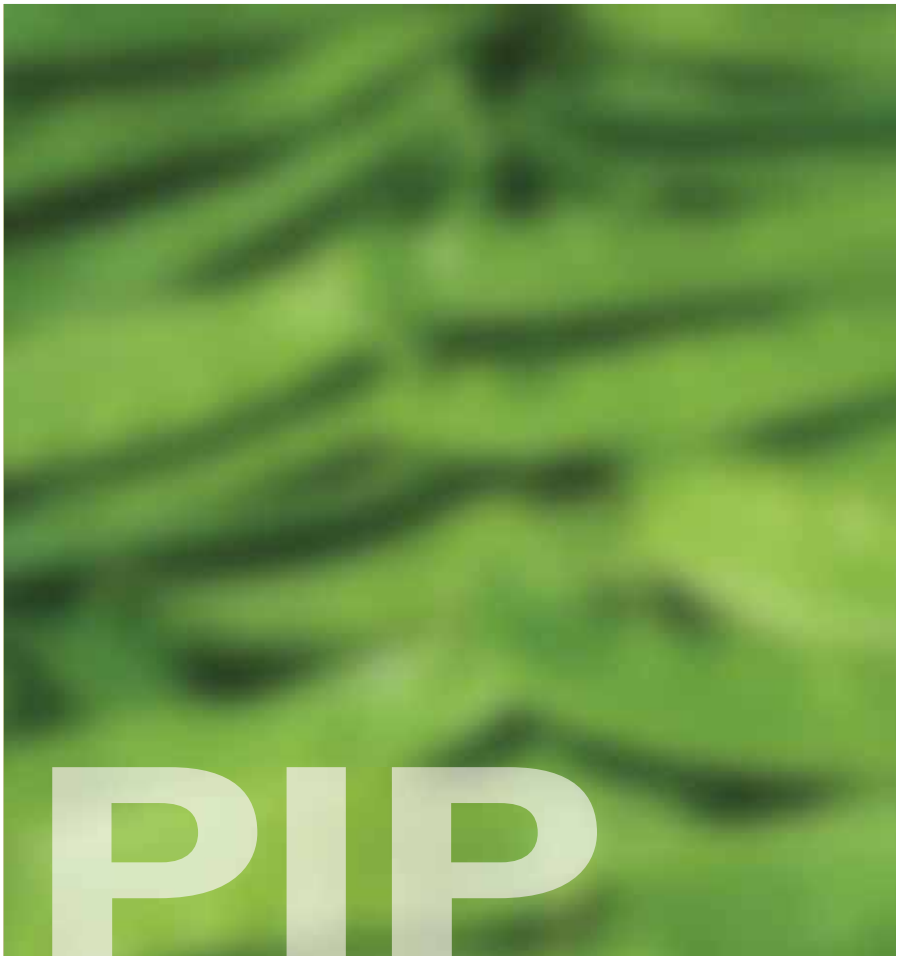

CROP PRODUCTION PROTOCOL

PAPAYA (*CARICA PAPAYA*)

COLEACP is an international network promoting sustainable horticultural trade.

PIP is a European cooperation programme managed by COLEACP. It is financed by the European Development Fund and implemented at the request of the ACP (Africa, Caribbean and Pacific) Group of States.

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".

www.coleacp.org/pip

PIP

FOR SUSTAINABLE DEVELOPMENT OF THE ACP HORTICULTURAL INDUSTRY

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The document « Technical Itinerary » (fruit or veg.) describes all the agricultural practices linked with the (fruit or veg) and suggests control of pests and diseases. It recommends primarily the active substances supported by pesticides manufacturers in the framework of EU Directive 91/414, to be replaced by Regulation 1107/2009 from 14 June 2011, which must comply with standards for pesticide residues. Most of these active substances have been tested through a field trials programme and the residue level of each active substance has been measured. The pests and diseases control suggested is therefore dynamic and will be adapted continuously integrating all information gathered by the PIP (see the web site www.coleacp.org/pip). Nevertheless, each grower has the possibility to select among the products listed a set of active substances of no concern regarding residues.

It is obvious, that usage is allowed only for those formulations which have been legally registered in the country of application. It is each grower obligation to check with the local registration authorities whether the product he/she wishes to use is mentioned 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

FOR SUSTAINABLE DEVELOPMENT OF THE ACP HORTICULTURAL INDUSTRY

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CARICA PAPAYA FAMILY: CARICACEAE

Papaya originates from tropical Central and South America, ranging from Mexico to Bolivia. This fruit, however, is now found year-round throughout tropical and equatorial regions.

I. Description

Botanical features and description

Papaya plants range from 3 to 10 m in height, usually with a single trunk without lateral branching. The trunk is marked by very large leaf scars, and this vertical stem is lignified. It has a tap root. The leaves are palmatilobate (7 or 9 lobes, depending especially on the population considered), whereas juvenile plants have simple to slightly lobed leaves.

Inflorescences develop in the axils of the leaves. The flowers can be male, female or hermaphroditic. The melon-like fruit has a very aromatic yellow to reddish flesh. The seeds have a gelatinous coating. These trees are monoecious, dioecious or hermaphrodite. The shape of the fruit depends on the sex of the flower that gave rise to it. Generally only fruit produced by hermaphrodite plants is exported.

II. Varieties

The choice of papaya variety grown depends on the preferences of the importer and potential consumers, which in turn depends on the organoleptic features, appearance, as well as the agricultural performance and resistance to different pests.

Companies should be aware of the pest and disease susceptibility of the cropped varieties. Where reasonably practicable, varieties that meet export demand while having the highest insect and disease tolerance will be selected. In some cropping areas, it is sometimes hard to fulfill all requirements, but the best possible choice should still be made.

Note that no commercial varieties, except for transgenic varieties, are tolerant of or resistant to papaya ringspot or bunchy top virus diseases.

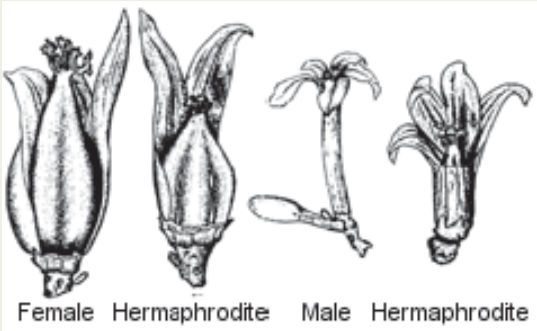
Solo N° 8: The most commonly cultivated variety, orange-yellow flesh, 300-400 g oblong fruit from hermaphrodite plants and round fruit from female trees.
Sunrise: Red flesh, same characteristics as Solo.
Sunset: Red flesh, same characteristics as Solo.
Golden: Red flesh, paler skin than Solo, weighs 300-500g, fruit from hermaphrodite plants oblong, those from female plants round. Better disease resistance and high demand on European markets. Sea transport possible.

Solo 8

Golden

2.1. Types of plant

Dioeciousness



The papaya has male, female and hermaphrodite plants. Only the pearshaped fruit from hermaphrodite plants are exported, while the round fruit from the female plant are sold on local markets. At present here is no reliable way to sort plants by sex before they flower. Seeds from selffertilised hermaphrodite flowers give the highest proportion of hermaphrodite plants at the next generation.

For export, the plant's dioeciousness makes it obligatory to use selffertilised seeds and plant 3 or 4 times as many plants as needed, weeding out unwanted males and females at flowering.

2.1.1. Male plants

Male inflorescences are characterised by their length, which can reach 40-120 cm. Male flowers are pentamerous, gamosepalous and gamopetalous. The septals are small, greenish and fused at the base. Stamens are fused to the corolla.

Male plants generally never bear fruit, but sometimes plants more than 2 years old can produce bisexual flowers and subsequently bear fruit.

2.1.2. Female plants

Female inflorescences are short and bulky and have substantially fewer flowers than male cymes.

After pollination, a single spherical melon-like fruit forms per inflorescence. There are no stamens.

2.1.3. Hermaphrodite plants

Hermaphrodite inflorescences are short and bulky and slightly longer than those produced by female plants. The flowers have stamens and pistils, so they can self-pollinate. It bears an oblong melon-like fruit. The fruit are oblong berries.

III. Requirements

3.1. Climate

This plant requires warm humid conditions to thrive. Fruit ripening is delayed and pollination can be hampered when conditions are too cold.

Under 25°C, the length of the growth cycle is extended, with a potential loss of fruit flavour. Climates suitable for papaya also favour disease-causing fungi. These must be controlled before harvest.

3.2. Rainfall

Papaya requires abundant and well-distributed rainfall, ranging from 1 800 to 2 000 mm per year. Irrigation is necessary during the dry season, at a total monthly rate of 150-200 mm.

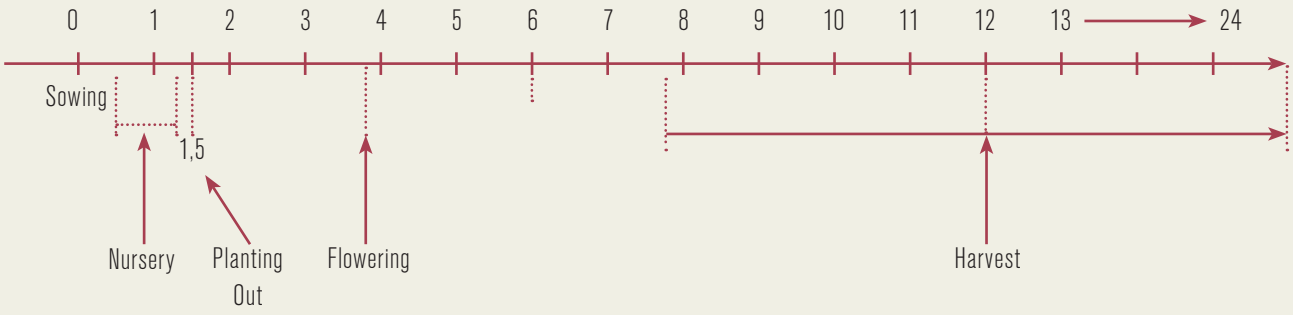
3.3. Soil

Acid soils and dry periods weaken the plant's natural resistance to fungal infection and favour fruit deformation (particularly due to boron deficiency). Calcium deficiency during fruit growth makes fruit susceptible to chilling injury during cold storage.

Soils in which papaya is to be planted should have a high humus content, and be well aerated and drained, with a pH of 4.5 to 7.0. It is likely that the crop will fail if the clay or silt contents in the soil are too high.

- Do not plant seedlings in heavy moist soil.
- Add a substantial quantity of manure (50-100 t/ha).
- Plant in mounds.

IV. CROP CYCLE



The nursery period should not last more than 5-6 weeks (plantation to the orchard).

