PIP

GUIDE TO GOOD CROP PROTECTION PRACTICES

FOR MANGO (*MANGIFERA INDICA*) IN ORGANIC FARMING

COLEACP is an international network promoting sustainable horticultural trade.

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

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PIP

FOR SUSTAINABLE DEVELOPMENT OF THE ACP HORTICULTURAL INDUSTRY

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Notice

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.

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

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Table of contents

1. Main pests and diseases and importance

1.1 Extent and impact on the quantity and quality of fruit produced

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

- the 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 fruit and consequently end up causing a loss of financial income. The presence of pests and diseases can reduce yield and cause losses at different levels: fewer plants per hectare, less fruits per plant, smaller-sized fruits, lower quality of fruits.

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

INSECTS								
Importance	Organs attacked			Types of loss				
	Leaves	Fruits	Trunk	Number of plants	Number of fruits/plant	Size of fruit	Quality of fruit at maturity	Post-harvest quality of fruit
Fruit Flies *Ceratitis* spp. QO, *Bactrocera* spp. QO, *Anastrepha* spp.								
+++		Larvae do holes on surface and penetrate in the fruit			Fruit fall		Rotting of fruit	Destruction of fruits by importer's country if detected
Mango seed weevil *Sternochetus mangifereae* QO								
+++		Presence of the larva in the seed			Premature fruit drop when the infestation is severe.		Damages the flesh of the ripe fruits.	Destruction of fruits by importer's country if detected
Mealybug *Rastrococcus invadens*								
+++	Presence of sucking larvae mainly on underside	Presence of sucking larvae			Reduced if young plants are weakened when present in large numbers.		Fruits are dirtied by the honeydew secreted or the sooty mould that can develop	

INSECTS *(CONTINUED)*

Importance	Organs attacked			Types of loss				
	Leaves	Fruits	Trunk	Number of plants	Number of fruits/plant	Size of fruit	Quality of fruit at maturity	Post-harvest quality of fruit
Soft & hard scale insects *Icerya seychellarum, Coccus mangiferae, Aulacapsis tubercularis, Pseudoaonidia tribitiformis, Ceroplastes* spp., *Protpulvinaria mangiferae…*								
++	Presence of sucking larvae on underside	Presence of sucking larvae			Reduced if young plants are weakened when present in large numbers. Fruits may fall.		Develop holes or blemish.	
Thrips *Selenothrips rubrocinctus. Scirtothrips aurantii*								
++	Presence of sucking larvae on underside	Presence of sucking larvae on flowers and young fruits			Fruits' development may be stopped when the attack is severe.		Fruits can be slightly distorted	
Whiteflies *Aleurodicus dispersus* QO, *Aleurocanthus woglumi.*								
++	Presence of sucking larvae on underside				Reduced if may cause wilt when population density is high. Leaves become black and can fall.		Honeydew can fall on fruits	

FUNGI

Importance	Organs attacked			Types of loss				
	Leaves	Fruits	Trunks	Number of plants	Number of fruits/plant	Size of fruit	Quality of fruit at maturity	Post-harvest quality of fruit
Anthracnose *Colletoricum gloeosporiodes*								
+++	Presence of the fungus on underside surfaces	Spores germinate on immature fruit but then the fungus remain quiescent until harvest			When infestation spreads during blossoming, yields may drop tremendously		Symptoms appear as epidermal spots sometimes shortly before harvest	Fruits after harvest also develop brown spots.
Powdery mildew *Oïdium mangiferae*								
++	Shoots, flowers and sometimes fruits are affected .They are covered by a white powder			Fruits may fall prematurely				

1.2. Identification and damage

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

INSECTS

Fruit fly – *Ceratitis* spp., *Bactrocera* spp., *Anastrepha* spp.

Females puncture the fruits before ripening to lay their eggs. Larvae develop inside the ripening fruit eating its flesh. The tunnels created by the larvae facilitate secondary infestation by fungi and bacteria. Larval feeding causes premature fruit drops. The fruit also ripens prematurely and is unfit for marketing.

Ceratitis cosyra

Bactrocera invadens

Damage on a fruit

Mango seed weevil – *Sternochetus mangifereae*

Females lay their eggs in fruits in development. The larvae burrow and enter the seed. When it reaches adult stage, it emerges from the seed and damages the flesh of the ripe fruit. When infestation is severe, there is a premature fruit drop. The adult remains dormant most of the year under the bark of the mango tree.

Detail of mango seed weevil's attack

Adult of mango seed weevil

Mealybug – *Rastrococcus invadens*

Feeds on leaves and fruits. Leaves are distorted (rolled or folded), stunted and yellow. Mealybugs puncture the tissues and produce honeydew that facilitates the development of fungi, the sooty mould. Sometimes leaves drop and fruits can be dirtied.

Melybugs on the underleaf

Sooty mould on the upper face of leaves

Soft & hard scale insects - *Icerya seychellarum, Coccus mangiferae, Aulacapsis tubercularis, Pseudoaonidia tribitiformis, Ceroplastes* spp., *Protpulvinaria mangiferae*

At the nursery they feed on young shooting parts, creating distortion in the growth of seedlings. Scale insects damage field orchards by feeding on cell sap and injecting toxic saliva. They can infest leaves and fruits, causing leaves falls, branches death, poor fruit setting and discolouration.

Armoured scales are small, about 3 mm long. They do not produce honeydews but they secrete armour wax in an oyster shell or circular pattern. They remain attached to the host plant when shells are lifted up.

The eggs of Soft Scales are found under the mother scales. Eggs hatch into crawlers (nymphs), which are flattened and looking like dusts on the plant surface. Soft scales secrete honeydews which attract ants. The shells of the soft scales are not left on the plant when lifted up. The soft covering they secrete cannot be separated from the scale's body. Soft scales typically move between branches and leaves during their lifecycle

Scales and ants on a fruit

Scales on the upper face of a leaf

Thrips - *Selenothrips rubrocinctus; Scirtothrips aurantii*

Thrips attack young leaves, creating curling and premature drop of the leaves. S. *Rubrocinctus* is found only in the nurseries. It feeds on the underside of the leaves. Thrips are also found on the field. The sooty mould from thrips feeding gives rise to fruit which is out-of-grade. It causes damage also by ovipositing and feeding on the flowers, which may result in premature loss of pollen.

Thrips on the underleaf

White fly - *Aleurodicus dispersus* and *Aleurocanthus woglumi*

Those leaves sap sucking insects cause wilt when their population pressure is high. The female oviposits on the underside of the leaves. Eggs are layed in a typical spiral shape. Larvae produce honeydew creating a sooty mould.

Adults and larvae

African weaver ants - *Oecophylla longinoda*

This red ant is not a major pest of the mango tree as it creates only small damages (very few spots on the fruits). It is even an important predator of pest of mango trees (like flowers cecidomyiid, *Erosomya mangiferae)*. The problem is that its biting is very painful for the pickers.

Nest of ants

FUNGI

Anthracnose - *Colletotrichum gloeosporioides*

Anthracnose can occur on all parts of the mango tree. Small black spots are formed on the leaves which affect photosynthesis. Infected young fruits may drop and ripen fruits are also affected by dark spots as a result of infection. After harvest, fruits lose their resistance and the disease develops more rapidly especially if not refrigerated.
Infected leaves present dark spots (necrosis). On the fruits, the brown spots will develop after harvest.
Tear-stain is also a typical symptom.

Inflorescence affected

Small black spots on a leaf

Brown spots

Tear-stain

Other post harvest diseases

Black spots appearing after harvesting and caused by *Alternaria* sp.

Young lesions concentrated in the stem-end zone

More advanced spots

Post harvest spots of rot associated with *Cercospora* sp.

Spots of rot slightly concaves and associated with *Stemphylium* sp.

Rot associated with Dothiorella and *Lasiodiplodia* sp.

Stem-end rot

Diffuse spots developing randomly on the surface of a fruit

Stem-end rot developing from an infection of the stem-end at harvesting (left) or from an injury to the skin (right) and caused by *Aspergillus* sp.

