PIP

GUIDE TO GOOD CROP PROTECTION PRACTICES

FOR COCONUTS (*COCOS NUCIFERA*)

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PIP

FOR SUSTAINABLE DEVELOPMENT OF THE ACP HORTICULTURAL INDUSTRY

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Note

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

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

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

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1. Main pests and diseases

1.1. Importance and impact on yield and quality

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

- the level of economic importance generally observed in ACP countries rated on the following scale: + = low, ++ = average, +++ = high;
- the parts of the plant affected and how they are attacked;
- the resulting types of loss, all of which decrease the yield of marketable fruits and consequently end up causing a loss of financial income. The presence of pests and diseases can reduce yield and cause losses at different levels: fewer plants per hectare, less fruits per plant, smaller-sized fruits, lower quality of fruits.

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

INSECTS								
Extent	Organs attacked				Types of loss			
	Stalks	Leaves	Flowers	Fruits	Number of plants	Number of fruits/plant	Size of fruit	Quality of fruit at maturity
Coconut bugs (coreid bugs) ***Pseudotheraptus wayi*** (East Africa) ***Pseudotheraptus devastans*** (West Africa) ***Amblypelta cocophaga*** (Pacific)								
+++			Adults and nymphs suck on flowers, young fruits up to five months old and sometimes older nuts			Reduced by flowers and young fruits shedding		Attacks on older nuts may cause deformations
Pentatomid bug - *Axiagastus cambelli*								
This bug is wide spread in the Pacific area.								
+++			It sucks the flowers			Reduced by flowers shedding		
Coconut scale - *Aspidiotus destructor*								
Mostly young coconut trees of up to 10-15 years are vulnerable to damage.								
+	Scales feed mainly on the undersides of the leaves, but frond stalks, flower clusters and young nuts can also be attacked				The crowns of severely attacked palms die leading to collapse of the palms	Attacked young nuts shrivel and fall off prematurely		

INSECTS (continued)								
Extent	Organs attacked				Types of loss			
	Stalks	Leaves	Flowers	Fruits	Number of plants	Number of fruits/plant	Size of fruit	Quality of fruit at maturity
Greater Coconut Spike Moth - *Tirathaba complexa*								
Reported from many Pacific islands.								
+			The caterpillars bore on male and female flowers as well as young fruits			Flowers and fruits fall prematurely. Damage is often limited, since an important percentage of the flowers and fruits are shed in any case		

INSECTS (continued)							
Extent	Organs attacked			Types of loss			
	Roots	Stem	Leaves	Number of plants	Number of fruits/plant	Size of fruit	Quality of fruit at maturity
The African palm weevil - *Rhynchophorus phoenicis* - QO							
Rhynchophorus phoenicis usually damages young palms, yet may also, in exceptional cases, cause damage to mature crops.							
+		Grubs feed inside the stem making several galleries		Grubs may destroy the growing point killing the palms As the galleries become more extensive, the trunk weakens and may break in a storm			
Rhinoceros beetles - *Oryctes monoceros, O. boas* (African rhinoceros beetles) and *Oryctes rhinoceros* (The Asian rhinoceros beetle present in Papua New Guinea, Samoa, Tonga, Fiji, Micronesia and Mauritius)							
Attacks by adults may provide entry points for lethal secondary attacks by the palm weevils or by plant pathogens (diseases).							
+++			The adult chews and cuts the youngest unopened leaves and the vegetative bud. In rare cases unopened spadices are attacked	Young palms, particularly palms less than four years old, usually die if the whole growing point is eaten Severely attacked young palms may survive but their development to the nut-bearing stage is greatly retarded	The yield of nut-bearing trees is hardly affected by slight feeding damage of the beetles on the leaves. However, severe defoliation may lead to reduction in nut yield		
Termites ***Macrotermes bellicosus (Bellicositermes nigeriensis)*** (West Africa) ***Allodontermes morogoroensis = Allontodermes tenax*** ***Macrotermes goliath*** (East Africa) ***Nasutitermes novarumhebridarum*** (the Pacific) ***Microcerotermes biroi*** (on the Solomon Islands)							
The commonest pest termites in Africa belong to species in the genera *Macrotermes, Odontotermes* and *Microtermes.*							
++	Termites feed on all parts of young coconut palms			Losses can be higher than 50% of nursery seedlings or recently transplanted palms			

MITES						
Extent	Organs attacked		Types of loss			
	Leaves	Fruits	Number of plants	Number of fruits/plant	Size of fruit	Quality of fruit at maturity
Coconut mite - *Aceria (=Eriophyes) guerreronis*						
+++		Adults and nymphs feed on the upper part of the nutlets under the bracts, on nutlets of up to 6 months old		Attacked nuts may fall prematurely	In coconuts with light scarring on the husk due to mite feeding, the nut inside is not seriously affected, but heavily scarred nuts are smaller, with reduced kernel content (reduction in copra content). The production decline may on average be about 10 to 20%	

FUNGI					
Extent	Organs attacked	Types of loss			
	Leaves, buds, fruits	Number of plants	Number of fruits/ plant	Size of fruit	Quality of fruit at maturity
Bud rot - *Phytophthora palmivora, P. katsurae*					
Phytophthora palmivora and *P. katsurae* exhibit similar losses on coconuts but they differ on extent of host range and geographical distribution. *P. palmivora* has an extensive host range of more than 200 plant species and it is widespread in the tropics including tropical Africa. *P. katsurae* is restricted to Japanese chestnut tree, cocoa and coconut, and in terms of distribution, particularly in Africa, it has only been reported in Ivory Coast in West Africa. However, both share the same epidemiological parameters.					
+	The fungus enter into the plant by infecting the tender host tissue (leaves, buds, young nuts)	Bud rot disease is sporadic in East Africa but may cause severe losses in other regions of the world due to loss of mature trees 15-25 years old. In certain regions in Ivory Coast up to 50% of the coconuts initially planted are reportedly killed by bud rot	Young nuts fail to mature; they then fall off. In Ivory Coast 20 to 25% nut fall can be attributed to *Phytophthora* infection		

FUNGI (continued)					
Extent	Organs attacked	Types of loss			
	Roots	Number of plants	Number of fruits/ plant	Size of fruit	Quality of fruit at maturity
Lethal bole rot - *Marasmiellus cocophilus*					
Host range of *Marasmiellus cocophilus* extends to *Echinochloa colonum* (jungle rice), *Eleusine indica* (fowlfoot grass), and *Cynodon dactylon* (Bermuda grass).					
+	The fungus enters the palm via the roots, Root infections occur, leading to decay of basal tissues and finally a rot of the spear leaf	Infection by this fungus causes death of palms up to 8 years old, seedlings being highly susceptible on transplanting to the field. Losses of over 90% have been recorded in East Africa			

MYCOPLASMA-LIKE ORGANISMS (MLOS) / PHYTOPLASMAS					
Extent	Organs attacked	Types of loss			
	The whole plant	Number of plants	Number of fruits/ plant	Size of fruit	Quality of fruit at maturity
Lethal disease (lethal yellowing)					
Phytoplasmas are transmitted in a persistent (circulative-propagative) manner primarily by insect vectors belonging to the families *Cicadelloidea* (leafhoppers) and *Fulgoroidea* (planthoppers). The disease is particularly serious in the East African coast.					
+++	The phytoplasma spread in the whole plant after entering in the plant	Infected palms usually die within 3 to 6 months after the appearance of the first symptoms. Lethal disease may decimate entire plantations	Necrosis of inflorescences and premature nut fall regardless of the developmental stage of nuts lead to lack of fruit set		

Others various Coleoptera occurs in Pacific Islands:

Promecotheca coeruleipennis (*Chrysomelidae Hispinae*) occurs in many Pacific Islands: Fidji, Tonga, Samoa, etc. (Taylor, 1937). *P. coeruleipennis* is normally controlled by the egg parasite *Oligosita utilis* Kowalski (*Trichogrammatidae*) and the parasite of the larvae, *Elasmus hispidarum* Ferrière (*Elasmidae - Hymenoptera*). The omnivorous mite *Pyemotes ventricosus* Newport can destroy almost all larvae and nymphs, which has caused important imbalances between the pest and its other parasites, resulting in even greater pest infestation the following year. This required the introduction of *Pediobius parvulus*, which also feeds on *Pyemotes cumingi* and which can survive the time span between one generation of its host and the next. This species has been equally successfully introduced in New Britain (Papua New Guinea) for the control of outbreaks of *Promecotheca papuana* Csiki (Gressit, 1959), where the local egg parasite *Closterocerus splendens* Kowalski and the parasites of the larvae, *Eurytoma promecothecae* Ferrière and *Apleurotropis lalori* Girault did not give sufficient control. On Vanuatu *Promecotheca opacicollis* Gestro is mainly controlled by the egg parasite *Oligosita utilis* Kowalski (Kowalski, 1917 and Risbec, 1937).

