PIP

GUIDE TO GOOD CROP PROTECTION PRACTICES

FOR AVOCADO (*PERSEA AMERICANA*) IN ORGANIC FARMING IN ACP COUNTRIES

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 Crop Protection Practices (organic fruit or vegetable) details all plant protection practices and recommends primarily the active substances supported by Plant Protection Products (PPP) manufacturers in the framework of EU Directive 91/414, allowed for usage by the EU Regulation 2092/91 on organic production and 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 and their efficacy. 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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DISCLAIMER

Ongoing regulatory reviews and the implementation of stricter standards have led to many changes to authorisations of plant protection products (PPPs) and maximum residue limits (MRLs), both within the European Union (EU) and at international level. This has a direct impact on producers, who often must change their production practices (good agricultural practices, GAP) to comply with the new rules. Any non-compliances can lead to the interception and destruction of produce, causing significant financial losses as well as reputational damage.

Please note that this document has not been updated since 2011, and information it contains regarding the status of PPP authorisations and MRLs may not be up-to-date. This document is currently under revision.

Before applying any PPP, it is advisable to consult the latest regulatory changes. Producers may supply diverse markets that follow different regulations. EU approval of active substances and MRLs can be consulted in the **EU Pesticides database**[1]. For domestic and regional markets, a list of PPPs registered for use is usually provided by the national competent authorities. African, Caribbean and Pacific (ACP) countries generally apply the MRLs set by the **Codex Alimentarius**[2].

Keeping track of PPP authorisations and MRL changes is complex and time-consuming, but is essential to ensure regulatory compliance. COLEACP has responded to requests to provide a PPP information service that keeps members up-to-date with the changes that are most critical for the ACP fruit and vegetable sector. This includes a database (**e-GAP**) for COLEACP members and partners, which lists EU and Codex Alimentarius MRLs for key horticultural crops in ACP countries. It also provides the GAP (dose rate, intervals between treatments, pre-harvest intervals) that ensure compliance with these MRLs. Additional information is also offered – type of pesticide, registration status of active substance in the EU and in ACP countries, classification recommended by the World Health Organization, and resistance group (FRAC code for fungicides; IRAC classification for insecticides. The e-GAP database can be accessed via COLEACP's e-services website: eservices.coleacp.org.

1 https://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/public/?event=homepage&language=EN

2 http://www.fao.org/fao-who-codexalimentarius/codex-texts/dbs/pestres/pesticides/en/

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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: less fruits per plant, fewer plants per hectare, 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 - *Bactrocera invadens* QO and *Ceratitis* spp. QO								
+++		Lay eggs under skin of maturing fruits			Fruits may drop earlier		Fruits rotten	Fruits are destroyed when infected
Ants - *Linepithema humile ; Formica aerata ; Solenopsis xyloni*								
+		Chew tender bark or peel of the fruits					Discolouration brownish skin	Sold on local market instead of export
Thrips - *Scirtothrips perseae*								
+	Feeds on young leaves	Feeding starts at calyx and young fruits up to 2 cm in length					Develops a leathery, brown skin	Sold on local market instead of export
Loopers, Leaf roller - *Sabulodes aegrotata, Amorbia cuneana*								
+	Feed on young succulent leaves	Feed on young developing fruits			Reduced by slowing down plant growth		Misformed fruits	

MITES								
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
Sixspotted Mite, Persea Mite, Avocado Brown Mites (ABM) - *Eotetranychus sexmaculatus, O. perseae, O. punicae*								
Not present in ACP countries								
+	Leaf undersides attacked ABM feeds on upper leave surfaces				When heavy infestations fruits can drop			

NEMATODES						
Importance	Organs attacked	Types of loss				
	Roots	Number of plants	Number of fruits/plant	Size of fruit	Quality of fruit at maturity	Post-harvest quality of fruit
Nematodes - *Rotylenchulus reniformis*						
+	Nematodes enter into the roots after hatching of eggs in the soil		Reduced by slowing tree growth			

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 - *Colletotrichum gloeosporioides*								
+++	Presence of mycelium on leaves	Spores germinate on immature fruit but the fungus can remain quiescent until harvest *			Considerable losses, fruit fall pre-mature but also mature fruits are affected		Symptoms appear as epidermal spots sometimes shortly before harvest	Post harvest decay
* The fungus carried on harvested fruits will invade the flesh through small cracks occurred during post harvest handling								
Dothiorella Fruit rot - *Botryosphaeria* spp.								
++	Ascospores produced on dead leaves	Ascospores produced on fruits. Damaged fruits are affected	Ascospores produced on dead bark, twigs				Lesions on skin when ripening	Post harvest decay. Go together with other diseases (anthracnose e.o)
Scab (fruit & leaf) - *Sphaceloma perseae*								
+	Young leaves (< 1 month) are infected	Fruits are infected until half grown			Fruits drop		Spots on peel	Sold on local market instead of export
Cercospora spot or Black spot - *Pseudocercospora purpurea*								
+	Fungus develop on the leaves	Fruits from ¼ to ¾ size are susceptible	Develop also on twigs and fruit pedicels		On fruit pedicels, lesions develop resulting in fruit drop		Small infections beings as flecks, which become brownish black sunken	
Powdery mildew - *Oidium* spp.								
+	Young flushes are affected				Terminal shoots may be killed weakening the tree			

BACTERIAL DISEASE								
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
Bacterial soft rot - *Erwinia herbicol, Erwinia carotovora*								
These bacteria often are common saprophytic epiphytes on leaves, stems and fruit. Under stressful situations and after wounding they can become pathogenic. They infiltrate the peel during rainy weather, especially if it follows a dry period.								
++	Bacteria can enter in all these organs						Dark portions, metallic sheen. Inside fruit is brown	Harvested fruits can be infected especially when over mature and damaged or in combination with other diseases (anthracnose a.o)

1.2. Identification and damage

This section provides information and illustrations to help with the identification of the pests and diseases identified in 1.1.

INSECTS

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

Bactrocera invadens

Fruit flies are small about 4-8 mm in length including the wings. Populations tend to be greatest during harvest season as they infest cracked avocado. They are generally found hovering around decaying vegetation and overripe fruit. Fermenting materials, such as leftover beer or soft drinks, also are a favourite food of these flies.

Female fruit flies puncture the skin of a healthy fruit, often in an area where some break in the skin already has occurred. Eggs are deposited under the skin of fruit which is just beginning to ripen. Larval development is completed within the fruit (which may become rotten as a result) and the fully-grown larvae then drop into the soil where they form a puparium.

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

Ants - *Linepithema humile : Formica aerata : Solenopsis xyloni*

Ants are primarily a problem in young avocado trees where mealy bugs and other honeydew-producers are occasional pests. Ants protect these food sources from natural enemies, causing phloem-sucking insects to become more abundant. Ants are general predators that attack most any other predator or parasite they encounter, regardless of what host that natural enemy is seeking. Thus ants also increase populations of armoured scales and some other pests that do not excrete honeydew. Ants can do scars on fruits by eating the peel.

Thrips - *Scirtothrips perseae*

Thrips are typically small, slender bodied insects around 0.5-15 mm in length. Although winged, thrips are poor fliers but can be transported long distances by winds and storm fronts. The majority of thrips feed on plant juices. Thrips have unusual mouthparts in that they only have one mandible. This single mandible is used like a needle to puncture plant tissue from which food and liquids are siphoned into the mouth through a straw like structure which is formed from moveable appendages around the mouth.

Thrips attack young leaves, creating curling and premature drop of the leaves. Feeding damage to foliage is observed on upper and lower leaf surfaces and bronze coloured damage initially follows leaf veins. When disturbed they run to leaf edges and move to the leaf's under surface. As the thrips population and feeding damage increases bronzing is observed in random patterns between leaf veins (see picture) Avocado thrips larvae and adults feed on developing fruit while hidden under the calyx. Fruit is susceptible to damage until it exceeds the size of a half dollar. Feeding scars develop from the calyx and as feeding continues scars radiate towards the top of fruit. Fruit scarring can be severe resulting in "alligator skin".

Affected fruits

Scirtothirps persea

Loopers, Leaf roller - *Sabulodes aegrotata, Amorbia cuneana*

Adults loopers are mostly tan to orange on top, with a narrow black band across the middle of the wings. They are white on the underside and have a wingspan of about 1.75 to 2 inches. Mature larvae are 2 to 2.5 inches long and mostly yellow to pale green or pink, with a gold-coloured head. Older larvae have variable dark brown, black, green, or orange lines along their sides. In addition to three pairs of true legs behind the head, avocado looper has two pairs of appendages (prolegs) near its rear on abdominal segments 6 and 10. Larvae travel in a characteristic looping manner, where they extend their body forward, then draw their rear forward to meet their forelegs. This arches their body up into a loop. When disturbed, loopers often drop and hang from leaves on a silken thread.