In a well managed plantation, the first flowers form about 2 months after planting and the flowering period is continuous throughout the year, except in cool areas (during the harmattan), when pollination cannot take place due to the low temperatures. In such regions, there will be a blank in the harvesting period 100-190 days thereafter (mean flowering to harvest). The earliest exportable fruit are ready for harvest in the eighth or ninth month after planting.

V. The Nursery

5.1. Choice of seed

The seed should come from hermaphrodite fruit derived from pure Solo or Golden papaya lines.

Seeds are collected from ripe fruit, the pulp is removed and they are dried. Only seed from fully identified sources should be planted. A papaya plantation containing only one variety will not necessarily produce pure progeny because they could be pollinised by other wild and/or indigenous papayas growing in the vicinity. To be sure to collect seed from the desired variety, it is important to:

1 - select the best trees in the plantation (colour, yield, fruit shape– hermaphrodite)
2 - cover the flowers with a bag once they form to ensure selfpollination
2- mark these flowers
2- collect them at maturity.

5.2. Preparing the seed

Ripe fruit is harvested and the seeds are removed. They are small and coated with a gelatinous material that can be removed by washing in a water-sand solution. Floating seeds are discarded. After washing the seeds are set in a shady area to dry for 2-4 days.
The seeds quickly become non-viable so they should be planted as soon as possible after being extracted from the fruit.

5.3. Preparing the seed compost

Planting soil consists of about 1/3 loam, 1/3 sand and 1/3 decomposed organic matter, e.g. decomposed cow manure that has been well watered and aerated to promote good fermentation.

Seed compost should be evenly mixed, then disinfected either by solarisation (a heat process in which moist soil is heated in the sun under a plastic film, reaching temperatures high enough to kill many pathogenic germs, insects and parasitic plants), by heat treatment (this method, which consists of spreading the moist compost on a heated metal sheet, is often used, because it is cheap and easy), or with dazomet (Basamid) (200g Basamid per m2 on a 30-cm layer of compost. The product is then thoroughly mixed into the compost, which must be regularly watered and left for three weeks to one month before use). This planting soil is placed in 15 cm diameter, 20-25 cm deep planting bags.

5.4. Sowing

The seeding period can vary markedly in different areas (depending on the planned planting date), and the experience of the papaya growers is a crucial factor.

For instance, in southern Ivory Coast some growers sow in October, other in January, while in the north seeding is done between June and September. The planting bags are set side by side in a shady area. Three seeds are planted in each bag, as wide apart as possible, at a depth of around 0.8 cm.

Some growers prefer to sow single seeds in small planting bags and then to place three of these bags in each planting hole. The bags are then watered regularly with clean water, while avoiding excessive or over-moderate watering. The germination period for fresh seed ranges from 8 days to 3 weeks depending on the climatic conditions, but generally it takes around 12 days. The seedlings are gradually taken out of the shade as they grow in order to "harden" them prior to transplanting them in the field.

While the plants are in the nursery, weeding must be done regularly and plant health monitored, as the young plants are susceptible to *Pythium*, *Phythophthora*, mites, snails, rodents, and lizards in some regions. Planting out takes place five or six weeks after sowing.

The nursery phase is very important and should not be neglected (e.g. avoid setting up nurseries in the shade of a papaya orchard or along the edge of a road). Moreover, the pest and disease status of the seedlings should be checked regularly so that only healthy material with a good growth rate is planted in the orchards.

VI. Creating an orchard

6.1. Wind-break

Papaya plantations are quite vulnerable to wind, so they should be well protected in order to avoid plant damage and pest contamination. Wind-breaks should thus be set up around windy sites 2 years before planting the papaya seedlings to ensure efficient protection.

6.2. Planting density

Papaya stands can range from 2 000 to 2 500 plants per hectare depending on the cropping technique used. A triangular 2 x 2 planting design can be adopted for non mechanised cultivation, and 2 x 2 x 4 in double rows for mechanised cultivation.

The following plant spacing can be used:

- 2 m x 2 m => 2500 plant/ha,
- 2.5 m x 1.60 m => 2500 plant/ha,
- 2.5 m x 1.8 m => 2222 plants/ha,
- 2.7 m x 1.8 m => 2060 plant/ha,
- 2.7 m x 3 m => 1230 plants/ha.

6.3. Soil preparation

Papaya requires large amounts of the main fertilising elements and organic matter. Apart from a few specific cases such as planting on peat, considerable amounts of organic matter must be added. Adding 20 kg per plant amounts to an input of 40 to 50 tonnes per hectare. The grower therefore needs a supply of organic matter and adequate means of transport.

6.3.1. Mechanised tillage

If the soil is compact, deep subsoiling is necessary (60-70 cm) and then, depending on the availability, apply cow manure at 50-100 t/ha and plough it under while forming ridges.

6.3.2. Non-mechanised tillage

Dig a 50 cm x 50 cm x 50 cm planting hole for each plant and mix the dug soil with 20 kg of well decomposed manure, then fill in the hole and form a mound; mix in 500 g superphosphate or tricalcium phosphate, 200 g potassium sulfate and dolomite if necessary.

VII. Planting out

7.1. Planting layout

Carefully stake out the plot to ensure proper alignment of rows, diagonals and row perpendicularity. To keep the rows straight when digging the planting holes, the stake marking the position of each tree is replaced by two other stakes using a planting rule. The tree can thus be planted exactly in the position allocated in the layout.

7.2. Seedling supply

It is recommended to contact a reliable nursery as to the availability of papaya plants prior to beginning the planting operation. The plants should have been propagated from certified seed, with the flowers self-pollinated and bagged to avoid unwanted pollination from other plants in the vicinity. It is not possible to produce pure stands when the planted seedlings are derived from non-selected seed.

7.3. Planting

The beginning of the rainy season is the best period for planting papaya because growth is stimulated in these conditions. Plants will begin producing around 8-9 months after planting, depending on the area. In the Sahel region, the end of the rainy season is the best planting time, thus allowing the plants to grow properly during the harmattan period (this applies in northern Ivory Coast).

Place the plant in a block of earth, after removing the plastic bag, and then into a small hollow dug at the top of a ridge, when mechanical tillage is used, or in a bank-bed according to the planting layout established when the planting holes are dug manually.

Shovel loose earth, obtained between the rows, around the plants without piling it higher than the planting block. Moderately loosen the earth around the block throughout the operation. Water the seedlings well after planting. Mulch can be applied after the first irrigation in order to maintain the relative humidity at a level that is favourable for plantlet growth.

VIII. Crop maintenance

8.1. Irrigation

As mentioned earlier, the water requirements for papaya range from 150 to 200 mm/month. During the dry season, irrigation is essential to ensure fruit set. Microjet and drip irrigation are the most efficient systems. In dry areas, **sprinkler irrigation on foliage** is effective because it humidifies the air and **reduces mite populations**. Furrow irrigation is no longer used because of the high water losses that occur with this system.

To evaluate irrigation quality, it is necessary to determine:

- the gross irrigation dose.
- the soil moisture storage capacity.

Estimating the gross irrigation dose

The total quantity of water supplied to the plot per unit area represents the gross irrigation dose. This quantity generally is not all available for use by the crop, but this parameter must be known to be able to determine whether the crop is being efficiently irrigated.

This dose is generally expressed in mm or cubic metres per hectare (m^3/ha). 1 mm = 10 m^3/ha = 1 l/m^2

$$\text{Gross dose} = \frac{\text{Gross volume}}{\text{Irrigated area}} = \frac{\text{Time} \quad X \quad \text{Flow rate}}{\text{Area}}$$

Estimating the gross irrigation dose involves determining:

1: the irrigation time (timing device).
2: the flow rate at the plot inlet valve (generally at the irrigation station).
3: the irrigated area.

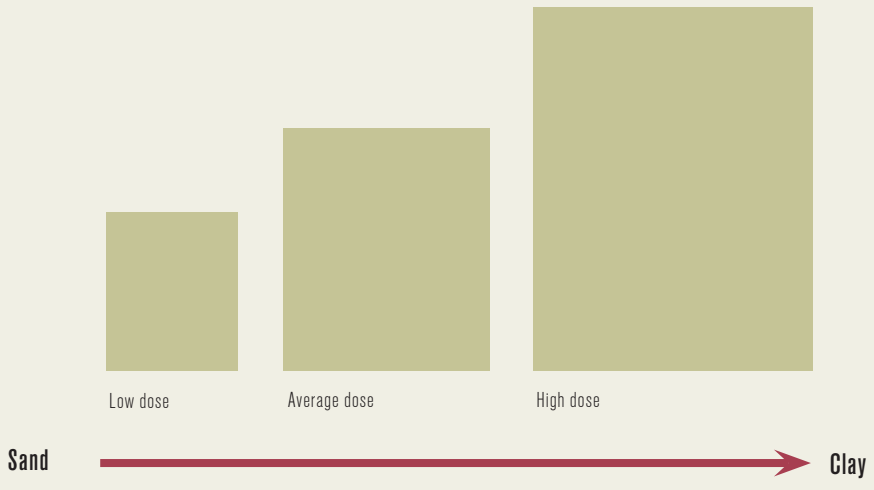
Soil moisture storage capacity

The water volume that a soil can effectively store depends on its **granulometric composition, physical status**, initial **moisture status**, the **crop** and the depth utilised by the roots.

The soil moisture storage capacity depends particularly on the soil texture, which increases with the clay content and decreases with the sand content, i.e. the finer the soil elements the greater its moisture storage potential.

It also depends on the moisture status of the soil at the time of irrigation:

- A dry soil will absorb a high quantity, so the storage capacity will be high.
- A moist sol will absorb little, so the storage capacity will be low



Soil moisture storage capacity according to the soil type

Note that this capacity depends on the soil depth utilised by the roots of the crop.

8.2. Weeding

Papaya is susceptible to herbicides, so hand weeding should be carefully carried out when the plants are young. A shield should be used to apply herbicides (Paraquat) at the beginning and afterwards, and then, once the plants are 6-months old, Glyphosate at 8-10 ml of trade product/10 l water.

Herbicide treatments are to be conducted in calm windless conditions and care should be taken to not spray the tree trunks. Under irrigated cropping conditions, intercropping with pueraria or a legume is always beneficial in terms of enhancing soil fertility and controlling erosion. This cover crop should be mowed regularly to avoid colonisation by pest insects (mites, thrips, aphids).

8.3. Fertiliser

8.3.1 Roles of fertilising elements

8.3.1.1. Nitrogen

This is a key element for plant growth. It is applied regularly during the cropping cycle. An excess of nitrogen will lead to the production of soft tasteless fruit with a very short postharvest shelflife. The plants can have excessive growth and extended internodes. Moreover, a nitrogen excess will produce trees that are more susceptible to mite infestation, and the plant will secrete latex upon even light contact with the petioles.

