PIP

GUIDE TO GOOD CROP PROTECTION PRACTICES

FOR PRODUCTION OF BANANA (*MUSA* SPP. - BANANE PLANTAIN *(MATOKE)*, APPLE BANANA, RED BANANA, BABY BANANA AND OTHER ETHNICS BANANAS)

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

POUR UN ENVELOPPE DE DEVELOPPEMENT DURABLE DU SECTEUR FRUITS ET LEGUMES ACP

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

Document drawn up by PIP with the technical collaboration of:
Suzanne Neave

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Notice

The Guide to Good Plant Protection Practices (fruit or vegetable) details all plant protection practices (for fruit or vegetable) and recommends primarily the active substances supported by pesticides manufacturers in the framework of EU Regulation 1107/2009, for organic production those allowed for usage by the EU Regulation 2092/9 and that must comply with standards for pesticide residues. Currently, these active substances have not been tested by PIP in ACP countries to check their conformity with European MRLs. The information given on the active substances suggested is therefore changeable and will be adapted on an ongoing basis in accordance with the new information collected by PIP.

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

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

PIP
FOR SUSTAINABLE DEVELOPMENT OF THE ACP HORTICULTURAL INDUSTRY

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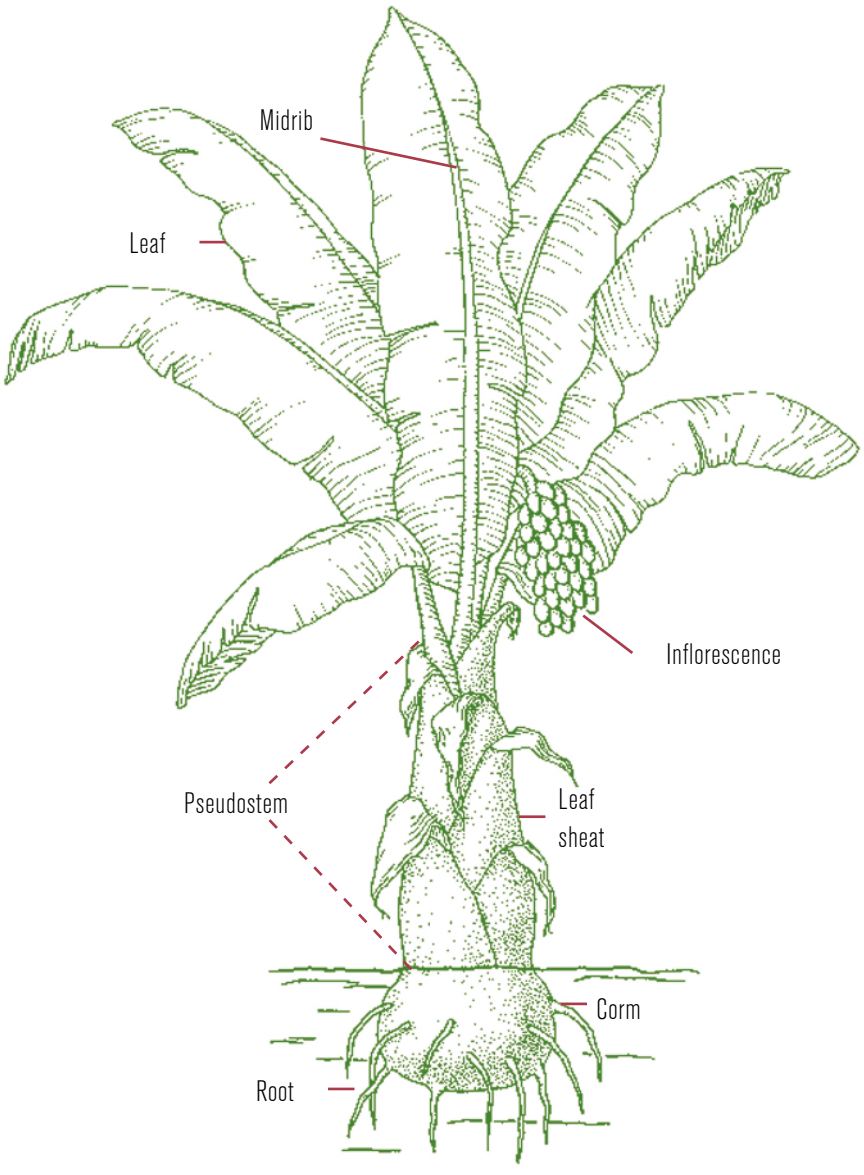
Introduction

The livelihoods of over 70 million people are intimately linked to banana (banana and plantain), a major food staple and premier fruit. It occupies an important position in the agricultural economies in sub-Saharan Africa. Banana plantations produce fruits all year round, providing farmers with food and income, even during fallow seasons, thus contributing to food security.

Various types of banana are grown in sub-Saharan Africa: plantain in the humid lowlands of West and Central Africa; highland cooking banana in East Africa; and introduced dessert banana in all the subregions.

The world's greatest variability in the crops is held in West and Central Africa for plantain and Great Lakes Zone in Eastern Africa for highland banana. These regions are considered as secondary centers of banana diversity.



Banana plants are of the family Musaceae. They are cultivated primarily for their fruit, and to a lesser extent for the production of fibre and as ornamental plants. As the banana plants are normally tall and fairly sturdy, they are often mistaken for trees, but their main or upright stem is actually a pseudostem. For some species, this pseudostem can reach a height of up to 8 m, with leaves of up to 3.5 m in length. Each pseudostem can produce a bunch of green bananas, which when ripened often turn yellow or sometimes red. After bearing fruit, the pseudostem dies and is replaced by another.

The banana fruit grows in hanging clusters, with up to 20 fruits to a tier (called a 'hand'), and 3-20 tiers to a bunch. The total of the hanging clusters is known as a bunch, or commercially as a "banana stem", and can weigh from 30-50 kg. The fruit averages 125 g, of which approximately 75% is water. Each individual fruit (known as a banana or 'finger') has a protective outer layer (a peel or skin) with a fleshy edible inner portion. Both skin and inner part can be eaten raw or cooked. Western cultures generally eat the inside raw and throw away the skin while some Asian cultures generally eat both the skin and inside cooked.

While the original bananas contained rather large seeds, triploid (and thus seedless) cultivars have been selected for human consumption. These are propagated asexually from offshoots of the plant. The plant is allowed to produce 2 shoots at a time; a larger one for fruiting immediately and a smaller "sucker" or "follower" that will produce fruit in 6-8 months time. The life of a banana plantation is 25 years or longer, during which time the individual stools or planting sites may move slightly from their original positions as lateral rhizome formation dictates.

Cultivated bananas are *parthenocarpic*, which makes them sterile and unable to produce viable seeds. Lacking seeds, another form of propagation is required. This normally involves removing and transplanting part of the underground stem (called a corm). Usually this is done by carefully removing a sucker (a vertical shoot that develops from the base of the banana pseudostem) with some roots intact. However, small sympodial corms, representing not yet elongated suckers, are easier to transplant and can be left out of the ground for up to 2 weeks; they require minimal care and can be boxed together for shipment.

Contrary to what is widely believed, it is not actually necessary to include any of the corm or root structure to propagate bananas; severed suckers with no root material attached can be successfully propagated in damp sand, although this takes somewhat longer.

In some countries, bananas are also commercially propagated by means of tissue culture. This method is preferred since it ensures disease-free planting material. When using vegetative parts such as suckers for propagation, there is a risk of transmitting diseases (especially the devastating Panama disease).

1. Main enemies of banana

1.1 Extent and impact on the quantity and quality of fruits 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 produce and consequently end up causing a loss of financial income. The presence of pests and diseases can reduce yield and cause losses at different levels: fewer plants per hectare, smaller size of bunches and fruits, lower quality product.

Quarantine organisms in Europe are followed by the abbreviation **"QO"**.
One should check the status of quarantine organisms on the websites: http://europa.eu/scadplus/leg/fr/lvb/f85001.htm and http://www.eppo.org/QUARANTINE/quarantine.htm since regulation can change.

INSECTS						
Extent	Organs attacked			Types of loss		
	Corms	Leaves	Fruits	Number of plants	Size of bunches and fruits	Quality of fruits at maturity
Banana aphid - *Pentalonia nigronervosa*						
Aphids cause indirect damage as vectors of the important virus Bunchy Top (BBTV), which causes major economic loss.						
+++		Feeding by nymphs and adults			Reduced if feeding weakens plants	Fruit bunches are distorted
Thrips - *Hercinothrips bicinctus* (banana thrips), *Franlinella parvula* (banana flower thrips), *Chaetanaphothrips signipennis* (banana rust thrips)						
+		Feeding by nymphs and adults				The superficial damage to the skin results in down-grading or rejects
Banana weevil - *Cosmopolites sordidus*						
++	Burrowing of larvae into corms, pseudostems, roots and rhizomes			Severe infestations can result in plants toppling	Smaller bunches are produced	

FUNGI

Extent	Organs attacked			Types of loss		
	Roots	Leaves	Fruits	Number of plants	Size of bunches and fruits	Quality of fruits at maturity
Sigatoka disease and Black Leaf Streak disease - *Mycosphaerella musicola and M. fijiensis*						
+++		Development of mycelium in the leaves		If infection is severe the entire plant may die	Small fruit which fails to ripen due to reduction in leaf function	Maturing fruit becomes angular, with a pinkish flesh
Fusarium wilt (Panama wilt) - ***Fusarium oxysporum f.sp. cubense***						
+++	The pathogen penetrates the root and enters the xylem tissue			Whole plantations can be destroyed if conditions favourable		
Anthracnose and crown rot of bananas - Mainly due to *Colletotrichum musa* Crown rot may also be caused by *Fusarium, Acremomium, Verticiulium* et *Curvularia*						
+++			Enter in the fruits mainly through wounds			These diseases develop during fruit conservation and ripening and highly depreciate fruit marketability

BACTERIA

Extent	Organs attacked	Types of loss		
	Whole plant	Number of plants	Size of bunches and fruits	Quality of fruits at maturity
Banana wilt disease (Moko Disease) - *Ralstonia solanacearum* race 2 "QO"				
++	The bacteria is transmitted mechanically by insects (transmitting ooze from infected male buds to distant flowers causing rapid spread) or through soil particle movement and enters through the roots and through wounds	Plants may die	Reduced due to weakening of the plant	Pulp becomes discoloured and decays. Premature ripening and discolouration of mature fruit
Xanthomonas Wilt - *Xanthomonas campestris pv. musacearum*				
++	All parts of the plant may become infected The disease is transmitted through inflorescence from inoculum dispersed by insects and mechanically by contaminated tools used in pruning. The disease enters the plant through wounds from mechanical injuries, nematodes and insect damage	Kills the entire plant	Reduced due to weakening of the plant	The fruit prematurely ripen on the bunch, rotting of the fruit. Fruit becomes hardened and unpalatable

VIRUS				
Extent	Organs attacked	Types of loss		
	Above ground organs	Number of plants	Size of bunches and fruits	Quality of fruits at maturity
Banana Bunchy Top Virus				
+++	The virus is transmitted by aphids into the plant		Rarely infected plants flower or produce fruit. If produced, the fruit is stunted and deformed	