Other species of *coleoptera* in all stages of their development, live between the leaflets of leaves not yet unfolded. *Brontispa longissima* Gestro is widespread in south east Asia and the Pacific. Larvae and adults feed on the leaflet tissue in narrow. In cases of severe attack, the palms may become completely defoliated. This type of damage is very harmful to the coconut palm, particularly when the emission of new leaves is rather slow, especially when the palm is young, or when it grows under unfavourable agronomic conditions. The life cycle differs according to the situation and also according to the various authors. In Indonesia, the complete cycle covers 5-7 weeks (Kalshoven, 1957). Adults are slender and long, measuring 8-12 mm. The colour varies between localities. Thus, the reddish brown types dominate in Java, whereas the almost completely black ones are found in the Solomon Islands and Papua New Guinea. Some authors attach special importance to the geographic races. The parasite composition includes various species, as much for the eggs (the chalcids from the *Trichogrammatidae* family like *Haeckeliana brontispae* (= *Hispidophila brontispae*) Ferrière and *Trichogrammatoidea nana* Zehntner, and *Ooencyrtus* sp. from the family *Encyrtidae*), as for the larvae (*Tetrastichus brontispae* Ferrière from the *Eulophidae*).

1.2. Identification and damage

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

INSECTS

Coconut or coreid bugs - *Pseudotheraptus wayi, P. devastans, Amblypelta cocophaga*

Adult bugs are brown in colour and 12 to 16 mm long according to their sex, the males being somewhat smaller with antennae as long as their bodies. Females lay eggs singly on the flowers, young nuts and spathe. Nymphs are red brown to green brown in colour and have long antenna. Adults and nymphs suck on flowers and developing fruits. The toxic saliva of the bugs causes necrotic sunken lesions (scars) and cracks on the nuts. Attacked young nuts exude gum. Many of the attacked young nuts fall off. Nuts older than three months at the time of attack may not be aborted but remain small and have scars. Nuts which abort naturally do not show scars or gummosis.

Egg

Coconut bug on young bunch

Nutlet damaged

Low nut set due to abortion caused by coconut bug

Nutlet damaged

Coconut bug damage

INSECTS (continued)

Pentatomid bug (coconut spathe bug) - *Axiagastus cambelli*

Adults are 13 mm long and 7 mm wide. They are dark brown with yellow marks. They give off a bad smell when disturbed.

Coconut scale - *Aspidiotus destructor*

The coconut scale is bright yellow and round (females) or reddish and oval (males); the body is covered with a semitransparent greyish white flat scale. The scale diameter is 1.5 to 2.0 mm. Females are always wingless and remain under their scale their entire life. Adult males have one pair of membranous wings, move about actively in search of females and do not feed during the adult stage. Eggs are laid under the scale or shell of the mother scale. Upon hatching the young scales crawl out from underneath searching for a site to feed, usually on the undersides of leaves and tender shoots and on leaf tips. Once they take up position and start feeding they do not move. Scales are mainly found on the undersides of the leaves, but frond stalks, flower clusters and young nuts can also be attacked. A severe infestation of this armoured scale forms a continuous crust over flower spikes, young nuts and the lower surface of leaves. The leaves become yellow and, in extreme cases, the leaves dry out, entire fronds drop off and the crown dies. Attacks of young nuts cause shrivelling of nuts leading to premature nut falls.

Scales on coconuts

Scales on a leaf

Greater Coconut Spike Moth - *Tirathaba complexa*

The moths have a span of about 25 mm and are uniformly greyish brown coloured with a silvery aspect. The caterpillar reaches a length of 27 mm, it is glossy brown and has long antennae projecting forward. The pupal stage develops in a silken cocoon. The caterpillars develop on male and female flowers as well as young fruits into which they bore.

The African Palm weevil - *Rhynchophorus phoenicis*

Adults are large beetles, 40-55 mm in length, reddish brown in colour, and generally has two reddish bands on the thorax. Female beetles lay eggs on wounds of various origins, on the mature stem as well as in the crown. Upon hatching the larvae (grubs) penetrate into the living tissues of the palm, feeding on the shoot and young leaves, where the insect completes its development in about 3 months. The damaged tissues turn necrotic and decay. Sometimes the grubs feed on the growing point killing the palm. Grubs are whitish-yellow, legless, and oval in shape; their head is reddish brown, and is armed with strong mandibles. Fully-grown grubs are 50 to 60 mm long. The pupal stage is passed within a cocoon of vegetal debris made by the grub at the end of its development.

Adults

Cocoon

INSECTS (continued)

Rhinoceros beetles - *Oryctes monoceros, O. boas, O. rhinoceros*

The rhinoceros beetles are stout insects, about 3.5 to 5 cm long, shiny dark brown to black in colour with a curved horn on the head, hence its common name. The horn is more developed on males than on females. The adult flies at night to palms and bore into the heart of the palms spear, chewing and cutting the youngest unopened leaves and the vegetative bud. Attacked leaves continue to develop and unfold showing the characteristic V-shape damage. The boreholes are often marked with a bundle of frass pushed out of the hole by the beetle. Eggs are laid in rotting plant material, especially dead palm trunks, compost heaps and rubbish dumps. They are white, oval, and about 4 mm long. The larvae (grubs) are white-greyish, have three pairs of well developed legs and a brown head equipped with strong mandibles. They are usually found curled in a characteristic "C" shaped position. They develop in rotten coconut logs and other decaying material. The pupa is fat, brown and about 4 cm long. The pupal stage, which takes about 20-25 days, is passed in a chamber cut in the harder part of the wood, or within a fibrous cover. Nursery seedlings are attacked at the level of the collar and both the terminal bud and the nut are penetrated, which kills the plant. One-year-old trees become infested at the axils of the later-developing fronds, while trees that are at least 2 years old are attacked at the level of the first fronds, nearer the base.

Adult

Grubs

Eggs

Young palm damaged

Dead palms serve as breeding ground for the pest

INSECTS (continued)

Termites - ***Macrotermes bellicosus (Bellicositermes nigeriensis)*** (West Africa),
Allodontermes morogoroensis = Allontodermes tenax, Macrotermes goliath (East Africa),
Nasutitermes novarumhebridarum (the Pacific), ***Microcerotermes biroi*** (on the Solomon Islands)

Termites are small to medium-sized (4-15 mm long), soft-bodied insetcs. They are whitish to brownish in colour and have short thread or bead-like antenna. Termites live in colonies (consisting of many workers, soldiers and reproductive forms) in the soil in mounds, from which they construct subterranean tunnels to the palms and feed on all parts of young coconut palms. Termites may also reach feeding sites via surface foraging trails.

MITES

The coconut mite - ***Aceria (=Eriophyes) guerreronis***

The coconut mite is tiny (200-250 microns long and 36-52 microns broad) and difficult to see with the naked eye. When very many mites are together they appear as fine whitish dust. This mite lives under the protection of the floral parts of the fruits, the bracts, where it feeds on the developing tissues. Attacked nuts may prematurely fall or have a scarred husk, which often splits. Heavily attacked nuts that do not fall are smaller than healthy nuts.

Coconut bunches with severe mites damage

Damage on a coconut

FUNGI

Bud rot - *Phytophthora palmivora, P. katsurae*

Seedling infected with bud rot

The first symptoms of bud rot is turning yellow then brown of spear leaves and withering of the youngest unfolded leaf. The disease may spread to older adjacent leaves and spathes. Light brown speckles are present on the petiole bases of the youngest leaves, and on those of older leaves large yellowish to brown necrotic areas may be observed. As the spear wilts and collapses, it hangs down between the older leaves, which remain green and retain their position for several months, producing a dead centre with a fringe of living leaves which is very characteristic of this disease. The leaves fall progressively, one by one, starting with the youngest ones; the fall of the leaves extends over a period of 8-12 months until only the bare stem remains. Apparently healthy trees in contaminated areas may show symptoms in the petiole bases alone, or also in stem and bud. Dissection of trees with nascent external symptoms often invisible to the untrained eye reveals the existence of a bad-smelling internal rot, already in an advanced stage of development, with a consistency of soft cheese, and purple to pale pink in colour. However, this bad smell is not a characteristic of bud rot alone, as it develops in all palm diseases that cause the death of the central spear. However, bud rot is surrounded by a brown border, and a few brown fibres can be seen towards the base in the unaffected area. Infected nuts show brown to black necrotic areas with a yellow border developing on the surface; internally, they have a mottled appearance. Young nuts are highly susceptible and fail to mature, they then fall off the tree; older infected nuts ripen normally. However, in Hawaii abnormal loss of small to almost mature nuts has been observed as a common early sign of the disease.