8.3.1.2. Phosphorus

Phosphorus is important for root development, flower initiation and the behaviour of the fruit on the tree. Superphosphate is generally used, which is not very soluble and it takes a long time to reach the root system. It should thus be applied before planting or well before the rainy season. The efficacy of phosphorus can be reduced by a low pH and high iron level, especially in laterite soils. Phosphorus deficiency is characterised by poor fruit behaviour, aborted flowers and a thin tree trunk.

8.3.1.3. Potassium

This element is essential for producing fruit with good organoleptic quality and postharvest performance. Potassium requirements peak during fruit growth and plant development. Potassium will be applied with potassium sulfate, containing 18% of sulphur and no chlorine, this fertilizer is adapted to crop sensitive to chlorine. An excess of potassium weakens the petioles and can also reduce calcium and magnesium inhibition, thus inducing deficiencies of these elements. When there is a potassium deficiency, the edges of the leaves become necrotic and turn brown. The plants are more susceptible to diseases and the fruit quality and Brix degree decline.

8.3.1.4. Magnesium

An excess of magnesium causes a potassium and calcium imbalance. Magnesium is applied with dolomite in soils with acidic pH and as magnesium sulfate in high pH soils. Magnesium deficiencies affect old leaves, thus giving the plant a Christmas tree appearance. The veins are small and green and the tissues between the veins turn yellowish.

8.3.1.5. Calcium

Calcium can be supplied in acidic soils in the form of dolomite, natural (or tricalcium) phosphate and gypsum in low pH soils.
Calcium deficiencies lead to poor fruit quality and performance on the plant (soft fruit), and to a very low postharvest shelflife.

8.3.1.6. Boron

Papaya is very susceptible to boron deficiency, which can induce early yellowing of leaves on juvenile plants. On fruit-bearing plants, this deficiency causes fruit deformation, a reduction in fruit behaviour on the plant and poor plant growth. Soluble boron treatments (30 cm from the trunk, apply 10 g Borax every second month as soon as the fruit begins swelling) can quickly overcome this deficiency. Remember that an excess of boron can be highly toxic to papaya trees. The edges of leaves become necrotic, turn brown and die, and necrotic spots can develop between the veins.

8.3.1.7. Zinc

Zinc is required for the growth of young leaves. An excess of phosphous can cause a zinc deficiency.

8.3.2. Fertilisation

It would be difficult or even impossible to draw up accurate technical guidelines for fertilisation because of the broad range of different soils in which papaya trees are grown. The fertiliser compositions and dosages can differ markedly.

Basal dressing (booster application)

20 kg well-rotted farm manure
500 g superphosphate or tricalcium phosphate
200 g potassium sulphate and if necessary dolomite.

We therefore only give a few examples, as follows:

1- Once a month, place around each plant:

Age	15-5-30 S
1 month	50
2 months	50
3 months	50
4 months	50
5 months	50
6 months	50
7 months or over	100

2- Fertiliser applications in grams per tree:

Age	Urea	Potassium sulfate	Magnesian lime	Tricalcium phosphate
1 month	50			
2 months	75	40		
4 months	100	100		
6 months	100	125		
8 months	100	150		
10 months	125	80		125
12 months			1000	
14 months	100	150		125
16 months	100	150		
18 months	100	150		125

3- Fertilisers used in Northern Ivory Coast (CNRA Station, Korhogo/Lataha)

Age	Urea	Potassium sulfate	Magnesian lime	Tricalcium phosphate
1 month	50			
2 months	100			
5 months	125	200		10
7 months	150			10
9 months	150	200		10
11 months	150		100	10
13 months	150	200		10
15 months	150		125	10
17 months	150	200		10

In nitrogen-rich soils, urea inputs are decreased, especially between the 3rd and 5th months. The same fertiliser quantities can be applied with monthly applications, so fertilisation can thus be more effectively managed on the basis of plant growth patterns.

These fertiliser inputs should be adjusted according to soil test results.

IX. CROP PROTECTION

Papaya trees are very susceptible to phytotoxicity, which is a major constraint for pest and disease control in this plant. Many crop protection products commonly used to treat a variety of plants, without damaging them, induce serious burns on papaya plants.

Many animal or plant parasites, which are linked more or less to vegetation stages or climatic conditions, attack papaya plants. Integrated pest management (IPM) is thus essential, but involves delicate techniques and often dangerous products. The efficacy of a treatment depends both on how well it is distributed–spray mixture volume, active ingredient dose, spraying quality–and on the efficacy of the product used.

Many active ingredients are not very selective and destroy both the target parasites and auxiliary organisms, thus upsetting fragile natural balances that farmers would be wise to protect.

Finally, it is crucial to comply with the authorised treatment guidelines as well as preharvest treatment times established in countries where the crop is grown.

Note: A certain degree of pest resistance to the products used to control them has been noted. Hence, to be able to continue efficiently controlling these pests, it is important to successively use products belonging to different chemical families, and that do not belong to the same class, even though they might not have the same efficacy.

Each control treatment should thus be carefully managed and the operator should have a clear overall understanding of the orchard and in-depth knowledge on the pest and disease situation.

9.1. Integrated pest control: what to do?

WHAT TO DO ?	HOW ?	WHY ?
IDENTIFY AND QUANTIFY: from the beginning of the cycle (even in the nursery), monitor susceptible organs twice weekly (flowers, shoots, fruit, etc.)	- By visually monitoring the different organs. - By installing fruit fly traps.	To identify and quantify the diseases and pests on the crop.
ESTIMATE: the risk to the crop on the basis of field observations.	- By monitoring population variations weekly	To start treatment when the crop is actually threatened by pests in order to optimise treatment efficacy.
CHOOSE: after assessing the risk, treat accordingly	- By choosing the most selective treatment method and the most suitable for the current situation	To destroy parasites while preserving auxiliaries, user's health and the environment.

GEOGRAPHICAL DISTRIBUTION OF DIFFERENT DISEASES AND PESTS

Diseases	Geographical Distribution			Importance for export	Ecological context
	West context Africa	South Africa and the Indian Ocean	Caribbean Islands		
Anthracnose	X	X	X	5	All areas
Phomopsis	X	X	X	5	All areas
Oidium	X	X	X	5	Cool areas
Alternaria	X			5	Postharvest
Rhizophus stolonifer	X			4	Postharvest
Insects					
Fruit flies	X	X	X	5	All cropping areas
Red spider mites	X	X		5	All cropping areas
Broad mites	X			5	All cropping areas
Mealybugs and scales	X		X	1	
Thrips	X	X	X	1	
Whiteflies	X	X		2	

9.2. Apply products at the correct dosage

Each control product should be applied at the registered dosage, depending on the crop, the pest and treatment method. This dosage ensures optimal treatment efficacy without harming the plant or potential consumers.

The authorised dosage is given on the product label, either per hectare (e.g. 1.5 l/ha) or per hectolitre (e.g. 0.2 kg/hl). The volume of spray mixture to be applied per hectare must be known to be able to properly use the per hectare dose given. Less product is used with a motorized sprayer (e.g. 500 l/ha). However, higher doses (e.g. 2000 l/ha) are used for some specific treatments.

Sprayers to be used:

The product can be sprayed on the trees with:

- a pneumatic knapsack sprayer equipped with a centrifugal pump enabling the product to be dispersed uniformly and regularly, including on the upper parts of the trees.
- a high pressure sprayer (tractor- or trailer-mounted with a tank capacity from 200 to 1000 l) that produces streams that uniformly and regularly disperse the active ingredient diluted in a fluid, in the form of droplets that are projected by a powerful air blast on to the organs of the plants needing treatment.
- some tanks are equipped with hoses for carrying out treatments that require both high pressure and large flow rates. This equipment is recommended for treatments against mealybug.

Practical advice:

- Treatment should not be performed in high temperatures to avoid burning.
- Treatment should be performed preferably on windless days to avoid spray drift on neighbouring crops.
- Avoid treatment when weather may turn as any rainfall of 25 mm or more will wash off contact and systemic substances that have been applied in the last 3 hours.

- Treat dry vegetation for better product adherence.
- Alternate between families of active ingredients as far as possible to avoid forming resistances.

Spraying trees:

Pesticide recommendations commonly are given in two ways. One is an amount of product to apply per ha. Another is an amount of product per volume of water, with the assumption that the volume mentioned covers an hectare.
The recommendations for the amount of product to apply assume the trees or target crop is average size and age and the entire area is sprayed, not just a tree here and there.

The calibration of sprayer delivering a constant quantity of water at all stages of the crop is not difficult. At times, backpack sprayers are used to spray trees for insect or disease problems and this is more difficult to calibrate as the volume of water used per hectare will depend on the size (volume) of the trees and the number of trees per hectare.

For calibration of a backpack sprayer follow these steps:

1. Pick out a row or area where the trees represent the "average" tree height and spacing for an orchard which is achieved at full development.
2. Fill the sprayer with a known volume of water. (Let's assume 20 litres.)
3. Spray the trees as you would with the spray mix, trying for adequate coverage for the target pest.
4. After spraying the 20 litres of water, count the number of trees you sprayed. (Let's say you sprayed 12 trees.)
5. Next, determine what part of an hectare you sprayed with 20 litres.

$$\frac{\text{12 trees}}{\text{120 trees/hectare (plantation density)}} = \text{0.10 hectare}$$

6. Determine your litres/hectare output by dividing volume by area.

$$\frac{\text{20 litres}}{\text{0.10}} = \text{200 litres/hectare}$$

7. Finally determine how to divide the recommended quantity for the hectare application.

$$\text{for example } \frac{\text{1 kg/hectare}}{\text{200 litres/hectare}} = \text{5 ml/l}$$

This dilution must be maintained for the calibrated sprayer and the targeted pest at all stage of the crop in order to avoid any problem of phytotoxicity.

The tables below provide values for some common preparations of pesticide solutions .

Treatment with 1000 l/ha

	Surface area treated 1 hectare	Surface area treated 1000 m^2	Surface area treated 100 m^2
Approved dose	Amount of substance to be diluted in 1000 litres of water	Amount of substance to be diluted in 100 litres of water	Amount of substance to be diluted in 10 litres of water
0.5 l/ha = 0,05 l/hl	500 ml	50 ml	5 ml
1 l/ha = 0.1 l/hl	1 l	100 ml	10 ml
1.25 l/ha = 0,125 l/hl	1.25 l	125 ml	12.5 ml

Treatment with 500 l/ha

Doses of substances per unit surface area are the same as a treatment with 1000l/ha.
However, the volumes of water change and the mixture is therefore twice as concentrated.

	Surface area treated 1 hectare	Surface area treated 1000 m^2	Surface area treated 100 m^2
Approved dose	Amount of substance to be diluted in 500 litres of water	Amount of substance to be diluted in 50 litres of water	Amount of substance to be diluted in 5 litres of water
0.5 l/ha = 0.1 l/hl	500 ml	50 ml	5 ml
1 l/ha = 0.2 l/hl	1 l	100 ml	10 ml
1.25 l/ha = 0.25 l/hl	1.25 l	125 ml	12.5 ml

Treatment with 2000 l/ha

Doses of substances per unit surface area are the same as a treatment with 1000l/ha.
However, the volumes of water change and the mixture is therefore twice as diluted.