Powdery mildew - *Oïdium mangiferae*

The juvenile parts of the plants (inflorescences, leaves) are covered by a white mycelium that causes necrosis. It can lead to defoliation.

Infloresence affected

Symptoms on leaves

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	Fruit flies		Mango seed weevil		Mealybug		Scale insects		Thrips		White flies		Anthracnose		Powdery mildew	
Nursery	6 Months					■	■	■	■	■	■	■	■	■		■	
Blossoming						■		■		■	■	■		■	■	■	■
From fruit-set to enlargement	3 Months	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Harvest		■		■		■		■		■		■		■		■	
Vegetative growth				■		■		■		■		■		■		■	
Fruit after harvest		■		■		■		■						■			

■ Periods during which pest or pathogenic agent is potentially present
■ Periods during which the appearance of a serious infestation can cause the greatest loss

1.4. Importance by country – periods of the year and climate conditions favourable to crop enemies

Key:
GHA = Ghana, BUR = Bukina Faso, DOR = Dominican Republic
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.

Mouches des fruits – *Ceratitis* spp., *Bactrocera* spp., *Anastrepha* spp.

Favourable conditions Warm, humid weather is favourable to their development.

Month	1	2	3	4	5	6	7	8	9	10	11	12
GHA	+	+	++	++	+++	+++	+++	+++	+	+	+	+
BUR	++	+++	+++	+++	+++	++	++	++	+	++	+	++
DOR	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX

Mango seed weevil - *Sternochetus mangiferae*

Favourable conditions Not known.

Month	1	2	3	4	5	6	7	8	9	10	11	12
GHA	+++	+++	+++	+++	+++	++	+	+	+	+	+++	+++
BUR	+	+	+	+	0	0	0	0	+	+	+	+
DOR	X	X	X	X	X	X	X	X	X	X	X	X

Mealybug - *Rastrococcus invadens*

Favourable conditions Generally more prevalent in the dry season.

Month	1	2	3	4	5	6	7	8	9	10	11	12
GHA	++	++	+++	+++	+++	+++	+++	+++	++	++	++	+++
BUR	++	++	+	+	+	+	+	+	+	+	+	++
DOR	0	0	0	0	0	0	0	0	0	0	0	0

Diaspidides et coccides - *Icerya seychellarum, Coccus mangiferae, Aulacapsis tubercularis; Pseudoaonidia tribitiformis, Ceratoplastes* spp., *Protpulvinaria mangiferae*

Favourable conditions Generally more prevalent in the dry and hotseason.

Month	1	2	3	4	5	6	7	8	9	10	11	12
GHA	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
BUR	0	0	+	+	+	+	+	+	+	+	0	0
DOR	X	X	X	X	X	X	X	X	X	X	X	X

Thrips - *Selenothrips rubrocinctus, Scirtothrips aurantii*

Favourable conditions Generally more prevalent in the hot and dry season.

Month	1	2	3	4	5	6	7	8	9	10	11	12
GHA	+++	+++	+++	++	+	+	+	+	+	++	++	++
BUR	++	++	++	+	+	+	+	+	+	++	++	++
DOR	X	X	X	X	X	X	X	X	X	X	X	X

White fly - *Aleurodicus dispersus* and *Aleurocanthus woglumi*

Favourable conditions Generally more prevalent during long dry season. Rainfalls have a negative impact in their development.

Month	1	2	3	4	5	6	7	8	9	10	11	12
GHA	++	++	+++	++	+	+	+	+	+	++	++	++
BUR	++	++	++	+++	++	+	+	+	+	+	+	++
DOR	0	0	0	0	0	0	0	0	0	0	0	0

Anthracnose - *Colletotrichum gloeosporioides*

Favourable conditions Water plays a central role in the contamination process, because the spores are always waterborne. In conditions of high humidity, masses of slimy spores are produced on the surface of pre-existing lesions on leaves and inflorescences, twigs, etc. Repeated precipitation and possibly abundant dew with run-off are needed for the dissemination of spores from these organs to receptive healthy organs (inflorescences, young leaves, and fruit) in the immediate area. After a rainfall, a high hygrometry (≥ 95%) and temperatures between 10 and 30°C (with temperatures at about 25°C being optimal) are very favourable conditions for spore germination and the formation of appressoria (quiescent form).

Month	1	2	3	4	5	6	7	8	9	10	11	12
GHA	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
BUR	++	++	++	++	++	++	++	++	++	++	++	++
DOR	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX

Powdery mildew - *Oidium mangiferae*												
Favourable conditions The disease may be particularly severe when temperatures are mild and the air is moist but not excessively (no rain). High temperatures and heavy rain prevent proper germination of spores. The conidia are carried by the wind. They germinate at temperatures ranging from 9 to 32 °C (optimal temperature 23 °C) and relative mois tures of as little as 20%. These temperature and relative moisture conditions often occur at the beginning of the cycle when new leaves and, moreover, new inflorescences are emerging. In the tropics, the cool areas at higher elevations are more severely affected by the disease than the coastal areas that are hot and humid.												
Month	1	2	3	4	5	6	7	8	9	10	11	12
GHA	+++	+++	+++	+	+	+	+	+	+	++	++	++
BUR	++	++	+	+	+	+	+	+	0	0	0	0
DOR	++	++	++	++	++	++	++	++	++	++	++	++

2. Main control methods

2.1. Introduction

Successful organic production requires an integrated approach to managing pests and diseases. An important part of this approach involves a number of underlying preventative strategies that can contribute to minimising the likelihood and severity of problems. When these measures are ensured adequately, insect pest and disease infestation will hardly reach economic threshold.
A range of preventative measures is important to minimise susceptibility to pest and disease pressures. Some key preventative measures are as follows:

- Location/regional occurrence - Understanding the prevalence, timing and severity of specific pests or diseases for a given location is very important and can have a significant impact on production costs and reliability of production. An organic management plan can be developed to minimise identified risks. Organic mango production in areas prone to wet weather during fruiting is likely to be difficult.

- Surrounding land use – Neglected orchards or poorly managed surrounding properties can be a constant source for new outbreaks of pest or disease.

- Rootstock and variety – Selection of plant material with resistance characteristics should be used wherever possible. Selecting varieties that are well suited to the local growing conditions will ensure healthy growth and resilience to problems.

- Healthy trees – Emphasis on maintaining healthy trees that are naturally able to cope with minor pest or disease problems is important. The foundation for healthy trees stems from healthy soil. This is achieved via biologically active soil with adequate organic matter and nutrient cycling to balance the chemical, biological and physical condition of the soil.

- Canopy management – Pruning to open structure that allows good airflow and adequate internal light without burning fruit can be important to minimise disease risk and assist good fruit coloration.

- Biodiversity – Orchard floor management that involves a mix of plant species and timely mowing to encourage and maintain beneficial predators. Windbreaks and shelterbelts can also be designed to encourage biodiversity.

- Hygienne – Vigilant an thorough orchard hygiene is very important. Removal of infected wood, fruit and other plant tissue can reduce the severity of subsequent problems.

- Rapid decomposition – Infected plant material – as a source of future inoculant – can be reduced by rapid decomposition assisted with mulch from the orchard floor.

