PIP

GUIDE TO GOOD PLANT PROTECTION PRACTICES

FOR YAM (*Dioscorea* spp.) in ACP countries

COLEACP is an interprofessional network promoting sustainable horticultural trade.

The **PIP Programme, implemented by COLEACP**, has two overriding objectives: to enable ACP companies to **comply with European food safety and traceability requirements**; and to consolidate the position of **small-scale producers** in the ACP horticultural export sector.

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Note

The Guide to Good Plant Protection Practices details all plant protection practices regarding the production of the fruit or vegetables in question and recommends primarily the active substances supported by pesticides manufacturers in the framework of EU Directive 91/414, which must comply with European standards for pesticide residues. Currently, these active substances have not been tested by PIP in ACP countries to check their conformity with European MRLs. The information given on the active substances suggested is therefore changeable and will be adapted on an ongoing basis in accordance with the new information collected by PIP.

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

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1. Main enemies and significance

This guide deals with the plant protection of yam. This crop is grown for its underground tubers. There is often a great deal of confusion in the nomenclature of this plant which, according to the country, have a variety of local names, the same name or a similar name that might denote different species in two countries.

The term **yam** denotes plants belonging to the genus *Dioscorea* (family Dioscoreaceae). There are approximately 600 species of *Dioscorea* in the world, mostly wild, mainly in a tropical environment. Only a handful of them have been domesticated and are regularly cultivated. Of those species cultivated in ACP countries, the most common are listed in the table below:

Species Botanical name	Main area of cultivation	Most common commercial names
D. rotundata *	West Africa. Cultivated in Latin America and the Caribbean	White yam, puna (Ghana)
D. alata	Oceania, South-East Asia, Africa, the Caribbean, Latin America	water or greater yam, cuscus (GB)
D. cayenensis *	West Africa Cultivated in Latin America and the Caribbean	yellow yam
D. trifida (cush-cush)	Guyana, Brazil, Central America and the Caribbean	Cush-cush, yampi, Indian yam
D. esculenta (lesser yam)	South-East Asia	Lesser yam, sweet yam
D. opposita (chinese yam)	China, Temperate Asia, France (Blois)	Chinese yam, French yam

* Botanists, especially Francophone ones, often group these two species together under the specific complex name, *D. cayenensis - D. rotundata.*

1.1 Extent and impact on the quantity and quality of the production

The forms given below show the list of the main pests and diseases that will be dealt with in this Guide. For each pest/disease, the following is given:

- The level of significance of the economic impact generally observed in ACP countries according to the following scale:
  (+) insignificant, (++) quite significant, (+++) significant.
- The parts attacked on the plant.
- The type of losses sustained that are responsible for yield losses of marketable tubers which thereby results in economic losses for those involved in the industry.

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

INSECTS						
Significance	Organs affected		Type of losses			
	Leaves	Tubers	Number of plants	Number of tubers per plant	Size/weight of the tubers	Quality of the tubers
Lepidoptera - *Loxura atymnus* (+++) (Fam: Lycaenidae) *Theretra nessus* (+) (Sphingidae) *Tagiades gana* (+) (Hesperidae)						
++	Attack of the leaves by larvae then the stems on *D. alata*.		Destruction of plants			
Lepidoptera - Yam moth: *Euzopherodes vapidella* (sometime confused with *Ephestia cautella*) Mann; (Fam: Pyralidae)						
+++		Larvae enter in the tubers at post harvest. Presence of galleries				Deterioration of the tubers especially in *D. alata*. Decrease in commercial value
Lepidoptera - Yam moth: (Species not determined, similar to *Opogona* spp.) (Tineidae)						
+++		Post-harvest damage. Often in the former galleries of *E. vapidella*				Deterioration of the tubers especially in *D. alata*.
Coleoptera - Yam leaf beetle: *Crioceris (= Lilioceris) livida* & *Lema armata* (Chrysomelidae)						
+	Defoliating larvae. Significant but temporary local surface damage		No effect			
Coleoptera - Yam beetle: *Heteroligus* spp. (Scarabaeidae): *H. meles* and *H. appius* – Present in Africa						
++		In-field damage by the adults including upon germination of seeds				Decrease in commercial value due to holes left by the insects and fungi developing inside
Coleoptera - Maruca: *Diaprepes abbreviatus* (Curculionidae) – Present in Caribbean Islands						
++	Eaten by adults	Damages by larvae				
Coleoptera - Coffee bean weevil: *Araecerus fasciculatus* (Anthribidae)						
This is the most harmful of all beetles, but it is less widespread than lepidoptera						
++		Larvae and adults develop in the tubers. Holes upon emergence of the adults				Decrease in commercial value due to presence of holes
Coleoptera - Weevil: *Tenebrio guinensis* (Tenebrionidae)						
+		Gnaws the surface of the tubers then bores into them				Decrease in commercial value due to presence of holes