Amorbia adults are bell-shaped when their wings are folded at rest. Their variably coloured forewings are typically orange to tan with dark markings. The adult (moth) is more or less bell-shaped, and has a wingspan of about 1 inch. The moth is active only at night.
Leaf damage is especially evident on terminal shoots. Young larvae of both species feed and chew only on the leaf surface, leaving a characteristic brown membrane. Young Amorbia larvae often web terminal leaves together and feed within them. Mature caterpillars chew all the way through the leaf, often leaving only the midrib and large veins and can consume an entire leaf in 1 day. Healthy avocado trees tolerate considerable leaf damage without severe effects on growth or yield.

Fruit damage occurs where a larva webs a leaf against the side of a fruit, or where it webs between touching fruit. In such protected sites the larvae feed on the skin of the fruit. Such feeding will scar or misshape the fruit and, if severe enough, the fruit may have to be downgraded or discarded as a cull. White sugary exudates are often seen near the feeding damage, this may attract ants.

Nematodes - *Rotylenchulus reniformis*

Nematodes are microscopic roundworms that live in diverse habitats. Plant parasitic nematodes live in soil and plant tissues and feed on plants by puncturing and sucking the cell contents of the roots. Infested trees appear stunted with very few feeder roots. These symptoms are indicative of root lesion nematode problems but are not diagnostic as they could result from other causes as well. If the trees are not vigorous it may be necessary to dig a test hole to examine the roots and determine whether nematodes are causing the problem.

Nematode females penetrate the root cortex, establish a permanent-feeding site in the root and become immobile. In the soil, roots are discoloured and necrotic (dead) with areas of decay. Above ground symptoms on host plants include dwarfing, shedding of leaves, formation of malformed fruit and seeds, and general symptoms of an impaired root system. Nematodes itself, usually do not have a large effect on the avocado trees. Damaged cells are more susceptible to other diseases like avocado root disease caused by *Phytophtora cinnamomi.*

Mites - Sixspotted Mite, Persea Mite, Avocado Brown Mite

Sixspotted mite (*Eotetranychus sexmaculatus*) feeds only on the lower avocado leaf surface. It causes irregular brown to purplish discolouring, mostly along the midrib and larger veins. Sixspotted mite produces webbing, but not the dense round silk patches formed by Persea mite. Sixspotted mite feeding causes brown to purplish irregularly shaped blotches, in comparison with the round, mostly scattered spots created by Persea mite (*Oligonychus perseae*) Light green or yellow areas on undersides of leaves along the midrib and larger veins. Six-spotted mites are tiny, yellow to pale green. It is a pest of avocados primarily in coastal areas.


Persea mite feeding on the underside of leaves causes discrete circular chlorotic to brown spots on the lower leaf surface. These spots become visible on the upper leaf surface. Persea mite colonies are small and can become very numerous. Each colony can produce dense webbing, which resembles a silvery spot on the underside of the leaf. High Persea mite populations can often be recognized by premature leaf drop and defoliation, numerous brown-spotted, green leaves hanging from trees and on the ground beneath infested trees. Heavily infested canopies can appear lighter coloured overall when viewed from a distance. Defoliation leads to sunburned bark and fruit, aborted or dropped fruit, and severely stressed trees, which later reduces yields.

The Persea Mite is a yellowish mite, barely visible. This mite spreads rapidly as its webbing protects it from the major predacious mites. Persea mites feed and lay eggs beneath their webbing. On severely infested leaves, the mite population can reach 1000 mites/leaf. Its numbers peak with dry hot temperatures and decline rapidly when getting cooler.


Avocado brown mite is a sporadic pest, mostly in coastal growing areas. Severe infestations tend to occur in border row trees along dirt roads, where road dust is detrimental to mite predators. Ash deposited on leaves from wildfires reportedly also causes brown mite outbreaks. Avocado brown mite feeds almost entirely on upper leaf surfaces. It causes no significant damage when population densities are low to moderate (about 10 to 20 adult females per leaf). Damage occurs if Avocado brown mite averages about 50 to 70 adult females per leaf (about 100-200 motile stages, adults and nymphs combined). Bronzing of leaves and partial defoliation is noticed. Avocado Brown Mites are tiny, brown-coloured mites.


FUNGI

Anthracnose - *Colletotrichum gloeosporioides*

Anthracnose can occur on all parts of the avocado 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.

Colletotrichum gleosporioides varies very little between different hosts and is characterized by dark depressed lesions on ripe fruit, often accompanied by pink slimy spore masses. Infections on stems leaves and young inflorescence are manifested as subcircular or angular black lesions which enlarge and coalesce, frequently destroying leaf edges or entire inflorescence. On avocados two type of symptoms occur before harvest. Small lesions near lenticels of immature fruits and large spreading areas from infection through wounds and insect feeding sites.

Black spots on fruits

Infected leaves present dark spots (necrosis)

Dothiorella Fruit Rot - *Botryosphaeria* spp.

Dothiorella fruit rot (also named as *Physalopspora* canker) is usually not obvious while fruit is on the tree. Small, superficial lesions can develop on fruit in the grove, but the disease usually is apparent only on fruit that is very over mature, hanging on dead limbs, or dropped on the ground. Infections usually become active after the fruit is picked and starts to soften. Initially lesions are small, irregular brown to reddish discolorations on the skin. Under the skin, brown streaks running lengthwise in flesh may be observed because decay initially spreads along vascular bundles in the fruit. Small, purplish brown spots may appear on any part of the fruit, most often at the stem end. As fruit ages, the surface lesions gradually enlarge and become sunken and black. Fruit shrivels, and the black surface can become covered with greyish brown fungal mycelium and spores. Decay then spreads throughout the entire fruit, causing the flesh to turn brown and watery with an offensive odour.

Affected avocado fruits

Dothiorella fruit rot is caused by several *Botryosphaeria* and *Fusicoccum* species that not only cause Dothiorella fruit rot, but also stem end rot, canker, or leaf and stem blight.
Infection occurs in the grove, but disease usually is not obvious until after fruit is picked and starts to ripen.

Damage from Dothiorella fruit rot closely resembles that from anthracnose and stem end rot. Fruit damaged by these pathogens should be graded out in the packing house. During its early stages, Dothiorella fruit rot lesions can occur anywhere on the avocado skin, while stem end rot initially occurs only near the narrow end of fruit, where decay begins under the button.

Scab (fruit & leaf) - *Sphaceloma perseae*

Spore of *Sphaceloma perseae* may be formed on infected leaves, twigs and fruits throughout the year under favourable conditions. Wind, rain and insects carry the spore to other plants. Blister-like structures erupt from leaves or fruits lesions as small, white, cream to olive masses of clustered spores. It infects young tissue. Leaves become resistant 1 month after emergence and fruit when they are half grown. The injuries that are caused by scab are often used as entry points by other diseases.

Oval fruit spots, brown to purple-brown and slightly raised with a sandpaper like surface develop on the fruits. Spots may enlarge and coalesce. Large rough, corky areas my form over the surface. Lesions on leaves are less conspicuous because they often are high in the tree canopy. They are initially <3.5 mm in diameter and become necrotic and brown to black. Often they are concentrated along leaf veins. Leaves become stunted, crinkled and distorted. Lesions may coalesce into star like patterns, and shot holes develop in leaves. Raised, corky rough lesions also occur on twigs and pedicals.

Infected leaves

Affected fruits

Close up of fruit

Cercospora spot or black spot - *Pseudocercospora purpurea*

Cercospora has many different names, including *Pseudocercospora* spot, blotch and black spot. *P. purpurea* is slow growing and very difficult to isolate. After penetration the pathogen remains latent for up to 3 months.

Leaves, stems and fruits may be affected. Small angular lesions (1-5 mm) purple to brown appear near the leaf margins. Older leaf spots are surrounded by chlorotic haloes. Signs of the fungus may appear under humid conditions as grey, mycelium in the centre of the lesions. Lesions may coalesce to form large, brown, dead areas on the leaf. Leaves eventually become curled and deformed resulting in defoliation of the tree. On fruits flecks develop which will coalesce. It becomes slightly sunken, brown to black and it will crack. If defoliation occurs, fruit can become chlorotic, shrivel and drop. Twigs and fruit pedicals develop dark brown to black lesions which can result in drop of fruit.

Dead spots on leaf

Affected fruit

Powdery mildew – *Oidium* spp.

The juvenile parts of the plants (inflorescences, leaves) are covered by a white mycelium that causes necrosis. Leaves show a dark, watery discoloration on the surface, along the midribs and may be curled and distorted. On the underside of the leaves, white, powdery mycelium and spores are visible. Eventually purplish, vein like spots appear on the underside of the leaves. Often young succulent flushes are affected and terminal shoots may be killed. It can lead to defoliation.