	Surface area treated 1 hectare	Surface area treated 1000 m^2	Surface area treated 100 m^2
Approved dose	Amount of substance to be diluted in 2000 litres of water	Amount of substance to be diluted in 200 litres of water	Amount of substance to be diluted in 20 litres of water
0.5 l/ha = 0,025 l/hl	500 ml	50 ml	5 ml
1 l/ha = 0,05 l/hl	1 l	100 ml	10 ml
1.25 l/ha = 0,0625 l/hl	1.25 l	125 ml	12.5 ml

$$\text{Dose of product} = \frac{\text{Dose of active ingredient (g/ha)}}{\text{Active ingredient concentration in commercial product (g/litre or g/kg)}}$$

Warning

Applying crop protection chemicals is one possible way of controlling pests and diseases in papaya. This document deals with this subject at length. As a guide to readers we suggest chemicals that can be used for this purpose. We draw the reader's attention to the following points:

- The chemicals mentioned are not the only possibilities.
- These chemicals are dangerous for humans and the environment. It is up to each user to comply with the uses recommended by the manufacturer, and the related safety rules.
- Using some of the chemicals mentioned in this document may involve a risk of exceeding European MRLs (Maximum Residue Limits), since the EU has so far very few proper MRLs for papaya and several are very low because they have been set at the Limit of Quantification (LOQ). Companies should be approached to find out the commercial forms of the chemicals listed and their conditions of use.
- Refer to current list of pesticides registered in the country of use and comply with standards in force in the consumer country.

9.3. Pests

9.3.1. Nematodes

Host plants:

The main species that parasitise papaya can also be found on many other crops such as pineapple, citrus trees, banana, tomato etc.

Conditions favourable to infection:

The external symptoms caused by proliferation of plant parasites are often attributed to soil fatigue. Nematodes are transported by the plants themselves and by irrigation water.

Symptoms and damage:

- The name "gall nematodes" refers to the common symptom of infestation by all *Meloidogyne* species. At the point where the nematodes attach, the plant tissues react by cell proliferation. The galls so formed are often small (some millimetres across) but a severe attack can result in a gall sized as a golf ball.

- Reniform nematodes (*Rotylenchulus* spp.) cause no clearly visible symptoms on roots.

In both cases, the growth of new secondary roots declines and the root system becomes inadequate for the plant.

There are **no typical symptoms** on the aerial parts of the plant; chlorosis and wilting may be due to nematodes or to moisture or mineral deficit. Infestations by both these genuses reduce growth and yield (small fruit, less flavour, plant lifespan shortened). In nurseries, the most severe infestations (for both genuses) can kill seedlings.

Biology:

- Root-knot nematodes: From the egg hatches a juvenile nematode (not a larva) of the second stage; the first moult takes place in the egg. The nematode penetrates the tip of a root and travels up through the plant tissue near the pericyle before settling at its feeding site, where it triggers a reaction in the plant tissues. The now sedentary nematode develops to the female stage, taking the form of a swollen bag (hypertrophy of the ovaries). The eggs are laid in a mucilaginous envelope, forming a globular mass containing an average 200-300 eggs. This egg mass generally emerges from the root (unless the gall is too large).

- Reniform nematodes: Same life cycle as *Meloidogyne* at the beginning, but the nematode's entire life is spent in the soil. The young female penetrates the root and attaches there, but the rear part of her body remains visible outside the root (semi-endo-parasite) and swells into the shape of a kidney ("reniform" means kidney-shaped). This genus too lays its eggs in a mucilaginous mass, a few dozen eggs per egg mass. The duration of the life cycle varies according to species.

Observation methods:

No typical external symptoms – if there is chlorosis and wilting with no apparent cause, roots should be examined.

- Root-knot nematodes: easy to diagnose by the presence of galls on roots (but not the responsible species).

- Reniform nematodes: by examining the roots with a magnifying glass one can see the rear ends of swollen females emerging from the roots.

In either case, the species involved can only be identified by means of laboratory tests.

Preventive measures:

Crop rotation is one of the most usual methods used to limit infestation. Certain species (e.g. maize, crotalaria) sown in a fallow period can act as nematode traps. Tilling the ground in the dry season and so exposing the soil to sunshine before planting can considerably reduce infestation. Steam disinfection of nursery substrates, use of well-rotted manure and making sure to plant only gall-free seedlings are all factors for a successful crop. Adequate drainage of plantations and good control of irrigation also help to prevent nematode problems.

Pesticides applications:

When symptoms are detected, control includes crop rotations and disinfecting the soils with a nematocide (cadusafos) 2 months before planting. This compound is the least toxic to papaya plants.

Do not conduct systematic nematode control treatments, this problem only occurs in plots previously cropped with papayas.

9.3.2. Broad mite: *Polyphagotarsonemus latus* (banks)

Susceptible stage of crop:

Observed **in seed beds and on leaves of grown crop.**

Other host plants:

Mango, avocado, citrus trees and many vegetables; over 30 known host species. Useful treatment period in West Africa:

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Broad mite												

Symptoms and damage:

This small, whitish acarian (0.2 to 0.3 mm) is very widespread in the inter-tropical zone. It multiplies very rapidly and a crop can be heavily infested by the time the first symptoms are observed. The leaves yellow, and the heavier the infestation the faster this occurs.

Defoliation follows; this can kill young plants. On old leaves, the lamina thickens and becomes deformed. Symptoms can be similar to distortion ring spot. When the mites attack terminal leaves, the plant ceases to grow.

Conditions favourable to infestation:

The broad mite's biological cycle is very rapid; in optimum conditions (21-27°C) it takes only 4 to 5 days. Each female can lay 4 to 7 eggs a day. It has also been noted that the use of certain organo-phosphates to control mites increases their proliferation and rate of egg-laying.

Observation methods:

Early yellowing of leaves and deformation of the leaf blades. In each 0.5 ha of orchard, examine 5 plants in 6 different places spaced far apart. Spray if more than 2 plants are damaged and the mites are still present. Mites can be seen with a field magnifying glass.

The presence of damage can be used as a guide for control measures. Inspect the plant's terminal meristem very closely, every two months during the dry season, to detect the earliest signs of apical damage; this is necessary if treatment measures are to be taken before terminal growth is seriously compromised;

Non-chemical control: Sprinkler irrigation on foliage.

Pesticides applications:

As soon as the first symptoms of deformation appear, treat with one of the acaricides in the annex 1.

Remark:

Micronized wettable sulphur: e.g. 80 g commercial product at 80 % /10 l water at 2000 l/ha. Treatment must be carried out in the early morning or, better still, in the evening, to prevent burning of flowers or fruit when temperatures rise above 25°C. If treatment is carried out when temperatures are over 25°C, the dosage should be reduced to avoid possible burning of foliage. Warning: sulphur is less effective when air humidity is very low.

9.3.3 Spider mite: *Tetranychus* sp.

Other host plants: Spider mites also cause damage on banana, citrus and avocado crops as well as weeds, cotton, bean, tomato etc. . . .

Effective treatment period in West Africa:

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Tetranychus												

Crops should be monitored throughout the dry season. Nursery beds should be monitored more frequently if propagation is taking place in the dry season.

Adults
Adult spider mites are usually 0.3 to 0.5mm long. Their colouring can range between shades of red, orangeish and purple. There are some long strands on the body and darker patches on the top side of the abdomen.

They generally live on the undersides of leaves, where most of them weave thin webs in which their eggs are attached.
The eggs are a flattened sphere in shape, with a stalk of variable length on the top. They are red and measure 0.10 mm to 0.15 mm.

Conditions favourable to infestation:
Infestation can be very severe in the dry season. The appearance of spider mites often indicates over-use of pesticides, as insecticides kill their natural predators.

Symptoms and damage:
Spider mites generally live on the undersides of leaves, where they weave thin webs in which their eggs are attached. Symptoms are a gradual colour change in leaves, from the usual green to a yellowish colour. Affected leaves age and fall prematurely.
Colonies can also develop where two fruit touch each other; this severely damages the two fruit.

Observation methods:
Infestation levels can be established by regular examination of the young leaves of five trees in different parts of each hectare of plantation. Chemical treatment should only be used if spider mites are present on 50% of the leaves observed and no auxiliary is present.

Auxiliaries that control spider mite population levels are *Amblyseius* spp. and *Phytoseiulus persimilis*. A precautionary measure against the proliferation of spider mites is to gather and burn old affected leaves.

Preventive treatment:
Foliar irrigation and prudent choice of crop protection chemicals reduce proliferation of spider mite populations. An effective windbreak system also helps to reduce attacks. Intercropping is to be avoided, especially with an intercrop that is also a host species. Ladybirds and small predator acarians eat spider mites and can provide effective natural control.

Pesticides applications:
Chemicals should be applied to the undersides of leaves as soon as the first symptoms appear. As not all the chemicals used kill the eggs, treatment every 6 days is needed to halt an infestation. Spider mites may develop resistance to certain chemicals or groups of chemicals. Alternating between different families of chemicals will minimise this risk. If using wettable or micronised sulphur, it is advisable to spray early in the morning or very late in the afternoon to avoid burns on leaves and young fruit. Never apply when temperatures are over 25°C.

See pesticides that can be used in annexes.

9.3.4. Whiteflies: *Aleurodicus dispersus* and *Bemisia tabaci*

These small insects (1 mm) have white wings with a black dot, thus explaining the name "whitefly". It is the vector of many virus diseases, including leaf curl on tobacco and cotton. In India (Uthar Pradesh), it transmits the same type of virus disease to papaya plants. Apart from the virus damage it causes, it also induces leaf roll and crinkle.

Susceptible stage of the crop:

Seedlings in nursery, and during the hot season; cool conditions greatly reduce their activity.

Other host plants:

The whitefly is a highly polyphageous insect and is now recorded as attacking over 300 plant species, with a particular preference for cotton, tobacco, bean, sunflower, aubergine, tomato, citrus trees and sweet pepper.

Useful treatment period in West Africa:

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Whitefly												

As attacks mostly occur during the dry season, particular vigilance is required.

Symptoms and damage:

The damage is due to the insects sucking out plant fluids and producing an abundance of honeydew, with resulting sooty mould. The direct effect of larvae and adults sucking the sap is to reduce the vigour of the host plant. As they feed, whitefly also inject into the plant saliva containing enzymes and toxins that perturb the plant's physiological processes. This can cause fruit to ripen early with irregular colouration. Chlorotic patches appear on leaves.

The indirect damage is the development of sooty mould, a fungal disease that hampers photosynthesis by forming an opaque black layer on leaves.

Conditions favourable to infestation:

Depending on climate, there can be 9 to 15 generations of whitefly in a year. Unfavourable conditions include a cool, damp climate but also dry winds. A complete generation cycle requires an accumulated total of 370 degree-days.