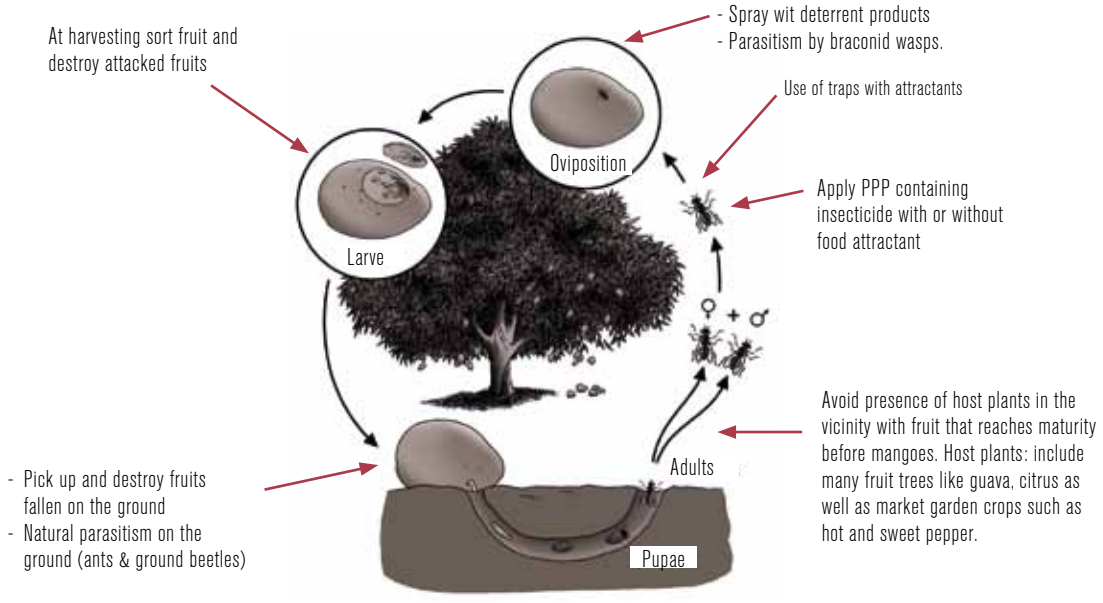
Proper identification, regular monitoring and timely intervention are essential for successful pest and diseases management.

2.2. 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, 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.

FRUIT FLIES – *Ceratitis* spp., *Bactrocera* spp., *Anastrepha* spp.

Position of control methods on the growth cycle of the pest



The female oviposits in clusters under the skin of fruit close to maturity. Larvae emerge from the eggs 2 to 5 days later. After spending some 9 to 15 days in the fruit, maggots (third larval stage), leave the fruit and become pupae in the soil. The adult flies emerge from these pupae.

Position of control methods on the growth cycle of the crop

In the orchard

Sanitation is very important in the control of any fruit fly.

At beginning of fruits set

- Fruits with dimples and oozing clear sap should be removed since it signals that a female has laid eggs. This method is more effective although laborious than picking rotten fruits from the ground as the maggots may have left the fruits to pupate.

- Trapping the flies:
  - ➢ Traps can be used for monitoring and control of fruit flies.
  - ➢ When controlling fruit flies populations with traps the density of traps needs to be high.
  - ➢ Depending on the traps, the local conditions, climate, the density can reach 50 to 100 traps/ha.
  - ➢ There are two main kinds of attractants:
    - Sexual attractants, or parapheromones, which attract only males. Each parapheromone attracts different species of fruit flies.
    - Food attractants, most often protein hydrolysate, which attract both male and female flies.
  - ➢ Traps also contain an organic insecticide solution to kill the flies.
  - ➢ Fly traps with fresh bait should be hung in the trees just above the lower leaves. Baits should be replaced 2 times a week.
  - ➢ Examples of fresh baits: Pieces of ripe bananas with sugar and water or vinegar, with honey and water.
- Fruit flies are attracted to yellow surfaces. Yellow sticky traps can be used to catch fruit flies.

At harvesting

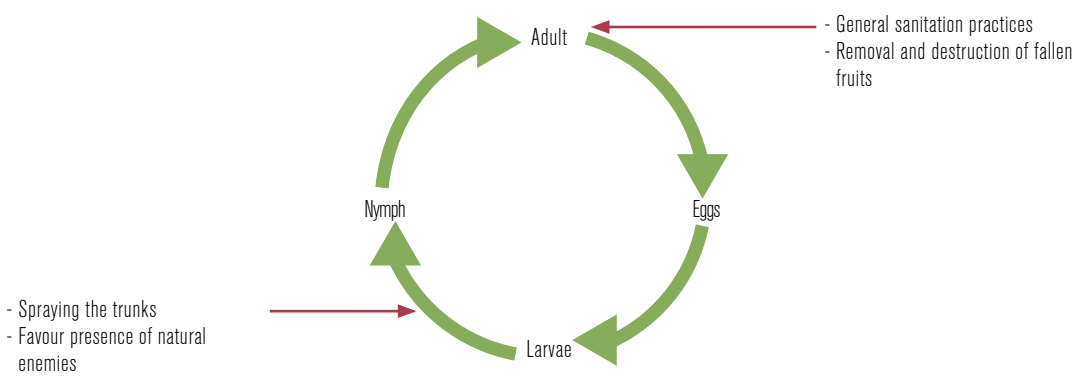
- Harvest fruits early when mature green. This is the stage of maturity when crops are not susceptible to fruit fly attack.
- Avoid movement of fruits from infested areas to un-infested ones.
- Practice crop and field sanitation. All the fallen and damaged ripe fruits should be collected every day and destroyed to eliminate all sources of possible breeding sites. Pick overripe fruits. These are good breeding sites for fruits flies.
- Do not put collected damaged fruits in compost heaps. They should be buried 2 feet below the soil surface that adult flies will not be able to emerge.

Post harvest

- Heat treatment could eventually be done to kill fruit flies at all its stages in the fruit. Fruits should be dipped in hot water (46, 3 °C) for 75 to 90 min depending on their size. This post-harvest treatment might not be economically interesting and must be adapted to the species to control. By heating the quality of the fruit could be also reduced.
- It is essential to identify the fruits that bear traces of punctures. They should then be removed at the time of harvesting or during sorting operations.

MANGO SEED WEEVIL *Sternochetus mangiferae*

Position of control methods on the growth cycle of the pest



Females randomly oviposit on developing mango fruit. The eggs are laid in depressions along the fruit surface. After hatching, the larvae burrow through the pulp of the developing seed. Generally, only a single larva completes development in each fruit. Larval development occurs within the seed and only very rarely in the pulp.

Adults generally emerge from the seed about one or two months after fruit drop.

The flesh of ripe fruit is damaged when adults emerge from the seeds, and weevil-damaged seeds may limit plant propagation in nurseries and orchards. Premature fruit drop may be caused by severe weevil infestations

The adults spend the over season under bark and stone walls, where they remain dormant until the next flowering season. During their period of activities, adults are active only during the night.

Position of control methods on the growth cycle of the crop

In the orchard

At all stages

- Orchards free of seed weevil may be maintained weevil free by preventing the entry into the orchard and surrounding areas of any mango fruit suspected of harbouring weevils within the seeds. A strict policy of not bringing mango fruit onto the property will greatly reduce the chance of infestation. It is also advisable to remove all non-commercial mango trees in the immediate vicinity.

Before flowering

- During their diapause, adults are dormant under the bark of the trunk and very vulnerable. Destroying the adults in bark crevices before the trees come to flowering is a good way to control any outbreak.

At harvesting

- Infested fruits are very difficult to detect as damages are not visible from outside. So it is not possible to select the fruits.
- Field sanitation, i.e., the removal of all fallen fruits and seeds, is very labour-intensive, and demands complete removal and disposal of fallen fruits from affected orchards. This procedure has been only partially effective for pest control.
- Fallen fruits and seeds from affected orchards should be carefully destroyed.

MANGO MEALY BUG *Rastrococcus invadens*

Mealybugs are mainly carried by ants as secondary host. They lay eggs on surfaces of leaves and inflorences, thereby impeding fruit formation and photosynthesis.

Main stages of the cycle are : adults, eggs and nymphs.