NEMATODES				
Extent	Organs attacked	Types of loss		
	Roots	Number of plants	Size of bunches and fruits	Quality of fruits at maturity
Root knot nematodes - *Meloidogyne spp.*				
+	The hatched juveniles usually enter the root or often feed on destroyed tissue from lesion forming nematodes. The formation of giant cells within the root tissue disrupts the xylem function		Reduced if heavy infestation	
Root lesion nematodes - *Pratylenchus coffeae*, *P. goodeyi*				
The presence of *Praytlenchus* also aggravates the expression of soil borne diseases				
++	The nematodes develop in the roots	Plants may topple	The reduction in root development leads to stunted growth, and decreased bunch weight	
Burrowing nematodes - *Radopholus similis*				
The damage makes the plant prone to secondary attack from insects and diseases An increase in lag between harvests is observed				
+++	Penetration occurs preferably in root apex. As the nematode migrates through the root it feeds on cytoplasm of cortex cells, causing cell walls to collapse	Plant become prone to toppling over in strong winds and heavy rain	Bunch weight reduction of 1.5 to 2kg per annum	

1.2 Identification and damage

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

INSECTS

Banana aphid – *Pentalonia nigronervosa*

Aphids are 1-2 mm long, shiny brown, roundish bodies, with brown and cream stripped legs. The winged adults have clear wings with distinct dark venation. They are found in colonies, the presence of a single winged adult is an indication of the start of a new colony. Aphids hide, in colonies, under leaf sheaths on young suckers and within whorls of developing leaves on mature plants. The brown, roundish aphids, with banded legs, are tended by black ants that protect them from predators.

Banana thrips – *Hercinothrips bicinctus* (silvering thrips), *Franklinella parvula* (flower thrips), *Chaetanaphothrips signipennis* (rust thrips)

C.signipennis adult

Adult thrips are small (0.5-2.0mm), slender with fringed wings. Body colours range from yellow to black depending on species. Nymphs are a yellow/orange colour and look similar to the adults except the absence of wings.

There are a variety of different thrips that attack bananas, that live in colonies in sheltered places on the plants Thrips prefer to feed on young, succulent, immature fruit and whorls of leaves.

The feeding of rust thrips on leaf sheaths results in a dark V-shaped mark on the outer surface of the leaf petioles. Damaged tissue becomes rust coloured with age. Feeding activity on fruit occurs soon after flowering and initially appears as water-soaked marks. Irregular feeding tracks can be seen on the surface of the fingers. On mature fruit reddish stains are observed where the fingers touch and cracks may also appear that can lead to rotting.

Symptoms of *F. parvula* on fruit

Flower thrips cause the flower bracts to become mottled and deformed. Raised black dots with a water-soaked margin can be observed on the fruit.

The banana silvering thrips causes silvering scars on the surface of the fruit, which can be attacked at any stage. Severe blemishes may turn reddish brown and form deep cracks.

Excreta from the insects drop onto fruit and dries forming dark spots on fruits and leaves.

Scars on a fruit

Banana weevil – *Cosmopolites sordidus*

The adults (10-15mm long) is oval, shiny and black with a prominent snout that can live up to 2 years. They are initially attracted to volatiles from the plant, particularly from recently cut rhizomes. They are commonly found between leaf sheaths, under crop residue or in the soil at the base of the mat and are nocturnal.

Larvae are small and creamy coloured with a brown head capsule, that burrow into the corm and pseudostem as well as between the lateral roots and rhizome and disrupting root development, delay flowering and provide entry wounds for other pests and diseases.

The external symptoms are often confused with stress-induced factors such as poor nutrition or water stress. Vigour decline is usually the initial signs of an infestation. Young plants become stunted and leaves turn yellow and wilt. The rhizomes often snap in half exposing the dark galleries formed by the feeding larvae.

FUNGI

Banana Sigatoka – *Mycosphaerella musicola*, *M. fijiensis*

Symptoms of M. *fujiensis*

There are two types of Sigatoka, Black and Yellow. Black Sigatoka (*M. fijiensis*) is more severe than Yellow Sigatoka (*M. musicola*), producing more ascospores and developing faster.

Yellow Sigatoka first appears a small, light yellow spots or parellel streaks, which turn brown with grey centres. Black Leaf Streak Disease/Black Sigatoka first appears as dark brown streaks on the lower leaf surface. The spots enlarge and the surrounding tissue turns yellow and dies. If infection is severe the entire plant may die within a few weeks. Immature bunches fail and maturing fruit becomes angular and undersized, with a pinkish flesh. Uneven ripening may also result in fruit fly damage.

Advanced symptoms of Sigatoka

Fusarium wilt (Panama wilt) – *Fusarium oxysporum* f.sp. *cubense*

The first symptoms of the diseases appear in the older leaves, which turn yellow and split lengthways. The leaves wilt and buckle at the petiole base, turning brown and hang down. This spreads progressively from the old to the young leaves. Eventually leaving a stump with a skirt of dead leaves. In some cases, when the plants are stressed, green leaves can also be seen hanging. The emerging young leaves are paler in colour and usually stand erect giving a "spiky" appearance. The initial symptoms can be confused with potassium deficiency.

The xylem tissue appears yellow streaks, later becoming red/brown and brown. This can be seen in older leaf sheaths, when the plant is cut down to expose the rhizome.

Anthracnose and crown rot - mainly due to *Colletotrichum musa*

In both types of infection, disease symptoms can extend into the banana fruit pulp.

With crown rot, a brown to black color develops on the "crown" where the hand was severed from the bunch. Frequently, a layer of whitish mold later develops on the cut crown surface. The mold can penetrate deeply into the crown and the necks of the fingers, causing a dry, black rot. Fingers may detach prematurely from severely infected crowns. Disease may increase rapidly during fruit ripening.

Anthracnose lesions on banana fruits

Rot of banana bunch

With anthracnose, symptoms occur as peel blemishes, as black or brown, sunken spots of various sizes on fruits. The spots may bear masses of salmon-colored fungal acervuli with their associated conidia in the lesions. The spots may have triangular-shaped or angular edges. The pathogen may cause symptoms on green fruit and may also enter the cut crown after hands are severed from stalks. Premature ripening of affected fruits may occur after infection.

BACTERIA

Bacterial Wilt (Moko Disease) – *Ralstonia solanacearum* race 2

The symptoms are seen on the young leaves that break at the petiole due to partial wilting. The bracts and vascular bundles in the midrib become discoloured. In old plants the inner leaves turn dirty yellow colour near the petiole, the leaf wilts and dies, outer leaves turn yellow become necrotic and die.

Developing fingers turn black and shrivel or ripen prematurely and split. The mature fruit shows no outward symptoms, but pulp is discoloured and decays, exuding a bacterial ooze when cuts.

The disease is often confused with Panama disease, however Moko disease affects young plants unlike Panama and the fruit becomes discoloured.

Xanthomonas Wilt – *Xanthomonas campestris* pv. *musacearum*

Shrivelled male bud

Xanthomonas is a vascular disease, resulting in permanent wilting and eventual death of the plant. It can affect the plant at all stages, although is more prevalent when the plant matures past the maiden sucker stage. Symptoms may appear on any part of the plant, depending on the site of initial infection. Commonly the central heart leaf at the apex wilts and pale yellowing occurs on newly expanded leaves. Infected leaves tend to snap one-third of the way down from the tip.

Yellow ooze from pseudostem

The male bud is often the point of entry in insect-mediated infection. The colour of the bracts fades, and the bud eventually shrivels and dries up.

The fruit prematurely ripen on the bunch, rotting of the fruit. Fruit becomes hardened and unpalatable. A cross section through the fruit reveals a dark brown discolouration of the pulp.

Internal yellow discolouration of the vascular bundles is observed in certain varieties. A cross section of the pseudostem results in an excretion of a yellowish bacterial ooze after 5 - 30 minutes.

infected fruit

VIRUS

Bunchy Top Virus

The leaves develop "morse code" symptoms (dark green dots and dashes) on their petioles. Green J-hooks can be seen long the leaf veins.

The most severe and familiar symptom is when the leaves on the top of the plant become narrow with yellow fringes, stand upright and are close together, giving the bunchy appearance. This is usually more obvious in young plants.

The inflorescence and fruit usually fail to form or fail to emerge from the pseudostem. On mature plants however, the flower bracts have a mottled appearance and developing fruit become stunted and deformed.

Bunchy top close up

The plant takes up to 125 days to show symptoms after infection.

Virus is transmitted by propagative materials and banana aphid *(Pentalonia nigronervosa).*

Note: the symptoms can often be confused with zinc deficiency.

NEMATODES

Root knot nematodes – *Meloidogyne* spp.

Meloidogyne spp. are generally not a major pest if the other nematodes are present as it is readily replaced, but is most abundant where for example, the climate is too cold for *Radopholus similis*.

Females imbedded in root

The roots swell forming galls or the root tip stops growing and new roots develop above the infection. The above ground symptoms are similar to those seen when the plant lacks nutrients and water: yellowing of leaves, stunted growth, poor fruit production.

Root damage

Root Lesion nematodes – *Pratylenchus coffeae, P. goodeyi*

P. coffeae usually occurs with other species of nematodes.

Both species are migratory endoparasites of the root cortex and corms. Extensive black or purple necrosis is observed on the epidermal and cortical root tissue resulting in lesion. The root stele remains white. Plants may also topple.

Burrowing nematodes – *Radopholus similis*

Cavities and tunnels are formed which turn necrotic. The roots rot and plant become prone to toppling over in strong winds and heavy rain. Nematodes that move into the rhizome, cause black rotten areas.

The symptoms observed on the plant are as a result of water and nutrient uptake being restricted resulting in poor growth, fewer and smaller leaves, premature defoliation, a reduced bunch weight and an increase in lag between harvests.

1.3 Appearance of pests and diseases in terms of the phenological stage of the plant

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

Stage	Length of stage	Banana aphid		Banana thrips		Banana weevil	
Nursery	6 - 8 weeks						
From transplanting or appearance of a new pseudostem to flowering	9 - 15 months						
From fruit set to harvesting	3 months						

Stage	Length of stage	Banana Leafspot		Fusarium wilt		Banana wilt disease		Xanthamonas wilt		Nematodes		Bunchy top virus	
Nursery	6 - 8 weeks												
From transplanting or appearance of a new pseudostem to flowering	9 - 15 months												
From fruit set to harvesting	3 months												

Periods during which pest or pathogenic agent is potentially present

Periods during which the appearance of a large numbers of pest or pathogenic agent can cause the greatest loss

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

Key:
CAM = Cameroon, CIV = Côte d'ivoire (Ivory Coast), DOR = Dominican Republic, UGA = Uganda, ZAM = Zambia
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.

Banana aphid - *Pentalonia nigronervosa*

Favourable conditions: Colonies and migration occur during warm weather, particulary when vegetation surrounding plantations start to dry up.