Biology:

Whitefly go through six development stages: the egg (0.25 mm, yellowish in colour), four larval stages and the adult. The newly-hatched larva is mobile for a few hours, during which it seeks out a place where it can feed. In its second stage it is flat and transparent, and so difficult to see. The adult fly (1 mm) develops in a whitish pupa. The adult has two pairs of wings and a body covered with whitish, waxy down.

Methods of Observation:

Monitoring should begin by observing the entire crop looking for variations in the colour or vigour of the plants. Signs of whitefly attack are chlorotic patches on leaf surfaces and the presence of honeydew and sooty mould.

Preventive measures:

Eliminate host plants around field edges.
Yellowglue traps are also useful monitoring tools for whitefly control.

Trapping provides information on:

- Whitefly migrations
- Movements of adults
- Fluctuations in population levels
- The effectiveness of insecticide treatments.

Non-chemical control:
Biological control has already proven its worth with auxiliaries such as *Eretmocerus* sp. and *Encarsia*, which are natural enemies of the whitefly.

Pesticides applications:
Chemicals with a contact action attack the insect's cuticle and sometimes its internal system. These chemicals have to be in direct contact with the whitefly. Treat the undersides of leaves, as this is where the whitefly lives.

Whitefly does not often proliferate in great numbers on papaya. Treatment with a 1 to 2% soap solution controls the problem.
Prior to use, check for possible phytotoxicity.

See pesticides that can be used in annexes.

9.3.5. Thrips: *Thrips tabaci* LIND

This pest causes leaf crinkle and localised decoloration of leaves, but these symptoms should not be mistaken for those induced by mosaic virus disease. This is a small elongated insect (around 1 mm) which is yellowish to pale brown with darker rings on the abdomen.
Crop protection products are only effective for controlling adults. Propagation rates are high, with egg/adult development taking 19-20 days under favourable hot dry climatic conditions.

See pesticides that can be used in annexes.

9.3.6. Fruit fly: *C.capitata*, *B. dorsalis*, *B. invadens*, *B.zonata*, *B.cucurbitae*

These dipterans invade fruit once are past the marketable stage. Ripe fruit remaining on the plants should thus be collected and discarded. sometimes yellow fruit can be attacked between the carpels, and these flies lay their eggs in the fruit.

Susceptible stage of the crop:
From final fruit development phase to harvest.

Suitable control period in West Africa:

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Mediterranean fruit fly												

Other host plants:
Many fruit trees including guava, citrus, custard apple, mango and tropical almond, and vegetables such as pimento and sweet pepper.

Useful treatment period:
Trapping is the only way to identify fruit fly population thresholds and define the best method for controlling the pest.
Traps should be set after the first flowering and monitored until the end of the cycle, i.e. for 18 to 24 months.

Symptoms and damage:
The adult female, which varies in size from about 3.5 to 6 mm depending on the species, makes two kinds of hole in the fruit.
Feeding holes appear as small superficial spots on the skin; these holes do not greatly reduce the value of the fruit and have few consequences.
The pin-prick sized egg laying holes appear as small brown spots on fruit still on the tree, with an accompanying slight ooze of gum. When the eggs hatch in these fruit, the maggots grow and hollow out galleries as they eat the pulp. Fruits attacked fall naturally early and rot on the ground.

Tender-skinned fruits suffer severe attacks.

Development cycle and conditions favourable to infestation:
The cycle can only take place if there are nearly-ripe fruit available. In moist but not excessively wet conditions, with temperatures between 25 and 30°C, the cycle varies according to the type of fly. For *Ceratitis capitata* (Mediterranean fruit fly) it takes 15 to 20 days.

After mating, the female lays her eggs (1 mm) in a mass under the skin of nearly-ripe fruit. After 2 to 5 days, the eggs hatch and larvae emerge. After spending 9 to 15 days in the fruit, the maggots (7 to 9 mm) that represent the third development stage leave the fruit and turn into pupae on the ground.

From these pupae (4 to 5 mm) the adult flies emerge after a variable length of time, depending largely on weather conditions (temperature, rainfall / dryness of the ground).
As they are polyphageous, these flies do not depend on only one plant species for food. Fruit flies are multivoltine (i.e. several generations per year). They migrate from one host species to another according to the season and the ripening stage of the fruit. The risk of infestation in papaya is greatly increased if there are other host plants nearby whose fruits ripen before or at the same time as the papaya.

Observation methods – Trapping System:
At present trapping is only used to monitor fly populations, it is not a control method in itself. There are sexual attractants, parapheromones, that attract only male flies, and food lures, usually protein hydrolysate, that attract flies of both sexes. Using these attractants, a trapping system has been developed to capture adult flies and assess the level of infestation. The trap contains at least one sexual attractant and a block of insecticide to kill the flies. The choice of attractant or attractants depends on which species are present. For optimum efficacy, part of the trap should be yellow, as this colour attracts fruit flies. The attractant used for the Mediterranean fruit fly is Trimedlure (which should be renewed every two months), together with the insecticide dichlorvos (which should be renewed once a month). Regarding *Bactrocera zonata* and *Bactrocera invadens*, methyl eugenol should be used as an attractant.

Choice of traps:
There are several types of trap available. The most commonly used are Tephritrap, Addis, Mac Phail.

Prevention:
There are few preventive control methods for keeping fruit fly populations low; they concern the entire plantation environment:

=> gathering and destroying fallen fruit and fruit with holes, both in the orchard concerned and in neighbouring orchards; the fruit can be gathered in hermetically sealed plastic bags and left in the sun to destroy the larvae by heat.
=> destruction of other host plants.

Non-chemical control:
Some pupae are destroyed on the ground (by ants and other insects), but fruit fly have few natural parasites so population control cannot be achieved by biological control.
The system used in the Pacific for exporting fruit to New Zealand is to force hot air at 48.5°C over harvested fruit for 3 hours.

Pesticides applications:

Infestation level	Weekly count no. of flies per trap	Type of treatment
zero to low	fewer than 25	no treatment
medium	25 to 120	local treatment
severe	over 120	whole orchard treatment

There are two chemical control methods; their use depends on the degree of infestation revealed by the trapping system and parasite pressure connected with the orchard environment.

Whole orchard treatment:
An insecticide is sprayed throughout the orchard, at 800 to 1000 l/ha.
The pre-harvest interval is more restrictive and prohibits spraying near or during the harvest period.

As flies are subject to obligatory quarantine, no fruit with holes can be exported; if any fruit arrives with holes, the European phytosanitary services will reject and destroy the entire batch.
It is therefore essential to identify and reject any fruit with holes during harvest and sorting at the packing station.

9.3.7. Mealy bugs and scales

There are two main forms:

- Small relatively flat chitinous disks protecting the actual insect underneath, which moves very little. These are diaspine scales.
- Or insects coated with relatively abundant waxy secretions which gives them a mealy appearance. These are called mealy bug.

In both cases, only the larvae are mobile and susceptible to pesticides. This stinging-sucking insect is mainly found on the trunks of papaya trees, so contaminated areas can be quickly treated if the trunks are monitored regularly in papaya orchards. These pests are also naturally controlled by parasites (hymenopterans) and predators (larval and adult ladybugs).

The periods prior to and after the rainy season seem to be the most favourable for mealybugs. Five generations a year can be produced. See pesticides that can be used in annexes.

The papaya mealybug (*Paracoccus marginatus*) was accidentally introduced in Ghana apparently in 2009. This species is believed to be native of Mexico and/or Central America, where it never acquired the status of a serious pest, probably due to the presence of an endemic natural enemy complex.

The papaya mealybug is an emerging insect pest that is currently found also in others ACP countries: in 14 Caribbean countries and recent introduction to the Pacific regions include Guam, Republic of Palau, Bali and West Java.

Papaya mealybug attacks the foliage and fruit of papaya plants, causing the fruits to be unmarketable, and eventually kills plants completely if left unchecked. Biological control of P. marginatus can be very effective. Effective chemical control of papaya mealybug is difficult to achieve.

During feeding, this mealybug injects a toxin that can cause leaf yellowing (chlorosis), premature leaf and fruit drop, stunting, deformation, and buildup of honeydew. When mealybugs are found on the fruit, the fruit can be rejected at the packing house. The papaya mealybug has numerous alternate hosts, including plumeria, hibiscus, avocado, citrus, guava, tomato, eggplant, beans, cassava and many weed species, which increases the difficulty of control.

Mealybug control often involves the control of attendant ants that are important for the proper development of mealybugs. Without the ants, mealybug populations are small and slow to invade new areas and the field would be free of a serious mealybug infestation.

For management of mealybugs, it is important to know the species present as management programs for the various mealybugs may differ. Plant protection products are of limited effectiveness against mealybugs because of the presence of waxy covering of its body.

Management of mealybug involves the following tactics:

- Monitoring and scouting to detect early presence of the mealybug
- Removal and burning of crop residues

- Removal of weeds/alternate host plants in and nearby crop
- Avoiding the movement of planting material from infested areas to other areas
- Avoiding flood irrigation
- Sanitization of farm equipment before moving it to the uninfested crop
- Application of sticky bands or a band of insecticide on main stem to prevent movement of crawlers

9.3.8. Synthesis of effective treatment periods in West Africa

Pest	Season											
	Dry			Humid and rainy					Dry			
	Jan	Fev	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spider/Broad mites												
Whiteflies												
Thrips												
Mealybugs and scales												
Fruit flies												

9.4. FUNGAL DISEASES

9.4.1. Papaya powdery mildew: *Oïdium caricae*

Susceptible stage of crop:
Seen on leaves in nursery beds and on leaves and ripening fruit throughout the crop's life during the dry season.

Other host plants:
Only papaya is susceptible to *O. caricae*

Useful treatment period in West Africa:

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Powdery mildew												

Symptoms and damage:
The first symptoms typical of powdery mildew attack are separate round, chlorotic spots on leaves; the white mycelium generally grows on the underside of the leaf, especially in parts of the lamina close to the veins, but from time to time patches of whitish powder may appear on the top side. If the attack is severe, premature leaf fall may occur. Young plants are particularly vulnerable. Initially, infected parts turn pale green and chlorotic and the lesions may be edged in dark green.

Both leaves and fruit can be infected. Although leaves of all ages are considered susceptible, infection is largely limited to old leaves nearing senescence. The leaves of young plants are particularly susceptible and can be seriously affected. Defoliation and stem and fruit lesions can lead to major yield losses.

Epidemiology:
The conidia of *O. caricae* are dispersed by wind.

Conditions favourable to infestation:
Cool temperatures and strong sunlight favour the development of powdery mildew.

Observation methods:
Chlorotic spots on leaves and appearance of a light dusting of mycelium.

Preventive methods:
A good windbreak network reduces dispersal of inoculum.

Non-chemical control:
None.

