	X					X	X	
Lambda-Cyhalothrin	Horticultural crops	X	X	X	X	X	X	X	
Malathion	Horticultural crops	X	X	X	X	X	X	X	X
Methomyl	Vegetables	X					X	X	
Omethoate	Vegetables								
Phytoseilus persimilis	Vegetables								X
Pirimicarb	Vegetables	X							
Propargite	Vegetables								X
Spinosad	Vegetables					x	X		
Tetradifon	Vegetables								X
Thiacloprid	Vegetables including chillies	X					X	X	
Thiametoxam	Vegetables	X				X	X	X	
Thiocyclam	Vegetables	X				X	X		

5.3. Registration of fungicidesand nematocides in Ghana

Active substance	Type of registration	Targeted diseases								
		Bacterial diseases	Antrachnose	Damping off	Fusarium wilt	Leaf spots	Phytophthora	Powdery mildew	Viral diseases	Nematodes
Carbofuran	Vegetables									X
Mancozeb	Vegetables		X	X		X	X			
Maneb	Vegetables		X	X		X	X			

5.4. Registration of insecticides and acaricides in Ghana

Active substance	Type of registration	Targeted pests							
		Aphids	Cutworms	Fruit worms	Fruit flies	Leafminers	Thrips	Whiteflies	Mites
Carbofuran	Vegetables		X						
Chlorpyrifos	Vegetables		X	X					
Cypermethrin	Various crops	X	X	X	X	X	X	X	
Deltamethrin	Various crops	X	X	X	X	X	X	X	
Diazinon	Vegetables	X	X			X			X
Dimethoate	Various crops	X	X	X	X	X	X	X	X
Fenitothrion	Vegetables								
Fipronil	Vegetables						X		
Lambda-Cyhalothrin	Various crops	X	X	X	X	X	X	X	

5.5. Registration of fungicides in Tanzania

Active substance	Type of registration	Targeted diseases								
		Antrachnose	Damping off	Fusarium wilt	Leaf spots	Phytophthora	Powdery mildew	Viral diseases	Nematodes	Nématodes
Captan	Various crops			X						
carbendazim	Vegetables		X							
Carbofuran	Vegetables (non-leafy)									X
Chlorothalonil	Vegetables						X			
Copper hydroxide										
Copper oxychloride	Vegetables									
Dazomet	Vegetables									X
Difenoconazole								X		
Iprodione	Vegetables			X		X				
Kresoxim methyl	Vegetables							X		
Mancozeb	Vegetables		X			X	X			
Metiram complex	Vegetables		X	X		X	X			
Penconazole								X		
Sulphur	Vegetables							X		
Thiphanate	Vegetables					X		X		
Thiphanate methyl	Vegetables					X		X		
Tolyfluanid	Vegetables						X			
Triadimefon	Vegetables							X		

5.6. Registration of insecticides and acaricides in Tanzania

Active substance	Type of registration	Targeted pests							
		Aphids	Cutworms	Fruit worms	Fruit flies	Leafminers	Thrips	Whiteflies	Mites
Acephate	Vegetables	X					X	X	
Acetamiprid	Vegetables	X		X					
Bifenthrin		X		X	X		X	X	X
Carbofuran	Vegetables (non-leafy)		X						
Deltamethrin	Vegetables		X	X					
Diazinon	Vegetables/ varius crops	X				X		X	
Dicofol + tetradifon	Vegetables								X
Dimethoate	Various crops	X							X
Endosulfan	Various crops	X	X	X	X	X	X	X	
fenproparhrin	Vegetables	X						X	X
Gamma cyhalothrin	Vegetables								
Hexythiazox + dichlorvos	Vegetables	X							X
Imidacloprid	Vegetables	X					X	X	
Indoxacarb	Vegetables		X	X					
Lambda-Cyhalothrin	Vegetables	X	X	X	X	X	X	X	
Methamidophos	Vegetables	X	X	X	X	X	X	X	
Methomyl	Vegetables	X	X	X	X	X	X	X	
Oxydemeton methyl	Various crops	X						X	
Phenthoate	Various crops	X	X	X	X		X		X
Phosphamidon	Vegetables	X	X	X	X	X	X	X	X
Profenaphos	Vegetables	X	X	X	X	X	X	X	
Quinalphos	Vegetables	X	X	X	X	X	X	X	X
SAlpha Cypermethrin	Various crops	X	X	X			X		
Spinosad						x	X		
Tau-fluvalinate	Vegetables	X	X	X			X	X	

6. European regulation and pesticide residues

Status of the active substances in Directive 91/414; European and national MRLs in European countries in September 2007

Caution: The information contained in this table is subject to change by future directives of the Commission of the European Communities.