Month	1	2	3	4	5	6	7	8	9	10	11	12
CAM	/	/	/	/	/	/	/	/	/	/	/	/
CIV	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/
UGA	+	+	+	+	++	++	++	++	++	++	++	+
ZAM	+	+	+	+	+	+	++	+++	+++	+++	+	+

Banana thrips - *Hercinothrips bicinctus, Franklinella parvula, Chaetanaphothrips signipennis*

Favourable conditions: Hot and dry conditions. Outbreaks often occur when hot weather following a spell of rain.

Mois	1	2	3	4	5	6	7	8	9	10	11	12
CAM	/	/	/	/	/	/	/	/	/	/	/	/
CIV	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/
UGA	+	+	+	+	+	+	+	+++	+++	+++	+	+
ZAM	+	+	+	+	+	+	+	+	+	+	+	+

Banana weevil - *Cosmopolites sordidus*

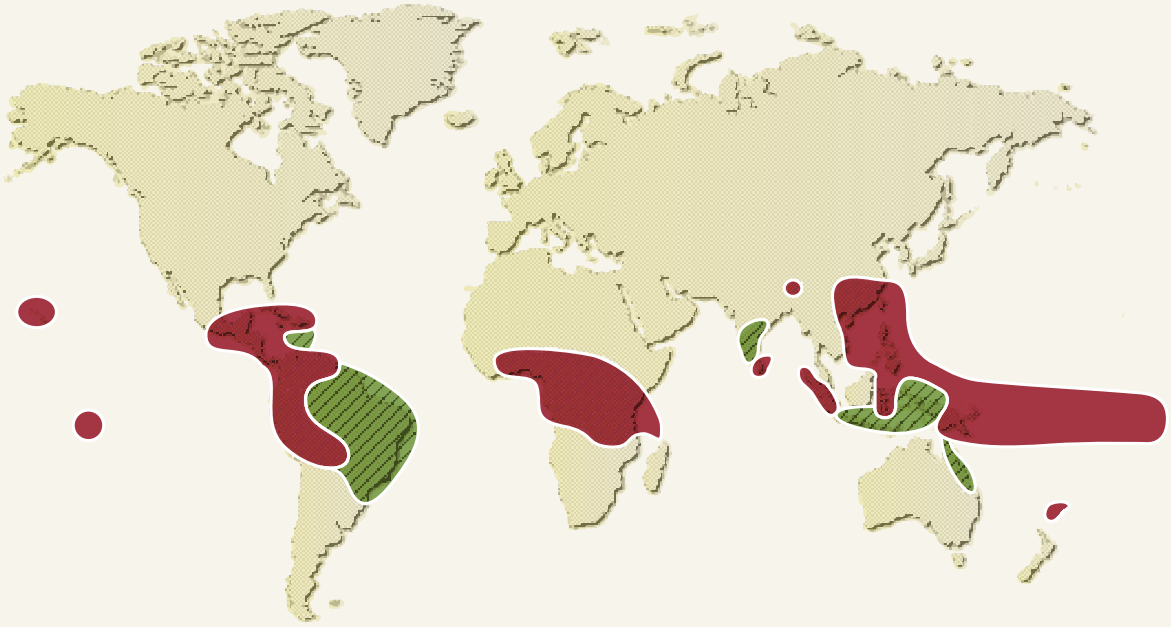
Favourable conditions: Adults tend to be more active just after or during rainy periods.

Geographical Distribution of Banana weevil in Africa (red marked) – source http://www.infonet-biovision.org/default/text/-1/license

Month	1	2	3	4	5	6	7	8	9	10	11	12
CAM	/	/	/	/	/	/	/	/	/	/	/	/
CIV	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/
UGA	+	+	+	++	+++	+	+	+	+	++	++	+
ZAM	0	0	0	0	0	0	0	0	0	0	0	0

Banana Sigatoka - *Mycosphaerella musicola, M. fijiensis*

Favourable conditions: Present all year round, incidence increases during the rainy season. Ascospores disseminated by wind causing the damage to young leaves during warm, moist conidtions. Conidia disperse by droplets onto other leaves. M.musicola is rarely seen in Africa and occurs mainly in high altitude area (1,200 - 1,400 m) where M. fijiensis rarely occurs.



Distribution of *M. fijiensis* and *M. musicola* in the world – from *Musa* disease fact sheet N° 8, INIBAP

Mycosphaerella fijiensis ditribution
M. musicola distribution

Month	1	2	3	4	5	6	7	8	9	10	11	12
CAM	/	/	/	/	/	/	/	/	/	/	/	/
CIV	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/
UGA	+++	+++	+++	+	+	+	++	++	+++	+++	+++	++
ZAM	+++	+++	+++	+	+	+	+	+	+	+	++	+++

Fusarium wilt (Panama wilt) - *Fusarium oxysporum f.sp. cubense*

Favourable conditions: High temperatures (24-30°C) and high soil moisture favour the disease development.

Month	1	2	3	4	5	6	7	8	9	10	11	12
CAM	/	/	/	/	/	/	/	/	/	/	/	/
CIV	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/
UGA	+	++	+++	+++	+++	++	+	+	+	+	++	++
ZAM	+	+	+	+	+	+	+	+	+	+	+	+

Anthracnose and crown rot - mainly due to *Colletotrichum musa*

Favourable conditions: More prevalent in high-rainfall and high relative humidity areas.

Month	1	2	3	4	5	6	7	8	9	10	11	12
CAM	/	/	/	/	/	/	/	/	/	/	/	/
CIV	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/
UGA	/	/	/	/	/	/	/	/	/	/	/	/
ZAM	/	/	/	/	/	/	/	/	/	/	/	/

Bacteria wilt - *Ralstonia solanacearum* race 2

Favourable conditions: The disease is most servere at temperature between 24-35°C. High soil moisture (-0.5 to -1 bar) and periods of wet weather are also associated with disease severity.

In central Africa bacterial wilts due to *Ralstonia* species are present elsewhere.

Month	1	2	3	4	5	6	7	8	9	10	11	12
CAM	/	/	/	/	/	/	/	/	/	/	/	/
CIV	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/
UGA	+	+	+++	+++	+++	+	+	+	+	+++	++/+	+
ZAM	0	0	0	0	0	0	0	0	0	0	0	0

Banana Xanthamonoas Wilt (BXW) - *Xanthamonas vasicola* pv. *musacearum*

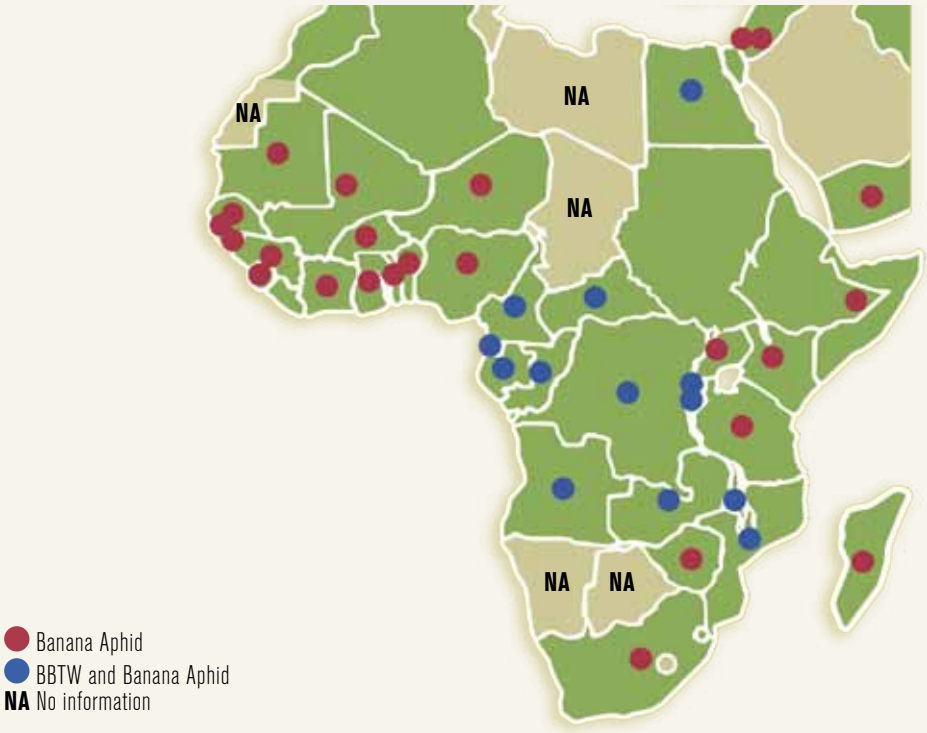
Favourable conditions: Rapid and severe disease development can under warm wet conditions.

In Africa, *Xanthamonas* bacterial wilt is present in Ethiopia, Uganda, Rwanda, Western Kenya, North Western Tanzania, and North and South Kivu in DR Congo.

Month	1	2	3	4	5	6	7	8	9	10	11	12
CAM	/	/	/	/	/	/	/	/	/	/	/	/
CIV	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/
UGA	+	+	+++	+++	+++	+	+	+	+	+++	+++	+
ZAM	0	0	0	0	0	0	0	0	0	0	0	0

Bunchy Top Virus (BBTV)

Favourable conditions: Spread of virus is dependent on aphid activity.



Distribution map of BBTV and the banana aphid in Africa. Map by IITA.

The map shows presence of BBTV in Angola, Burundi, Cameroon, Congo, DR Congo, Egypt, Equatorial Guinea, Gabon, Malawi, Mozambique, Rwanda, and Zambia; but currently Uganda, Kenya and Tanzania are also affected.

Month	1	2	3	4	5	6	7	8	9	10	11	12
CAM	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx
CIV	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/
UGA	+++	+++	++	++	++	+++	+++	+++	+++	+++	++	++
ZAM	+	+	+++	+++	+++	+++	+++	+++	+++	+++	+++	+

Root knot nematodes - *Meloidogyne* spp.

Favourable conditions: Plant prone to nematode attack during the rains when the water table rises. Optimal temperature is 27°C.

Month	1	2	3	4	5	6	7	8	9	10	11	12
CAM	/	/	/	/	/	/	/	/	/	/	/	/
CIV	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/
UGA	++	++	++	++	++	++	++	++	++	++	++	++
ZAM	+++	+++	++	+	+	+	+	++	++	++	++	+++

Root lesion nematodes - *Pratylenchus coffeae, P. goodeyi*

Favourable conditions: *P. coffeae* usually occurs with other species of nematodes and has a wide distribution. In contrast. P.goodeyi is believed to be indigenous to Africa and occurs mainly at higher altitudes, particularly in East and Central Africa, preferring cooler temperatures than *P. coffeae.*

Month	1	2	3	4	5	6	7	8	9	10	11	12
CAM	/	/	/	/	/	/	/	/	/	/	/	/
CIV	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/
UGA	/	/	/	/	/	/	/	/	/	/	/	/
ZAM	/	/	/	/	/	/	/	/	/	/	/	/

Burrowing nematodes - *Radopholus similis*

Favourable conditions: More prone in low-lying areas in Central-East Africa. Optimal temperature for reproduction is 30°C.