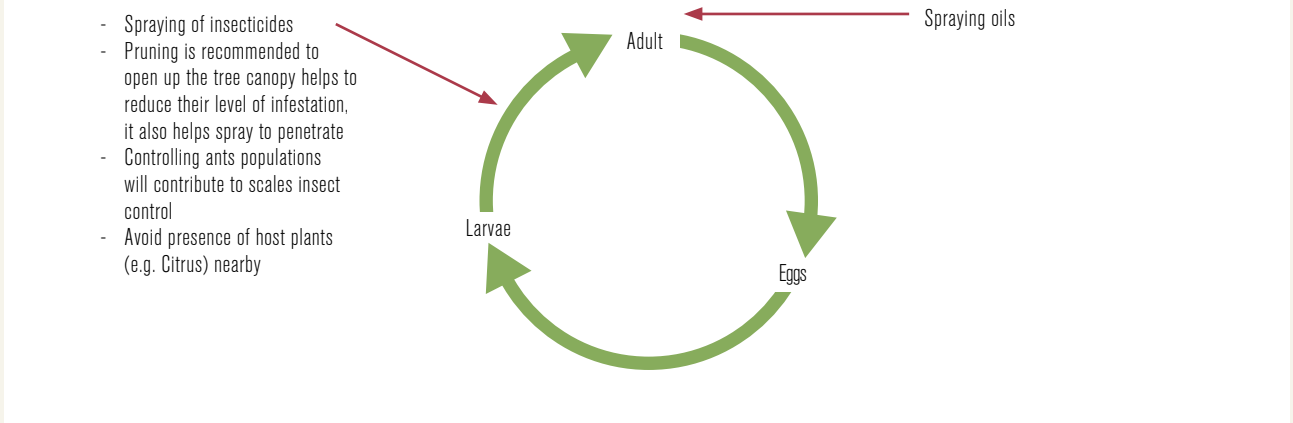
Main control methods in nursery and orchard are as follow:

- When mealybugs are identified on surrounding host plants, it is possible to control them by spraying a steady stream of water (reasonably high pressure) on the host plant to knock-off mealybugs. Once on the ground, the fallen ones will be available to ground predators and this will also make their return to the plant difficult. Wetting mealybugs encourages fungal pathogens that may infest on them.
- Rubbing or handpicking of mealybugs from affected plants contributes to reduce populations. They release chemicals that signal others to drop and leave.
- It is also recommended to prune affected plant parts where mealybugs are located. This will cut down sites and reduce future populations.
- Avoid presence of host plants nearby.
- Disturb activity of ants that attend mealy bugs.

SOFT and HARD SCALES INSECTS

Icerya seychellarum, Coccus mangiferae, Aulacapsis tubercularis;
Pseudoaonidia tribitiformis, Ceratoplastes spp., *Protpulvinaria mangiferae*

Position of control methods on the growth cycle of the pest



The Adult lays eggs which are very difficult to detect, the eggs are observed to be laid under the scale of the adult female. The larvae then claws out in search for feed.

Position of control methods on the growth cycle of the crop

In the orchard

At all stages

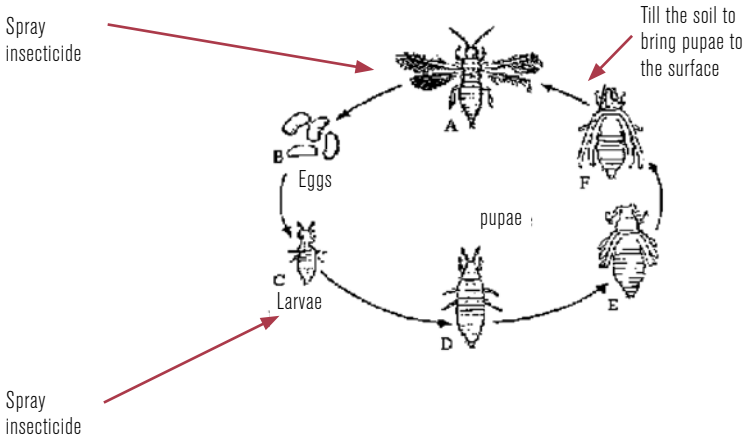
- Avoid presence of host plants (e.g. Citrus) nearby.
- Some scales (i.e. Coccus sp.) are attended by ants. Therefore controlling ants populations of fire ants (Solenopsis spp.) will contribute to scales insect control.

Post harvest

- Post harvest. Pruning is recommended to open up the tree canopy helps to reduce their level of infestation, it also helps spray to penetrate

THRIPS *Selenothrips rubrocinctus, Scirtothrips aurantii*

Position of control methods on the growth cycle of the pest



To control all stages

- Avoid presence of host plants like avocado, citrus, cashew, cocoa, palm and guava trees
- Pruning will allow light penetration
- Thrips move by wind, establishment of windbreaks reduces thrip populations.
- Natural enemies: predatory mites, predatory thrips, pirate bugs, *Entomophthora*.

Eggs are laid by inserting them into tissues on the lower leaf surface and covered with drop of fluid. Nymph emerges in about 12 days, on generation is completed in two weeks.

Position of control methods on the growth cycle of the crop

In the orchard

Before orchard plantation

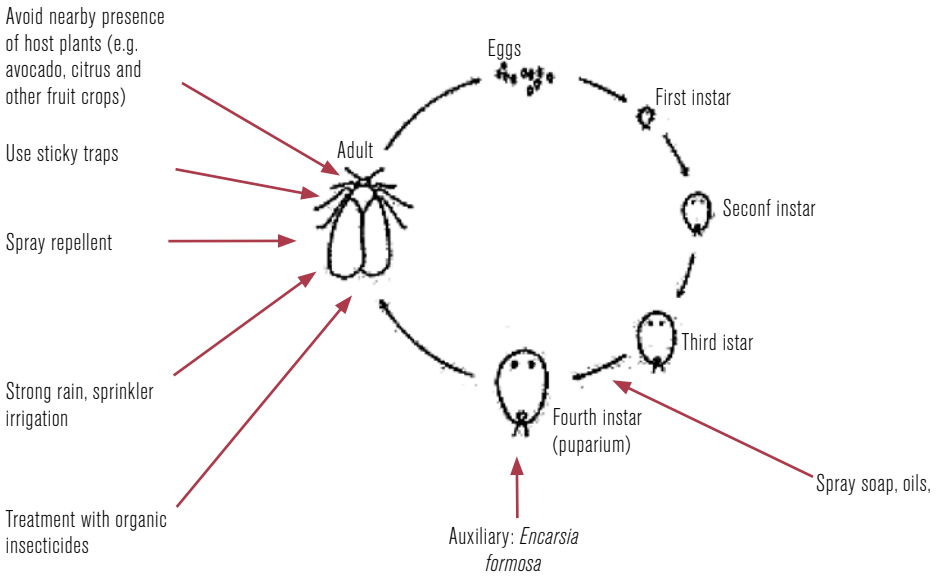
- Thrips move by wind, establishment of windbreaks reduces thrip populations.
- Avoid presence of host plants like avocado, citrus, cashew, cocoa, palm and guava trees

At all stages

- Young and adults are sensitive to light. Pruning will allow light penetration.
- If necessary, spray insecticide not harmful to natural enemies.

WHITE FLIES *Aleurodicus dispersus* and *Aleurocanthus woglumi*

Position of control methods on the growth cycle of the pest



Position of control methods on the growth cycle of the crop

In the orchard

At all stages

- Avoid nearby presence of host plants (e.g. avocado, citrus and other fruit crops)
- Plant Marigold (*Tagetes* spp.) which is used as repellent for spraying
- Spray organic insecticides, soap, oils if heavy infestation
- Associate susceptible crops with crops capable of tolerating whitefly populations as a means of increasing numbers of beneficial insects.
- Yellow sticky traps can collect a large number of whiteflies. The density needs to be evaluated and adapted to the local conditions. They are easily home made. What are needed are yellow plastic and a sticky substance. The plastic should be yellow since it is the yellow colour which attracts the insects. The sticky substance is applied on the yellow plastic. As a sticky substance grease or resin from certain pines. Grease should not melt in the sun and should not be dark, the yellow colour should be seen after covered with grease. The sticky substance should not be edible otherwise animals might lick it off. The plastic is tied on to sticks so that it can be held vertical. The sticks can than be used to support the plastic. When placed vertically, both sides can be smeared with the sticky substance. When used in seedbeds it can be placed horizontally on the surface or wound around small branches placed around the edges of the seedbeds. Any size and shape of plastic can be used. For the vertical traps a typical size is between 0.5 to 1 m tall by 0.7 to 1.5 m wide. This is placed about 0.5 m above the ground. For horizontal traps much smaller pieces could be used. Vertical traps should be placed around the crops. If enough yellow sticky traps are made, these should be placed next to each other so that they catch any insects arriving from neighbouring crops or other plants. The most important place is in the path of prevailing winds to catch any insects before they reach the crop. Also mobile yellow sticky traps are used.