Lethal bole rot - *Marasmiellus cocophilus*

Seedling affected by dry bole rot

Lethal bole rot is caused by the fungus *Marasmiellus cocophilus* that infects roots of palms via wounds. In East Africa, symptoms of infection are decay of basal tissues and finally a rot of the spear leaf. These symptoms are most often seen on seedlings after transplanting to the field. On older palms, the first symptoms are a general wilt of the fronds, which remain as a 'skirt' around the trunk. The spear leaf dies and a foul-smelling soft rot develops at the base of the leaves. A dry, reddish-brown rot with a yellow margin is typically present at the base of the bole. Cavities within these areas of rot are lined with mycelium (fungal growth) in young palms, 2-4 years old, but rare in 4-6 year-old palms, and absent in mature palms. Fungal bodies (like small mushrooms) commonly occur on exposed roots, leaf bases of seedlings, exposed tops of seed nuts and on the soil surface around holes (growing from coconut debris) where diseased palms had been removed 2 years previously. Generally there are only 8 weeks from the time of onset of symptoms till the death of the palm; this interval depended on the extent of fungal decay in the bole.

MYCOPLASMA-LIKE ORGANISMS (MLOs) / PHYTOPLASMAS

Lethal yellowing

Symptoms include premature shedding of all nuts regardless of their developmental stage, necrosis of inflorescences and yellowing of leaves. Aborted nuts often develop a brown-black calyx-end rot reducing seed viability. Premature nut fall is accompanied or followed by inflorescence necrosis. This next symptom is most readily observed as newly mature inflorescences emerge from the ensheathing spathe. Affected inflorescences are partially blackened (necrotic) usually at the tips of flower spikelets. As disease progresses, additional emergent or unemerged inflorescences show more extensive necrosis and may be totally discoloured. This results in the death of most male flowers and an associated lack of fruit set. Yellowing of the leaves usually starts once necrosis has developed on two or more inflorescences and discoloration is more rapid than that associated with normal leaf senescence. Yellowing begins with the older (lowermost) leaves and progresses upward to involve the entire crown. Yellowed leaves turn brown, desiccate and die. In some cases, the advent of this symptom is seen as a single yellow leaf (flag leaf) in the mid-crown. Affected leaves often hang down forming a skirt around the trunk for several days before falling. A putrid basal soft rot of the newly emerged spear (youngest leaf) occurs once foliar yellowing is advanced. Spear leaf collapse and rot of the apical meristem invariably precedes death of the palm at which point the crown topples away leaving a bare trunk. Infected palms usually die within 3 to 6 months after the appearance of the first symptoms. Lethal Yellowing symptomatology may be complicated by other factors. For example, non-bearing palms lack fruit and flower symptoms. Foliar discoloration also varies markedly among coconut ecotypes and hybrids. For most tall-type coconut palms, leaves turn a golden yellow before dying whereas on dwarf ecotypes leaves generally turn reddish to greyish-brown.

Progression of lethal diseases on inflorescence

Necrosis of inflorescences due to the lethal disease

Young palm affected

Plant affected by lethal disease

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

The presence of a pest, disease or pathogenic agent is not always harmful to the crop. 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.

Stage		Length of stage [1]	Coconut bugs	Pentatomid bug	Coconut scale	Thirathaba	Palm weevil	Rhinoceros beetles	Termites	Coconut mite	Bud rot	Lethal bole rot	Yellowing diseases
Germination or seed bed		From about 45 days to 3 months											
Nursery		From six months to one year											
From transplanting to flowering		Tall varieties may start flowering at the age of 5 - 7 years, hybrids during the fourth year, and dwarfs during the third year											
From beginning of flowering to end of harvest	Flowering and nutlets period	Coconut palms are considered to have an economic life span of about 60 years											
	Older nuts												

1 Length of stage will vary with type (tall, dwarf or hybrid), mode of production and environmental conditions.

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

Key:
0 = no damage
+ = limited damage
++ = moderate 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 moderately important, 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.

Coconut (coreid) bugs (*Pseudotheraptus wayi*, *P. devastans, Amblypelta cocophaga*)

Favourable conditions: More severe after long and short rain seasons.

Country / Month	1	2	3	4	5	6	7	8	9	10	11	12
West Africa :												
Côte d'Ivoire, Ghana, Benin, Nigeria	/	/	/	/	/	/	/	/	/	/	/	/
East Africa :												
Kenya	/	/	/	/	/	/	/	/	/	/	/	/
Tanzania	+++	+++	++	++	++	+++	+++	++	++	++	++	++
Carribean :												
Dominican Republic, Cuba, Dominica, Windward Islands	/	/	/	/	/	/	/	/	/	/	/	/
Pacific :												
Fiji	/	/	/	/	/	/	/	/	/	/	/	/

Pentatomid bugs *(Axiagastus cambelli)*

Favourable conditions: Unknown.

Country / Month	1	2	3	4	5	6	7	8	9	10	11	12
West Africa :												
Côte d'Ivoire, Ghana, Benin, Nigeria	/	/	/	/	/	/	/	/	/	/	/	/
East Africa :												
Kenya, Tanzania	0	0	0	0	0	0	0	0	0	0	0	0
Carribean :												
Dominican Republic, Cuba, Dominica, Windward Islands	/	/	/	/	/	/	/	/	/	/	/	/
Pacific :												
Fiji	/	/	/	/	/	/	/	/	/	/	/	/

Tirathaba complexa												
Favourable conditions: Unknown.												
Country / Month	1	2	3	4	5	6	7	8	9	10	11	12
West Africa :												
Côte d'Ivoire, Ghana, Benin, Nigeria	/	/	/	/	/	/	/	/	/	/	/	/
East Africa :												
Kenya, Tanzania	0	0	0	0	0	0	0	0	0	0	0	0
Carribean :												
Dominican Republic, Cuba, Dominica, Windward Islands	/	/	/	/	/	/	/	/	/	/	/	/
Pacific :												
Fiji	/	/	/	/	/	/	/	/	/	/	/	/

African palm weevil *(Rhynchophorus phoenicis)*												
Favourable conditions: Unknown.												
Country / Month	1	2	3	4	5	6	7	8	9	10	11	12
West Africa :												
Côte d'Ivoire, Ghana, Benin, Nigeria	/	/	/	/	/	/	/	/	/	/	/	/
East Africa :												
Kenya	/	/	/	/	/	/	/	/	/	/	/	/
Tanzania	+	+	0	0	0	+	+	0	0	0	0	0
Carribean :												
Dominican Republic, Cuba, Dominica, Windward Islands	/	/	/	/	/	/	/	/	/	/	/	/
Pacific :												
Fiji	/	/	/	/	/	/	/	/	/	/	/	/

Termites												
Favourable conditions: Damage occurs mainly during the dry season when weakened young palms provide sufficient dry matter, which is very attractive to termites.												
Country / Month	1	2	3	4	5	6	7	8	9	10	11	12
West Africa :												
Côte d'Ivoire, Ghana, Benin, Nigeria	/	/	/	/	/	/	/	/	/	/	/	/
East Africa :												
Kenya	/	/	/	/	/	/	/	/	/	/	/	/
Tanzania	+++	+++	+++	++	++	++	++	++	++	++	++	++
Carribean :												
Dominican Republic, Cuba, Dominica, Windward Islands	/	/	/	/	/	/	/	/	/	/	/	/
Pacific :												
Fiji	/	/	/	/	/	/	/	/	/	/	/	/

Coconut mite *[Aceria (=Eriophyes) guerreronis]*

Favourable conditions: Dry, hot weather.

Country / Month	1	2	3	4	5	6	7	8	9	10	11	12
West Africa :												
Côte d'Ivoire, Ghana, Benin, Nigeria	/	/	/	/	/	/	/	/	/	/	/	/
East Africa :												
Kenya	/	/	/	/	/	/	/	/	/	/	/	/
Tanzania	+++	+++	+++	++	++	++	++	++	+++	+++	++	++
Carribean :												
Dominican Republic, Cuba, Dominica, Windward Islands	/	/	/	/	/	/	/	/	/	/	/	/
Pacific :												
Fiji	/	/	/	/	/	/	/	/	/	/	/	/

Bud rot (*Phytophthora palmivora, P. katsurae*)

Favourable conditions: The disease is favoured by conditions of high humidity, such as found on low, badly drained lands, in plantations with a very dense stand and under conditions of extensive rainfall periods.