Month	1	2	3	4	5	6	7	8	9	10	11	12
CAM	/	/	/	/	/	/	/	/	/	/	/	/
CIV	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/
UGA	/	/	/	/	/	/	/	/	/	/	/	/
ZAM	/	/	/	/	/	/	/	/	/	/	/	/

2. Main control methods

2.1. Introduction

Bananas will grow in almost any soil (do not tolerate salty soils), but thrive in well-drained and with high organic matter content soils. They prefer acid soil with a pH between 5.5 and 6.5. The best growing temperatures range between 26 and 35oC during the day and 22 to 28oC at night. The plants grow best in full sunlight, although bright sunlight can scorch the fruit. The plant stops growing at temperatures below 11oC; they are also prone to frost and wind.

Bananas are susceptible to a range of pests and disease and correct identification is important in order to take effective action to minimise economic loss. Pest control decisions, whether the crop is grown conventionally or organically, should be made within Integrated Pest Management (IPM) strategies in order to optimise economical aspect, at the same time as protecting the environment and non-target organisms. This can be achieved by adopting agronomic practices that promote a healthy crop, the use of preventative (to avoid attack) and curative (to suppress attack) measures within an IPM framework that focuses (in conventional production) on the rationalisation of pesticides. One of the key components to achieving a healthy crop is the adoption of good cultural/agronomic practices that optimise growing conditions.

2.2. General Cultural/Agronomic Practices

The main focus of cultural practices is to produce a healthy plant by providing good planting material with a healthy optimal growing environment above and below the soil. A weakened plant is more susceptible to pest and diseases.

- Selection of an appropriate site with loose and well-drained soil to avoid waterlogging. It should be high in organic matter, which can be maintained through mulching with un-diseased pruning material, between the rows.
- The site should be protected from wind, if necessary windbreaks could be planted, including neem, *Gliricidia* or *Cassia*. Windbreaks also have the added benefit of helping arrest movement of aphids.
- Select improved varieties and clean propagation material. Ideally tissue culture stock should be used and planted into a nursery that is insect proofed and use sterilised growing media/soil. Only use healthy suckers, wash away soil and pare scale leaves. Only plant sword suckers, destroy any water suckers.
- Before transplanting immerse corms into hot water (53-55°C) for about 20 minutes. The temperature can be maintained by adding a candle to the water when it starts to melt the temperature is too high.
- Plant in rows that are easy to walk through and therefore enable easy management. Spacing will also help with air circulation that will assist with suppression certain diseases.
- Apply water either with sprinkler/microjet systems or dig trenches to collect and direct water. Mulching helps conserve soil moisture.
- Regularly remove and destroy any diseased leaves, weed – either by hand or with herbicides.
- Intercropping with vegetables, taro, cereals and pulses (note: maize and sweet potatoes are highly competitive with bananas and therefore do not make good intercropping plants) can help to control pests such as weevils by disrupting movement through the plantations.
- Increasing organic matter in the soil, not only improves the nutrient capacity but also encourages soil dwelling beneficial organisms such as predatory ants (*Tetramonium* and *Pheidole*) that prey on weevil eggs and larvae; as well pathogen antagonists *Pseudomonas fluorescens* for soil borne diseases. This can be achieved by using clean pruning material as mulch, adding compost or manure (3 kg per plant).

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

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

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

The control methods for pests or diseases whose cycle is not illustrated are presented in a table.
The first column of the table shows what actions should be taken to control. The actions that can be referred to as "cultivation practices" are shown in green boxes, and actions that can be referred to as "application of plant protection products", in orange boxes.

- Cultivation practices
- Application of plant protection product

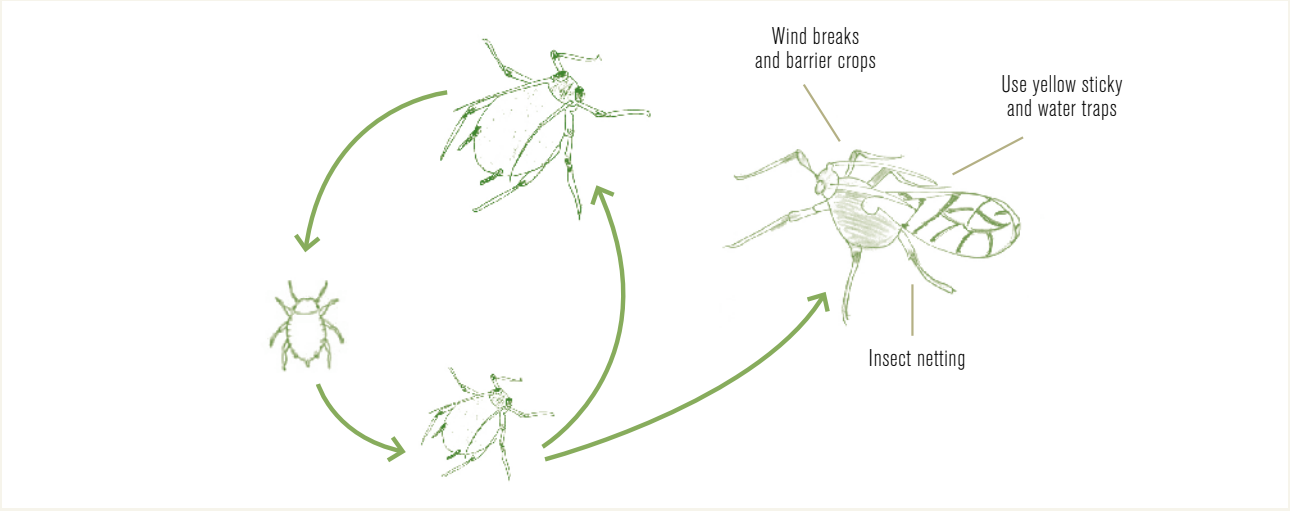
The remaining column shows the cultivation stage during which these actions should be taken.

BANANA APHIDS

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

To control all stages:

- Inspect alternate hosts (including weeds) regularly and remove those that harbour the same species of aphids.
- Destroy wild bananas in the area.
- Keep mats pruned of suckers and remove useless water suckers.
- Use systemic insecticides, soap solutions and neem products.
- Natural enemies – parasitoids and predators
- Control ants in the field that protect aphids from predators.



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

Nursery

- Use insect netting that will prevent winged aphids from entering the area and making contact with the plants.
- Regularly scout and treat areas when adults are detected.
- Use yellow sticky traps at the entrance to the nursery and around the perimeter to monitor any winged adult activity.
- Treat with a systemic insecticide before transplanting in the field.

Field

During the production cycle, and particularly in the growth stage

- Remove any host plants that potentially harbour the banana aphids (for example Ageratum spp., taro and ginger).
- Remove any wild bananas, particularly those upwind from the plantation.
- Treat young suckers with systemic insecticide if they are located near a potential threat.
- Use soaps and neem products on colonies detected through scouting.
- Control ants using boric acid baits to prevent them aggressively protecting aphids from predators.

Validity and relevance to be checked in local conditions

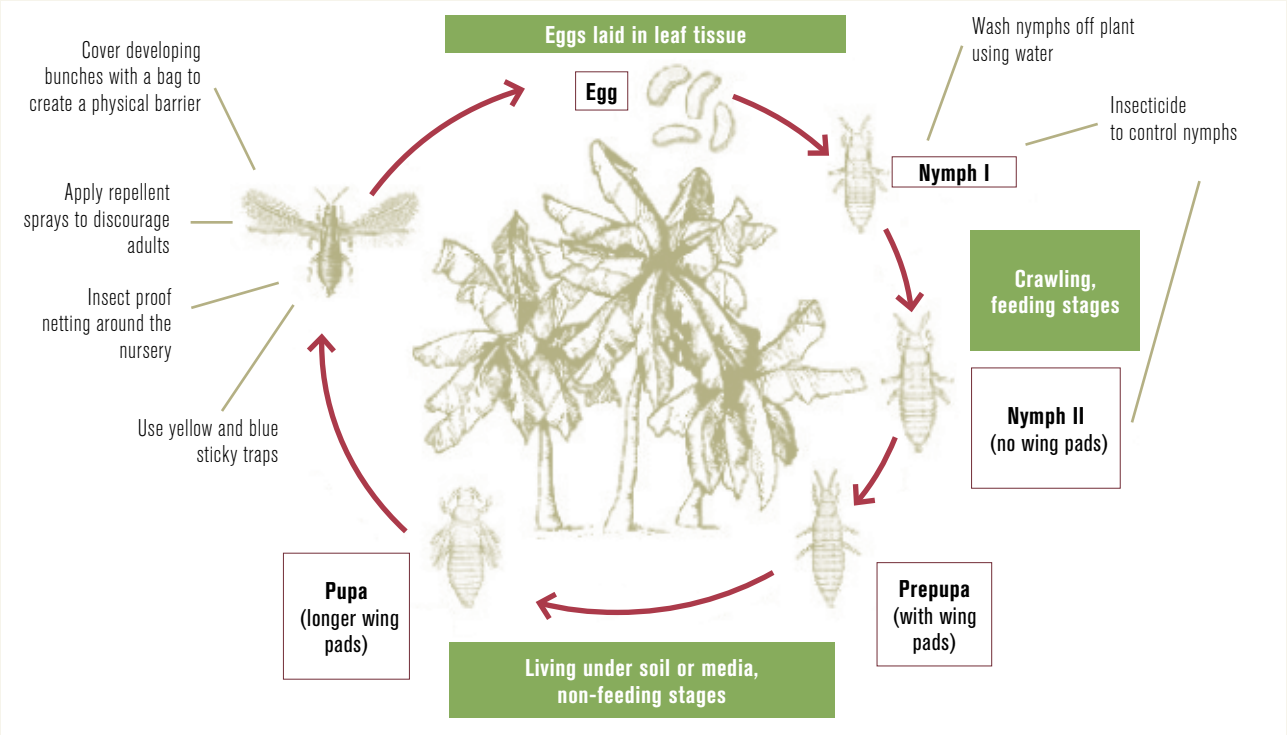
Areas where small-scale production and wild bananas are growing are potential sources of aphids carrying viruses. It is important to keep a large distance away from any other production areas that are upwind or plant a physical barrier to disrupt migration of winged aphids by the prevailing wind.

THRIPS

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

To control all stages:

- Use tissue cultured or clean propagation material.
- Encourage biological control agents e.g *Orius* sp. and predatory mites.
- Remove and discard infected flowers and foliage.



Insect drawing from D. Schulz ~1950

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

Nursery

- Protect young plants by using insect proof netting around the nursery.
- Treat with insecticides if necessary.