Symptoms on leaves

BACTERIAL DISEASE

Bacterial soft rot – *Erwinia herbicola; E. carotovora*

Portions of the fruit skin become dark with a metallic sheen and a soft or mushy texture. Internally the fruit is brown, often liquefied and has a putrid odour.

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 most important 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 fly		Ants		Thrips		Looper Leaf roller		Anthracnose		Dothiorella Fruit Rot		Scab		Cercospora spot		Powdery mildew		Bacterial soft rot	
Nursery	6 Months			■		■	■	■	■	■		■		■		■		■	■	■	
Blossoming	3 Months			■		■	■	■	■	■	■	■	■	■		■	■	■	■	■	■
From fruit set to enlargement	10 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:
UGA = Uganda, KEN = Kenya, TOG = Togo, CAM = Cameroon
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.

Fruit Flies – *Ceratitis* spp. and *Bactrocera invadens*

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

Months	1	2	3	4	5	6	7	8	9	10	11	12
UGA	0	0	0	0	0	0	0	0	0	0	0	0
KEN	+	+	+	++	++	++	++	++	++	+	+	+
TOG	0	0	0	0	0	0	0	0	0	0	0	0
CAM	++	++	+++	+++	++	+	+	+	+	+	++	++

Ants - *Formicidae*

Favourable conditions: Those conductive to the development of insects producing honeydew (aphids, scales and mealybugs).

Months	1	2	3	4	5	6	7	8	9	10	11	12
UGA	0	+	+	++	+	+	0	0	0	+	+	+
KEN	0	0	+	+	+	+	0	0	0	+	+	0
TOG	0	0	0	0	0	0	0	0	0	0	0	0
CAM	0	0	0	0	0	0	0	0	0	0	0	0

Thrips - *Scirtothrips perseae*

Favourable conditions: Generally more prevalent in the cool seasons.

Months	1	2	3	4	5	6	7	8	9	10	11	12
UGA	0	0	0	0	0	0	0	0	0	0	0	0
KEN	+	+	+	+	+	0	0	0	0	0	+	+
TOG	+	+	+	0	0	0	0	0	0	0	+	+
CAM	++	++	++	++	+	+	+	+	+	+	+	++

Looper Leafroller - *Sabulodes aegrotata, Amorbia cuneana*

Favourable conditions: Population increases with increasing temperatures.

Months	1	2	3	4	5	6	7	8	9	10	11	12
UGA	++	++	++	+	+	+	+	+	+	++	++	++
KEN	/	/	/	/	/	/	/	/	/	/	/	/
TOG	0	0	0	0	0	0	0	0	0	0	0	0
CAM	0	0	0	0	0	0	0	0	0	0	0	0

Nematodes - *Rotylenchulus reniformis*

Favourable conditions: No information available.

Months	1	2	3	4	5	6	7	8	9	10	11	12
UGA	0	0	0	0	0	0	0	0	0	0	0	0
KEN	/	/	/	/	/	/	/	/	/	/	/	/
TOG	0	0	0	0	0	0	0	0	0	0	0	0
CAM	X	X	X	X	X	X	X	X	X	X	X	X

Anthracnose - *Colletotrichum gloeosporioides*

Favourable conditions: Humid and sub humid tropical zones. 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).

Months	1	2	3	4	5	6	7	8	9	10	11	12
UGA	+	++	++	++	+++	++	++	+	+	+	+	+
KEN	+	++	++	+++	+++	++	++	++	+	+	+	+
TOG	0	0	0	0	0	0	0	0	0	0	0	0
CAM	+++	+++	+++	+++	++	++	++	++	++	++	++	+++

Dothiorella Fruit Rot – *Botryosphaeria* spp.

Favourable conditions: Cooler and from cool to warmer periods. Can survive in cool periods. It likes humid areas.

Months	1	2	3	4	5	6	7	8	9	10	11	12
UGA	0	0	0	0	0	0	0	0	0	0	0	0
KEN	/	/	/	/	/	/	/	/	/	/	/	/
TOG	0	0	0	0	0	0	0	0	0	0	0	0
CAM	0	0	0	0	+	++	++	++	+	+	0	0

Scab – *Sphaceloma persea*

Favourable conditions: Cool moist weather. Most severe when heavy rains or foggy weather keep the humidity above 80% and when avocado tissue is at a susceptible growth stage.

Months	1	2	3	4	5	6	7	8	9	10	11	12
UGA	0	0	0	0	0	0	0	0	0	0	0	0
KEN	X	X	X	X	X	X	X	X	X	X	X	X
TOG	0	0	0	0	0	0	0	0	0	0	0	0
CAM	+	+	+	+	++	++	++	++	++	++	+	+

Cercospora spot - *Pseudocercospora purpurea*

Favourable conditions: Severe disease development when warm, humid, rainy weather occurs when fruit are about a quarter size.

Months	1	2	3	4	5	6	7	8	9	10	11	12
UGA	0	0	0	0	0	0	0	0	0	0	0	0
KEN	+	++	++	+++	++	++	++	+	+	+	+	++
TOG	0	0	0	0	0	0	0	0	0	0	0	0
CAM	0	0	0	0	+	+	+	+	+	0	0	0

Powdery mildew – *Oidium* spp.

Favourable conditions: Damp shaded areas with mild temperatures (23 °C) and drier seasons. Especially nurseries. 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. Spores are disseminated by wind and rain to the young leaves. High temperatures and heavy rain prevent proper germination of spores.

Months	1	2	3	4	5	6	7	8	9	10	11	12
UGA	0	0	0	0	0	0	0	0	0	0	0	0
KEN	/	/	/	/	/	/	/	/	/	/	/	/
TOG	0	0	0	0	0	0	0	0	0	0	0	0
CAM	+	+	+	+	+	+	+	+	+	+	+	+

Bacterial Soft Rot - *Erwinia* spp.

Favourable conditions: Relatively high humidity (wet (sub)tropical climates). Uninjured tissues may become infected when the humidity approaches 100 percent or when free moisture is present. Rains, poorly drained or waterlogged soils, and warm temperatures favour infection in the field, as does high humidity in storage or transit.

Months	1	2	3	4	5	6	7	8	9	10	11	12
UGA	0	0	0	0	0	0	0	0	0	0	0	0
KEN	/	/	/	/	/	/	/	/	/	/	/	/
TOG	0	0	0	0	0	0	0	0	0	0	0	0
CAM	X	X	0	0	0	0	+	++	++	++	+	X

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 preventative strategies that minimise the likelihood of occurrence and when infection occurs, its severity. When these measures are implemented adequately, insect pest and disease infestation will hardly reach economic thresholds.
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. One has to consider location, its (micro)climate and soils. An organic management plan should be developed to identify and minimise risks. Organic avocado 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, and infestation of properly managed fields.
- **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. For example, Duke 7 should be used as a rootstock in the case of *Phytophthora* root rot (which is not given as a problem in West Africa).
- **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 a healthy soil. This is achieved by creating a biologically active soil with adequate organic matter and nutrient cycling (mulch) to balance the chemical, biological and physical condition of the soil.
- **Canopy management** – Cautious pruning to maintain an open structure that allows good airflow and adequate internal light but without burning the fruit is important to minimise disease risk and assist in good fruit coloration.
- **Biodiversity** – Orchard floor management that involves a mix of plant species and mowing at the right time to encourage beneficial predators (which like flowers) while preventing high humidity under the tree. Windbreaks and shelterbelts can also be designed to encourage biodiversity.
- **Hygiene** – Vigilant and 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.

As a result, when the right varieties of avocados are planted in the right location, and taken care of as above, pests and diseases will rarely pose problems.
However, this does not mean that pests and diseases are neglected. Proper identification, regular monitoring and (preparation for) timely intervention are essential for a sustainable production of high quality fruit.