Active substance	European regulations		National MRLs of European countries															
	Status DIR 91/414	European MRL	DE	AT	BE	DK	ES	FI	FR	IT	LU	NL	UK	SE	PT	SI	PL	SK	EE
Abamectin	Notified List 3a	0.05																	
Acephate	Withdrawn	0.02																	
Acetamiprid	Annex 1	0.3																	
Acrinathrin	Notified List 3b	/	0.01				0.2		0.2	0.2		0.05	0.2		0.2				
Alpha-cypermethrin	Annex 1	0.5																	
Amitraz	Withdrawn	0.05																	
Azadirachtin	Notified List 4c	/								0.5						1.0			
Azoxystrobin	Annex 1	2																	
Bacillus thuringiensis	Notified List 4a	/																	
Benomyl	Withdrawn	/	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Beta-cyfluthrin	Annex 1	0.3																	
Bifenthrin	Notified List 3a	0.2																	
Bitertanol	Notified list 3a	/	0.05	0.05	0.05	.	0.05	0.05	0.05	0.05	0.05	0.05		0.05	0.05	0.05	0.05	0.05	0.05
Bupirimate	Notified List 3b	/	0.01	0.01			0.5					0.5							
Buprofezin	Notified List 3a	/	0.02	0.5	0.05		0.5		0.2	0.5	0.05	0.2			0.5		0.5		
Carbaryl	Withdrawn	/	0.05	1	0.05	1	0.05	1	0.05	1	1	3	0.05	1					
Carbendazim	Annex 1,	/	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Carbofuran	Withdrawn	0.02																	
Chlorothalonil	Annex 1	2																	
Chlorpyriphos-ethyl	Annex 1	0.5																	
Chlorpyriphos-methyl	Annex 1	0.5																	
Clofentezine	Notified List 3a	/	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Copper hydroxide	Notified List 3a	/	20 copper							20 copper									
Copper oxichloride	Notified List 3a	/																	
Cyfluthrin	Annex 1	0.3																	
Cyhexatin	Notified List 3b	0.05																	
Cypermethrin	Annex 1	0.5																	
Cyromazine	Notified List 3b	1																	
Dazomet	Notified list 3b	/	0.05	0.05	0.05		0.1			0.02	0.05	0.05							
Deltamethrin	Annex 1	0.2																	
Diazinon	Withdrawn	0.5																	
Dicofol	Notified List 3b	0.02																	
Difenoconazol	Notified List 3b	/	0.05	0.02	0.02		0.02				0.02	0.05							
Diflubenzuron	Notified List 3a	/	0.05	0.05	0.05		0.05				0.05	0.05	1						
Dimethoate	Annex 1	0.02																	
Dithianon	Notified List 3a	/	0.1	0.1	0.05		0.2			0.6	0.05	0.05							
Endosulfan	Withdrawn	1																	
Esfenvalerate	Annex 1	/	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Ethoprophos	Annex 1	/	0.02	0.02	0.02		0.02		0.01	0.02	0.02	0.02							
Ethofenprox	Notified List 3a	/					0.01			2		0.01							
Fatty acids	Notified List 4	/																	
Fenbutatin oxide	Notified List 3b	1																	
Fenazaquin	Notified list 3a	/	0.01		0.01		0.01			0.5	0.01								
Fenitrothion	Withdrawn	0.01	0.01	0.5	0.01	0.5	0.01	0.5	0.01	0.5	0.5	0.5	0.01	0.5					