Country / Month	1	2	3	4	5	6	7	8	9	10	11	12
West Africa :												
Côte d'Ivoire, Ghana, Benin, Nigeria	/	/	/	/	/	/	/	/	/	/	/	/
East Africa :												
Kenya	0	0	0	+	+	+	0	0	0	+	+	0
Tanzania	0	0	0	+	+	0	0	0	0	0	+	+
Carribean :												
Dominican Republic, Cuba, Dominica, Windward Islands	/	/	/	/	/	/	/	/	/	/	/	/
Pacific :												
Fiji	/	/	/	/	/	/	/	/	/	/	/	/

Lethal bole rot *(Marasmiellus cocophilus)*

Favourable conditions: Unknown.

Country / Month	1	2	3	4	5	6	7	8	9	10	11	12
West Africa :												
Côte d'Ivoire, Ghana, Benin, Nigeria	/	/	/	/	/	/	/	/	/	/	/	/
East Africa :												
Kenya	+	+	+	+	+	+	+	+	+	+	+	+
Tanzania	/	/	/	/	/	/	/	/	/	/	/	/
Carribean :												
Dominican Republic, Cuba, Dominica, Windward Islands	/	/	/	/	/	/	/	/	/	/	/	/
Pacific :												
Fiji	/	/	/	/	/	/	/	/	/	/	/	/

2. Main control methods

2.1. Pests and diseases management strategy in relation to the phenological stages of the crop

Nursery stage

- Start a crop with healthy, vigorous seedlings free from pests and diseases.
- Select fully mature seed nuts that are relatively free from pest damage; store them in the open until their husk is completely dry.
- Plant them horizontally in shallow trenches at the beginning of the rainy season at such a depth that the husk is just visible above the soil.
- Keep the seedbed moist, well weeded and mulched.
- Remove all nuts, which have not germinated within the first four months.
- Protect young seedlings from stray livestock.
- Seednuts may be planted in polybags.

Transplanting

- Transplant at the beginning of the rains.
- Select only the best-developed seedlings for transplanting (straight strong stems, plants with at least 8 leaves).
- Observe recommended spacing according to type/cultivar.
- To protect seedlings from termite damage include an insecticide in the planting hole.
- At planting most roots in naked seedlings are slashed from the nut surface to allow emergence of new roots.

Field stage

- Intercropping with annual crops and host trees of weaver ants is recommended.
- Regular clean weeding or low slashing and cycle weeding are highly recommended.
- Keep a circle of about 2m in diameter around the base clear of weeds and mulch this area with grass, coir dust or coconut husk.
- Remove regularly dead palms, fronds, and fallen nuts and other litter from the plantation.

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 on coconuts, 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.

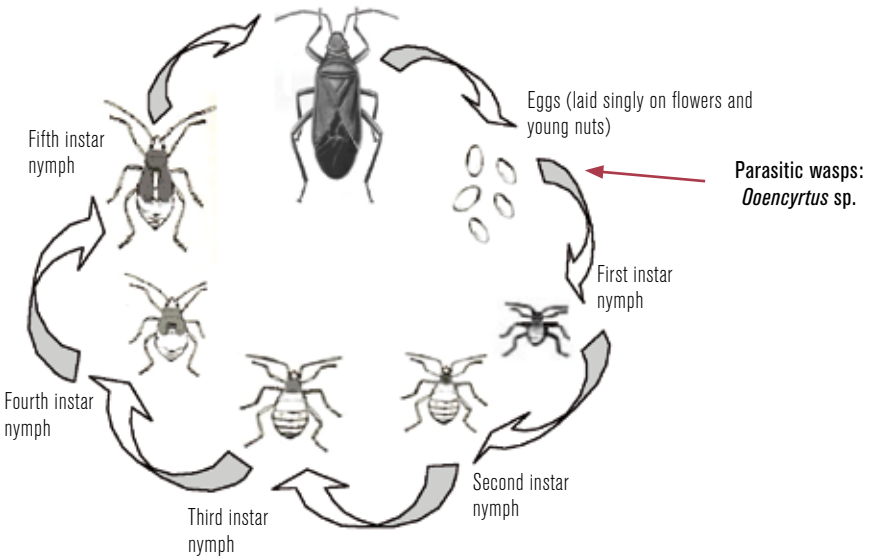
Important remark: the illustrations (sketches) of the cycles represent the different stages of development, but in no case should these illustrations be used to identify pests or diseases. For identification, please return to part 1.2 of this guide.

COCONUT BUG - *Pseudotheraptus* spp.

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

To control all stages

- Encourage weaver ants. They prey on all stages except eggs.
- Use of selective insecticides



The development cycle is usually completed in about five weeks

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

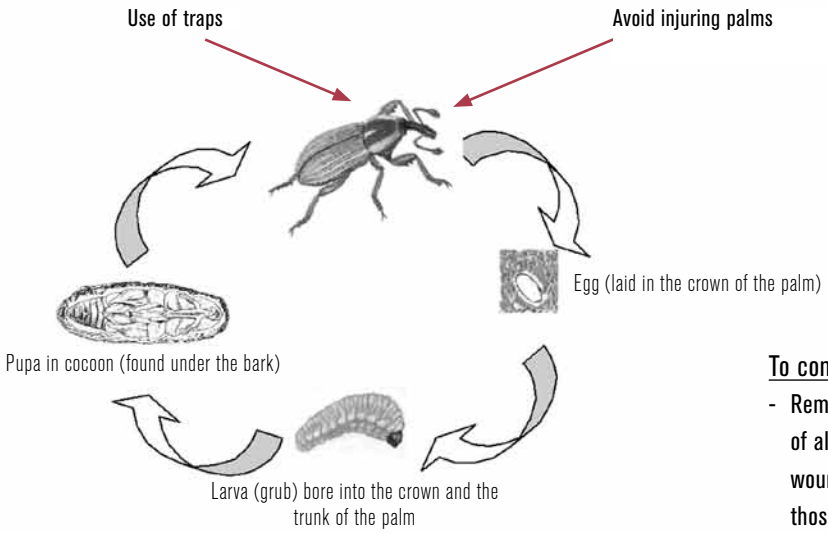
Field

Throughout the production cycle

- Intercrop coconuts with plants favoured by weaver ants such as citrus, soursop, guava, mango, etc. Damage is usually less serious in inter-cropped coconuts.
- Keep bushes and old trees that are hosts for weaver ants in the surrounding of coconut fields.
- Keep controlled ground vegetation in areas where the bigheaded ant (*Pheidole megacephala*) is dominant. See 2.4.
- Apply an ant bait (e.g. "Amdro") in areas where the bigheaded ant (*Pheidole megacephala*) is dominant.
- Connect the canopy of neighbouring palms/trees with sticks, wire, or ropes. Weaver ants can easily walk among trees searching for food and set up new nests avoiding other ants active on the ground.
- Transfer weaver ants to areas where they are not present. This can be done by collecting nests from bushes around and placing them onto coconut palms or other host plants in the field. Care should be taken not to mix ants from different colonies since they would fight. Do not place nests collected from different trees or trees far apart on the same trees since they are likely to belong to different colonies and will kill each other. The best time for collection of nests is during the rainy season, since in this period many new queens are present in the ant nests, and these may get established in the orchard and start new colonies. Ants in nests introduced without the queen will die out after some time (they may live up to 8 months) and new introductions are needed.

PALM WEEVILS - *Rhynchophorus* spp.