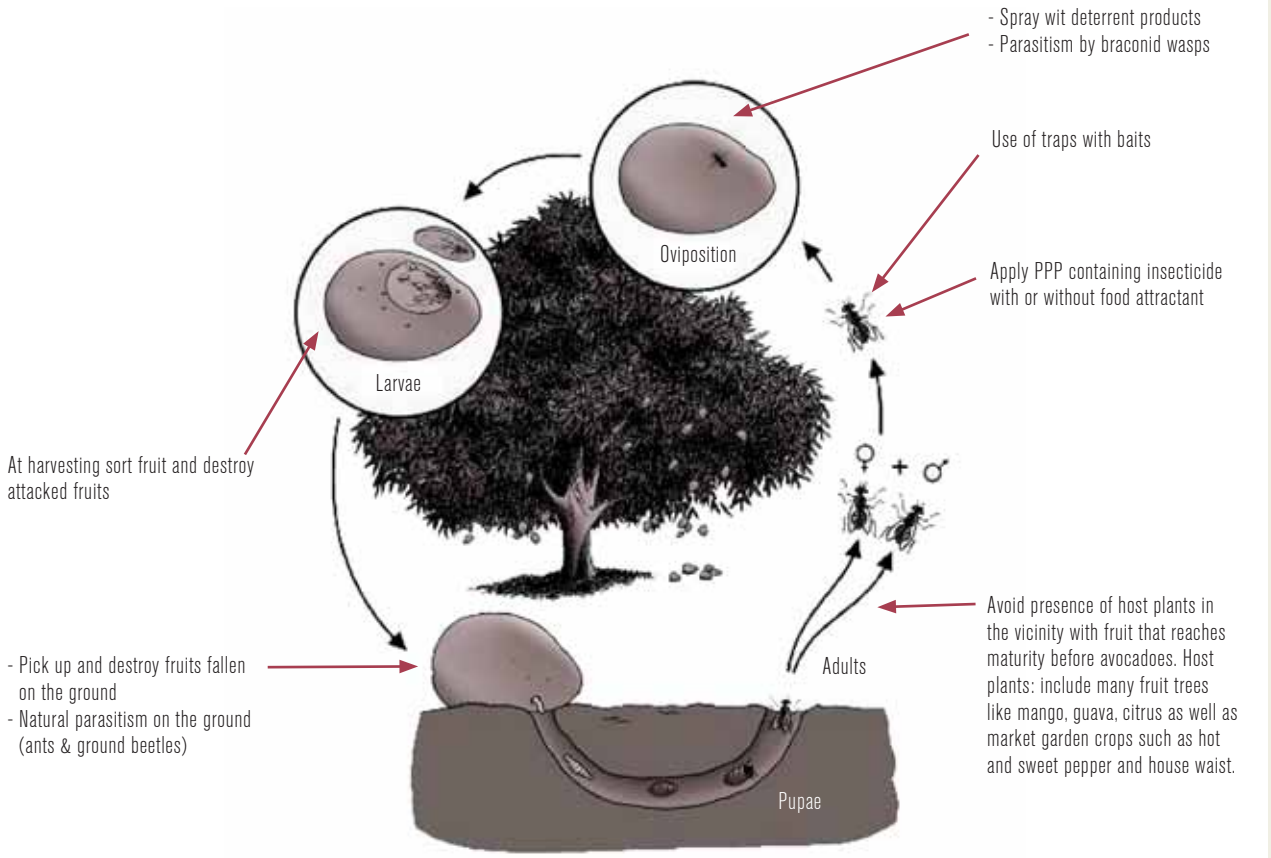
2.2. Pest growth cycle or disease cycle and position of control methods and factors influencing development

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. AND *BACTROCERA* SPP.

Position of control methods on the growth cycle of the pest



The above drawing describes the lifecycle of fruit flies in mango trees which is the same as in avocado trees.

Like all flies, fruit flies develop by complete metamorphosis. The female oviposits in clusters under the skin of fruit close to maturity. Fruit flies need protein during their egg-laying period. 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

At beginning of fruit 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 more laborious, than picking rotten fruits from the ground as by then the maggots may have left the fruits to pupate.

- Collect and remove prematurely fallen or aborted fruits. Burry them at least 1 foot under the soil. Better even with an addition of sufficient lime to kill the larvae.
- Trapping the flies:
  - Electronic ultraviolet light traps are very efficient and functional for an ongoing problem.
  - 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 para-pheromones, which attract only males. Each para-pheromone 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. Yellow dishes filled with soapy water can trap 10-15 fruit flies every two days.
- Special fruit fly traps are constructed in such a way that once flies have entered to take the bait, they can no longer escape.
- Scavenging poultry are an enormous help in fruit fly control.

At harvesting

- Harvest fruits early when mature on a weekly basis. This is the stage of maturity when crops are less 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. Burry these 2 feet below the soil surface that adult flies will not be able to emerge.
- Larvae can be suffocated by soaking the infected fruits in water that is topped with a layer of kerosene for three days.
- Cook infested food and feed it to chickens and pigs.

Post harvest

- 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.

AFRICAN ANTS

Ants are important natural predators of pest enemies in avocado trees and generally benefit the ecosystem, can for example improve soil conditions. Ants are found near honeydew producers like mealy bugs, white flies and scales. They are beneficial predators when existing in controlled numbers. On the other hand, ants are disturbing workers and bite them when pruning the trees or harvesting the fruits. Their bites can be rather painful.

Position of control methods on the growth cycle of the crop

Inspect ants and bark damage of young trees periodically. If honeydew producing insects are a problem, check for ants on all trees. Ants with swollen abdomens indicate that they are honeydew-collecting species. Ants forage when the soil surface temperature is between 20 to 35°C.
The most effective natural enemy of ants are other ants. It is possible to control ants' population in avocado plantations in two approaches.

By attracting predatory birds:

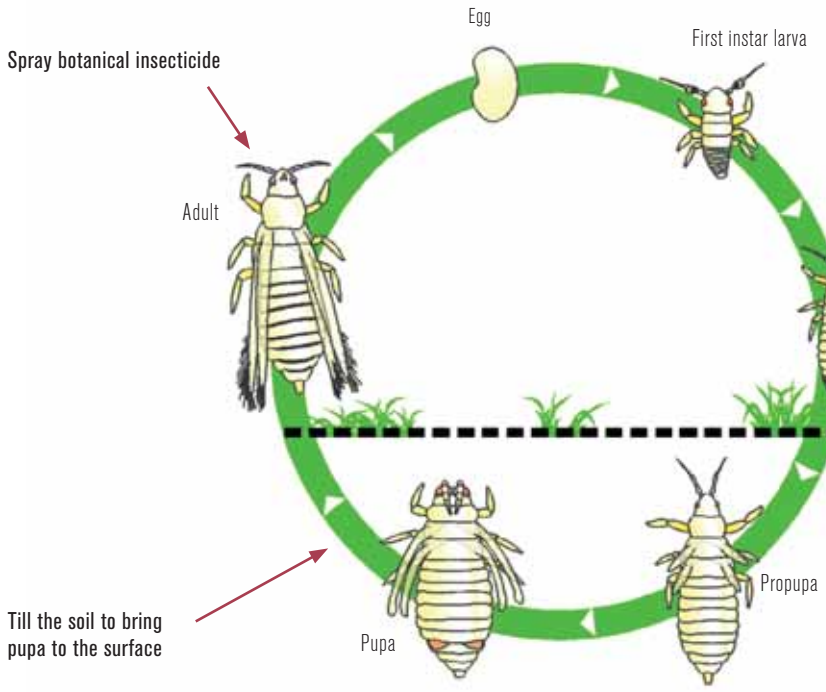
- Birds feed on other pest larvae in production fields like worms, borers etc.
- Cook 1 kg of rice and mix this with turmeric powder so that the rice gets a yellow colour. Put small lumps of rice in the field in various places (8-10) in a way that mice and rates cannot reach it. High poles should be placed in the fields for birds to have a resting place. As soon as larvae are observed this procedure can start and this should continue until the crop has reached the flowering stage. Turmeric rice should be renewed every two to three days.

By managing the ants population:

- Increased biodiversity promotes presence of a variety of ants as they prefer stabilized ecosystems. The ants among themselves will find some balance of populations.
- When the population of bad ants is too high, it helps to cultivate the soil, although one should take care not to damage the roots of the avocado trees.
- Populations of good and bad ants can be controlled by carefully moving or relocating the nests close to or away from the avocado trees.
- It might also help to reduce the opportunities for ants to travel up and down into the trees. All climbers and epiphytes that connect the tree to the ground should be removed. Prune low hanging branches to about 2ft above the ground so that ants have to use the trunk.
- A band of sticky material can be fixed around the base of the trunk to mechanically block ants, or use an appropriate grease.
- When ants encounter a fence or wall they are likely to travel the course of the fence rather than up and over the fence to forage on the other side. Physical barriers such as ant fences running parallel to the field periphery are partially successful in keeping ants out of the field.

THRIPS - *SCIRTOTHRIPS PERSEAE*

Position of control methods on the growth cycle of the pest



To control all stages

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

Female *Scirtothrips* lay eggs singly in an incision made into soft plant tissue with the ovipositor. Eggs are kidney shaped and whitish-yellow in colour. Following egg hatch, developing thrips pass through two actively feeding immature stages called larvae. All thrips species have more than one pupal stage. The first *Scirtothrips* pupal stage is the pro-pupa and the second is the pupa. Thrips do not feed as pupae and many drop into the soil and leaf litter below host plants to pupate. 89% of pupating thrips are found in the uppermost noncomposted layers of leaves. Following pupation adult thrips move back onto the host plant to commence feeding and reproduction. A full lifecycle takes about 16 days to be completed.