Active substance	European regulations		National MRLs of European countries															
	Status DIR 91/414	European MRL	DE	AT	BE	DK	ES	FI	FR	IT	LU	NL	UK	SE	PT	SI	PL	SK	EE
Fenpropathrin	Withdrawn	/	0.02	0.02	1		0.5				1	1							
Fenvalerate	Withdrawn	/	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.2	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Fipronil	Annex 1	/			0.02		0.01				0.02	0.01							
Fluvalinate	Notified List 3b	/		0.01	0.05					0.5	0.05	0.05							
Garlic	Notified list 4c	/																	
Heptenophos	Withdrawn	/	0.01	0.01	0.02		0.1	0.1	0.1		0.1	0.02							
Hexythiazox	Notified List 3a	/	0.05	0.1	0.01		0.5		0.2	0.5	0.01	0.1					0.5		
Hexaconazol	Withdrawn	/	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Imidacloprid	Notified List 3a	/	1			0.5	0.5			1		0.5				1			
Indoxacarb	Annex 1	/	0.02	0.02			0.5			0.2									
Insecticidal soap	/	/																	
Kresoxim-methyl	Annex 1	1																	
Lambda-cyhalothrin	Annex 1	0.1																	
Lufenuron	Notified list 3b	/					0.3			0.05		0.05							
Malathion	Withdrawn	3																	
Mancozeb	Annex 1	5 Sweet pepper 0.05 Chilli																	
Methiram	Annex 1	/																	
Methomyl	Notified List 2	0.2																	
Methoxyfenozide	Annex 1	1																	
Mineral oil	Notified list 4h	/																	
Myclobutanil	Notified List 3a	0.5 Sweet pepper 0.3 Chilli																	
Oxamyl	Annex 1	0.02																	
Permethrin	Withdrawn	0.5																	
Petroleum oil	Notified list 4h	/																	
Pirimiphos-methyl	Annex 1	1																	
Propargite	Notified list 3b	0.1 ?	0.01	0.01			0.05			2		0.05							
Propineb	Annex 1	5 Sweet pepper 0.05 Chilli																	
Pymetrozine	Annex 1	1																	
Pyrimicarbe	Annex 1	pending/ongoing	0.5	0.5	0.05	1	0.5		0.3	0.2	0.05	1		0.5					
Pyrethrins	Notified list 4c	1																	
Soap concentrate	/																		
Spinosad	Annex 1	/			1		1			1		1				1			
Sulphur	Notified List 4h	/	50	50	50				50	50		50			50		50	50	50
Tebufenozide	Notified list 3a	/	0.02	0.02	0.2		1				0.01	0.05							
Tebufenpyrad	Notified List 3b	/	0.05	0.05	0.05		0.05			0.5	0.05	0.05							
Tetraconazole	Notified List 3a	/			0.02		0.01			0.2	0.02								
Tetradifon	Withdrawn		0.5	0.05	2	1	1	2			2	2		2					
Thiacloprid	Annex 1	1																	
Thiamethoxam	Annex 1	/					0.3			0.5		0.05			0.5				
Thiocyclam hydrogenoxalate	Withdrawn	/	0.05	0.05			0.05					0.05							
Thiophanate-methyl	Annex 1	0,1																	
Triadimefon	Withdrawn	0.5																	
Trichoderma	Notified list 4a	/																	
Trifloxystrobin	Annex 1	/	0.02	0.02	0.02							0.3							
Triforine	Withdrawn	0.05																	
Zeta-cypermethrin	Annex 1	0.5																	

Boxes in red: real EU harmonized MRLs

Code of EU countries used in the tables are as follow:

DE	AT	BE	DK	ES	FR	FI	IT	LU	NL	UK	SE	SI	PL	PT	EE	SK
Germany	Austria	Belgium	Denmark	Spain	France	Finland	Italy	Luxemburg	The Netherlands	United Kingdom	Sweden	Slovenia	Poland	Portugal	Estonia	Sklovakia

Note on European MRL harmonisation:

The DG Health and Consumer Protection (DG SANCO) has undertaken an MRL harmonisation process on the European level. A list of national MRLs has been gathered by DG SANCO in June 2005 and submitted it to EFSA for approval. EFSA should complete the review before end of 2007. Nevertheless, for the time being (September 2007) only 92 active substances out of 236 have been found fully safe and the decision regarding the remaining ones is pending.

The completion of the procedure is expected by the end of 2007. In the meantime the existing system of national MRLs remains valid.

When no specific MRLs exist for a crop, a default MRL is set at 0,01 mg/kg by the Regulation (EC) n° 396/2005 . However this default limit is not yet entered into force (it twill be applicable 6 months after publication of the last regulation regarding the annexes I,II,III and IV (normally earliest mid 2008).

Annexes : References, websites and useful documents.

Annon. (1996). Chillies . Horticultural Crops Development Authority. Export Crop Bulletin: No 10, June 1996. Excerpted from the KEDS-Supported HCDA Export Crop Manual.

Annon. (no date). Farmer's Bookshelf. An information system of tropical crops in Hawaii. Department of Tropical Plant and Soil Sciences. University of Hawaii at Manoa. http://www.ctahr.hawaii.edu/fb/pepper2/pepper2.htm

Anon. (2003). Bell pepper and non-bell pepper pest management strategic plan. The Ohio State University Columbus, Ohio. September 30, 2003. 53 pp.

Anon. (2004). A pest management strategic plan for pepper production in California. The California Pepper Commission (CPC) and the California Minor Crops Council (CMCC).

Anon. Sweet Pepper. Capsicum spp. http://www.uga.edu/vegetable/pepper.html

Anon. Management of powdery mildew, Leveillula taurica, in greenhouse peppers.Cro Protection Factsheet. British Columbia Ministry of Agriculture, Food and Fisheries.

Anon. IPM Package for Chillies/Capsicum.
http://www.assamagribusiness.nic.in/pdf22/IPM%20Book.pdf.