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



To control all stages

- **Removal and destruction of all heavily attacked and wounded palms, along with those showing distinct growth disorders, discourage further infestations.**

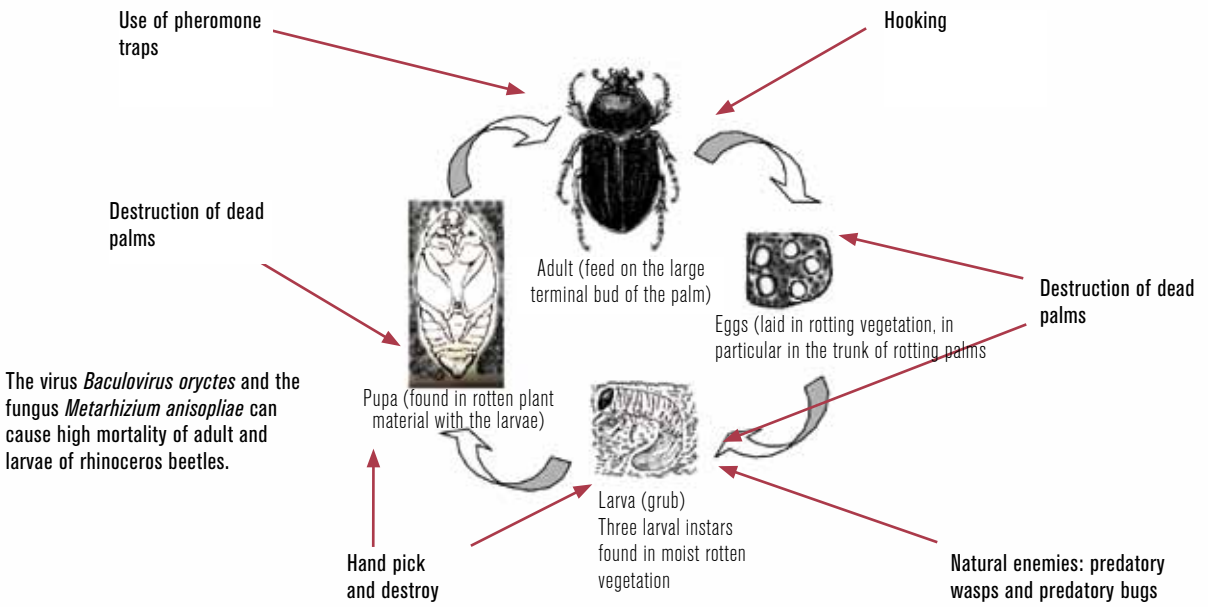
Positioning of control methods in terms of the development cycle of the plant

Throughout the production cycle

- Avoidance of wounds during plantation management and wounds caused by rhinoceros beetles is important to avoid/minimise attack by weevils. Adult weevils are very good fliers, and are attracted to the odour of feeding sites and to injured palms. Upon emerging from their cocoons in a rotted palm they disperse to other palms in which they lay their eggs.
- Removal and destroyal of all heavily attacked and wounded palms, along with those showing distinct growth disorders, discourages further infestations.
- Traps made from thinned or wild palms that have been felled and split into longitudinal sections divert weevils away from cultivated palms, because adults are attracted to the chemicals emitted from damaged wood. Trap-heaps are frequently burnt and replaced with fresh trap wood. Older traps can be sprayed with palm sap to maintain their effectiveness. Application of an attractive pheromone excreted by the male insects increases the efficiency of the traps considerably. Synthetic pheromones can also be used to trap adult weevils.

RHINOCEROS BEETLES - *Oryctes* spp.

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



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

Transplanting

- At the stage of land preparation it is recommended that all possible future breeding places be planted with a cover crop such as *Pueraria phaseoloides* (kudzu tropical).

Throughout the production cycle

- Dead palms should be felled, chopped and removed to destroy the breeding site. If logs cannot be removed the decaying end should be checked regularly for grubs, which should be collected and destroyed.
- Compost heaps should be turned over regularly killing all visible adults and grubs. Grubs can be fed to chicken.
- Beetles tunnel their way to the inside of the logs through the soil. Turning over the logs twice a week and killing the larvae is a very effective way of control.
- The beetles can be controlled in young palms by hooking. A 30 cm long iron rod with a hook at one end is pushed into the tunnel bored by the beetle while feeding. If the beetle is still inside it will be hooked out.

- Large plantations, in which attack is limited to the edges, are recommended, as they are less vulnerable than small ones.
- Trapping. Heaps of debris can be used to attract ovipositing females. Split pieces of coconut stem laid down with their flat side downwards can also be used as traps. The effectiveness of traps can be improved by treating them with attractants, the most effective of which is ethyl dihydrochrysanthemumate (Chrislure). Regular inspection of these traps is labour-intensive and the high cost of chemical attractants is a disadvantage.
- Smelling baits treated with ethyl chrysanthemate can be used against *O. monoceros*. The trap consists of a covered plastic bucket with a hole pierced in the lid, placed 2.5 m above ground level; a flask is placed within, containing a mixture of 2 ml ethyl chrysanthemate and 0.2 ml of an olfactory booster, which evaporates slowly through a wick over a period of 1 month. The rate of capture is extremely variable according to the degree of infestation, the situation of the traps, which are more effective on the border than in the centre of the plantation, and the condition of the oviposition sites in the rotting felled coconut palms. If these sites are left bare, few beetles are caught in the traps, but if there is a cover plant (*Pueraria javanica*), the olfactory attraction of the sites is masked and more beetles are drawn to the traps on their way to a breeding site, either after a feeding period or coming from another site. This type of trapping can be used as a means of control, but does not prevent attacks completely; it is complementary to the use of a cover plant.
- As the beetles are also attracted by the silhouette of the young palms, interplanting young coconuts with high intercrops, such as maize and bananas may reduce beetle attack.

For the following pests and diseases control measures cannot be directed to a particular lifestage. Therefore the control methods are tabulated as follows.

- Cultivation practices
- Application of plant protection product

Pest/disease	Action	Cultivation stage			
		Germination	Nursery	Planting to flowering	Post flowering
Coconut mite	Remove mature and prematurely fallen nuts. Although few mites are normally found on old bunches, these low numbers could allow rapid colonisation of young bunches				X
	Avoid excessive application of nitrogen. Damage seems to increase with increasing levels of nitrogen			X	X
Scales	Provide good growing conditions for the palms. Healthy palms in well-drained soils are seldom seriously infested		X	X	X
	Destroy infested plants and plant parts, particularly during the early stages of an infestation		X	X	X
	Restrict movement of infested plants or infested nuts		X	X	X
	Apply systemic insecticides			X	X
Termites	Place nurseries in land without termites. Alternatively, raise palms in polyethylene bags and check them always for termites	X	X		
	Pour a thin layer of sand from the soil over the exposed parts of the buried nuts	X			
	Flood termite mounds	X	X	X	X
	Dig out mounds and destroy the queens	X	X	X	X
	Suffocate the colony by burning	X	X	X	X
	Apply termiticide by incorporating it in planting hole	X	X	X	
	Apply termiticide		X	X	

Pest/disease	Action	Cultivation stage			
		Germination	Nursery	Planting to flowering	Post flowering
Bud rot	Fell and burn affected palms to reduce spread of the disease. This deters breeding of rhinoceros beetles, which serve as carriers of the fungi spores			X	X
	Remove all diseased material from the plantation		X	X	X
	Reduce the relative humidity in the plantation. This can be achieved by improved drainage, wide spacing for better aeration, and adequate weed control		X	X	
	Disinfect knives used on diseased palms		X		X
	Use resistant cultivars (Refer to section 2.2)	X	X	X	X
	Do not irrigate nurseries at dusk or at night to avoid prolonged periods of free moisture		X		
	Apply fungicides		X	X	X
Lethal bole rot	Cut down and burn all palms showing initial symptoms of the disease			X	X
	Replant with healthy seedlings		X	X	
	Avoid movement of infected palms or infected nuts		X	X	X
	Remove coconut palm debris from fields			X	X
Lethal disease	Cut down and burn all palms showing intial symptoms of the disease			X	X
	Avoid/restrict movement of seedlings from disease to non disease areas		X	X	
	Use resistant cultivars (See section 2.2)	X	X	X	X

2.3. Cultivar resistance or tolerance

Company/seed source	Cultivar	Resistance or Tolerance		
		Coconut mite	Bud rot	Lethal yellowing
India	Chowgart Dwarf	+		
South East Asia	Malayan Yellow Dwarf Bali Tall Malayan Yellow Dwarf x Palu Tall hybrids		+	
West Africa	Malaysian Tall PB 121 (West African Tall x Malayan Yellow Dwarf)	+		
South East Asia	Malayan Yellow dwarf Malayan Yellow dwarf x Panama Tall			+