Position of control methods on the growth cycle of the crop

In the orchard

Before orchard plantation

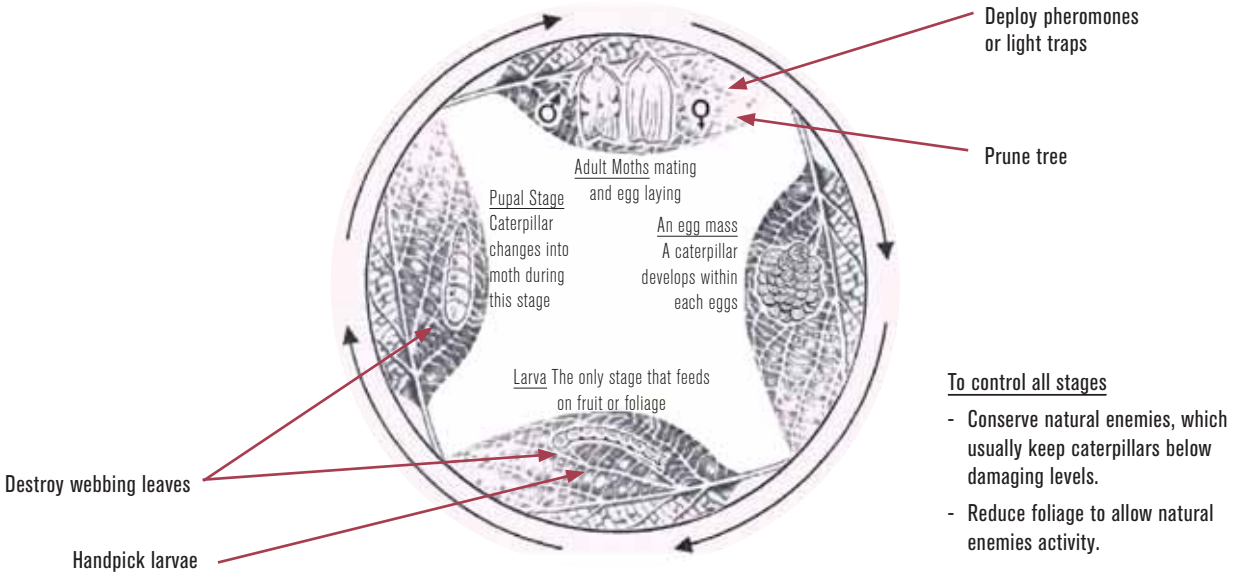
- Thrips move by wind, establishment of windbreaks reduces thrips populations.
- Avoid presence of host plants like mango, citrus, cashew, cocoa, palm and guava trees.

At all stages

- Young and adults are sensitive to light. Pruning will allow light penetration.
- Plants that have a natural repellent to thrips are citronella, garlic and pyrethrum. Plant these near avocado trees.
- Avocado thrips damage is affected by practices that increase or decrease the abundance of succulent foliage during set and growth of young fruit. Modifying manuring (amount, application method, formulation, and timing) and pruning (the extent and time of branch removal) alters the extent to which trees continue to produce tender foliage.
- If absolutely necessary, spot spray repellent or biological insecticide but be wary about its impact on the thrips' natural enemies.

OMNIVOROUS LOOPER, LEAF ROLLER - *SABULODES AEGROTATA, AMORBIA CUNEANA*

Position of control methods on the growth cycle of the pest



Female moths live 2 to 3 weeks, laying eggs in clusters of 3 to 80 on the underside of leaves for the looper and 150 to 200 eggs for the Amorbia. These light green, oval-shaped eggs occur mostly on the upper side of leaves close to the midrib. Eggs hatch about 8 or 9 days after oviposition, leaving transparent shells.

Looper larvae feed about 6 weeks, then pupate within rolled or webbed leaves. Pupae are 1 to 1.25 inches long and white when first formed. The case darkens as a moth with brownish wings develops and can be seen through the pupal case. Pupation lasts 1 to 4 weeks.

Amorbia larvae develop through five instars Amorbia pupate for 2 to 3 weeks in rolled leaves. The 0.5 to 0.75 inch long pupae initially are pale green, gradually turn tan, and become brown when mature.

Egg to adult development time is about 1.5 months at an average temperature of 25°C.

Position of control methods on the growth cycle of the crop

In the orchard

At all stages:

- Prune to avoid canopy bridges that facilitate insect movement between trees, and to minimize dead twig and plant debris accumulation in canopies. Thin or selectively harvest fruit in clusters to reduce protected sites.
- Remove abandoned citrus to reduce the likelihood that Amorbia will move from citrus to nearby avocado. Control weeds near avocado that host the caterpillars.
- Reduce dust in groves by driving slowly and oiling or watering dirt roads. Dusty conditions reduce the effectiveness of parasites and predators that attack caterpillars.
- Destroy leaf rollers by picking them out of the tree and squashing them in place or feed them to the chickens.
- Light traps will give good knowledge on the seriousness of the pests
- Deploy pheromone-baited sticky traps for adults to identify the species in groves and indicate peaks in flights of egg-laying adults. Each trap is baited with a separate pheromone to attract adult male Amorbia or the Omnivorous looper.

NEMATODE - RENIFORM NEMATODE

The Reniform nematode reproduces sexually but can also reproduce parthenogenetically. Around 40-60 eggs per mass are laid in a gelatinous substance and hatch in 8-10 days.
Juveniles undergo 3 stages in the soil without feeding.

All juvenile stages and males are found in the soil.

Young females are the infective stage and only females are parasitic. Soon after the final stage the young female adult, the infective stage, penetrates host roots. On penetration, only the anterior part of the body becomes embedded within root tissue. Feeding occurs on cortical tissue, phloem and pericycle. About one week after penetration the reproductive system matures and the posterior region of the body swells to form the typical reniform (kidney) shape, and the reproductive system matures.

Position of control methods on the growth cycle of the crop

In the orchard

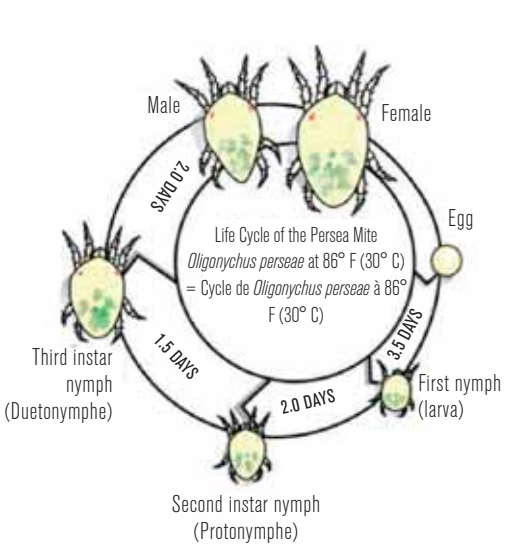
At all stages:

- Keep land free of nematodes by preventing their introduction and spread:
  - Use of nematode-free planting material.
  - Eliminating nematodes from seed beds and potting soil.

- Cultural and physical field and soil methods by the use of:
  - Rotation of crops.
  - Fallows.
  - Soil solarization controls the Reniform nematode for 60 days after planting; it improves plant growth and increased yields by 25 to 40 percent in in various types of soils.
  - Post harvest destruction/removal of infected crop residues.
  - Amending soil by adding organic matter not only improves the soil water holding capacity and nutrients, its increased organic content in soils can reduce nematode pest damage by increasing the activity of soil microorganisms antagonistic to nematodes, and by production of decomposition products which can be nematicidal.
  - Different cover crops reduce the presence of the Reniform nematode; *Crotalaria juncea* (Sunhemp), *Lolium multiflorum, Triticum aestivum, Indigofera spicata, Sinapis alba* (yellow mustard), *Tagetes erecta* (Marigold) and *Glycine javanica*.
  - Application of sawdust and chicken manure improves crop nutrition and has a side benefit of controlling root knot nematodes.

MITES

Position of control methods on the growth cycle of the pest



Persea mite (*Oligonychuis perseae*) has five developmental stages (egg, larva, protonymph, deutonymph, and adult). All life stages are predominantly found in nests where feeding, mating, reproduction, and development occurs. Sex ratio is generally two females to one male. Cool winter temperatures slow Persea mite population growth.