Field

Planting

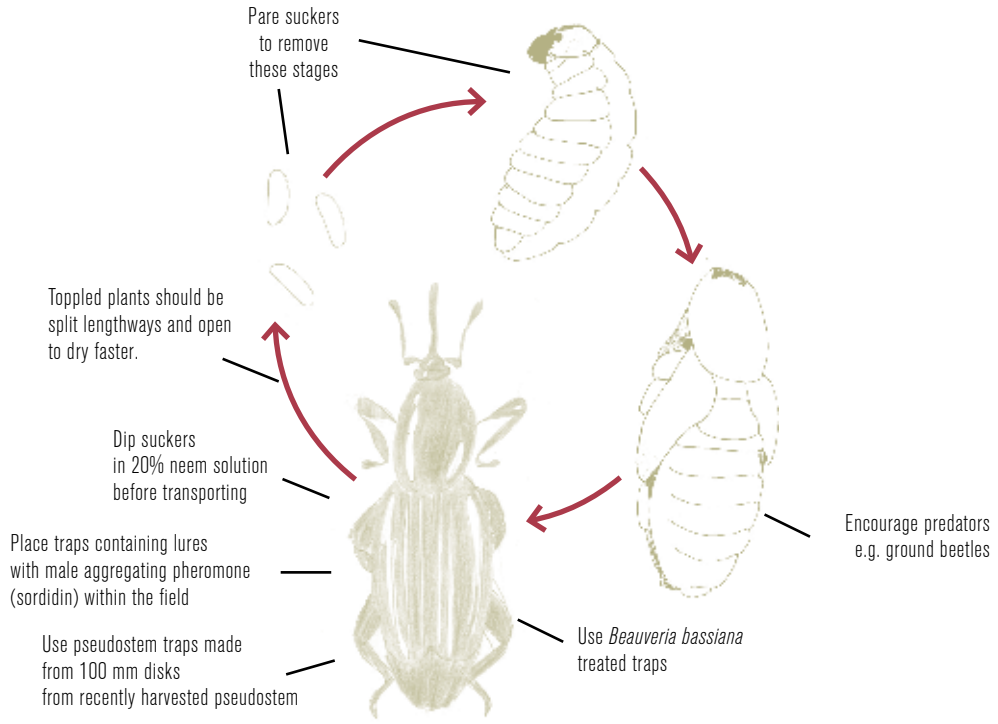
- Use tissue cultured or clean propagation material.

During the production cycle, and particularly in the growth stage

- Use yellow and blue sticky traps to monitor presence of thrip adults.
- Water can be used to wash nymphs off the plants.
- Apply insecticides if necessary, particularly just before placing a bag over the developing bunches. Alternatively, use insecticide impregnated bags (e.g. with bifenthrin or chlorpyrifos insecticide). Bags are placed over the developing bunches once the flower remnant has hardened and the fingers of the fruit curl upwards. Bags should attached to the bunch stalk and remain on the bunch until harvest.
- In organic production plastic bags can be used to cover the developing fruit as a physical barrier.
- Remove and discard infected flowers and foliage.

BANANA WEEVIL

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



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

Nursery/Transplanting

- Where plantings are with suckers all possible precautions should be taken to ensure suckers are clean before transplanting.
- Suckers should be pared to remove weevil larvae and eggs.
- Dip suckers in 20% neem solution to repel adults and potentially lower egg laying.

Field

During the production cycle

- Place pseudostem traps in the field to monitor and mass trap adults. Adults are fond of congregating under damaged plants. Cut 100 mm diameter disks from recently harvested pseudostems. 50 traps per ha, inspect every 5 days.
- If the male aggregating pheromone is available place traps, made from a container with soapy water (3% solution), with the pheromone impregnated lure hung under the cover, in the field in a 20m radius. Four traps per hectare is usually sufficicent. The traps should be monitored weekly and lures changed monthly.
- Toppled plants should be cut lengthways to aid faster drying to minimise attraction by adult weevils and become oviposition sites.

SIGATOKA - *MYCOSPHAERELLA* SPP.

Major elements of the control strategy:

Development stage of the fungus	Action	Cultivation stages					
		Land preparation	Nursery/Transplanting	From transplanting to flowering and fruit set	From fruit development to harvest	Harvesting	After final harvest
Germination on plant	Humidity control is important to suppress spread of the disease, through low density planting, drip irrigation, air flow control		X	X	X	X	
	Plant bananas at least 10 km away from unmanaged plantations	X					
	Apply protectants when temperatures approach 18oC		X	X	X		
	Garlic spray can be applied as a protectant in organic production		X	X	X		
Development in the plant	Use disease free plant material		X				
	Apply systemic fungicide during wet season when disease is more prevalent			X	X		
Development on the crop or weeds	Remove infected leaves, weekly during the rains and monthly during the dry season, to reduce the inoculum in the field			X	X	X	
Conservation in the soil	Select lands with good drainage	X					

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

FUSARIUM WILT (PANAMA WILT) - *FUSARIUM OXYSPORUM F.* SP. *CUBENSE*

Natural factors favourable to the fungus:

Drainage, environmental conditions and soil type influence the development of *Fusarium*. Biologically active soil (high organic matter content) can help suppress the pathogen population.

Major elements of the control strategy:

The disease is spread primarily by infected suckers, less so by water and machinery. If spores get into surface water they can be spread rapidly.

In many countries fungicides have proven uneffective against control of Fusarium wilt. Therefore strict preventive measures should be adopted on the farm to minimise risk of infection. Selection of resistant varieties is the main focus of research at present, although currently no variety is resistant to all four races of the disease.

Development stage of the fungus	Action	Cultivation stages					
		Land preparation	Nursery/Transplanting	From transplanting to flowering and fruit set	From fruit development to harvest	Harvesting	After final harvest
Germination on plant	Use disease free planting material, preferably tissue culture		X				
Development in the plant	A mixture of animal urine, ash and crushed chillies in water is used in organic production of banana in Uganda			X	X	X	X
Dissemination by equipment and water	Restrict movement of people and machinery/tools and water flow in suspected areas of infection			X	X	X	X
Conservation in the soil*	Select lands with good drainage and free from pathogen	X					
Development on crops or weeds	If an area becomes infected. Inject infected trees and a buffer zone with herbicide in situ to reduce disturbance of contaminated material	X	X	X	X	X	X

*As the plant dies the fungus moves into the soil and overseasons as chlamydospores in plant residue, where it can survive for over 20 years.

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

ANTHRACNOSE AND CROWN ROT – MAINLY DUE TO COLLETOTRICHUM MUSA

Natural factors favourable to the fungus:

These pathogens exist in banana fields on dead banana leaf or inflorescence tissues. They disperse by wind and water, and by some insects, birds, and rats.

Major elements of the control strategy:

Development stage of the fungus	Action	Cultivation stages					
		Land preparation	Nursery/Transplanting	From transplanting to flowering and fruit set	From fruit development to harvest	Harvesting	Post harvest
Dissemination	During manual removal of stalks use clean knives and avoid ragged cuts					X	
	Enclose banana bunches on plants in fields with perforated polyethylene sleeves				X		
Germination on fruits	Thin out plant population density and weed to reduce humidity				X	X	
	Wash and dry fruits after harvesting						X
Development in the fruits	Refrigerate fruits after harvest and before ripening (56°F after packing and during shipping is appropriate)						X
	Harvest fruits on time (fruit bunches should be harvested green when the fingers are about three fourths the calliper size of their maximum diameter)					X	
Conservation in the packinghouse	Good sanitation in banana fruit packinghouses (facilities kept clean and orderly)						X
Development on crops or weeds	Regularly prune mats (no more than 3 to 4 pseudostems per mat), de-trashing (once per week), control weeds			X	X	X	

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

BACTERIAL WILT (MOKO DISEASE) – *RALSTONIA SOLANANCEARUM* RACE 2

Natural factors favourable to the bacteria:

High soil moisture is a major factor affecting reproduction and survival.

Major elements of the control strategy

Development stage of the bacteria	Action	Cultivation stages					
		Land preparation	Nursery/Transplanting	From transplanting to flowering and fruit set	From fruit development to harvest	Harvesting	After final harvest
Development on the plant	Drench newly dug hole with EM (effective microorganisms), after activating. Leaf petioles and suckers can also be treated with a dilute solution (1:5). EM compost can be made and placed around the base of the plant	X	X	X			
Development in the plant	Destroy any diseased plants by burning			X	X	X	X
Dissemination by equipment and water	Disinfect tools when moving between plantings	X	X	X	X	X	X
Development on crops or weeds	Remove any host weeds which may provide a bridge for the pathogen between crops	X		X	X	X	X
Conservation in the soil	Crop trash should be removed and destroyed immediately after harvest						X

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

XANTHOMONAS WILT – *XANTHOMONAS VASICOLA* PV. *MUSACEARUM*

Natural factors favourable to the bacteria:

As neutral flowers dehisce "bleeding" occurs from the scars; in infected plants this fluid contains infective bacteria which is picked up by visiting insects (nectar collecting and foraging). This transmission appears to be mechanical, no symbiotic relationship has been found.

Major elements of the control strategy:

Development stage of the bacteria	Action	Cultivation stages					
		Land preparation	Nursery/Transplanting	From transplanting to flowering and fruit set	From fruit development to harvest	Harvesting	After final harvest
Infection in plant	Destroy diseased plants either by rouging and burying or injecting 1.2 ml herbicide into the stem			X	X	X	
Dissemination by mechanical means	Removal of the male bud as soon as the last hand of the bunch is formed, this prevents flower infection				X		
	Disinfect pruning tools during de-suckering once the disease has been detected using flame sterilisation or soaking in sodium hypochlorite solution			X	X		X
	Livestock should be kept out of fields as they can move disease from plant to plant		X				X
	Adopt strict movement controls of plant materials from areas where disease is suspected		X	X	X	X	X
Conservation in the soil	Use sterilised potting media in the nursery. The pathogen is reported to survive for up to two weeks in the soil		X				

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

BANANA BUNCHY TOP VIRUS

Natural factors favourable to the virus:

The virus is transmitted by the banana aphid, *Pentalonia nigronervosa*.