Pesticides application:
Since this pathogen can become resistant to some fungicides, it is best to treat with chemicals of different families so as to minimise any tendency to resistance. Treatments must be initiated as soon as this white mildew appears. The plantation should be monitored during cool humid periods when this disease commonly develops. Control involves removing contaminated leaves and treating plants with a fungicide. See annexes.

9.4.2. Anthracnose: *Colletotrichum gloeosporioides*

Susceptible stage of crop:
Susceptibility is higher during the rainy season, but because the ascospore stage lasts some time, anthracnose may be present all year round and in particular can affect harvested fruit.

Other plant hosts:
Mango, avocado.

Useful treatment period in West Africa:

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Anthracnose												

Symptoms and damage:
Anthracnose is the main fungus disease affecting papaya. It is found in all parts of the world.
The characteristic symptoms appear on fruit at the colour-change stage, sometimes on the tree but more often during ripening. Small, round, slightly sunken spots can be seen, a darker green than the rest of the fruit; these spots rapidly enlarge to form the circular sunken lesions typical of anthracnose. In the middle of the lesions the fungal fruiting bodies appear, often in concentric circles. These are small cushions of pink, grey, salmon or greenish spores. The underlying flesh is vitreous, soft and bitter tasting.

Within a few days the lesions coalesce, the rot spreads to the whole fruit, the pulp liquefies and numerous secondary parasites appear. The fungus that causes anthracnose also attacks the petioles of leaves that are on the point of wilting. These petioles hang down from the trunk and are a major source of potential inoculum for the fungus to attack green fruit on the tree.
Anthracnose is of major economic importance in Africa.

Conditions favourable to anthracnose outbreak: Rainy season conditions (hygrometry 90%) with temperatures around 28°C encourage the development of the disease; the inoculum is dispersed by wind and rain. Plantations should be monitored regularly to detect early attacks on ripe fruit and treat as required. Anthracnose is less active in the dry season owing to the amount of sunshine and the temperature range of 18 to 25°C.

Observation methods:
Anthracnose is hard to identify before the fruit ripen, because the symptoms develop progressively with the ripening of fruit. Unlike other types of anthracnose, there is no method for diagnosis on harvest.

Preventive methods:
The usual hygiene precautions:
- Destruction of petioles
- Destruction of rotten fruit
- Early harvesting.

Heat treatment:
A hot water dip to eliminate fungal spores, anthracnose spores especially, on fruit skins. Crates of fruit are plunged into hot water. Soaking time depends on water temperature, which varies according to fruit susceptibility, region and papaya variety. The standard is 20 minutes' soaking at 49°C, or 30 minutes at 42°C. Another method is to spray fruit with hot water at 54°C for 3 minutes.

Pesticides application:
As a preventive measure, it is recommended to treat throughout the rainy season. Post harvest, prochloraz can be used at 250 to 500 ppm.

See tables of fungicides in annexes.

9.4.3. *Phomopsis* sp.

Areas on the fruit that are infected by this fungus are slightly depressed and translucent. The causal agent grows rapidly, inducing lesions that can quickly reach the seed cavity. The fungus is also sometimes detected around the fruit stalk.
Under very moist conditions, infected areas of the fruit can become coated with a whitish-grey mycelium.

Pesticides application:
Anthracnose control treatment also prevents *Phomopsis* problems.

9.4.4. *Cercospora papayae*

This fungus induces the development of small black spots (never more than 3 mm dia.) which are limited to the skin of the fruit. It does very little damage apart from diminishing the appearance of the fruit.
Fungicide sprays used to control anthracnose are also effective in protecting fruit from *Cercospora papayae* infestation.

9.4.5. Root, collar and stem rot caused by *Phytophthora* and *Pythium*

These different serious diseases often kill infected papaya trees.

Infestation period:
This disease can be present throughout the year in heavy, clayey and poorly drained soils or where irrigation is not adequately controlled. The general term "rot" covers a range of serious problems that can kill the tree. As regarding damping-off disease, the seedling can be affected before the shoot reaches the soil surface, or after emergence.

Useful treatment period in West Africa:

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Phytophthora and *Pythium*												

Conditions favourable to infestation :
Heavy, poorly-drained soils or an inefficient irrigation network are very favourable to this disease.

Symptoms and damage:

1) **In nursery beds**, young plants wilt rapidly and wither after emergence. In this case one can observe blackish, water-soaked patches at the collar caused by one or several fungi that rapidly invade the plant tissues at ground level. The plant dies once the necrosis has encircled the stem. This disease is particularly serious when both temperature and humidity are high, or if watering is too frequent or too abundant.

2) **In adult plants**, foliage yellows and dies prematurely, newly formed leaves remain small with unusually short leaf-stems, few seeds set and if any fruits form these remain small and never ripen.

At a later stage the only left thing is a small bunch of leaves at the tip of the stem. At ground le el, the base of the trunk softens and rots and the sick tree will fall easily if pushed. The disease does not spread to neighbouring trees, but is encouraged by particular weather conditions such as cold and wet. The fungus can also invade the stems of healthy leaves, flowers or fruit and cause them to fall prematurely. Another symptom is the appearance of dark green watery spots on fruit and on the fruit-bearing parts of the stems. Fruit can be affected at any stage of development; they build a whitish coating of mycelium containing sporangia. Then they shrink, become mummified and fall from the tree.

Observation methods:

The symptoms described above are easy to observe. On trunks, the patches are to be found on scars left by leaves or fruits. They then spread and often completely encircle the trunk, killing that part of the tree above the affected part. The yellowing and premature death of leaves are also easy to detect. During the hot wet season, yellowish rings on immature fruit are also easy to detect.

Preventive measures:

Choose suitable areas for planting (healthy fields not located in an area that can be flooded) and make sure the entire field is well drained. One should uproot and burn trees with diseased trunks or roots.

Pesticides applications:

As a preventive treatment, daub trees with specific fungicides (fosetyl-for example).

9.4.6. Synthesis of effective treatment periods in West Africa

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Anthracnose												
Oïdium												
Phomopsis												
Phytophthora												

9.5. VIRAL DISEASES

The papaya tree is susceptible to many viral diseases. In West Africa the most frequent, in order of importance, are as follows.

9.5.1. Ringspot

Cause:

Type P papaya ringspot virus (PRSV-P). There are two strains of PRSV; P (for papaya) infects both papaya and cucurbitaceae such as squash, cucumber and watermelon, while W (for watermelon) only infects cucurbitaceae. Apart from the inability of the W type to infect papaya, the two types are very closely related.

Conditions favourable to infection: Cool weather favours infection. Symptoms appear less often in high temperatures. The virus is mechanically transmitted by aphids, especially *Aphis gosypii* and *Myzus persicae*, which are its most effective vectors. The virus is not persistent in the vector.

Symptoms:
The first symptom is yellowing of leaves and paler coloured veins in young leaves. These first symptoms are followed by yellow patches (mosaic) along with greasy or oily patches on leaves, streaks on petioles and round patches on stems. The name of the disease refers to the rings that appear on the fruit. These rings are dark green to brown, turning grey on ripening. Patches or rings caused by Hawaii ringspot are yellow with green centres. As the symptoms persist when the fruit is ripe, affected fruit are not for export.

Host plants:
This virus does not have a wide range of host species. Its natural hosts are papaya and cucurbitaceae. This means that the virus can be transferred to papaya from cucurbitaceae.

Importance:
Papaya ringspot is found in many countries where the papaya is grown: Hawaii, Brazil, Thailand, the Caribbean, the Philippines, Ivory Coast and Ghana. Wherever the virus is present, it makes papaya growing very difficult because there is no method of control.

Preventive measures, recommendations: All affected plants should be pulled up and burnt as soon as the disease is identified. In some countries (Mexico), yellow glue traps are set for aphids so as to reduce transmission.

Vectors:
The aphids (order *Hemiptera*, family *Aphididae*) that spread the virus live in colonies and congregate along young shoots. They feed by sucking sap from the young shoots, which quickly become deformed. This is when the virus is transmitted to a healthy plant.

Use of auxiliaries:
Many natural predators such as lacewing, ladybirds and some micro-hymenoptera destroy aphids and can be used as auxiliaries to avoid using chemicals.

9.5.2. T.S.W.V. Tomato Spotted Wilt virus

This is a quarantine virus, transmitted by thrips (10 species, the best known being *Frankliniella occidentalis*) which use many plants as hosts, including *Solanaceae, Compositae* and many other wild or ornamental plants.

It occurs in warm climates that encourage thrips. These vector insects transmit persistent viruses, meaning that the thrips acquire the virus slowly and transmit it over a longer period. Symptoms are concentric yellow or brown rings, small brown patches large irregularly-shaped necrotic patches, necrotic sections of stems (brown to black) and necrotic tissue at the junction between leaf and petiole. Dwarfing, mis-shaping, necroses of all kinds, chlorotic mottling and mosaics in various patterns and stem necrosis may also occur. Visual identification is very complicated. As soon as a plant is identified as a doubtful case, it should be pulled up and tested to identify the virus with certainty.

9.5.3. Bunchy top

Transmitted by the leaf-hopper *Empoasca papaya*. The newly formed leaves are small, thick chlorotic and borne by very short rigid petioles that extend horizontally, whereas normal petioles are almost vertical. There are green areas on the fruit that are paler than normal, without any latex secretion.

9.5.4. Yellow crinkle

Transmitted by the brown leafhopper *Orosius argentatus* The first symptom is marked yellowing of old leaves whose petioles curve downwards from the insertion point. This leads to premature leaf fall.

Between the veins of the youngest leaves, thin translucid areas develop that can later detach from the normal parts. Yellow crinkle mainly develops during hot dry periods.

9.5.5. Mosaic

This virus disease is transmitted by aphids and whiteflies. The symptoms can vary substantially depending on the age of the plant when it becomes infected. Generally, the veins on young leaves become clear, followed by relatively marked mosaic symptoms. Plants infected with this disease should be destroyed.

X. Harvesting – yield

10.1. HARVESTING

Papaya can be harvested when the fruit turns yellow between the carpels (yellow spot). The right moment for picking depends on the desired storage time. If the fruit is harvested green, it will not ripen and will be more susceptible to chilling damage. Harvesting generally begins between the 7th and 8th month after planting, and continues straight through until around 20-22 months.

One papaya plant can yield as much as 35-40 kg of fruit, which represents a per-hectare yield of around 60-80 t/ha over a 22 month period. This harvesting is done by well trained staff, with gloves, cutters or knives (0.5- 1 cm fruit stalk to cut), which should be disinfected on a regular basis to avoid transmitting fungal diseases between trees, and plastic boxes containing
foam to cushion the freshly harvested and delicately handled fruit.

During harvest, all fruits showing a turning colour are collected, whereas fruits for export are stored in different boxes than those designated for domestic markets or processing.