Position of control methods on the growth cycle of the crop

In the orchard

At all stages

- Maintain good biological control by conserving natural enemies.
- Natural enemies and temperature (hot or cold weather) usually maintain this mite at innocuous levels. Naturally occurring populations of the spider mite destroyer (*Stethorus picipes*) provide the majority of Avocado brown mite biocontrol. Predaceous mites (especially *Euseius hibisci* and *Galendromus* spp.) are also helpful, but predatory mites are primarily effective against Sixspotted (*Eotetranychus sexmaculatus*) and Persea mites (*O. perseae*). Most other natural enemies listed as attacking Persea mite also feed on Avocado brown mite.
- Avoid applying broad-spectrum insecticides as this decreases the presence of natural enemies. When treating any pest, including mites, spot treat where possible.
- Controlling dust, which improves predator activity, is critical for maintaining biological control when this mite is a problem. Planting hedges along roads reduced dust drift onto trees. Make car and truck drivers drive slowly. Use a water truck or trailer to wet dirt roads to prevent airborne dust.
- Spraying the underside of leaves with a forceful stream of water r washing can reduce mite populations on small trees. Adding insecticidal soap will be more effective.
- To minimize initial infection, avoid drought and other stress. Appropriate irrigation frequency and amounts, good management of avocado root rot and other key pathogens, and harvesting fruit early will reduce the adverse impact of mite feeding.
- Good sanitation practices (i.e., elimination of favoured weed species) and removal of alternate host plants (i.e., ornamental plants and non-commercial fruit trees in orchards) that act as mite reservoirs are useful cultural control practices.

ANTHRACNOSE (*COLLETOTRICHUM GLOEOSPORIOIDES*) AND OTHER FUNGAL DISEASES

Spores are produced on dead branches and leaves, and are spread by water. This fungus is considered to be a "weak" pathogen of avocado; i.e., its damage is enhanced by wounds created by wind, insects, and other pathogens that assist penetration and subsequent disease development. Scab and *Pseudocercospora* spot (blotch) lesions are common entry sites for the anthracnose fungus. Since all varieties of avocado are susceptible, good anthracnose control depends on adequate control of other diseases and avoidance of cuts and bruises to the fruit in handling. Fruits showing any sign of anthracnose should not be packed in cartons with healthy fruit. Harvesting fruits in an immature condition may substantially contribute to anthracnose appearance at the market place, because the fungus may be carried on the immature fruit and will subsequently invade the flesh through small cracks made during post-harvest handling procedures.

Position of control methods on the growth cycle of the crop

Nursery

- Before planting, the seedlings should be hardened and come from nurseries free from anthracnose.

In the orchard

When planting the orchard

- Plant trees with sufficient spacing to encourage air circulation.
- Nearby presence of host plants like citrus, banana, papaya trees, coffee, mango, cashew should be avoided.

For upkeep of the orchard

- If many dead leaves are entwined in the canopy, remove them from the tree. Limit the height of the avocado trees through pruning so that phytosanitary treatments reach all foliage.
- Prune low limbs to at least 2 feet (60 cm) off the ground to reduce humidity within canopies by improving air circulation.
- Ventilation within the fields is very important to keep anthracnose under control. Prune out on a regular basis dead limbs and twigs where fungi sporulate.
- It is also very important to balance nutrients especially nitrogen, apply composted manures.
- Effective pruning of orchard immediately after harvest, allows sun rays to strike the ground of avocado orchards.
- Clean orchards and collect and destroy affected fruits.

Before flowering

- The flowering stage is very susceptible. It is thus very important that by the time of flowering, all the parts of the tree that have been attacked by anthracnose before (necrosis) are removed.
- Eliminate through pruning all dead or partially necrotised parts, which can later become sources of contamination.
- Dispose of dead wood and old fruit away from avocado trees before bloom.

At beginning of fruit set

- 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 and other insect 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 and post-harvest

- Keep fruit out of contact with the ground, particularly with sandy, abrasive soils and mud during the rainy season.

- Fruits should be handled carefully during and after harvest. Very small injuries caused to the epidermis of the fruit during harvesting, market preparation and transport can favour the reactivation of quiescent infections or direct infection by spores present on the fruit during the rainy season.
- At grading, attention should be paid to remove the infected avocado.
- Keep fruit dry and cool can aid in minimizing losses from post-harvest decays until sold. Post harvest temperature is especially critical to anthracnose development. Cool fruit to 5°C as soon as possible after harvest. Delays of longer than 6 hours before cooling and higher pulp (air) temperatures during these delays will result in increased post harvest fruit decay. Cooling fruit promptly is of increasing importance as the season progresses because fruit ripens faster as it increases in maturity. Avoid storage temperatures below 5°C because chilling injury may occur.

Throughout the year, and more frequently during flowering and during the rainy season

- Perform simple epidemiological monitoring: observe the avocado 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.
- Prune and harvest only during dry conditions and minimize fruit contamination and injury.
- Copper treatment will prevent the infection by the fungus.

DISEASES THAT EASILY RESULT IN ANTHRACNOSE

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

The protection of avocado 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.

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 and bacteria associated with post-harvest rot in West and East Africa: sources and dispersion of the inoculum, conditions of infection and development, and usefulness of protective measures

Fungus	Source of inoculum			Dispersion			Quiescent infection			Development		Usefulness of protective measures			
	leaves	flowers, branches	debris, soil, fruit	insectes	rain	wind	external	internal	at harvest	< 24°C	>24°C	in the orchard			post-harvest
												preventive	PPP control	careful harvesting	warm water
Colletotrichum	++	++	+++	+	+++		+++	+	++	+	+++	+++	+	++	+++
Dothiorella	+	++	+++	-	-	+++	++	+++	+++	+++	+	+++	-	+++	++
Scab	++	++	?	++	++	++	+++	+	++	+++	+	+++	+	++	?
Cercospora	++	++	?	++	++	++	+++	+++	++	?	++	+++	+	++	?
Powdery Mildew	++	-	+	-	++	++	++	+	+	+++	+	++	+	+	+
Bacterial Soft Rot	+	+	+++	+	+	-	++	+++	+++	+++	+++	+++	+	+++	?

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

BACTERIAL SOFT ROT – *ERWINIA HERBICOLA, E. CAROTOVORA*

Soft-rot bacteria overwinters in infected fleshy tissues in storages, in the fields and in the soil, and on contaminated tools, equipment, containers, and in certain insects. The bacteria enter primarily through wounds made during planting, cultivating, harvesting, grading, and packing and through injuries from insect, hail, growth cracks, and sunscald. They may also follow other disease-producing organisms.

It occurs in the field, but most often is a post harvest problem meaning care should be taken during harvest, pedicels should be left attached to the fruit.

The bacteria chiefly attack succulent, tender tissues of organs such as fruits, as well as bud, stem, petiole and leafstalk tissues. The causal organisms are common in most soils, particularly those frequently cropped with susceptible plants. Soft-rot bacteria are a constant threat because of their extensive host range and widespread distribution.

Position of control methods on the growth cycle of the crop

In the orchard

At all stages

- Remove infected plant debris from the field and remove plant residues after harvest.
- Prune excessive branches to increase air circulation in the foliage and avoid overcrowding.
- Orchard should be on well drained soils.
- Control nematodes and other insect pests.
- Severely diseased trees must be removed from the orchard and destroyed.

When planting the orchard

- Proper land preparation and orchard management might limit the infection.
- Plant only disease free plants.
- Do not plant in poorly drained, unfertile soils.
- Avoid close planting.

For upkeep of the orchard

- Avoid overhead irrigation and over-watering.
- Use mature compost, avoid too much nitrogen.
- Prune low limbs to at least 2 feet (60 cm) off the ground to reduce humidity within canopies by improving air circulation.
- Avoid wounding plants when cultivating, digging, handling during and after harvest, packing, and storing.

Before flowering

- Eliminate through pruning all dead parts, which can later become sources of contamination.
- Dispose of dead wood and old fruit from avocado trees before bloom.

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 insect populations like fruit fly.

At harvest

- Harvest during dry weather.
- Keep fruit out of contact with the ground, particularly with sandy, abrasive soils and mud during the rainy season.
- During hot weather, coordinate digging, sacking, packing, and trucking so that fruits do not lie on the soil surface exposed to the sun for more than 15 minutes.

Post-harvest Control

- Handle fruits with care.
- Store only dry, healthy, mature, blemish-free produce, and storage these in a clean, dry, well-ventilated area.
- If diseased material has been stored previously, first sweep the area very well.
- Place fruits in cool (5ºC) storage as soon as possible after harvest

2.3 Cultivar susceptibility to diseases

The following table shows which varieties are known to be susceptible to the listed disease.

Cultivar	Rate of susceptibility to:	
	Anthracnose	Scab
Fuerte		
Hass		
Jumbo		
Booth 7 & 8		
Reed		
Pinkerton		
Hickson		
Peterson		
Lula		

- Variety is moderately susceptible to the disease.
- The variety is very susceptible to the disease.
- No information known.

Late maturing cultivars appear to be more susceptible to *Cercospora* spot due to the longer period during which they can be infected.

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. Plenty of natural enemies are present in the environment and their presence should be encouraged by providing conducive habitat (flowers, humidity).

2.4.1. Fruit flies

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

- **Description of braconid wasps**

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

- **Conservation**

Adult 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. Thrips

Thrips are eaten by many generalist predators which are found in avocado orchards. The naturally occurring predaceous thrips, *Franklinothrips orizabensis*, is an important biological control agent that responds in large numbers to the presence of avocado thrips populations.