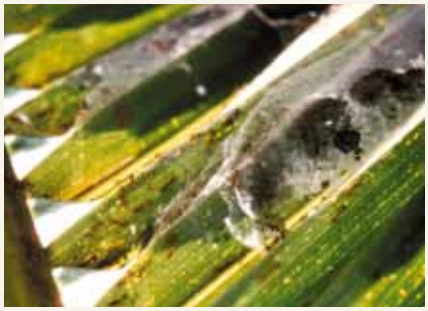
2.4. Use of natural enemies

Coconut bugs

The most important control method is through favouring the development of the weaver ant population of the genus *Oecophylla: Oecophylla smaragdina* in the Pacific zone and *Oecophylla longinoda* in Africa. These ants are efficient natural enemies of the coconut bugs. They nest on palms and other trees building their nests by joining several leaves. They deter or kill coconut bugs. Palms with weaver ants are usually free of damage by the coconut bug. Good control is achieved when 60% or more palms are occupied by thriving colonies of weaver ants. The development of the population of these ants is often constrained by antagonistic ants of the genera *Pheidole*, *Camponotus*, *Anoplolepis* and *Crematogaster*, which do not protect the palms or are not as effective as weaver ants against coconut bugs. As a result palms occupied by these antagonistic ants may be severely damaged by coreid bugs. A lot of progress has been made in the enhancement of the *O. longinoda* population in coconut groves in Tanzania. The poisonous ant bait AMDRO that was developed against fire ants in the USA has been successfully used for control of he big-headed ant *Pheidole megacephala*, the major enemy of the weaver ant, thus providing an opportunity for weaver ants to thrive and spread to other coconut trees. The other local enemy of the weaver ant, the crazy ant *Anoplolepis custodiens*, can be controlled with 3 applications of permethrin and related insecticides such as deltamethrin to the bases of the palms, nest entries and the ants' major foraging trails.

Weaver ant population development can be further favoured by:

- Keeping bushes and old trees that are hosts for weaver ants in the surrounding of coconut fields.
- Intercroping coconuts with plants much favoured by weaver ants such as citrus, soursop, guava, mango, etc
- Keeping ground vegetation in areas where the bigheaded ant is dominant. If there were no ground vegetation this ant would be forced to search food on the trees and would displace weaver ants.
- Connecting the canopy of neighbouring palms/trees with sticks, wire, or ropes. Weaver ants can easily walk among trees searching for food and set up new nests avoiding other ants active on the ground.
- Transferring weaver ants to areas where they are not present. This can be done by collecting nests from bushes around and placing them onto coconut palms or other host plants in the field. Care should be taken not to mix ants from different colonies since they would fight. Do not place nests collected from different trees or trees far apart on the same trees since they are likely to belong to different colonies and will kill each other. The best time for collection of nests is during the rainy season, since in this period many new queens are present in the ant nests, and these may get established in the orchard and start new colonies. Ants in nests introduced without the queen will die out after some time (they may live up to 8 months) and new introductions are needed.


Weaver ants nest on a coconut palm


Weaver ants nest on a mango tree


Weaver ants preying on a nymph

Coconut scale

Natural enemies usually keep scales under control. Ladybird beetles (e.g. *Chilocorus* spp, *Scynmus* spp., *Cryptognatha nodiceps*, *Rhyzobius pulchellus* and *Exochomus*) play an important role in controlling the coconut scale. *Cryptognatha nodiceps* has been introduced to a number of countries and oceanic islands, giving satisfactory control of the coconut scale. Introductions of *Rhyzobius pulchellus* were more effective in controlling this pest in the New Hebrides.

Important parasitic wasps of local significance include *Comperiella*, *Aphytis* and *Encarsia* species. Accidental introductions of *A. destructor* in various countries have been followed by generally successful adaptations of various coccinellid species. Thus, *Lindorus lophanthae* Blaisdell has been introduced in Vaté Island (Vanuatu), *Chilocorus nigritus* Fabricius in Mauritius and *Cryptognatha nodiceps* in the Fiji Islands.

Rhinoceros beetles

Virus and fungal diseases can cause high mortality of larvae of rhinoceros beetles. The adult beetles are susceptible to the virus *Baculovirus oryctes* and the fungus *Metarhizium anisopliae*. These two microorganisms have been used for control of rhinoceros beetles especially *O. rhinoceros*. The virus in particular has proved itself much more promising against *O. rhinoceros*. However, *O. monoceros* has been shown to be much more tolerant. The larvae (grubs) of *O. monoceros* are vulnerable to the same set of pathogens as the adult beetle, but in general they can only become infected if an adult beetle carries infection to the log or if infective material remains from the previous brood.

There are only few other natural enemies of *Oryctes*, e.g. the parasitic wasp *Scolia ruficornis* which attacks larvae, and the predatory bugs *Platymeris rhadamanthus* and *P. laevicollis*. The former has been introduced from Africa and Madagascar into the Pacific area. Exposed *O. monoceros* larvae are readily taken by chickens, pigs, Mynah birds etc. Generalized predators that are able to enter the logs where larvae are feeding include rats, crabs and centipedes (*Scolopendrium* sp.).

Tirathaba complexa

The caterpillars are attacked by various parasites, among which: *Apanteles tirathabae* Wilkinson (*Hym. Braconidae*), *Devorgilla palmaris* Wilkinson (*Hym. Ichneumonidae*) and *Argyrophylax basifulva* Bezzi (Diptera Tachinidae) have been successfully introduced from Java to the Fiji Islands (Lever, 1969).

Coconut mite

Various arthropod predators were found on the perianth and surface of the coconuts but are not considered to have a significant regulatory influence on mite populations (Mariau 1977, Hall 1981, Howard et al. 1990). Entomopathogenic fungi are likely to play a significant role in the control of coconut mite populations in the future. Tests conducted to determine the efficacy of *Verticillium lecanii* in regulating the coconut mite population in St. Lucia showed promise (Anonymous 1985). The entomopathogenic fungus, *Hirsutella thompsonii* Fisher was recorded on the coconut mite in Mexico, Jamaica and Ivory Coast (Hall et al. 1980). *H. nodulosa* Petch was recorded on the coconut mite in Cuba, (Carbrera and Dominguez 1987). The role of these fungi as control agents is being explored.

3. Crop monitoring and intervention thresholds

Coreid bugs

This bug is a low-density pest. Two bugs per palm can cause considerable damage. Therefore, regular and frequent monitoring is very important. Fortnightly surveys of fallen nutlets can reveal presence of characteristic coreid bug lesions the frequency of which should determine action to be taken. Appearance of several nutlets with such lesions should trigger a selective application of a suitable insecticide. Where weaver ants are encouraged for biological control, presence in the centre of the coconut grove of the competitor ant *Pheidole megacephala* should trigger an application of the selective ant bait (e.g. Amdro) in the whole coconut grove.

Coconut scale

It is important to spot early scale infestation on leaves and the inflorescence, especially during the dry season (as for *Aspidiotus destructor*), as brownish encrustation on the lower side of leaflets. To detect live scales run fingers over the encrustation, live scales, will produce watery, sticky liquid. Furthermore yellowing of such leaflets is another indicator of scale infestation. So, although scales may infest palms throughout the year monitoring should be intensified at onset of the dry season.

Palm weevil

Palms in endemic areas should be regularly scouted e.g. at three month intervals, to detect damage symptoms in the crown as pitted trunk near the crown, crown malformation and brown exudates on the ground underneath the canopy of a severely infested palm. A farmer may aid the observation by using a pair of binoculars in cases of tall palms. Farmers should be more vigilant in areas where infestation by *rhinoceros* beetle is rampant.

Rhinoceros beetles

Damage by *rhinoceros* beetle on young (most affected) palms can be monitored by fortnightly scouting of individual palms to identify recent central frond damage ("V" shaped cuts) and fresh entrance holes that exude fresh frass, which indicates presence of feeding beetles. In this case a hook is used to remove the beetles from the feeding tunnels.

Termites

Although termite damage may be more serious at certain times of the year, in endemic areas damage occurs throughout the year. Application of termiticides should therefore be done upon observing damage to the palm while in termite prone areas prophylactic treatments should be done at the seedbed to protect both seednuts and seedlings and at transplanting to protect yound palms in the field.

Mite

Mites start infesting fertilised nutlets that are one month old. Damage symptoms therefore start showing when the nutlet is one month old, as elongated white streaks below the perianth. These, in 2-3 months old nutlets, develop into small yellow triangular patches. The white streaks and the triangular patches are the most important initial and subsequent symptoms of infestation. Therefore regular inspection of 1-2 month old inflorescences should guide the farmer in detecting mite infestation and what control strategy to take.

Bud rot

Coconut nurseries should be inspected regularly to spot seedlings showing initial symptoms of bud rot and removal and destruction by burning all symptomatic palms.