10.2. POST-HARVEST

Soon after harvest, fruits are taken to the packing station where they are prepared for export.
The fruit should not be left for a long time in the plantation or the wrapping station (prior to packing), as often occurs, because it is hard to subsequently control problems of mould (anthracnose) which will accelerate the ripening process.

10.2.1. Hot water treatment

This process is intended to eliminate fungus spores, anthracnose spores especially, on the fruit skins. The crates of fruit are immersed in hot water. Soaking time depends on water temperature, which varies according to the sensitivity of the fruit, the variety of papaya and the geographical area.

Fruit may be soaked for 20 minutes at 49°C or 30 minutes at 42°C.

Once the standard is established (this is the reason tests are to be conducted), it might be necessary to add thiabendazole (TBZ) at 150 g/100 l water, to minimise postharvest problems. A wetting agent can be added to moisten the fruit peel.

10.2.2. Sorting fruit for export

After draining and drying, the fruit is sorted along the wrapping line by:

- size,
- weight,
- colour,
- consistency.

The ripeness ranges from R1 to R4 depending on the season and client demand.
Fruits with mechanical or animal-induced damage, or which are too ripe or not sufficiently ripe are discarded.

10.2.3. Packing

The papayas are packed in 4-5 kg boxes (6-12 fruits per box): of identical grade and identical ripeness

The papayas are laid down and protected with tissue paper or in special polystyrene protective sheaths to avoid damage during transport. The boxes are then placed on ISO standard pallets (1.2 X 1 m) with protective angles and horizontal and vertical banding if the pallets are "capped".

10.3. TRANSPORT

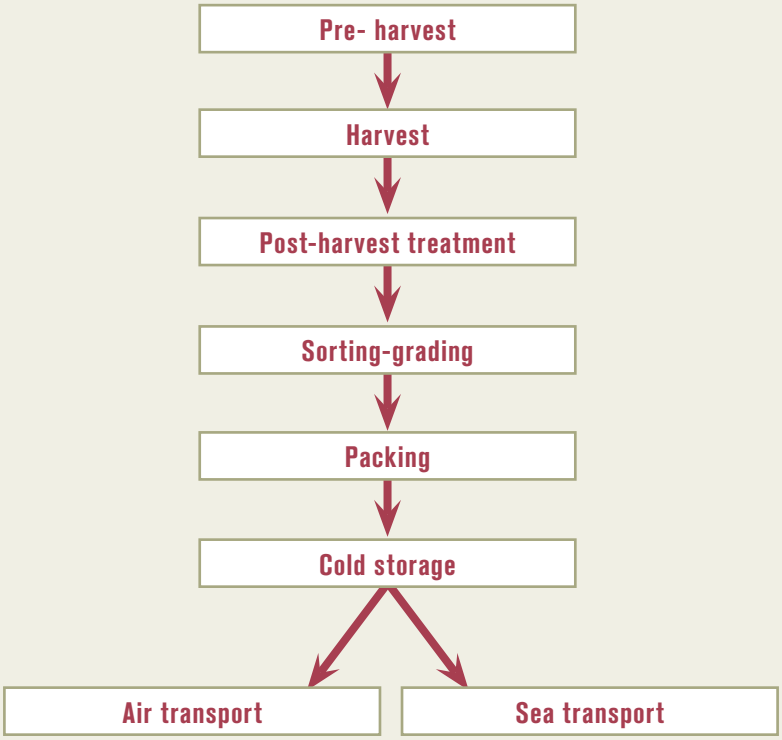
Two types of transportation can be used, depending on the ripeness of the fruit being exported:

A- Air
The ripest fruit are transported by aircraft. The transportation conditions required for ripe Solo variety fruit are 8°C and 90% relative humidity. Less ripe fruit should not be maintained below 12°C and 85-90% relative humidity.

B-Sea
Long haul sea transport (conventional) can be problematic for papaya unless the total travelling time is not more than 14/15 days. For long haul transport under controlled atmosphere conditions, the time can be extended to 21 days.

Temperature	10 – 12°C
CO_2	3% - 5%
O_2	3%
Relative humidity	90 – 95%

PAPAYA EXPORT LOGISTICS CHAIN



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http://www.ipmcenters.org/pmsp/pdf/HIPapayaPMSP.pdf

APPENDICES

Annex 1 : Known registrations in ACP countries and efficacy of active substances

Tables below give known registrations in ACP countries. Efficacy given are based on existing registrations, documents on papaya production and information from pesticides companies.

INSECTICIDES, NEMATOCIDES AND MITICIDES									
Active substance	Registration ACP countries	Nématodes	Broad mite	Tetranychus	Whiteflies	Aphids	Thrips	Fruit flies	Scales and mealy bugs
Abamectin	CIV[P] JAM[P]		X	X			X		
Acephate	CIV[1]		X		X	X	X		X
Acetamiprid	JAM[P]				X	X	X		X
Amitraz	KEN[1]		X		X				
Azadirachtin	JAM[P]				X	X	X		X
Bifenthrin				X	X	X	X	X	
Cadusafos		X				X			
Cypermethrin	CIV[1]					X	X		
Deltamethrin	CIV[1]				X		X	X	
Diazinon	KEN[1]								
Dicofol	KEN[1]		X						
Dicofol + Tetradifon	TAN[1]		X						
Dimethoate	KEN[1]								
Fatty acids (Soap)					X	X	X		X
Fenbutatin-oxyde			X	X					
Fenitrothion	GHA[1]				X	X	X	X	X
Fenvalerate	GHA[1]			X	X	X	X		
Fenpropathrine	JAM[P]		X	X	X	X			X
Hexythiazox			X	X					
Imidacloprid	JAM[P]				X	X			
Lambda-cyhalo-thrin					X		X	X	
Malathion	JAM[P]				X	X	X	X	X
Metarhizium anisopliae	GHA[P]								X
Mineral oil	JAM[P]		X		X				X
Oxydemeton-Methyl	KEN[1]		X		X	X			
Pirimicarb 50 %	KEN[1]					X			
Sulphur	GHA[2]		X	X					
Spinosad							X	X	
Spiromesifen			X	X	X				
Thiacloprid					X	X	X		X
Thiametoxam	JAM[2]				X	X	X		X

CIV = Côte d'Ivoire, GHA = Ghana, TAN = Tanzania, JAM = Jamaica, KEN = Kenya

P = Registered on papaya; 1 = Registered on fruit trees or fruits; 2 = Registered on various crops

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

Fungicides						
Active substance	Registration ACP countries	Powdery mildew	Anthrachnose	*Phomopsis*	Cercospora	*Phytophthora* and *Pythium*
Azoxystrobine		X	X	X	X	
Boscalid	JAM[P]	X	X		X	
Bupirimate	KEN[1]	X				
Chlorothalonil			X	X	X	X
Copper	JAM[P] GHA[1]		X			X
Difenoconazole		X	X		X	
Fosetyl	GHA[1]					X
Imazalil	CIV[1]		X			
Iprodione	CIV[1]		X	X	X	
Mancozeb	GHA[1] TAN[1] JAM[P]		X	X	X	X
Maneb			X	X	X	X
Metalaxyl	CIV[1]					X
Prochloraz	CIV[P]		X			
Propineb + Cymoxanil	KEN[1]					
Sulphur	GHA[2]	X	X			
Tebuconazole			X	X	X	
Thiabendazole			X			
Thiophanate-methyl		X	X			
Triadimenol			X			
Triforin	TAN[1]	X				
Trifloxystrobine		X	X			

CIV = Côte d'Ivoire, GHA = Ghana, TAN = Tanzania, JAM = Jamaica

P = Registered on papaya; 1 = Registered on fruit trees or fruits; 2 = Registered on various crops

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

Annex 2: Residues results on pesticides tested by PIP in Ivory Coast and in Ghana

Two residue trials have been undertaken in Ivory Coast in 2004 and in Ghana in 2005/2006. Tables below give the synthesis of the results and advices on the use of active substances to comply with the current EU or Codex MRL.

Information in the table are as follows:

- Column 1 – Active substance: Name of the active substance.
- Column 2 - EU Status: Status of the active substance in Directive 91/414 in July 2011.
- Column 3 – EU MRL: Existing MRLs in Europe in July 2011.
- Column 4 - Codex MRL: Current Codex MRL in July 2011
- Columns 4, 5, 6 and 7 – GAP tested: Good Agricultural Practices (GAP) tested in the trials (active substance dose, number of applications and interval between applications) are indicated in these columns.
- Columns 8 and 9 - PHI (days) tested that comply with current EU MRL or LOQ

The grower must first and foremost follow the instructions (doses, interval between treatments, number of applications and Pre-Harvest Interval) provided on the labels of locally authorised products. Following such instructions, however, does not necessarily guarantee compliance with MRLs currently in force in the European Union. To comply with European regulations on pesticide residues, it is recommended to producers to use pesticides only within the limits of the Good Agricultural Practices tested by the PIP. Any change to one or more elements of these GAPs (dose increase, frequency of application and number of applications, final application closer to harvest than the recommended Pre-Harvest Interval) may result in a failure to remain below the MRL or the LOQ.

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. Directive 91/414/EEC provides a comprehensive list (Annex I) of active substances that can be incorporated in plant protection products. This Directive and its amendments are available on: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31991L0414:EN:NOT

The status of active substances can be checked on the following web site: http://ec.europa.eu/sanco_pesticides/public/index.cfm.

Regulation (EC) No 1107/2009 concerning the placing on the market of plant protection products replaces Directive 91/414/EEC from June 14, 2011. http://europa.eu/legislation_summaries/food_safety/plant_health_checks/sa0016_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.

Insecticides, nematocides and miticides tested for residue level on papaya

Active substance	EU Status	EU MRL	Codex MRL	GAP tested in PIP trials			PHI (days)		
				Dose (g a.s./ha)	Number of applications	Interval between applications (days)	EU MRL	LOQ**	Codex MRL
Abamectin	Annex 1	0.05	0.01*	21.5	3	2 months	3	> 7***	> 7***
Acetamiprid	Annex 1	0.01*	/	250 g of Mospilan at 20 % per 100 litres of water. Apply 50 ml of mixture per tree at base of trunk	2	4 months	3	3	/
Bifenthrin	Withdrawn	0.5	0.05*	50	Total of 4	2 applications at 7 days interval, repeated after 2 months	3	> 28***	> 28***
Deltamethrin	Annex 1	0.05*	0.01*	12 Applied with Proteus 170 OD (150 g/l of thiacloprid and 20 g/l of deltamethrin)	2	4 months	3	3	3
Fenbutatin oxyde	Annex 1	0.05*	0.05*	495	Total of 6	2 applications at 7 days interval, repeated after 2 months	> 7***	> 7***	> 7***
Hexythiazox	Annex 1	0.5	/	50	3	2 months	3	7	/
Lambda-cyhalothrin	Annex 1	0.02*	/	25	Total of 4	2 applications at 7 days interval, repeated after 2 months	> 7***	> 7***	/
Malathion	Annex	0.02*	/	1,000	3	2 months	3	3	/
Sulphur	Annex	No MRL required	/	12,800	Total of 4	2 applications at 7 days interval, repeated after 2 months	n.a.	n.a.	/
Spinosad	Annex	0.5	0.01*	96	3	2 months	3	> 56***	> 56***
Spiromesifen	Pending	1	/	120	3	2 months	3	> 56***	/

Active substance	EU Status	EU MRL	Codex MRL	GAP tested in PIP trials			PHI (days)		
				Dose (g a.s./ha)	Number of applications	Interval between applications (days)	EU MRL	LOQ**	Codex MRL
Thiacloprid	Annex 1	0.5	0.02*	90 Applied with Proteus 170 OD (150 g/l of thiacloprid and 20 g/l of deltamethrin)	2	4 months	3	56**	56**
Thiamethoxam	Annex 1	0.05*	/	800 g of Actara 250 g/kg per 100 litres of water. Apply 50 ml of mixture per tree at base of trunk.	2	4 months	3	3	/

Annex 1 means inclusion in the positive list of the EC Directive 91/414
Withdrawn means not included in Annex 1
Pending means evaluation of this new a.s. is ongoing.