AFRICAN WEAVER ANT

These ants are also natural predators of pest enemies of mango crops. They feed on other insects such as white flies and scale insects. They are also in competition with the ants attending mealybugs.

But on the other hand, African weaver ants are biting workers when harvesting the fruits. Their bite is very painful.

Position of control methods on the growth cycle of the crop

In order to conciliate their benefit and disadvantages, it is possible to control ants' population before harvesting period:

- By mechanical means, they are controlled by carefully moving or relocating the nest of the ants.
- Measure to impede the ants from climbing into the trees:
  - ➢ Clear all undergrowth, prune and cut off parasitic plant and all climbers and epiphytes that connects tree to the ground.
  - ➢ Use appropriate grease.

ANTHRACNOSE (*Colletotrichum gloeosporioides*) and other post-harvest rot

How to protect orchards against agents causing post-harvest rot ?

The protection of mango orchards must be approached comprehensively, from the planting of the orchard up to harvest. Preventive measures and phytosanitary maintenance are valuable for promoting the general health of trees, reducing the duration of conditions of high humidity conducive to infections, and diminishing the quantity of inoculum present during sensitive cultivation stages. Pre-harvest fungicidal treatments must be well thought out, to provide specific protection, only as necessary, in conditions very favourable to infection by certain fungi. Used alone, they rarely guarantee satisfactory sanitation. Careful harvesting limits the risk of injuries and their subsequent contamination, as well as the reactivation of quiescent infections that have taken hold during the development of fruit. Post-harvest treatments inactivate quiescent infections and prevent their development during the marketing process. The following summary table shows the usefulness of various protective measures, sources of inoculum and conditions for fungal infection and development

Summary table of the main fungi associated with post-harvest rot in West Africa: sources and dispersion of the inoculum, conditions of infection and development, and usefulness of protective measures

Champignon	Source of inoculum			Dispersion		Quiescent infection			Development		Usefulness of protective measures			
						external	internal	at harvest	< 24°C	>24°C	in the orchard			post-harvest
	leaves	flowers,branches	debris,soil, fruit	rain	wind	branches	debris,				preventive	PPP control	careful harvesting	warm water
Alternaria	soil, fruit	rain	wind	++	+++	+++	+	+	++	+	+++	+	++	+++
Cercospora	++	?	?	++	++	+++	-	?	?	?	+++	?	++	?
Colletotrichum	++	++	+	+++		+++	-	+	+	+++	+++	+	++	+++
Stemphylium	?	?	+	?	?	+++	-	+ ?	+++	?	+++	?	++	?
Dothiorella	+	+++	+++	+++	+	++	+++	+++	+++	++	+++	-	+++	++
Lasiodiplodia	-	++	+++	+++	?	+	+++	+++	+	+++	+++	-	+++	+
Aspergillus	-	-	+++	-	+++	-	-	+++	++	++	++	-	+++	++
Cladosporium, Penicillium	-	-	+++	-	+++	-	-	+++	++	++	++	-	+++	++
Fusarium	-	-	+++	++	+	-	-	+++	++	++	++	-	+++	?

-: not applicable; + slightly applicable; ++ : somewhat applicable; +++ very important; ? relation unknown.

Preventive measures can considerably reduce the danger of contamination:

- When planting the orchard:
  - ◆ select young plants from nurseries where plants are kept completely disease-free;
  - ◆ plant trees with sufficient spacing to encourage air circulation.

- For upkeep of the orchard:
  - select young plants from nurseries where plants are kept completely disease-free;
  - Plant trees with sufficient spacing to encourage air circulation.
- For upkeep of the orchard:
  - prune excessive branches to increase air circulation in the foliage and avoid overcrowding;
  - limit the height of the mango trees through pruning so that phytosanitary treatments reach all foliage.
- Before flowering:
  - eliminate through pruning all dead or partially necrotised parts, which can later become sources of contamination.
- After flowering:
  - collect regularly and burn necrotised or dead organs scattered on the ground (remains of inflorescences, dry branches, dead leaves, including bedding leaves, etc.);
  - stake up lower branches to keep fruit off the ground;
  - implement measures to limit fruit fly populations;
  - regularly collect fruit that has dropped to the ground, bury it by covering with soil to prevent the dispersion of spores by wind or insects.
- At harvest:
  - handle the mangoes carefully to prevent injuries;
  - keep fruit out of contact with the ground, particularly with sandy, abrasive soils and mud during the rainy season;
  - manage sap flow by positioning the fruit on props that are easy to clean.
- Throughout the year, and more frequently during flowering and setting periods coinciding with the rainy season:
  - perform simple epidemiological monitoring: observe the mango trees' phenological stages, keep climatic records, take note of the appearance of symptoms and evaluate the level of contamination on new shoots, leaves and inflorescences.

How *Colletoricum gloeosporiodes* develops on the crop ?

Spores are produced on **dead branches** and **leaves** and spread by water.

On the surface of **fruit**, the infection cycle includes the germination of a spore followed by the formation of an external appressorium, which will germinate shortly afterwards. The resulting hypha will penetrate the top layers of the cuticle and epidermis without using pre-existing orifices, e.g. the lenticels or an injury. Its penetration will be blocked by the presence of inhibiting substances, i.e. resorcinol, found in immature fruit. The appressoria undergoing germination will remain quiescent until harvest. The symptoms appear as epidermal spots sometimes shortly before harvest, but more often afterwards, during conservation.

The contamination of the surface of fruit through run-off of spore-containing suspensions results in the 'tear-stain' shape.

Position of methods to control anthracnose on the growth cycle of the crop

Nursery

- Areas where there is less than 2 to 4 month of dry season before flowering should only plant non susceptible varieties.
- Before planting, the seedlings should be hardened and come from nurseries free from anthracnose.

In the orchard

- Presence of host plants like citrus, banana, papaya trees, avocado, coffee. avocado, cashew should be avoided nearby.
- Ventilation within the fields is very important to keep anthracnose under control. Therefore, pruning of dead leaves and twigs should be done regularly. It is also very important to balance nutrient especially with nitrogen
- Effective pruning of orchard immediately after harvest, allows sun raise to strike the ground of mango orchards.

Before flowering

- The flowering stage is a very susceptible one. It is thus very important to remove all the parts of the tree attacked by anthracnose (with necrosis).

At beginning of fruits set

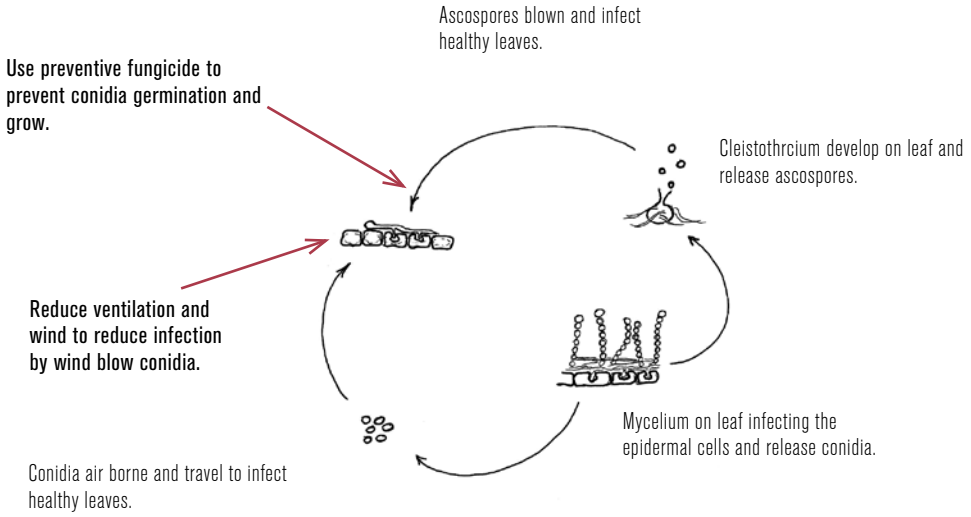
- Mango orchard should be cleaned ensuring that, there are no fallen fruits allowed to rot on the ground.