Major elements of the control strategy:

Development stages of the virus	Action	Cultivation stages					
		Land preparation	Nursery/Transplanting	From transplanting to flowering and fruit set	From fruit development to harvest	Harvesting	After final harvest
Dissemination by vectors	Use clean and indexed tissue-cultured material		X				
	Monitor and control aphids		X	X	X	X	
Development on other crops or weeds	Destroy any wild bananas to create a buffer zone around the farm	X	X	X	X	X	X
	Destroy weeds that harbour aphids	X	X	X	X	X	X
Development in the plants	Destroy all the plants in the affected mat and the plants immediately neighbouring them (as virus will move between connecting plants) by injecting with herbicide to kill the whole mat, before removing from field. Any re-growth should be moved immediately and destroyed. Do not cut back plant before it has died, as this may potentially spread the disease			X	X	X	X
	In organic production the infected plants should be dug up completely including the whole mat and any neightbouring plants that are in contact below ground. Material should be removed from site, dried and buried			X	X	X	X

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

NEMATODES

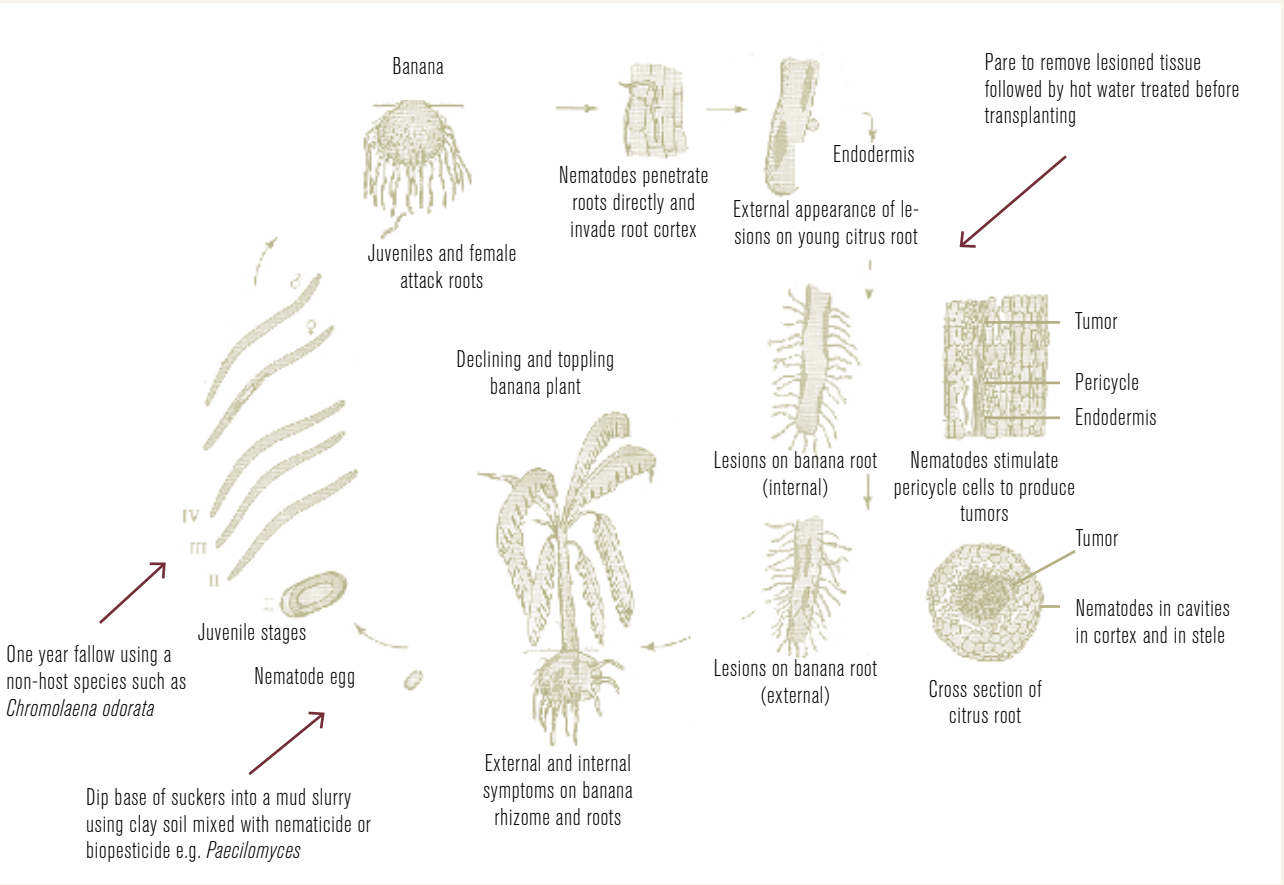
Positioning of control methods in terms of the development cycle for burrowing nematodes - *Rapopholus similis*

Natural factors favourable to the nematode:

Inhabit all types of soil, but are prevalent in poor, eroded soils. Low organic matter and levels of antagonistic micro-organisms contribute to favourable conditions.

To control all stages:

- Improve soil fertility.
- Establish good root development to increase tolerance to nematodes.
- Use nematode free plantlets or plants produced through tissue culture.
- Apply nematicides annually at beginning of rains.



(Adapted from Agrios, 2005)

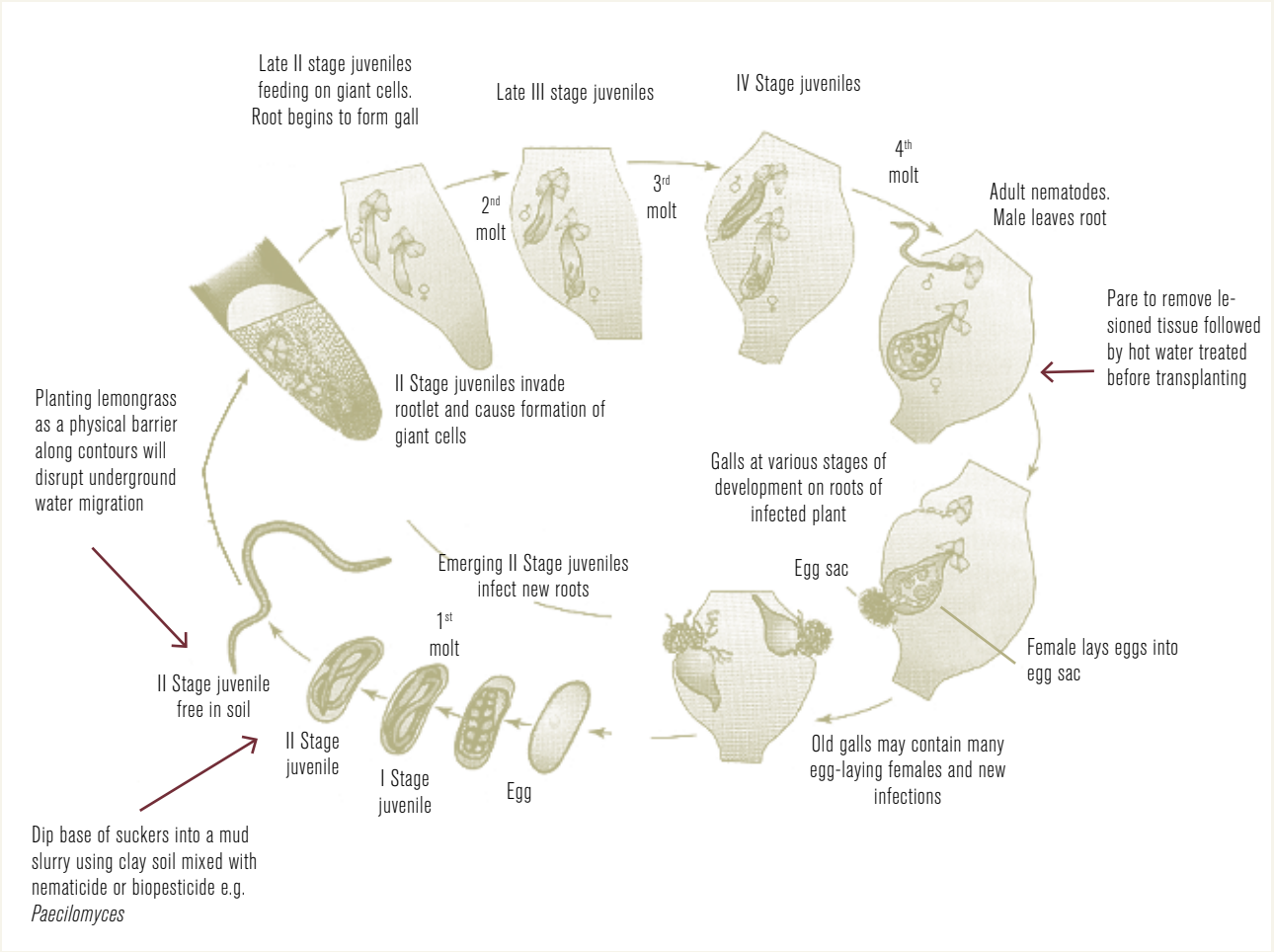
Positioning of control methods in terms of the development cycle for root knot nematodes - *Meloidogyne* spp.

Natural factors favourable to the nematode:

- Duration of lifecycle at optimal temperature of 27°C is 4 - 6 weeks.
- Poor competitors with other nematodes, often occur together with soil borne diseases e.g. fusarium.
- Low organic matter and levels of antagonistic micro-organisms contribute to favourable conditions.

To control all stages:

- Improve soil fertility
- Establish good root development to increase tolerance to nematodes
- Use nematode free plantlets or plants produced through tissue culture
- Intercropping with coriander, sesame, sunhemp and marigold can help suppress populations
- Apply nematicides annually at beginning of rains



(Adapted from Agrios, 2005)

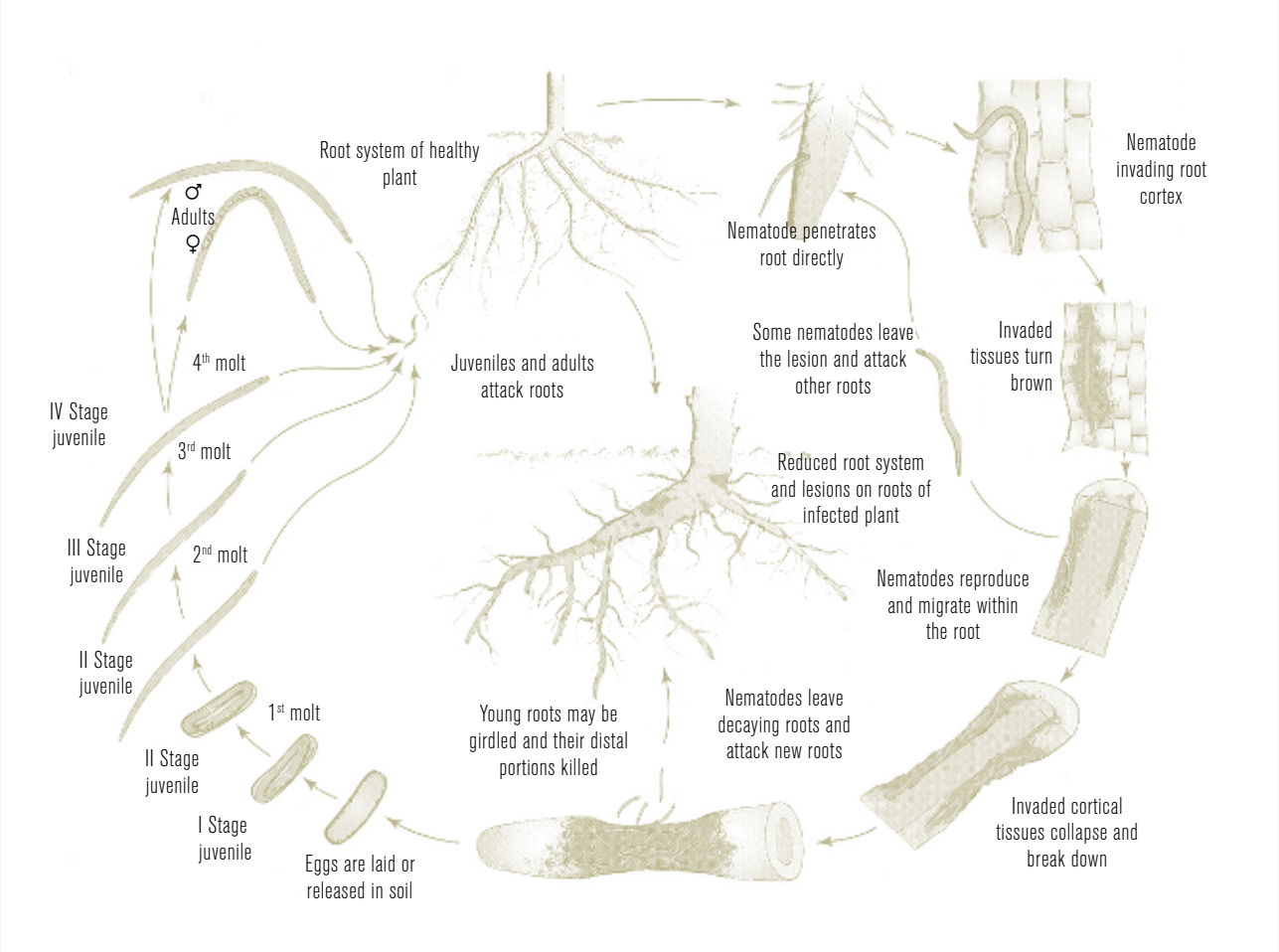
Positioning of control methods in terms of the development cycle for lesion nematodes - *Pratylenchus coffeae*

Natural factors favourable to the nematode:

- Low organic matter and levels of antagonistic micro-organisms contribute to favourable conditions.
- Low pH.