* LOQ
** Taking into account EU LOQ
*** So to not use during harvesting periods
/ means no data in the Codex data base and consequently not possible to define a PHI
n.a. non applicable

Fungicides tested for residue level on papaya

Active substance	EU Status	EU MRL	Codex MRL	GAP tested in PIP trials			PHI (days)		
				Dose (g a.s./ha)	Number of applications	Interval between applications (days)	EU MRL	LOQ**	Codex MRL
Azoxystrobin	Annex 1	0.3	/	80	6	14	3	> 7***	/
Chlorothalonil	Annex 1	20	0.01*	1,440	6	14	3	> 7***	> 7***
Difenoconazole	Annex 1	0.1	0.2	60	6	14	7	> 7***	3
Maneb	Annex 1	7 ****	5	1,600	6	14	3	> 7***	3
Mancozeb	Annex 1	7 ****	5	1,600	6	14	3	> 7***	3
Sulphur	Annex 1	Not required	/	12,800	Total of 4	2 applications at 7 days interval, repeated after 2 months	n.a.	n.a.	/
Tebuconazole	Annex 1	2	/	250	6	14	3	> 28***	/
Thiophanate-methyl	Annex 1	1	/	80	6	14	3	> 7***	/
Triadimenol	Annex 1	0.1	/	125	6	14	> 28***	> 28***	/
Trifloxystrobin	Annex 1	1	0.02*	125	6	14	3	> 28***	> 28***

Annex 1 means inclusion in the positive list of the EC Directive 91/414

* LOQ

** Taking into account EU LOQ

*** To not use during harvesting periods

**** Note, that papaya naturally contains CS2 between 0.17 and 0.35 ppm

/ means no data in the Codex data base and consequently not possible to define a PHI

n.a. non applicable

Sources of GAP validated by PIP trials

Active substance	Commercial product tested	Manufacturer	Trials	
			Year	Country
Abamectin	Vertimec 18 EC	Syngenta	2004	Côte d'Ivoire
Acetamiprid	Mospilan 200 SP	Nisso	2004	Côte d'Ivoire
Azoxystrobin	Ortiva 250 EC	Syngenta	2004	Côte d'Ivoire
Chlorothalonil	Bravo 720 EC	Syngenta	2004	Côte d'Ivoire
Bifenthrin	Talstar 100 EC	FMC	2004	Côte d'Ivoire
			2006	Ghana
Difenoconazole	Score 250 EC	Syngenta	2004	Côte d'Ivoire
Deltamethrin + thiacloprid	Proteus 170 OD	Bayer CropScience	2004	Côte d'Ivoire
			2006	Ghana
Fenbutatin oxyde	Torque S	BASF	2004	Côte d'Ivoire
Hexythiazox	Nissorun 10 WP	Nisso	2004	Côte d'Ivoire
Lambda-cyhalothrin	Karate 2.5 WG	Syngenta	2004	Côte d'Ivoire
Malathion	Callimal 500 EC	Arysta Lifescience	2004	Côte d'Ivoire
Maneb	Trimangol 80 WP	CerexAgri	2004	Côte d'Ivoire
Mancozeb	Dithane M45 WP	Dow AgroSciences	2004	Côte d'Ivoire
Sulphur	Thiovit 80 WG	Syngenta	2004	Côte d'Ivoire
Spinosad	Tracer 480 SC	Dow AgroSciences	2004	Côte d'Ivoire
			2006	Ghana
Spiromesifen	Oberon 240 SC	Bayer CropScience	2004	Côte d'Ivoire
			2006	Ghana
Tebuconazole	Folicur 250 EW	Bayer CropScience	2004	Côte d'Ivoire
			2006	Ghana
Thiametoxam	Actara 25 WG	Syngenta	2004	Côte d'Ivoire
Thiophanate-methyl	TopsSin M50 SC	Nisso	2004	Côte d'Ivoire
Triadimenol	Bayfidan 250 EC	Bayer CropScience	2004	Côte d'Ivoire
			2006	Ghana
Trifloxystrobin	Flint 50 WG	Bayer CropScience	2004	Côte d'Ivoire
			2006	Ghana

Note: GAPs indicated in previous pages are those corresponding to the PPPs listed above. User of this information should check if the product used is equivalent (same concentration and same type of formulation) to the reference product. If it is not the case, the indicated GAP could not be adequate.

Status and MRLs of active substances not tested for residues by PIP

Active substance	EU Status	EU MRL	Codex MRL
Acephate	Withdrawn	0.02*	0.02*
Amitraz	Withdrawn	0.05*	/
Azadirachtin	Annex 1	0.01*	/
Bupirimate	Annex 1	0.05*	/
Boscalid	Annex 1	0.05*	0.05*
Cadusafos	Withdrawn	0.01*	0.01*
Copper	Annex 1	20	/
Cypermethrine	Annex 1	0.5	0.05*
Diazinon	Withdrawn	0.01*	/
Dicofol	Withdrawn	0.01*	/
Dimethoate	Annex 1	0.02*	/
Fatty acids (soap)	Annex 1[2]	/	/
Fenitrothion	Withdrawn	0.01*	0.05*
Fenpropathrin	Withdrawn	0.01*	0.01*
Fenvalerate	Withdrawn	0.02*	/
Fosetyl	Annex 1	2	/
Imazalil	Annex 1	0.05*	0.01*
Imidacloprid	Annex 1	0.05*	0.05*
Iprodione	Annex 1	0.02*	/
Metalaxyl	Annex 1	0.05*	0.05*
Mineral oil	Annex 1	0.01*	/
Oxydemeton-Methyl	Withdrawn	0.01*	/
Pirimicarb	Annex 1	1	/
Prochloraz	Withdrawn	5	/
Propineb + Cymoxanil	Annex 1	0.05*	/
Pyraclostrobine	Annex 1	0.05	0.05*
Thiabendazole	Annex 1	10	10
Triforine	Withdrawn	0.05*	/

Annex 1 means inclusion in the positive list of the EC Directive 91/414
Annex 1 [2] To see which fatty acid is in Annex 1 check on http://scc-gmbh.de/SCC/Annex-I/
Withdrawn means not included in Annex 1
* LOQ
/ means no data in the Codex data base and consequently not possible to define a PHI
n.a. non applicable

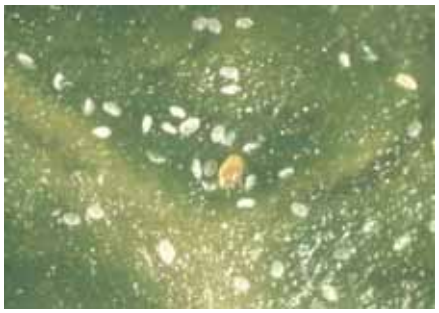
Annex 3: Identification of main pests and diseases

Pictures credits:

- Gilles Delhove
- Georges Thewys
- Milly Kyofa-Boamah
- Chistian Didier
- Wayne Nishijima, Scot Nelson: http://www.ctahr.hawaii.edu/nelsons/papaya/papaya.html
- Alton N. Sparks, Jr., University of Georgia, Bugwood.org

NEMATODES
***Meloidogyne* sp.**

Root galls of *Meloidogyne* sp.

MITES	
Broad Mites ***Polyphagotarsonemus latus***	
	
Symptoms on a fruit	
	
Mites	Leaf damage

SPIDER MITE

Tetranychus sp.

Adults and larvae

Symptoms in a nursery

Insects

Whiteflies *Aleurodicus dispersus*

Eggs

Larva

Adults

Thrips *Thrips tabaci* Lind.

Adult and immature thrips. The adult on left has four wings lined with long hairs. Immatures are wingless and generally are light colored

Fruit Flies			
Ceratitis capitata			*Bactrocera invadens*
			
Adult	Eggs	Larva	Adult

Mealy bug *Rastrococcus invadens*	
	
Larvae	

Paracoccus marginatus

Larvae

Deformed leave

Attacked fruit

Scales

On fruit

On trunk

FUNGI

Papaya Powdery Mildew
Oidium caricae

O. caricae on fruit

O. caricae on leaves

Anthracnose
Colletotrichum gloeosporioides

Symptoms on fruits after harvest

Phomopsis wet fruit rot
Phomopsis sp.

Single lesions on papaya fruit

Cercospora sp.	Stem-end rot *Lasiodiplodia theobromae*
	
Black spots	Damage on fruit

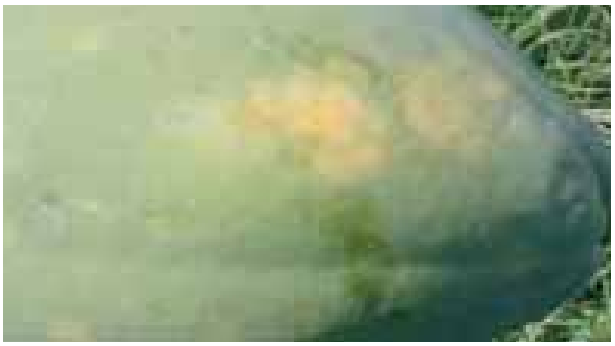
Root, collar and stem rot caused by *Phytophthora palmivora* or *Pythium* spp.	
	
Severe damage to papaya trees due to *Phytophthora* sp.	

VIRUS

Virus Ring spot

Black spots

Virus lesion on fruit



Ringspot infection on fruit

Virus Tomato Spotted Wilt Virus (T.S.W.V.)

Fruits infected with T.S.W.V.

T.S.W.V. infection on young leavest

CROP PRODUCTION PROTOCOLS

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

GUIDES TO GOOD PLANT PROTECTION PRACTICES

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

PIP
FOR SUSTAINABLE DEVELOPMENT OF THE ACP HORTICULTURAL INDUSTRY

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