Post-harvest Control

- Hot water treatment used exclusively in market preparation stations. This technique requires a high level of technical capacity. Fruit must be handled with extreme care both in the field and in the market preparation station, because heat treatment will accentuate the slightest lesion on the epidermis. This is particularly the case for regions with sandy soil. Heat treatment inactivates a large proportion of superficial quiescent infections of Colletotrichum, Alternaria and Dothiorella. Its efficacy can be increased through the addition of sodium hypochlorite or calcium hypochlorite and the application of wax (carnauba wax, guar gum, acrylic resin, polyethylene emulsion, etc.). The latter can delay maturation and consequently the reactivation of quiescent infections. In cases where infection is likely or where the peduncle is already infected, heat treatment is nevertheless insufficient.
  - ➢ Dipping newly harvested fruits in hot water at 50-55°C depending of the variety for 5-10 minutes) minimizes anthracnose and stem-end rot infestations.
  - ➢ The water should have a uniform temperature within the tank to be effective. Temperature must be carefully controlled, in order not to damage the fruits.
  - ➢ This hot water treatment is a very sensitive operation as fruits quality can be reduced if it is not done properly.
  - ➢ After dipping the fruits in hot water, dip them in tap water to about two hours or place them in a well ventilated room to cool down.

POWDERY MILDEW *Oidium mangiferae*

Position of control methods on the growth cycle of the pest



Position of control methods on the growth cycle of the crop

In the orchard

During sensible stage of the plant (see 1.3.)

- Apply protective fungicides where conditions are expected to encourage powdery mildew infections.
- Reduce ventilation and wind to reduce infection by wind blow conidia.

2.3. Cultivar resistance or tolerance

Cultivar	Resistance or tolerance
	Anthracnose
Amélie	
Haden	
Keitt	Moderately resistant
Kent	
Palmer	
Sensation	Moderately resistant
Tommy Atkins	Moderately resistant

2.4. Use of natural enemies

In organic agriculture, one of the most important goals is the achievement of healthy plants by encouraging an ecological balance between pests and beneficial species. Some natural enemies are present in the environment.

2.4.1. FRUIT FLIES

Fruit flies have several predators. Braconic wasps are egg parasites. Ants and ground beetles feed on the maggots present on the ground.

- Description of braconic wasps:
  Adult wasps are tiny, about 2.5 mm in size, slender black or brown with threadlike waists.
  Female wasps lay eggs into the eggs of hosts' pests.

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

2.4.2. MANGO SEED WEEVILS

Adults may be susceptible to predation by ants, rodents, lizards and birds.
Oecophylla smaragdina is a natural enemy of mango weevil.

2.4.3. MEALYBUGS

The introduction of beneficial parasites (*Anagyrus mangicola* and *Geranusodea tebegy*) in West Africa provides excellent biological control of the pest, especially in maritime regions.
In Ghana, the Plant Protection & Regulatory Services Department (PPRSD) used to release biocontrol agents.

The main natural enemy is the coccinelid beetle. Farmers can increase their population by creating a better habitat for them.

- Description of ladybird beetle:
  Eggs are yellow to orange in colour, and are laid on the underside of leaves. Newly hatched larvae are grey or black and less than 4 mm long. Adults are oval to hemispherical and strongly convex with short legs and antennae. Most species are brightly coloured. When disturbed, some of them emit a strong smelling yellow liquid as a protection against other predators. Their colours vary from red, orange, steel blue, yellow-brown, or yellow elytra, frequently spotted or striped with black.
  They feed on pollen, nectar, water, and honeydew but aphids or other prey are necessary for egg production.

- Conservation:
  Lady bird beetles are found in most agricultural and garden habitats. These beetles are attracted by the flowers of the Cruciferae and Compositae family. Planting these flowers around the fields or even within the fields will attract the beetle. Their presence indicates that natural biological control is occurring. It is important to maintain habitats planted with several flowering crops. These give the ladybird beetles varied food sources. When food is not available, they tend to eat each other. Their beneficial predatory behaviour and activities are continuous when there is no indiscriminate use of synthetic pesticides.

3. Crop monitoring and intervention thresholds

Essential measures to prevent diseases are general crop practices.
When a pest has been identified, it is recommended to look first at the corresponding control measures on how to lessen its population density. There are various options like: cultural practices (e.g. removal of weeds); physical control (e.g. handpicking), use of baits, before using plant protection products like plant extract (e.g. neem spray) or other homemade solution (e.g. soap spray). Most of the plant protection products are non selective and have a negative impact on beneficial species as well.
That is why it is important to monitor regularly the pest and diseases in the field in order to prevent any outbreak that would oblige to spray the entire field.

Example of monitoring guideline for mango pest & diseases:

Pest or disease monitored	When ?	Frequency	Where?	How?	Sampling
Fruit flies	2 months after blossoming	Weekly counting	Traps under the shade of the canopy.	Traps (pheromone or food attractant)	Density to be determined based upon local conditions, species…
Mango seed weevil	Before and after harvest		- Inflorescences - Maturing fruits - Fruits	- Visual - Slicing the seed	
Mealybugs	Entire cycle	Monthly	- Leaves - Inflorescences	- Visual	- 10 marked trees per block (1ha)
Soft & hard scale insects		Monthly	Young wigs and leaves	- Pulling the medium-aged leaves	- 10 arbres marqués par bloc (1 ha)
Thrips	- Nursery - Orchard	Weekly	- Inflorescences - Underside of the leaves	- Tapping the tips of branches over a white sheet. - Yellow sticky traps	- 10 marked trees per block (1ha)
Whiteflies			Fruits		- 10 marked trees per block (1ha)
Anthracnose	Pre and post harvest	Weekly	Flowers and fruits		- 10 marked trees per block (1ha)
Powdery Mildew	Before blossoming	Weekly	Inflorescences	Visual	- 10 marked trees per block (1ha)

Threshold levels:

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

The frequency of monitoring should be increased when there are favourable conditions for the development of the pest.
The operator in charge of monitoring on disease or pest should be the same one for each monitoring visit. A monitoring form should be filled in.

Critical periods for pest management are at flower induction, 3 to 4 weeks after flowering and then every 3 weeks.

Effective monitoring should be done in relation with the characteristics of the insects or the disease.

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

For more information on fruit flies trapping, see the guide « How to control fruit fly on mango » coedited by CTA and COLEACP/PIP in 2007 (CTA practical Guides series, N° 14).

4. Active substances and treatment recommendations

We give hereafter a list of the plant protection products allowed for usage by the EU regulation 2092/91 on organic agriculture and that can be recommended on mango. Prior to any usage, the producer should check with his certification body that such usage is allowed.

A distinction is done between the active ingredients from commercial products and the active ingredients from farm-made products. For each type of product we give the recommended GAP that allow conformity with European Regulation on residues. Proposed period of spraying are highlighted in the tables with green color.

Very often, organic farmers in ACP countries use farm-made botanical extracts for which exact concentration in active ingredients is not known. In most of the cases, the active ingredients of plant extracts are degraded very quickly and leave no residue. The PHI is then set at the minimum (2 days) and residues are hardly a problem even when MRLs are set at LOQ.

Our recommendation of usage for the following natural plant protection products are based on producers' experience, organic resources centres and other literature available, but very often it is difficult to get well documented scientific results of trials specific to mango production.

In the case of farm-made products, indications to prepare the farm-made products are given after the tables of products.

Fruit fly – *Ceratitis* spp., *Bactrocera* spp., *Anastrepha* spp.

Strategy: When monitoring indicates that pressure is high, it is recommended to prefer spot treatments to general treatment. Spot treatments are done using food attractants sprayed where there are no fruits.