To control all stages:

- Improve soil fertility
- Establish good root development to increase tolerance to nematodes
- Use nematode free plantlets or plants produced through tissue culture
- Fallowing (at least 6 months), and crop rotation
- Apply nematicides annually at beginning of rains



Positioning of control methods of nematodes (root knot, burrowing and lesion) in terms of the development cycle of the plant

In organic production the aim is to prevent nematodes entering the plantations and if present, suppress the build up of populations. There are no organic options to treat an infected plant so it is important to minimise the impact of an attack.

At field planting

- Planting leafy brassicas can be grown prior to planting and turned into the soil. As the plant material breaks down glucosinolates and isothiocynates are released which fumigate the soil.
- At least one year rotation with a non-host plant such as members of the Asteracea family e.g *Chromolaena odorata* will help suppress the mobile juvenile population of burrowing nematode in the soil. In Cameroon, pineapples and sweet potatoes are used in rotation.
- Removing discoloured tissues from banana sets by paring and then dipping into hot water (55°C for 10 minutes) will help minimise the number of nematodes.
- Apply a mud slurry ("pralinage") using a clay soil mixed with a nematicide or a biopesticide such as *Paecilomyces*.

Field:

During the production cycle

- Mulching the crop with clean crop residue or other plant material enhances root development and plant vigour, making the plant able to tolerate nematode damage. The increased organic matter also help enhance natural antagonists of nematodes such as *Mycorrhiza, Paecilomyces lilacinus* and rhizobacteria.
- Incorporating nematicidal plants (such as Tithonia, Neem and *Chromoleana odorata*) into the soil is a potential control for *R. Similis.*
- Apply nematicides if necessary following confirmation from analysed samples.

2.4. Resistant or tolerant varieties

Varieties	Resistance or tolerance			
	Sigatoka	Bunchy top	Panama wilt	Xanthomonas wilt
Ney Poovan (AB group)	X			
Pachanadan (AAB group)	X	X		
Monthan (ABB group)		X		
Karpuravalli (ABB group)	X			
Cavendish (except TR4)			X	X

2.5. Importance and use of natural enemies

Natural enemies such as certain beetles, green lacewing and syrphus fly larvae can play the role of auxiliaries, preventing and limiting population explosions of certain pests. Broad-spectrum insecticides should therefore be avoided as much as possible. The use of selective active substances, when available, is preferred as a means of protecting natural enemies.

Explanations of the importance of natural enemies and ways of encouraging their presence can be found in documents especially dedicated to this matter.

The banana aphid is exotic to Africa and lacks indigenous natural enemies. Classical biological control is being explored that includes testing known natural enemies and exploration for new ones for introduction into Africa.

Various antagonists can control the development of crown rot.

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

Growers should identify insect pests and diseases and inspect their crops regularly for all the species mentioned in this guide. It is easier to control infestations if they are detected at an early stage. It is recommended that growers visit their fields and monitor pest levels at least twice a week.

Certain information is given below on the thresholds whose validity and relevance are to be checked in local conditions.

Banana aphids
Scout plants for colonies at least twice per month, particularly in the young suckers. The first signs of new colonies should be treated to reduce threat of the deadly Bunchy Top Virus.

Banana weevils
If pseudostem traps are being used for monitoring, if more than 2 - 5 weevils/trap are observed control is necessary.

Diseases
Timely and correct diagnosis of diseases is essential for effective intervention. Scouting should be conducted regularly and crops inspected for signs of the initial symptoms of the diseases.

Bunchy Top Virus
Plant petioles should be inspected for morse-code symptoms by rubbing the white, waxy coating off. Plants showing signs of infection should be marked and treated when detected.

Nematodes
Soil samples can be taken regularly before planting and during crop development to monitor the level of the nematode build up.

4. Plant Protection Products and treatment recommendations

Introduction

For each pest or disease, proposals of the strategy for the use of Plant Protection Products (PPP) are indicated. Then a list of active substances is suggested and when available, the recommended critical GAP (Good Agricultural Practice) is also shown.

PHI (Pre Harvest Interval) are indicated to:
- either comply to EU MRL (for products exported to EU) ;
- either comply to Codex MRL (for products consumed in countries referring to Codex MRLs) ;
- either produce without quantifiable residues and so to comply with private standards requiring « 0 » residues.

Any change in one or more elements of these GAPs (increase in the doses, frequency of application and number of applications, last application before harvest not respecting the recommended pre-harvest interval) can result in residues in excess of the MRL in force. These GAPs does not represent a treatment calendar to be applied as such. In practice, the frequency of treatments must take account locally of the severity of attacks and the real risks of damage. No GAPs have been tested by PIP so far in ACP countries.

When there is intrinsically no residues issue for an active substance or a biological agent (highlighted in blue in the tables) the PHI is fixed by default to 2 days.

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

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

Within an organic system organic “teas” such as garlic, chillies and neem are used to deter potential pest threats. Garlic also has the added advantage of having fungicidal properties, and neem has an effect on nematodes.

Banana aphids - *Pentalonia nigronervosa*												
Strategy: It is vital to control aphids as they transmit the deadly Brunchy Top Virus.												
Active substance	Critical GAP*						Proposed application period					
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days) **			Preparation of soil	Nursery	Transplanting	Transplant to flowering	Flowering to harvest
				EU MRL	Codex MRL	LOQ					
Group 4 – Nicotinic acetylcholine receptor agonist/antagonists												
imidacloprid	80	2	/	7	7	7					
thiamethoxam	100	2	7	3	/	/					
Not classified												
garlic extract + pyrethrin + canola oil	/	3	5	2	2	2					
insecticidal soap	/	/	/	2	2	2					
Biologicals												
Metarhizium	/	/	/	2	2	2					

* : the critical GAP for this specific pest

** : see introduction in part 4 of this guide

n.a. : non applicable

/ : elements of the recommended GAP not available

Thrips

Strategy: Apply treatments every two - four weeks during optimal conditions for thrips. Direct sprays towards young developing buds and bunches. If bags are being used, spray before bagging, or use insecticide impregnated bags soon after bunch emergence, once the floral remnants have hardened. If required treat around the base of the plant to control emerging adults from the soil.

Active substance	Critical GAP*						Proposed application period				
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days) **			Preparation of soil	Nursery	Transplanting	Transplant to flowering	Flowering to harvest
				EU MRL	Codex MRL	LOQ					
Group 1 – Organophosphate and carbamates											
chlorpyrifos-ethyl	/	/	14	28	/	/					
diazinon	/	/	/	28	28	28					
Group 5 – Spynosines											
spinosad	0.1 l of a PPP at 480 g/l per 100 litres of water and 60 ml of solution per bunch	/	/	/	/	/					
Not classified											
garlic extract + pyrethrum + canola oil	/	3	5	2	2	2					
Biocontrol Agent											
Metarhizium	/	/	/	2	2	2					
Group 3 – Pyrethroids (sodium channel modulator)											
bifenthrin	33	2	/	1	/	/					

* : the critical GAP for this specific pest

** : see introduction in part 4 of this guide

n.a. : non applicable

/ : elements of the recommended GAP not available

Banana weevils - *Cosmopolites sordidus*											
Strategy: Optimal application time is immediately after rain which will be the best opportunity for adults to come into contact with inecticides. Treatment for nematodes often controls weevils as well.											
Active substance	Critical GAP*						Proposed application period				
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days) **			Preparation of soil	Nursery	Transplanting	Transplant to flowering	Flowering to harvest
				EU MRL	Codex MRL	LOQ					
Group 1 – Organophosphate and carbamates											
cadusafos	3 g/plant	3 times a year	/	/	/	/					
carbofuran	/	/	/	/	/	/					
ethoprophos	4.5 g/plant	3 times a year	90	/	/	/					
fosthiazate	2 g/plant	/	/	/	/	/					
terbufos	3 g/plant	3 times a year	/	/	/	/					
Group 18 – Ecdysone aganists/moulting disruptors											
azadirachtin	/	1	/	/	/	/					
Biologicals											
Beauveria bassiana	/	/	/	2	2	2					
Metarhizium	/	/	/	2	2	2					
Group 3 – Pyrethroids (sodium channel modulator)											
zeta-cypermethrin	0.1 g per pseudo stem***	1	n.a.	/	/	/					
Group 2 – GABA-gated chloride channel antagonists											
fipronil	0.15 g/plant	2 times a year	90	3	/	/					
Group 4 – Nicotinic acetylcholine receptor agonist/antagonists											
imidacloprid	0.25 g / plant 500 g/ha	1	/	/	/	/					

* : the critical GAP for this specific pest

** : see introduction in part 4 of this guide

*** : applied in powder in the soil around at the base and around the pseudo stem

n.a. : non applicable

/ : elements of the recommended GAP not available

Sigatoka – *Mycosphaerella* spp.

Strategy: Apply protectants when temperatures approach 18°C, use with oils to aid stickiness. Commence treatment at the beginning and then throughout the rainy season.

Active substance	Critical GAP*						Proposed application period				
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days) **			Preparation of soil	Nursery	Transplanting	Transplant to flowering	Flowering to harvest
				EU MRL	Codex MRL	LOQ					
Group M – Multisite activity											
chlorothalonil	1440	/	/	/	/	/					
copper oxychloride	340	/	21	14	/	/					
mancozeb + oil	1600 + 5 litre of oil	/	14	/	/	/					
Group 3 – DMI fungicides											
bitertanol	150	3	15	0	0	/					
difenoconazole	100	2	14	1	/	/					
propiconazole	100	3	42	1	/	/					
tebuconazole	100	3	21	0	0	/					
triadimenol	Nursery: 0.05 g/plant Transplanting: 0.5 g/plant Infection: 0.75 g/plant	1	/	14	14	/					
epoxiconazole	75	3	28	1	/	/					
triadimefon + oil	100 + 12 litre of oil	/	/	/	/	/					
Group 1 – MBC fungicides											
benomyl	125	/	14	14	/	/					
thiophanate-methyl	300	/	/	/	/	/					
Group 5 – Amines "Morpholines"											
fenpropidin	375	2	30	3	/	/					
fenpropimorph	440	6	28	1	/	/					
tridemorph	430	6	28	1	/	/					
Group 11 – QoI fungicides											
azoxystrobin	100	/	/	/	/	/					
pyraclostrobin	75-100	2	28	1	/	/					
trifloxystrobin	75***	4	12	0	0	/					
Group 7 – Carboxamides											
boscalid	150	2	28	1	/	/					
Biocontrol Agent											
Trichoderma + Bacillus subtilis	/	/	/	2	2	2					

* : the critical GAP for this specific pest

** : see introduction in part 4 of this guide

*** : maximum 27 % of oil in the solution. Application on packed bunches

n.a. : non applicable

/ : elements of the recommended GAP not available

Anthracnose and crown rot

Strategy: A fungicide could be applied to banana fruits after deflowering fingers and before bagging. Dips or sprays of fungicides at postharvest.