Lethal bole rot

Monitor seedlings and young palms of two to four years old. First symptoms are wilting and yellowing or bronzing of leaves. In older palms the first symptoms are a general wilt of the fronds, which remain as a 'skirt' around the trunk. The spear leaf dies and a foul-smelling soft rot develops at the base of the leaves. A dry, reddish-brown rot with a yellow margin is typically present at the base of the bole. Cut down and burn all palms showing initial symptoms of the disease.

Lethal disease

Action (cutting down symptomatic palm) to prevent spread of the disease should be taken upon observing a palm in the initial stages of the disease ie when the palm drops nuts of all development stages and yellowing of older leaves. The early symptoms should therefore be well understood.

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 below.

A list of active substances is suggested for each pest or disease. When available, the recommended GAP which allows compliance with European MRLs currently in force on coconut is also shown; the PHI (Pre-Harvest Interval) are indicated to comply with the European MRLs that are in fact for coconut LOQ set by default.

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 (specified in Part 6 of this guide). It should be noted that at this stage no test has been undertaken in ACP production environments to check compliance of MRLs with the GAPs indicated. These GAPs does not represent a treatment calendar to be applied as such. In practice, the frequency of treatments must take into account the severity of attacks and the real risks of damage at the local level.

The list of active substances proposed has been drawn up taking into account the products used by ACP producers and the products registered in ACP countries and elsewhere. The active substances are classified by resistance risk group (classification and codes of FRAC – Fungicide Resistance Action Committee - http://www.frac.info/frac/index.htm et IRAC - Insecticide Resistance Action Committee - http://www.irac-online.org/eClassification/). In practice, it is important to alternate active substances belonging to different groups.

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

Dosage are indicated for formulated product with the indicated concentration and for a knapsack sprayer fitted with a standard nozzle used to wet properly the plant. If a different formulated product is used, the user must modify the quantity to apply according to the concentration of the product. Dose is not indicated in quantity per hectare since the quantity to apply per hectare depend on the age of the coconut trees and the density of plantation.

Coreid bugs

Strategy: Chemical treatments are not practical due to the height of the trees. In addition, treatments should be repeated frequently, as even small populations of the order of 30 bugs per hectare can cause intolerable damage. However, where the palms are still short or when valuable germplasm is to be protected, a synthetic pyrethroid can be used. It is essential to limit spraying only to five susceptible inflorescences, excluding the leaves and older bunches to minimise unwanted effect on environment. Endosulfan or propoxur have been reported to be efficient against P. devastans. Trees colonized by weaver ants should not be treated.

Active substance	Recommended GAP*					Proposed application period			
	Dosage formulated product		Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)	Germination	Nursery	Planting to flowering	Flowering and post flowering
	Concentration formulated product	Quantity to apply							
Group 3 – Pyrethroids									
cypermethrin	100 g/l	3-5 ml/l of water	Initially once every two weeks; subsequent treatments depending on observing damage symptoms on fallen nutlets	3 months	/				
deltamethrin	25 g/l	0.5-0.8 ml/l of water		3 months	/				
lambda cyhalothrin	50 g/l	1-2 ml/l of water		3 months	/				
Group 2 – Organochlorins and fiproles									
endosulfan	350 g/l	1.5-3 ml/l of water	Initially once every two weeks; subsequent treatments depending on observing damage symptoms on fallen nutlets	3 months	/				

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

Coconut scale

Strategy: Chemical control may be difficult owing to the height of the trees and may not be commercially viable in some cases owing to the cost. Chemical control may be necessary in the dry season. Malathion has been used successfully, although systemic insecticides would be more effective and environmentally friendly. Contact or stomach acting insecticide sprays may also kill natural enemies and affect biological control.

Active substance	Recommended GAP*					Proposed application period			
	Dosage formulated product		Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)	Germination	Nursery	Planting to flowering	Flowering and post flowering
	Concentration formulated product	Quantity to apply							
Group 1 – Organophosphates and carbamates									
dimethoate	400 g/l	1-1.5 ml/l of water	4 applications /year	3 months	/		■	■	
malathion	/	/	/	/	/		■	■	

Tirathaba complexa

Strategy: No information available.

Active substance	Recommended GAP*					Proposed application period			
	Dosage formulated product		Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)	Germination	Nursery	Planting to flowering	Flowering and post flowering
	Concentration formulated product	Quantity to apply							
Group 1 – Organophosphates and carbamates									
trichlorfon	95 %	0.85 to 1.25 kg/ha	/	/	7				■

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

/ : Elements of the recommended GAP not available.

Palm weevil

Strategy: Chemical control is possible by applying insecticides to the leaf axils of healthy palms, by poisoning the baits (traps) used to trap the weevils (refer to section 2.1) or by injection of insecticides in attacked palm.

Active substance	Recommended GAP*					Proposed application period			
	Dosage formulated product		Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)	Germination	Nursery	Planting to flowering	Flowering and post flowering
	Concentration formulated product	Quantity to apply							
Coconut log traps with fermenting toddy or pineapple or sugarcane activated with yeast or molasses can be set in coconut plantation to attract and trap the free floating population of red palm weevil. Incorporate an insecticide to each trap to kill the weevils trapped.									
Group 1 – Organophosphates and carbamates									
methomyl	0.1 percent applied to the baits						■	■	■
Fill to the inner most leaf axils on the crown with insecticides									
Group 1 – Organophosphates and carbamates									
carbaryl + lindane	8 G	20 g + 200 g fine sand	3 per year	4 months	/		■	■	
Inject attacked palms with insecticides									
In attacked palms, observe for the bore-holes and seal them except the top most one. Through the top most hole, pour insecticide suspension at one litre per palm, using a funnel. When the infestation is through crown, clean the crown and pour the insecticidal suspension.									
Group 1 – Organophosphates and carbamates									
carbaryl	/	20 g/l	/	/	/		■	■	■
trichlorfon	/	2 ml/l	/	/	/		■	■	■

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

Termites

Strategy: Where termites may be expected to cause damage, the planting hole should be treated with an appropriate insecticide before the seedling is planted.

Active substance	Recommended GAP*					Proposed application period			
	Dosage formulated product		Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)	Germination	Nursery	Planting to flowering	Flowering and post flowering
	Concentration formulated product	Quantity to apply							
Group 1 – Organophosphates and carbamates									
carbofuran	5% G	70-80 g/ seedling	Once in the growing season Once every three months		/			**	
chlorpyriphos- ethyl	/	1.2-2 ml/l of water 100 ml/plant or apply to just dripping point	Once every month until damage symptoms cease to appear		/				
Group 2 – Organochlorins and fiproles									
endosulfan	350 g/l	1.5-3 ml/l of water 100 ml/ plant or apply to just dripping point	Once every month until damage symptoms cease to appear		/				
Group 4 – Nicotinic Acethylcholine receptor agonists/antagonists									
imidacloprid	200 g/l	/	/		/			**	

* The elements of the recommended GAP shown here allow to comply with the European MRL (see part 6 of this guide).
** Stop applications one year before expected first flowering since it is a systemic insecticide and the PHI is not known.
/ : Elements of the recommended GAP not available.
n.a. : Not applicable.

Rhinoceros beetles

Strategy: Place sawdust mixed with insecticide in the leaf axils. Treat all the axils of small trees, but only the first three fronds of 2-year-old trees. Treatment of breeding sites.

Active substance	Recommended GAP*					Proposed application period			
	Dosage formulated product		Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)	Germination	Nursery	Planting to flowering	Flowering and post flowering
	Concentration formulated product	Quantity to apply							
Insecticidal treatment of manure pits/breeding sites									
Group 1 – Organophosphates and carbamates									
carbaryl	/	0.01% carbaryl on w/w basis	/	3 months	/				
Fill to the inner most leaf axils on the crown with insecticides									
Group 1 – Organophosphates and carbamates									
carbaryl + lindane	8 G	20 g + 200 g fine sand	/	/	/				
Group 2 – Organochlorins and fiproles									
endosulfan	4 G	20 kg/ha	Once monthly (12/year)	/	/				

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

Coconut mite

Strategy: Chemical control may be practised under very special conditions, such as in seed gardens, but cannot be recommended for plantations due to the necessary frequency of application and height of the trees. The products for injection in the table have been applied in India.