Significance	Organs affected		Type of losses			
	Leaves	Tubers	Number of Plants	Number of tubers per plant	Size/weight of the tubers	Quality of the tubers
INSECTS (continued)						
Homoptera (scale insects) - Mealybug: (Pseudococcidae) *Geococcus coffea, Phenacoccus gossypii, Planococcus citri* & *P. dioscoreae*						
++		Develops especially towards the head, after harvesting				Necrosis of sprouts, decline in germination
Homoptera (scale insects) - Yam/ubi scale: *Aspidiella hartii* (Diaspididae)						
+++		Covers the tubers, sometimes significantly, after harvesting				Loss of germinating capacity, especially in the Florido variety (*D. alata*)
Isoptera - Termites: *Coptotermes* sp., *Amitermes evuncifer, Protermes minutus...*						
+		In barns during storage but occasional in-field damage before harvesting				Decrease in commercial value due to damage to tubers
NEMATODES						
Root-knot nematodes: *Meloidogyne* spp.						
++		Development of prominent root-knot galls before harvesting				Decrease in commercial and seed value
Yam/lesion nematodes: *Scutellonema bradys, Pratylenchus coffea*						
++		Enters tubers through growing point and cracks. Continues to feed and multiply while tubers are in storage			Decrease if heavy infestation. Opportunistic rotting after harvesting	Decrease in commercial and seed value

FUNGI						
Significance	Organs affected		Type of losses			
	Leaves	Tubers	Number of Plants	Number of tubers per plant	Size/weight of the tubers	Quality of the tubers
Anthracnose/die-back: fungi complex of which *Colletotrichum gloeosporioides*						
+++	Mycelium develops in leaves and stems		Destruction if severe attacks, especially on *D. alata*	Reduced if heavy attack		
Other leaf-spot diseases: *Alternaria* spp., *Curvularia* spp., *Cercospora* spp., *Sclerotum rolfsii, Rhizoctonia* spp.						
++	Mycelium develops in leaves		Destruction if severe attacks	Reduced if heavy attack		
Tuber wet rot: *Botryodiplodia theobromae, Rhizopus nodosus* and other fungi						
+		Internal rot during storage, entering through insect or harvest wounds				Decrease in commercial value due to destruction of tubers
Dry rot: *Fusarium, Aspergillus* spp. and other fungi						
+		Aggressive development in storage after in-field infection or by harvest wounds. Spread by lesion nematodes				Decrease in commercial value by destruction in depth of stored tubers
Green rot: *Penicillium* spp. of wich *P. sclerotigenum*						
++		Develops on the surface of the wounded parts in storage				Decrease in commercial value due to superficial destruction

1. Main enemies and significance

BACTERIA						
Tuber soft rot: *Erwinia carotovora* and other bacteria						
++		Internal, malodorous rot developing in storage, entering through insect or harvest wounds				Decrease in commercial value due to internal rot

VIRUSES						
Significance	Organs affected		Type of losses			
	Leaves	Tubers	Number of Plants	Number of tubers per plant	Size/weight of the tubers	Quality of the tubers
Yam mosaic virus: several, often interactive, families of viruses and viruses are involvedPotyvirus (QQ): Yam mosaic virus (YMV) and Yam mild mosaic potyvirus (YMMV) ; Cucumovirus: Cucumber mosaic cucumovirus (CMV) ; Badnavirus: Dioscorea bacilliform virus (DBV) ; Potexvirus: Dioscorea latent virus (DLV) *D. rotundata* often more susceptible than *D. alata*						
Vectors should be aphids (potyvirus) and mealybugs (badnavirus).						
++	Development in the whole plant			Up to 50% yield reduction due to stunting of plants		
Internal brown spot ISBV - on *D. alata* in Caribbean Islands						
++		Brown nodules in the tubers				Decline in the quality of the tubers

1.2 Identification and damage

This section contains information and illustrations to facilitate the identification of the main pests and diseases.

INSECTS

Defoliating caterpillar - *Loxura atymnus, Theretra nessus, Tagiades gana*

Caterpillars first eat the leaf blade and then attack the stems, sometimes causing severe damage. Only on the species *D. alata*.

Caterpillar

Caterpillar

Yam moth - *Euzopherodes vapidella* - Moth (undetermined species)

Pyralid moth larvae attack tubers in lofts by mining, especially during the first four months of storage. D. alata tubers are attacked more, with their higher water content favouring the development of insects. Moth larvae appear later and tend to use old moth mines. They progress rapidly and there may be total destruction of stocks after only one month.

Chrysomelid - *Crioceris (= Lilioceris) livida; Lema armata*

Larvae are shiny, black and covered in mucus, and may reach 1 cm. They are defoliating. They can cause major damage locally, especially during the first months of the crop, but without any real economic impact.