Franklinothrips vespiformis has been observed in high numbers in avocado orchards with heavy infestations of avocado thrips. The larval stage of this predator is easily identified by the red band on the abdomen. The adult thrips is black in colour, has a thin waist and legs which have white bands and is an ant mimic.

Lacewing larvae are voracious thrips predators that are commonly found in avocado orchards. Lacewing adults are not predatory and sustain themselves by feeding on honeydew or nectar.

Other general predators, such as six spotted thrips, predatory mites and parasitic wasps, and ladybird beetles also feed on avocado thrips. Adults may be susceptible to predation by ants, rodents, lizards and birds.

2.4.3. Looper and leaf roller

Birds, predaceous insects, and spiders commonly prey on caterpillars. Predators include assassin bugs, damsel bugs, lacewings, and pirate bugs. A naturally occurring nuclear polyhedrosis virus often kills Amorbia caterpillars when populations become high. The caterpillar pathogen *Bacillus thuringiensis* is commercially available as a selective insecticide.
Parasites, especially flies (family *Tachinidae*) are the most important natural enemies that usually keep Amorbia populations below economically damaging levels. Tachinids attacking Amorbia resemble a common house fly, but have more prominent stout hairs. A tachinid fly and several parasitic wasps attack the larvae stages. The tachinid fly attaches its eggs near the head of the larva and the emerging maggots bore into the Amorbia larva to develop inside.
At least 8 wasps species parasitize Amorbia, some wasps lay one to several eggs in each caterpillar egg. Black Amorbia eggs are probably parasitized by *Trichogramma*. One of the most effective egg parasites is the tiny wasp, *Trichogramma platneri*.

2.4.4. Mites

Naturally occurring populations of the spider mite destroyer (*Stethorus picipes*) provide the majority of brown mite biocontrol. Predaceous mites (especially *Euseius hibisci* and *Galendromus helveolus*) are also helpful, but predatory mites are primarily effective against Sixspotted mite. Most other natural enemies listed as attacking Persea mite also feed on Avocado brown mite.

Numerous predators feed on Persea mite. Predaceous mites include *Amblyseius* (=*Neoseiulus*) *californicus, Euseius hibisci, Galendromus annectens*, and *G. helveolus*. Black hunter thrips (*Leptothrips mali*), sixspotted thrips (*Scolothrips sexmaculatus*), brown lacewings (Hemerobius spp.) and green lacewings (*Chrysopa* and *Chrysoperla* spp.), dustywings (family *Coniopterygidae*), a predatory midge (*Feltiella* sp., *Cecidomyiidae*), a rove beetle (*Oligota oviformis, Staphylinidae*), and the spider mite destroyer lady beetle (*Stethorus picipes*) are other common predators. Most predators are not highly effective because of Persea mites' protective webbed nests but they do reduce Persea mite populations, and the same predators often provide good biological control of Avocado brown mite and Sixspotted mite.

Ladybird beetle, green lacewings and predatory mites are natural enemies of mites.
Ladybird beetle lays yellow to orange in colour eggs 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 biggest enemy is the use of broad spectrum insecticides, whether synthetic of botanical.

3. Crop monitoring and intervention thresholds

Usually, when sufficient measures are employed, pest and disease outbreaks are avoided. Even when a pest has been identified, it is recommended to look first at control measures to lessen its population density. One can look at cultural practices (e.g. removal of weeds); physical control (e.g. handpicking), use of baits, before taking recourse to plant protection products, be they commercial or home made. Any commercial grower should be prepared to intervene and does so based on observations, or monitoring of the crop.

The following is a monitoring guideline for avocado:

Pest or disease monitored	When ?	Frequency	Where?	How?	Sampling
Fruit flies	1 month before fruit maturation to end harvest	Weekly counting	Traps under the shade of the canopy	Traps (pheromone or food attractant)	- 4 traps per ha
Thrips	Fruit set until fruits exceed 0.75 inch in diameter	Weekly (7 – 10 days)	- Inflorescences - Underside of young leaves - Avoid taking hard dark green leaves	- Tapping branches over a white sheet - Count thrips on the leaves - Yellow sticky traps - Traps with bait	- 10 marked trees per ha
Loopers and Leaf rollers	When moths or affected leaves are found	Every 2 days Every 7-10 days	- Within or near orchard - Concentrate on those places showing leaf chewing	- Place light trap in dark - Place a cloth underneath foliage and shake different sections to collect about 25 shake samples	- Identify species of moths - 10 marked trees per ha
Mites	During dry periods and when leaves are bronze	Every 7 – 10 days	- Concentrate on trees near dirt roads	Randomly pick leaves from different ages	- 10 marked trees per ha
Anthracnose	When humidity is high	Weekly	Flowers, fruits and leaves	Check for pink sporulation on fruits surface	10 marked trees per ha
Dothiorella fruit rot	During harvesting time	Every 2 weeks	Fruits leaves	Check on fallen fruits	10 marked trees per ha

Pest or disease monitored	When ?	Frequency	Where?	How?	Sampling
Scab	Rainy season , new leaves, young fruits	Weekly	Young leaves, and young fruits	Check for blister like structures	- 10 marked trees per ha
Cercospora spot	During rainy season	Every 2 weeks	Leaves, fruits, stems	Grey mycelium in centre of lesions. Dead areas on leaves	- 10 marked trees per ha
Bacterial Soft Rot	During harvesting time	Every 2 weeks	Fruits	Check on fallen fruits	- 10 marked trees per ha
Powdery Mildew	Before blossoming	Weekly	Inflorescences	Visual	- 10 marked trees per ha

The person monitoring will soon recognise in which parts of the farm a problem tends to appear first. That area acts for early warning. It is recommended to implement prevention measures more strictly in that part of the farm to delay the infestation.

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 site to another threshold levels will be different. In most of Africa, threshold values have not yet been established. Nevertheless, careful monitoring is still recommended as pest population dynamics need to be monitored. It is very valuable to know and analyse the evolution of the pressure and to take action when a sudden increase in number is noted.

The frequency of monitoring should be increased when there are favourable conditions for the development of the pest, like humid weather.
The operator in charge of monitoring should be the same one for each monitoring visit. Ideally, monitoring forms should be filled in as this allows the pest and disease management to be evaluated after the season.

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 para pheromones 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.

4. Active substances and treatment recommendations

Hereafter a list of the plant protection products allowed for usage by the EU regulation 2092/91 on organic agriculture is given which can be recommended on avocado trees. Prior to any usage, the producer should check with his/her 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 some type of product the recommended GAP that allow conformity with European Regulation on residues is given. The proposed period of spraying is highlighted in the tables with green colour.

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

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

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

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

Srategy: When monitoring indicates that pressure is high, it is recommended to use spot treatments.

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			■	■			
Deltamethrin	Only for traps using specific lures for *Batrocera* sp. and *Ceratitis* sp.						■	■			■
Lambda-cyhalothrin	Only for traps using specific lures for *Batrocera* sp. and *Ceratitis* sp.						■	■			■
Spinosad	Only for use as spot or strip sprays						■	■			

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
Pyrethrum bait (1+2)	-	3 meters intervals	Replacing weekly	/			■	■			■
Vinegar bait	-	3 meters intervals	Replacing weekly	/			■	■			■
Fatty acids of potassium salt	8-10 g/l in 600-800 l/ha	/	/	/			■	■			
Ginger extracts	/	/	/	/			■	■			
Garlic extracts	/	/	/	/			■				
Chili extracts	/	/	/	/			■	■			

/ elements of the recommended GAP not available
- not applicable

Ants - *Linepithema humile* ; *Formica aerata ; Solenopsis xyloni*

Srategy: If treatment is decided, ants should be controlled only around harvesting time as ants are beneficial to crops and can control other pests unless ants are damaging the avocados. Only spot applications. No registered products for ant control are available.

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
Custard apple *(Anona reticulata)*	/	/	/	/		■	■	■			
Extracts of marigold (*Tagetes* spp.)	/	/	/	/		■	■	■			
Citrus oil	/	/	/	/		■	■	■			
Fish bean plant *(Tephrosia vogelii)* *	/	/	3 days	3		■	■	■			
Neem *(Azadirachta indica)*	/	/	/	/		■	■	■			

/ elements of the recommended GAP not available.
* Approval by certification body is required.

Thrips - *Scirtothrips perseae*

Srategy: Treatments target adult and nymph stages only in affected trees. Spot spraying is essential to avoid beneficial insects damages.

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	10	/	5-10	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	■	■	■	■	■		
Potassium soap	/	/	2 x/week	/	■	■	■	■	■		
Ginger – Garlic - Chili extract	/	/	/	/	■	■	■		■		
*Tephrosia vogelii** (Fish bean plant)	/	/	3	3	■	■	■		■		
Azadirachta indica (Neem)	/	/	/	/	■	■	■		■		
Andrographis paniculata	/	/	/	/	■	■	■		■		
*Derris elliptica**	/	/	/	/	■	■	■		■		

/ elements of the recommended GAP not available.
* Approval by certification body is required.