Active substance	Recommended GAP*					Proposed application period			
	Dosage formulated product		Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)	Germination	Nursery	Planting to flowering	Flowering and post flowering
	Concentration formulated product	Quantity to apply							
Spraying on young bunches									
For spraying 1 to 1.5 l of spray fluid is required per palm. Spraying has to be done on second to seventh bunches from top avoiding unpollinated inflorescence. Care should be taken to see that spray fluid reaches the perianth region of third, fourth and fifth bunches since these bunches harbour maximum number of mites. Three rounds of spraying are recommended in a year so that all the emerging bunches in the vulnerable stage receive one round of spraying. Rational rotation of the pesticides may be adopted to avoid chances of resistance.									
Group M – Multisite activity									
sulfur	80 % WP	4 g/l	/	/	2			■	■
Group 12									
cyhexatin	/	/	/	/	/			■	
Group UN – Mode of action unknown									
chinomethionate	25 %	20 g/l	/	/	/			■	
dicofol	/	/	/	/	/			■	
Group 18 – Ecdysone aganists/moulting disruptors									
azadirachtin	1%	4 ml/l of water	/	/	/			■	■
azadirachtin (neem oil) + garlic extract + soap	/	2 % emulsion	/	/	/			■	■
Group 6 – Avermectins									
abamectin	18 g/l	0.75 ml/l	To apply in the inflorescence and at development of the fruit in only one application		14			■	■
Stem injection									
Group 1 – Organophosphates and carbamates									
dicrotophos	/	Stem injection	Six annually	Six annually	/			**	
monocrotophos	/	0.04% stem injections	Six annually	Two months	/			**	

* The elements of the recommended GAP shown here allow to comply with the European MRL (see part 6 of this guide).
** Stop applications one year before expected first flowering since it is a systemic insecticide and the PHI is not known.
/ : Elements of the recommended GAP not available.

Preparation of neem oil + garlic emulsion (2%)

To prepare 10 litres of 2% neem oil + garlic emulsion, 200 ml neem oil, 200 g garlic and 50 g ordinary bar soap are required. Slice the bar soap and dissolve in 500 ml lukewarm water. Grind 200 g of garlic and take the extract in 300 ml of water. Pour the 500 ml soap solution in 200 ml neem oil slowly and stir vigorously to get a good emulsion. Mix the garlic extract in the neem oil + soap emulsion. Dilute this 1 litre stock solution by adding 9 litres of water to get 10 litres of 2 % neem oil + garlic emulsion.

Coconut bud rot

Strategy: Phosphonates are useful for the prevention of budrot disease in coconut but, by the time symptoms become visible, it is usually too late to cure the disease and removal of the affected plant is necessary. Fosetyl-Al wettable powder (aluminium fosetyl) and metalaxyl injected into the stem has shown to be effective in controlling the disease. Stem injection against P. katsurae is practised on a large scale in commercial plantations in the Ivory Coast. The Chemjet injector seems to be more effective and less traumatic for the stem than injecting after drilling a hole in the stem. Although metalaxyl is not effective against *Phytophthora*-induced nutfall, fosethyl reduces loss of crop by at least 80%. However, such stem injection is difficult, costly and may give variable results, perhaps because different Phytopthora species are involved, or resistant strains may have developed. Chemical spraying is difficult and costly in tall palms but may be an effective method in young plantations. A relatively inexpensive fungicide such as Bordeaux mixture (copper) may be used, as long as no copper toxicity is induced.

Active substance	Recommended GAP*					Proposed application period			
	Dosage formulated product		Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)	Germination	Nursery	Planting to flowering	Flowering and post flowering
	Concentration formulated product	Quantity to apply							
Group 33 – Phosphonates									
fosetyl-Al	/	/	/	/	/				
Group 4 – PhenylAmide fungicides									
metalaxyl	/	/	/	/	/				
Group M – Multisite activity									
copper	see below				2				

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

Use of copper

If the disease is detected when the central shoot is just withering, application of Bordeaux paste on the affected portion can check the dis¬ease. Firstly remove all the rotting tissue using a sickle or knife then clean the portion using water and apply Bordeaux paste for the cut portion. ¬The treated portion should be covered by polythene sheet to prevent washing off of the paste during rains. Soon after the development of the new spear leaf, remove the plastic cover. The removed af¬fected tissues should be burnt in order to prevent the spread of the disease to other palms.

As a prophylactic measures, adjacent healthy palms should be sprayed with 1 per cent Bordeaux mixture or with any other copper based fungicide. A pre and post monsoon sprays of the above fungicide is rec¬ommended for the management of the disease.

Preparation of 1 per cent Bordeaux Mixture

1. Dissolve one kilogram of Copper Sulphate in fifty litres of water.
2. Dissolve one kilogram of Quick Lime in fifty litres of water separately.
3. Pour Copper Sulphate solution into the Lime¬ water slowly with constant stirring.
4. To check the quality of the mixture, dip a pol¬ished knife in the solution for two minutes. If the knife gets a reddish stain, then the mixture is acidic and harmful to the plant, if sprayed. To neutralize the mixture, add more limewater, till the non-deposition of the red¬dish stain on the knife.

Preparation of 10 per cent Bordeaux paste

1. Dissolve one kilogram of copper sulphate in five litres of water.
2. Dissolve one kilogram of Quick lime in another five litres of water separately.
3. Mix the above two solutions to get the Bordeaux paste.

Cares to be taken

1. Use only wooden, earthen or plastic vessels, to avoid the corrosion of the metal vessels by the mixture.
2. Always spray freshly prepared mixture for ef¬fective management.

Lethal bole rot
Strategy: Seed treatment should always be considered as a precautionary measure whenever seed nuts are being moved between countries, or between areas within countries where coconut pathogens have a restricted distribution. Seednuts are taken directly from the mother palm, partially dehusked by trimming at the top and three sides and dipped in an appropriate fungicide (e.g. benomyl or carbendazime) for 15 minutes. The addition of a wetting agent is considered beneficial. Dip treatments are used to control disease development in seednuts.

Lethal disease
No PPP available.

5. Existing registrations in ACP countries

Remarks: The information below may have undergone changes and the user should check the laws in force in his country.

For the Caribbean and Pacific countries as well as Benin and Nigeria, we currently have no information on existing registrations.

Registration of PPP in Ghana

Following actives substances listed in part 4 of this Guide have PPP registered on various crops.
All crops : dimethoate, chlorpyriphos-ethyl, fipronil, fosetyl-Al.

Registration of PPP in Kenya

Following actives substances listed in part 4 of this Guide have PPP registered on fruits, fruit trees or various crops.
Various crops: azadirachtin, dimethoate, endosulfan.
Fruits: malathion.
Fruit trees: deltamethrin.

Registration of PPP in Côte d'Ivoire

Following actives substances listed in part 4 of this Guide have PPP registered on fruit trees.
Fruit trees: cypermethrin, deltamethrin, metalaxyl.

Registration of PPP in Tanzania

Following actives substances listed in part 4 of this Guide have PPP registered on fruits and various crops.
Various crops: cypermethrin, chlorpyriphos-ethyl, dimethoate, endosulfan, carbaryl, carbofuran, copper (treatment on trunk).
Fruits: mancozeb, dicofol + tetradifon.

Information: traps, with active substance hydramethylnon included, are registered for controlling ants in Tanzanian coconut plantations.

6. Regulation and pesticide residues

Status of the active substances in Regulation 1107/2009; European MRL and Codex MRL in August 2011.

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

Active substance	European regulations		Codex MRL (for tree nuts)
	Status Reg. 1107/2009	European MRL	
Abamectin	Approved	0.01**	/
Azadirachtin	Approved	0.1**	/
Carbaryl	Not approved	0.05**	1
Carbofuran	Not approved	0,02**	/
Chinomethionate	Not approved	0,01**	/
Chlorpyriphos-ethyl	Approved	0.05**	/
Copper	Approved	30	/
Cyhexatin	Not approved	0,1**	/
Cypermethrin	Approved	0.05**	/
Deltamethrin	Approved	0.05**	/
Dicofol	Not approved	0.05**	/
Dicrotophos	Not approved	0.01**	/
Dimethoate	Approved	0.05**	/
Endosulfan	Not approved	0.1 **	/
Fosethyl Al	Approved	2**	/
Imidacloprid	Approved	0.05**	/
Lambda cyhalothrin	Approved	0.05**	/
Lindane	Not approved	0.01**	/
Malathion	Approved	0,02**	/
Metalaxyl-M	Approved	0.05**	/
Methomyl	Approved	0,02**	/
Monocrotophos	Not approved	0.01**	/
Sulphur	Approved	*	/
Trichlorfon	Not approved	0.5**	/

* No MRL required
** = LOQ
/ No MRL specified

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

ACP countries don't have set their own MRLs therefore they usually admit Codex LMRs for foodstuffs marketed in their country.
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.

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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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