Commercial products

Active substance	Recommended GAP				Proposed application period						
	Dose g /ha	Number of applications	Interval between applications in days	PHI in days	Nursery	Blossoming	Fruit set to enlargement	Harvest	Growing season	Bud dormancy	Fruit Post-harvest
Azadirachtine	30	/	/	2							
Deltaméthrine	Only for traps using specific lures for *Batrocera* sp. and *Ceratitis* sp..										
Lambda-cyhalothrine	Only for traps using specific lures for *Batrocera* sp. and *Ceratitis* sp..										

Plant extracts or "farm-made" concoctions

Active substance	Recommended GAP				Proposed application period						
	Dose g /ha	Number of applications	Interval between applications in days	PHI in days	Nursery	Blossoming	Fruit set to enlargement	Harvest	Growing season	Bud dormancy	Fruit Post-harvest
Fatty acids of potassium salt	8-10 g/ (600-800 l/ha) l	/	/	/							
Ginger extracts	/	/	/	/							
Garlic extracts	/	/	/	/							
Chili extracts	/	/	/	/							

/ elements of the recommended GAP not available

Mango stone weevil *(Sternochetus mangiferae)*

Strategy: This insect is very difficult to control because of its feeding habitat inside the seeds. Spraying can target the adults in diapause in tree trunk after harvest or can be done just after flowering stages on the flowers.

Commercial products

Active substance	Recommended GAP				Proposed application period						
	Dose g /ha	Number of applications	Interval between applications in days	PHI in days	Nursery	Blossoming	Fruit set to enlargement	Harvest	Growing season	Bud dormancy	Fruit Post-harvest
Azadirachtin	30	/	/	2		■			■	■	

Mineral oil can be used to spray the trunks when adults are in diapause, but previous approval from the certification body is required.
/ elements of the recommended GAP not available

Mealybugs *(Rastrococcus invadens, Ferrisia virgata, ...)*

Strategy: Using organic insecticide should only be considered when biological control has not been efficient. Pruning should be done before any treatment.

TO CONTROL DIRECTLY MEALYBUGS

Commercial products

Active substance	Recommended GAP				Proposed application period						
	Dose g /ha	Number of applications	Interval between applications in days	PHI in days	Nursery	Blossoming	Fruit set to enlargement	Harvest	Growing season	Bud dormancy	Fruit Post-harvest
Azadirachtin	30	/	/	2					■		

Plant extracts or "farm-made" concoctions

Active substance	Recommended GAP				Proposed application period						
	Dose g /ha	Number of applications	Interval between applications in days	PHI in days	Nursery	Blossoming	Fruit set to enlargement	Harvest	Growing season	Bud dormancy	Fruit Post-harvest
Papaya leaves extracts	/	/	/	/	■	■	■	■	■		
Chili Extract	/	/	/	/	■	■	■	■	■		

TO CONTROL ANTS

Plant extracts or "farm-made" concoctions

Active substance	Recommended GAP				Proposed application period						
	Dose g /ha	Number of applications	Interval between applications in days	PHI in days	Nursery	Blossoming	Fruit set to enlargement	Harvest	Growing season	Bud dormancy	Fruit Post-harvest
Extracts of marigold (*Tagetes* spp.)	/	/	/	2	■	■	■				
Citrus oil	/	/	/	2	■	■	■				
Garlic extracts solutions	/	/	/	/	■	■	■				

/ elements of the recommended GAP not available

Soft & hard scale insects

Strategy: Application of white oil in order to smother these insects.

TO CONTROL DIRECTLY SCALES

Commercial products

Active substance	Recommended GAP				Proposed application period						
	Dose g /ha	Number of applications	Interval between applications in days	PHI in days	Nursery	Blossoming	Fruit set to enlargement	Harvest	Growing season	Bud dormancy	Fruit Post-harvest
Azadirachtin	30	/	/	2			■		■		
Horticultural oils *	Solution at 1-2 %	/	42	2			■		■		

Plant extracts or “farm-made” concoctions

Active substance	Recommended GAP				Proposed application period						
	Dose g /ha	Number of applications	Interval between applications in days	PHI in days	Nursery	Blossoming	Fruit set to enlargement	Harvest	Growing season	Bud dormancy	Fruit Post-harvest
Fatty acids of potassium salt	Solution at 1-2 %	/	/	2	■		■	■			

TO CONTROL ANTS

Plant extracts or “farm-made” concoctions

Active substance	Recommended GAP				Proposed application period						
	Dose g /ha	Number of applications	Interval between applications in days	PHI in days	Nursery	Blossoming	Fruit set to enlargement	Harvest	Growing season	Bud dormancy	Fruit Post-harvest
Extracts of marigold (*Tagetes* spp.)	/	/	/	2	■	■	■				
Citrus oil	/	/	/	2	■	■	■				
Garlic extracts solutions	/	/	/	/	■	■	■				

/ elements of the recommended GAP not available

*** Note on horticultural oil sprays:**

They are concentrated and must be mixed with water. Before spraying on a large scale, it is advised to test the concentration on a few trees as young leaves may be very sensitive to horticultural oil sprays. Avoid spraying at flowering and vegetative flush.

Spray 2% solution against insects and mites. Apply successive sprays at least 6 weeks apart. Following the mineral oil spray, use a high pressure water jet treatment to dislodge dead scales from trees. It is important to remove the dead scales remaining on the plant because this will ensure protection against newly hatched scales. To dislodge living scales is to use a forceful jet of water to ‘power wash’ them from barks.

Thrips

Strategy: Treatments target adult and nymph stages.

Commercial products

Active substance	Recommended GAP				Proposed application period						
	Dose g /ha	Number of applications	Interval between applications in days	PHI in days	Nursery	Blossoming	Fruit set to enlargement	Harvest	Growing season	Bud dormancy	Fruit Post-harvest
Pyrethrin	/	/	/	2					■		

Plant extracts or "farm-made" concoctions

Active substance	Recommended GAP				Proposed application period						
	Dose g /ha	Number of applications	Interval between applications in days	PHI in days	Nursery	Blossoming	Fruit set to enlargement	Harvest	Growing season	Bud dormancy	Fruit Post-harvest
Fatty acids of potassium salt	Solution 1-2 %	/	/	2	■	■	■	■	■		
Citronella (*Cymbopogon* sp.) extracts	/	/	/	2	■	■	■	■	■		
Garlic extracts	/	/	/	/	■	■	■		■		

/ elements of the recommended GAP not available

- Plants that have a natural repellent to thrips are citronella, garlic and pyrethrum:
- Pyrethrum, extracted from Chrysanthemum cinerariaefolium is productive mainly above an altitude of 1600m, so only commercial products are available to producers in Burkina Faso, Ghana and Dominican Republic.
- Soap spray will kill thrips. Treatment needs to be repeated twice a week.

Ants (Black ant-*Tetramorium aculeatum,* Red ant-*Oecophylla longinoda,* and *Crematogaster)*

Strategy: If treatment is decided, ants should be controlled only around harvesting time as ants are beneficial to mango crops.

Plant extracts or "farm-made" concoctions

Active substance	Recommended GAP				Proposed application period							
	Dose g /ha	Number of applications	Interval between applications in days	PHI in days	Nursery	Blossoming	Fruit set to enlargement	Harvest	Growing season	Bud dormancy	Fruit Post-harvest	
Extracts of marigold (*Tagetes* spp.)	/	/	/					■	■			
Citrus oil	/	/	/					■	■			

/ elements of the recommended GAP not available

Whitefly

Strategy: Spraying when whitefly pressure is high.