Loopers, Leaf roller (*Sabulodes aegrotata, Amorbia cuneana*)

Strategy: When damage is noticed on leaves, only spray the spots where damage is noticed.

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
Bacillus thuringiensis	/	/	/	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
Custard apple (*Anona reticulata*)	/	/	/	/		■	■		■	■	
Chili spray	/	/	/	/		■	■		■	■	
Neem (*Azadirachta indica*)	/	/	/	/		■	■		■	■	

/ elements of the recommended GAP not available.

- The pheromone compound 6,9-nonadecadien provides good trap catch of *S. aegrotata* males.
- The sex pheromones for A. cuneana are (E,Z)-10,12 and (E,E)-10,12 tetradecadien-1-o1 acetate.

Mites – *Oligonychus* spp.

Strategy: Treatments target adult and nymph stages in affected trees only. Spot spraying is essential to protect beneficial insect populations. No registered products for mites control are available.

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
Cow urine	/	/	/	/	■	■	■	■	■		
Potassium soap	/	/	2 x/week	/	■	■	■	■	■		
Flour preparation	/	/	/	/	■	■	■		■		

/ elements of the recommended GAP not available.

Anthracnose - *Colletotrichum gloeosporioides*

Srategy: 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 Fungicide*	2.5 l/ha	2	7 - 14 days	2		■	■				
Potassium bicarbonate	/	/	/	/		■	■				

/ 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.

Bacterial Soft Rot – *Erwinia herbicola*

Srategy: Using preventative and control measures are most important to keep infections of Bacterial Soft Rot low.

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
Copper Fungicide*	2.5 kg/ ha	2	7 – 14 days	2		■	■				

* Its need has to be approved by the certification body, as it is restricted. The maximum quantity which may be used each year per ha shall be calculated by subtracting the quantities actually used in the 4 preceding years from, respectively, 36, 34, 32 and 30 kg copper for the years 2007, 2008, 2009 and 2010 and following years.

Scab – *Sphaceloma persea*

Srategy: Using preventative and control measures are most important to prevent scab.

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
Copper Fungicide*	2.5 kg/ ha	2	7 – 14 days	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
Cow or goat urine	/	/	/	/		■	■		■		

* Its need has to be approved by the certification body, as it is restricted. The maximum quantity which may be used each year per ha shall be calculated by subtracting the quantities actually used in the 4 preceding years from, respectively, 36, 34, 32 and 30 kg copper for the years 2007, 2008, 2009 and 2010 and following years. .

/ elements of the recommended GAP not available.

Cercospora spot – *Pseudocercospora purpurea* & Dothiorella Fruit Rot – *Botryosphaeria* spp.

Srategy: Using preventative and control measures similar to those of Anthracnose are important to keep infections low. No registered products available to control these diseases. A suggestion is to research Citrex as this has good fungicidal activity in a number of other tropical fruits, like banana.

Powdery mildew – *Oidium* spp.

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

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		■				■	

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
Wood ash	/	/	/	/		■	■	■	■		
Neem	/	/	/	/		■	■		■		
Papaya leaves	/	/	/	/		■	■		■		
Cow, goat sheep urine	/	/	/	/		■	■		■		

/ elements of the recommended GAP not available.

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

- Fruit fly traps:

Traps for fruit flies typically contain baits with a mixture of protein and sugar. Fruit flies need protein during their egg laying period. The traps are constructed is such a way that once the flies enter, they no longer can escape. Traps with bait should be hanged in the orchard 6-8 weeks before the fruit ripens. Catches should be monitored regularly and baits changed, especially after rains. Hang baits on the west side of the trees, as fruit flies prefer to concentrate in the evenings on that side.

Constructing fruit fly traps:

1. Take a 2 litre plastic water bottle with a screw-on top. Cut two or more holes of a diameter of 0.5 cm, about 4 fingers high from the bottom in the side of the container.
2. Cut off the top of a plastic water bottle leaving 3-4 cm of the large bottle width intact. Invert this so the mouth is now facing inside the bottle. Add the bait in the bottle until just below the holes. Flies will enter through the inverted bottle mouth.

Pyrethrum bait

1 litre of water, ½ cup cow urine, 1 ½ teaspoons vanilla essence, 100g sugar, 10g pyrethrum. All ingredients are well mixed. Traps holding 50 cc are hung throughout the orchard.

Vinegar bait

Take 1 cup of vinegar, 2 cups of water, 1 tablespoon of honey and shake well. Fill the trap to just below the holes with this mixture and hang the bottle about 5 feet high. Fruit flies enter the bottle and fall into the attractant.

- Fatty acids of potassium salts:

This is an 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 chili 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 may remain for some time with the fruit so it is better not to spray near harvest time.

- Garlic oil spray: FChop 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.

- Chili spray: Boil 90 g of ripe pods or 100 g of chili 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.

- Custard apple seed: Prepare a spray made of 500 g finely ground seeds which are soaked in 20 litres of water for 2 days. After filtering it is ready to be sprayed. (Effective for ants and aphids).

- 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 peels in an equal amount of water for 10 days to two weeks. Adding garlic-pepper tea makes the spray even more powerful. It will also kill beneficials so don't use unless pests are a problem. As it is an oil there is a possible phytotoxicity, depending on the concentration used.

- ***Tephrosia Vogelii*:** Leaves from *T. vogelii* contain at least 4 insecticidal components, collectively known as rotenoids. Mature leaves may contain 80-90% rotenoids. Roots also contain this.
Precautions should be taken while preparing the concoction, as it can irritate human skin. When eating fish poisoned with Tephrosia, people can get sick. The spray may also cause some dizziness to the user. Cattle deaths have been reported as a result of drinking water of poisoned fish ponds. In organic production, the use of rotenone is permitted as an insecticide under European Union Regulation 2092/91, amended by 1488/97, Annex II (B). Based on a study that links rotenone to Parkinson's Disease, the UK Soil Association put a temporary ban on its use, pending further investigations.

1 litre of fresh *Tephrosia vogelii* leaves are pounded and soaked in 1 litre of water and left overnight. The spray is effective against ants, termites, aphids and many other insects. Application should be on the spot. It is possible to bait ants with a sugar solution with Tephrosia leaf powder, which kills ants. Care should be taken that no other mammals eat the bait.
Rotenone is rapidly broken down by sunlight which means that evening application provides the best results. Degradation in 24 to 48 hours, no risk of residues.

- **Use of neem (*Azadirachta indica*) 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.

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. 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. Operators should wash hands after handling neem seeds. 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.

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 for one night, is filtered and spot sprayed on targeted pest.

- Andrographis paniculata

Mix 2 kg of fresh plant material of *Andrographis paniculata* with 250 ml of water and grind it well. Add 2 litre of cow urine and 10 g of crushed dried chili fruits. Add 10 litres of water and leave the solution for a few hours. Filter the solution and it is ready for spraying.

- Derris eliptica

Wash fresh roots of *Derris eliptica* (oil tree) and cut them into short 5 cm lengths. Add small amounts of water and pound the roots until they are finely shredded. Filter de solution. Dilute with soap and water at a ratio of 1 part soap: 4 parts root solution: 225 parts water. Apply immediately.

- Cow urine

1 part cow (goat, sheep) urine is mixed with 2 parts water. (Urine from animals with a vegetarian diet is preferred above urine based on meat diet as the last one results in a higher concentration of urea as well as other substances which can have a detrimental effect). A dilution of 1:1 is suggested as undiluted urine cause slight phytotoxicity.

- Flour preparation

Mix 2 cups of fine white flour in 5-10 litres of water and mix well. Use this spray against mites and aphids. Apply this in the mornings as the heat of the sun dries up the mixture and leaves the insects encrusted in flour, shrivel and die. The coating of flour subsequently falls off the leaves so that their ability to photosynthesise is not essentially affected.

- Wood ash

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

- Papaya leaves extracts

4 kg of papaya leaves are pounded and soaked in 15 litres of water over night. The mixture is sieved and sprayed on infected parts.

5. Existing registrations

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

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

Existing registrations in Togo
Data not available

Registration in Uganda
Data not available

Registration of insecticides and fungicides in Cameroon
Only azadirachtin is registered

Registration of insecticides and fungicides in Kenya
On avocado only spinosad and copper is registered. whereas deltamethrin and pyrethrin are registered on fruit trees and Azadirachtin and Bacillus thuringiensis on horticultural crops.

Registration of insecticides and fungicides in Ghana
In Ghana only lambda-cyhalothrin and deltamethrin are registered on vegetables and various crops.

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www.ipmcenters.org

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
FOR SUSTAINABLE DEVELOPMENT OF THE ACP HORTICULTURAL INDUSTRY

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