Active substance	Critical GAP*						Proposed application period					
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days) **			Preparation of soil	Nursery	Transplanting	Transplant to flowering	Flowering to harvest	Post harvest
				EU MRL	Codex MRL	LOQ						
Group M – Multisite activity												
copper oxychloride	340	/	21	14	/	/						
Group 3 – DMI fungicides												
bitertanol	21 g /100 litre of water ***	1	n.a.	p.h.	/	/						
imazalil	37.5 g /100 litre of water ***	1	n.a.	p.h.	/	/						
Group 1 – MBC Fungicides												
thiabendazole	44 g /100 litre of water ***	1	n.a.	p.h.	/	/						
Biocontrol Agent												
Trichoderma asperellum	/	/	/	/	/	/						

Other treatments

Optimum temperature and exposure time for postharvest hot water treatment of banana were determined to be 50°C and 3 min, respectively. Temperatures higher than 50°C reduced the colour of fruit peel and gave a pale appearance to fruit even after ripening. Exposure times longer than 5 min substantially reduced the Brix value. A member of the Burkholderia cepacia complex, isolated from the fructosphere of banana was effective as an antagonist of postharvest pathogens even after 5 years of storage in sterile distilled water at ambient temperature.

The most effective control was achieved by repeated dipping of bananas in bacterial solution or by adding a wetter (Tween 20) to the bacterial solution. Combining hot water treatment with the bacterial antagonist also gave more effective control of anthracnose, crown rot and blossom end rot than using the two treatments individually.

Acetic acid, citric acid and ascorbic acid dips were reported to be effective in controlling postharvest diseases of bananas.

* : the critical GAP for this specific pest
** : see introduction in part 4 of this guide
*** : dipping
n.a. : non applicable
p.h. : post harvest
/ : elements of the recommended GAP not available

Nematodes												
Strategy: Treat soil, particularly around base of daughter plant, for nematodes at the beginning of the rainy season as the water table starts to rise, follow up with applications when necessary. If land is prone to nematodes treat at transplanting.												
Active substance	Critical GAP*						Proposed application period					
	Dose g/ ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days) **			Preparation of soil	Nursery	Transplanting	Transplant to flowering	Flowering to harvest	
				EU MRL	Codex MRL	LOQ						
Group 1 – Organophosphate and carbamates												
cadusafos	20 g/ plant	2 to 3 times a year	/	/	/	/						
carbofuran	3 g/plant	2 to 3 times a year	/	/	/	/						
carbosulfan	/	/	/	/	/	/						
ethoprophos	4.5 g/ plant	3 times a year	90	/	/	/						
fenamifos	3 g/plant	3 times a year	90	90	90	/						
fosthiazate	2 g/plant	1	/	/	/	/						
oxamyl	3600 g/ ha	1	/	/	/	/						
terbufos	3 g/plant	3 times a year	/	/	/	/						
Group 18 – Ecdysone aganists/moulting disruptors												
azadirachtine	/	/	/	2	2	2						
Biocontrol agents												
Paecilomyces lilacinus	/	/	/	2	2	2						
Trichoderma asperellum	/	/	/	2	2	2						
Aldehydes												
furfural	45	/	28	14	/	/						

* : the critical GAP for this specific pest

** : see introduction in part 4 of this guide

n.a. : non applicable

/ : elements of the recommended GAP not available

Banana Bunchy Top Virus									
Strategy: Herbicides used to kill any infected plants by injecting into the pseudostem at least 30cm above the ground (except in small plants where application should be vertically into the top).									
Active substance	Recommended GAP*				Proposed application period				
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days) **	Preparation of soil	Nursery	Transplanting	Transplant to flowering	First to final harvest
2.4 - D	1ml of a PPP at 720 g/l in 20 ml of water per plant	1	n.a.	Remove all fruits from the treated plant					
glyphosate	1ml of a PPP at 360 g/l in 20 ml of water per plant	1	n.a.						

* : the critical GAP for this specific pest

** : no PHI since all fruits should be removed from treated plants

n.a. : non applicable

/ : elements of the recommended GAP not available

5. Existing registrations in ACP countries

Registration in Ivory Coast

(source http://www.isysphyt.ci/index.php?option=com_docman&task=cat_view&gid=29&Itemid=60)
Post-harvest diseases: ascorbic acid (vitamin C), thiabendazole.
Banana leafspot: azoxystrobine, bitertanol, chlorothalonil, difenoconazole, fenpropimorph, mancozeb, propiconazole, pyraclostrobine, thiophante-methyl, tridimefon, boscalid, tridemorph, epoxiconazole.
Nematodes: cadusafos, carbofuran, carbosulfan, ethoprophos, fenamifos, fosthiazate, terbufos.
Weevils: carbofuran, sordidine (attractant), terbufos, zeta-cypermethrin.

Registration in Cameroon

Banana leafspot: tridemorph, fenpropimorph, epoxiconazole.
Weevils: fipronil.

Registration in Dominican Republic

Data not available

For **Zambie,** the registrations issued from other reputable countries apply. .

Registered insecticides/nematicides in Uganda

Active ingredient	Type of registration	Aphids	Thrips	Banana Weevil	Nematodes
Bifenthrin	All crops		X	X	
Chlorpyrifos	All crops		X		X
Imidacloprid	All crops	X	X		
Insecticidal soap	All crops	X	X		
Oxamyl	All crops			X	X

Registered fungicides in Uganda

Active ingredient	Type of registration	Sigatoka Banana leafspot
Mancozeb	All crops	X

6. Regulations and pesticide residues

Status of the active substances in regulation 1107/2009, European MRLs and Codex MRLs - Updated in September 2011

Caution: The information contained in this table is subject to change by future decisions of the EU Commission and Codex.

Active substance	European regulation		Codex MRL
	Status REG 1107/2009	EU MRL	
azadirachtin	Approved	/	/
azoxystrobine	Approved	0.01*	/
ascorbic acid	Pending	2	/
Bacillus subtilis	Approved	n.a.	/
Beauveria bassania	Approved	/	/
benomyl	Not Approved	0.1*	0.2
bifenthrin	Not Approved	0.1	/
bitertanol	Not Approved	3	0.5
boscalid	Approved	0.3	0.2
cadusafos	Not Approved	0.01*	0.01*
carbofuran	Not Approved	0.02*	0.1
carbosulfan	Not Approved	0.05*	/
chlorothalonil	Approved	0.2	0.01*
chlorpyrifos-ethyl	Approved	3	2
copper	Approved	20	/
diazinon	Not Approved	0.01*	/
difenoconazole	Approved	0.1	/
epoxiconazole	Approved	0.5	/
ethoprophos	Approved	0.02*	0.02*
fenamifos	Approved	0.05*	0.05*
fenpropidin	Approved	0.5	/
fenpropimorph	Approved	2	2
fipronil	Approved	0.005*	0.005*
fosthiazate	Approved	0.05*	/
furfural	Not Approved	1	/
garlic extract	Approved	n.a.	/
glyphosate	Approved	0.1	0.05*
imazalil	Approved	n.a.	/
imidacloprid	Approved	2	2
mancozeb	Approved	0.05*	0.05*
Metarhizium	Approved	2	2
oxamyl	Approved	n.a.	/
Paecilomyces lilacinus	Approved	0.01*	/
propiconazole	Approved	n.a.	/
pyraclostrobine	Approved	0.1	0.1
pyrethrins	Approved	0.02*	0.02*
rape seed oil (canola oil)	Approved	1	/
sordidine	/	/	/
spinosad	Approved	0.02*	/
tebuconazole	Approved	0.05*	0.05*
terbufos	Not Approved	0.05*	0.05*
thiabendazole	Approved	5	5
thiametoxam	Approved	0.05*	/
thiophanate-methyl	Approved	0.1*	/
triadimefon	Not Approved	1	/
triadiménol	Approved	1	0.2
Trichoderma asperellum	Approved	n.a.	/
tridemorph	Not Approved	0.05*	/
trifloxystrobin	Approved	0.05*	0.05*
zeta-cypermethrin	Approved	0.05*	/
2.4 D	Approved	0.05*	/

Approved: active substance allowed for selling in the PPPs market in EU

Not approved: active substance not allowed for sending in the PPPs EU market, but can be used by growers outside of EU as far as residues comply with current EU MRL if the commodity is exported to EU.

* = LOQ
n.a. not applicable
/ = doesn't exist or not available

Note on the status of active substances in EU

Before a Plant Protection Product can be marketed in EU, its active substance must be approved by the European Commission.

Regulation (EC) 1107/2009 (replacing former "Directive 91/414/EEC") came into force on 14th June 2011. By 25th May 2011 the Commission adopted the Implementing Regulation (EU) N° 540/2011 as regards the list of approved active substances. These Regulations and all other related Regulations can be accessed using the search facility on the following: http://ec.europa.eu/food/plant/protection/evaluation/index_en.htm

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

Note on MRLs:

The quantities of pesticide residues found in food must be safe for consumers and remain as low as possible.
The maximum residue limit (MRL) is the maximum concentration of pesticide residue legally permitted in or on food or feed.

MRLs in the EU

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

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

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

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

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

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

How are MRLs applied and monitored in EU?

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

MRLs in ACP countries – Codex

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

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

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

Annexes

References and useful documents

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http://bananas.bioversityinternational.org/files/files/pdf/publications/disease8fr.pdf

Useful Websites

http://www.aaas.org/international/africa/enset/enset.pdf - The "Tree Against Hunger" Enset-Based Agricultural Systems in Ethiopia.

http://www.eppo.org - Information relating to management of quarantine pests within the member countries.

http://www.promusa.org/index.php - A portal for sharing information about research and developments efforts with Bananas.

http://www.bioversityinternational.org/bioversity_international_homepage.html and http://bananas.bioversityinternational.org/ Publications and factsheets on different pests and diseases of banana.

http://www.ctahr.hawaii.edu/banana/index.asp - Useful information on Banana Bunchy Top Virus.

http://www.chemplastintl.com/biflex/ - Information about Biflex treebugs to protect bananas from a range of pests.

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CROP PRODUCTION PROTOCOLS

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

GUIDES TO GOOD PLANT PROTECTION PRACTICES

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

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