Anon. (2002). Insect control for commercial vegetables. 2002 North Carolina Agricultural Chemical Manual.
http://ipmwww.ncsu.edulagchem/chptr5/510.pdf

Anon. (2006). Consensus document on the biology of Capsicum annuum complex (chilli peppers, hot peppers and sweet peppers). Environment directorate. Joint Meeting of the Chemicals Committee and the Working Party on Chemicals, Pesticides and Biotechnolgy. ENV/JM/MONO (2006) 2. JT03208120. http://appli1.oecd.org/olis/2006doc.nsf

Berke, T. G., Black, L. L., Green, S. K., Morris, R.A., Talekar, N. S. and Wang, J. F. (1999). Suggested cultural practices for chili pepper. AVRDC pub # 00-483. International Cooperators' Guide.

Berke, T. G., Black, L. L., Morris, R.A., Talekar, N. S. and Wang, J. F. (2003). Suggested cultural practices for sweet pepper. AVRDC pub # 99-497R. International Cooperators' Guide. http://www.avrdc.org/lc/pepper/swtpepper.pdf.

Boerboom, C. M., Bundy, L. G., Bussan, A. J., delahaut, K. A., Kelling, K. A., Mahr, D. L., Michaelis, B. A., Stevenson, W. R., Wedberg, J. L. and Wyman, J. A. (2003). Commercial vegetable production in Wisconsin. A3422 ELAN Extension. Cooperative Extension of the University of Wiscounsin-Extension. htpp://www1.uwex.edu/ces/pubs

Carrol, L. E., White, I. M., Friedberg, A., Norrbom, A. L., Dallwitz, M. J., and Thompson, F. C. Pest fruit flies of the world.

Delahaut, K. A. and Newenhouse. A. C. Growing tomatoes, peppers, and eggplants in Wisconsisn. A guide for fresh-market growers. A3687.
http://s142412519.onlinehome.us/uw/pdfs/a3687.PDF

Dobson, H., Cooper, J., Manyangariwa, W., Karuma, J. and Chiimba, Wilfred. 2002. Integrated vegetable pest management – safe and sustainable protection of small-scale brassicas and tomatoes. Natural Resources Institute, University of Greenwich. 179 pp. (ISBN: 0-85954-536-9)

Heinrich Rogg. (no date). Farmer training handbook on fruit and vegetable propagation and management. Part two. SECAP-Lushoto (GTZ).

Hiil, D. S. (1983). Agricultural Insect pests of the tropics and their control. Second edition. Cambridge University Press. pp 76. ISBN: 0 521 24638 5.

Ike, E. (2004). Crop profile for pepper (sweet) in Ohio.

Kenneth A. Sorenson. (1995). Vegetable Insect Pest Management. Insect note # 39: Pepper Maggot. Department of Entomology, NCSU (North Carolina).

Labuschagne, L. (2004). Company diagnosis on Chillies. Report prepared for Sunripe Ltd, Kenya. Real IPM. 17 pp.

Nono-Womdim, R. An overview of major virus diseases of vegetable crops in Africa and some aspects of their control.

OEPP/EPPO (2004). EPPO Standards. Good plant protection practice. Organisation Européenne et Méditerraneenne pour la Protection des Plantes. Bulletin OEPP/EPPO Bulletin 34, 41-42. PP 2/29(1).

Roberts, C. Production systems used in CARDI hot pepper improvement programme.
http://www.cardi.org/publications/proceedings/hotpepper/4.3html

Seal, D. R., Ciomperlik, M and Lasser, W. (2005). Chilli thrips (castor thrips, Assam thrips, yellow tea thrips, strawberry thrips), Scirtothrips dorsalis Hood, Provisional Management Guidelines. The Entomology and Nematology Department, Florida Cooperative Extension service, Institute of Food and Agricultural Sciences, University of Florida. IFAS Extension. ENY-725. http://edis.ifas.ufl.edu/IN638

Seal, D. R., Ciomperlik, Richard, M. L. and Klassen, W. (2005). Comparative effectiveness of chemical insecticides against the chilli thrips (Scirtothrips dorsalis Hood (Thysanoptera: thripidae) on pepper and their compatibility with natural enemies. http://cta.ufl.edu/docs/Comparative.doc.

Smith, R., Hartz, T, Aguiar J. and Molinar, R. Chile pepper production in California. Vegetable Research and Information Center. Vegetable Production Series. University of California. Division of Agriculture and Natural Resources. Publication 7244.

Sweet pepper Capsicum spp. http//www.uga.edu/vegetable/pepper/html

Wagenbach, J. F., Sorensen, K. A. and Kennedy, G.G. (2006). Insect control for commercial vegetables. Peppers. 2006 North Carolina Agricultural Chemical Manual. http://ipm.ncsu.edu/agchem/5-10.pdf

Wagenbach, J. F., Sorensen, K. A. and Kennedy, G.G. (2002). Insect control for commercial vegetables. Peppers. 2002 North Carolina Agricultural Chemical Manual.