Commercial products

Active substance	Recommended GAP				Proposed application period						
	Dose g /ha	Number of applications	Interval between applications in days	PHI in days	Nursery	Blossoming	Fruit set to enlargement	Harvest	Growing season	Bud dormancy	Fruit Post-harvest
Azadirachtin	30	/	/	2		■	■	■	■		

Plant extracts or "farm-made" concoctions

Active substance	Recommended GAP				Proposed application period						
	Dose g /ha	Number of applications	Interval between applications in days	PHI in days	Nursery	Blossoming	Fruit set to enlargement	Harvest	Growing season	Bud dormancy	Fruit Post-harvest
Fatty acids of potassium salt	Solution at 1-2 %	/	/	2		■	■	■	■		
Garlic extracts	/	/	/	/		■	■		■		
Extracts of marigold (*Tagetes* spp.)	/	/	/	/					■		

/ elements of the recommended GAP not available

- **Soft soap** (ai. Fatty acids of potassium salts) can be used to reduce whiteflies population without any residual effect on the natural enemies. The eggs are resistant to such treatments. Only adults, nymphs and pupa are killed (although efficiency is lower on pupa).

Anthracnose - *Colletotrichum gloeosporioides*

Strategy. The action is mostly preventive as mainly contact fungicides are used.

Commercial products

Active substance	Recommended GAP				Proposed application period						
	Dose g /ha	Number of applications	Interval between applications in days	PHI in days	Nursery	Blossoming	Fruit set to enlargement	Harvest	Growing season	Bud dormancy	Fruit Post-harvest
Azadirachtin	30	/	/	2		■	■				
Copper compounds	5000 (max 6000 g/ha/ year EU 2092/91)*	2	7	2		■	■				
Potassium bicarbonate	/	/	/	/		■	■				

* Applicable to ACP countries as well. Its need has to be recognized by the certification body.
/ elements of the recommended GAP not available

Note : It is reported in Australia that a tea made from Casuarina leaves can help reduce the effects of anthracnose and black spot.

Powdery mildew

Strategy: In areas where the disease is expressed, treatment is aimed at protecting flowers that represent the production potential. This treatment must occur at an early stage before full blossoming as soon as any modification in the colour of the floral clusters is observed.
Contact fungicides are washed off by rain. Applications must be repeated every 8 to 10 days and more frequently in the case of rainfall in excess of 25 mm.

Micronised sulphur continues to be an economical active ingredient and is the basis for preventive.

Commercial products

Active substance	Recommended GAP				Proposed application period						
	Dose g /ha	Number of applications	Interval between applications in days	PHI in days	Nursery	Blossoming	Fruit set to enlargement	Harvest	Growing season	Bud dormancy	Fruit Post-harvest
Sulphur (micronised)	/	/	/	2							
Fatty acids of potassium salts	/	/	/	2							
Horticultural oils	/	/	/	2							

/ elements of the recommended GAP not available

Preparation and direction for use of "farm-made" concoctions:

- **Usage of neem tree (*Azadirachta indica*, family Meliaceae)** extracts for spot spraying treatments. The effective ingredients are present in all parts of the tree but are most highly concentrated in the seeds. The insect controlling substances are primarily azadirachtin A and B. In addition, neem contains a number of other substances such as Salannin and Meliantriol, which have primarily repellent effects, and Nimbin/Nimbidin, which seem to have antiviral effects. Some substances support each other, thus creating synergistic effects.
  Neem seeds should be dried well so that they do not produce the toxic aflatoxins which impair their pest control properties and which are highly toxic to humans. When harvesting neem seeds, care must be taken that the fruit colour is neither greenish-yellow nor brownish-yellow but plain absolute yellow. Greenish yellow fruits are not fully mature and are low in azadirachtin content. For the collection of the fruits, spread a plastic or cloth under the tree. Thus they do not come in contact with the soil and the danger of fungus attack and aflatoxin development is reduced. After collection, the fruit pulp should be removed. The seeds are then dried for one day in the sun, and the following three days in the shade, during which they are regularly stirred. Stored neem kernels should be kept in well aerated containers or jute bags to prevent mould, which would reduce effectiveness and produces the highly toxin aflatoxin.
  Seeds between 3 and 9 months after harvest have the highest quantity of azadirachtin. Germination of neem seeds will decrease about one month after harvest and if exposed to temperatures higher than 45°C.

Characteristics

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

Dosage recommendations:

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

- **Fatty acids of potassium salts**: Active ingredient present in soft soap;
  Take only the soft soap used for washing dishes and not washing powders since these can harm plants. Be careful with soap as it can be phytotoxic when too concentrated. First trial on a few trees is recommended before larger scale treatment.

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

- **Pawpaw Leaves extracts:** 4kg of pawpaw leaves is pounded and soaked in 15 litres of water over night sieve and spray on affected parts.

- **Chili spray:** In a pot, boil 90 g of ripe pods or 100 g of chilli seeds in water for 15-20 minutes. Take the pot from the fire and add 3 litres of water. Cool and strain. Add 30 grams of soft soap. Stir well. Strain.

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

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

- **Wood ash solution (100g/l) for planting material's dipping.**

- **Garlic oil spray**
  Method of preparation: Chop finely 100 g of garlic. Soak the chopped garlic in mineral oil for a day. Add 1/2 litre and 10 ml of soap. Dilute filtrate with 10 litres of water.
  Constantly shake the container or stir the extract while in the process of the application to prevent oil from separating.

5. Existing registrations

The market of ACP organic producers is still very small and young, therefore, organic plant protection products specific to mango are seldom developed. Even when an organic pesticide is registered in the producing country, it is for general use, and as such there are not specific recommendations for mango crops.

Registration of active ingredients was not required for the "farm concoctions" made out of plants extracts because in all the ACP countries we've received information from, there is no legislation for such products. It is not written that it is allowed to use them, they are just not mentioned and accepted as long as they don't leave residues.

Existing registrations in Dominican Republic:

Data not available

Existing registrations in Burkina Faso:

Data not available

Registration of insecticides and fungicides in Ghana

Active substance	Type of registration	Targeted pests and diseases								Registration GAP			
			Seed weevil	Scale insects	Mealybugs	Whiteflies	Thrips	Anthracnose	Powdery mildew	Dose g /ha	Number of applications	Interval between applications	PHI in days
Azadirachtin	Under consideration for papaya, mango & vegetables	X.			X					NA	NA	NA	NA
Copper hydroxide	Cocoa. Under consideration for Mango	.						X		NA	NA	NA	NA
Copper Oxychloride	Cocoa. Under consideration Mango							X		NA	NA	NA	NA
Cuprous oxide	Cocoa, coffee. Under consideration for mango							X		NA	NA	NA	NA
Sulphur (80 WP)	Under consideration Mango								X	NA	NA	NA	NA
Lambdacyhalothrine	Cowpeas & vegetables	X								NA	NA	NA	NA
Deltamethrine	Various	X								NA	NA	NA	NA

In order to be allowed to use a pesticide registered for another crop, there should be an application for extension of usage (from major to minor usage).
NA : non availabl secondaire).

Existing registration of insecticides in other countries

Active substance	Country of registration	Targeted pests and diseases								Registration GAP			
		Fruit flies	Seed weevil	Mealybugs	Scale insects	Whiteflies	Thrips	Anthracnose	Powdery Mildew	Dose g /ha	Number of applications	Interval between applications	PHI in days
Azadirachtin	USA (mango)	X.		X		X		X		NA	NA	NA	NA
Fatty acids of potassium salt	USA (mango)			X	X				X	NA	NA	7	NA
Copper hydroxide	USA (mango)							X		4500	NA	Monthly	0
Copper sulphate	USA (mango)							X		4500	NA	Monthly	0
Horticultural oils	Jamaica, not specific to mango									1,5-3% solution	NA	NA	0
Sulphur	USA (mango)		X	X				X	X	9 000-27 000	NA	NA	0
Pyrethrin	Kenya, US (mango)							X	X	56 (alone), 17 (in combination with Rotenone)	NA	NA	1
Rotenone	USA (mango)	X		X		X	X			14 (in combination with Pyrethrin)	NA	NA	1
Roténone	USA (mango)	X	X			X	X			14 (en combinaison avec pyrèthre)	ND	ND	1

NA : non available

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CROP PRODUCTION PROTOCOLS

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

GUIDES TO GOOD PLANT PROTECTION PRACTICES

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

PIP
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