Crioceris/lilioceris larvae

Adult *Lema*

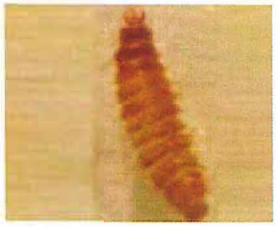
Yam beetle - *Heteroligus* spp.
Yam weevil - *Palaeopus costicollis*

Heteroligus is a blackish-brown insect reaching over 30 mm in size. Damage in the form of big holes in tubers a few cm deep is caused by adults in the fields, from germination until harvest. Larvae (*H. meles*) develop on the roots of other plants (grasses) in wet areas near yam fields or directly on the yam roots (*H. appius*). Palaeopus is found in the Caribbean and causes the same type of damage.

INSECTS (continued)

Coffee bean weevil: *Araecerus fasciculatus*

The damage is caused by the hairy yellowish larvae measuring up to 6 mm in length at maturity. The brownish-red adult is a good flyer. It makes circular perforations 2mm in diameter which yield a yellow powder. Its attacks are generally confined to areas around injuries caused by harvest or caterpillars.



Larva

Adult

Maruca: *Diaprepes abbreviatus, D. famelicus*

The larvae cause significant local damage to the tubers. The adults, 20 mm long, eat the leaf blades and sometimes the tubers as well. These polyphagous insects also attack macabo and manioc as well as citrus fruits.

Adult

Larvae

Weevil: *Tenebrio guinensis*

The larvae and the adults eat into the surface of the tubers and then bore large areas 5 to 10 mm deep. Despite the significant size of the insects the damage progresses quite slowly.

Citrus mealybug scale: *Geococcus coffea, Phenacoccus gossypii, Planococcus citri* & *P. dioscoreae*

These homopterae develop mainly during storage, forming a sort of white powder near the top of the tubers. They can cause complete necrosis of sprouts preventing the use of tubers as seed.

Attacked tubers

Yam scale (with carapace): *Aspidiella hartii*

This species sometimes grows until it totally covers tubers during storage in the form of small and more or less whitish scales. This does not cause a loss of volume but may cause germination to be delayed or even stopped.

Attacked tubers

Termites: *Coptotermes* sp., *Amitermes evuncifer, Protermes minutus...*

Termites can attack the tubers during storage, with the infestation possibly beginning in the field. The damage, which may be significant within a few weeks, is often difficult to detect when the colonies use only one gallery for penetration.

External damage

Internal damage

NEMATODES

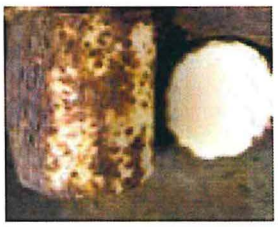
Root-knot nematode: *Meloidogyne* spp.

The symptoms include the development of prominent galls on the surface of tubers. There is sometimes a proliferation of tuberous roots on these galls (hirsutism). *D. alata* is more sensitive to this type of nematode than *D. rotundata*.

Attacked tubers

Yam nematode: *Scutellonema bradys - Pratylenchus coffea*

This type of nematode causes small cracks on the surface of tubers, with the proximal parts (head) affected most. Under these lesions are brownish-black necrotised areas whose size depends on how long ago the damage occurred. The species *D. rotundata* is generally affected most.



Necrotic area

Small cracks on the head

DISEASES

Anthracnose: fungus complex including *Colletotrichum gloeosporioides*

Anthracnose is one of the most severe yam diseases, in particular among the species *D. alata*. It causes black necrotic spots on the leaves which develop along the veins. The stems can be affected as well as the end buds, thus stopping growth. In the case of a severe attack, the plants can be completely destroyed.

Spots on leaves and plants

Other foliar spots: *Alternaria* spp., *Curvularia eragroistides*, *Cercospora* spp., *Sclerotium rolfsii*, *Rhizoctonia* spp.

These fungi cause more or less dark brown spots of various shapes on the leaves: surrounded by a yellow halo (*Curvularia*) or with concentric circles (*Sclerotium*). Severe attacks can kill the plant.

Curvularia

Sclerotium

DISEASES (continued)

Tuber wet rot: *Botryodiplodia theobromae, Rhizopus nodosus* and other fungi or *Erwinia carotovora* and other bacteria

These micro-organisms cause soft wet rot on tubers. They develop during storage where there has been damage to the tuber or a hole made by an insect. The bacteria have a putrid odour from a close distance.

Symptoms

Dry rot: *Fusarium, Aspergillus* spp. and other fungi

These fungi cause dry rot which often reveals a hollow cavity when pressed. They develop after harvest on damaged areas caused by tools or nematodes.

Symptoms

Green rot: *Penicillium* spp. including *P. sclerotigenum*

Penicillium causes green mould which grows on damaged parts of tubers after harvest. Incomplete drying after washing is favourable to the growth of this fungus.

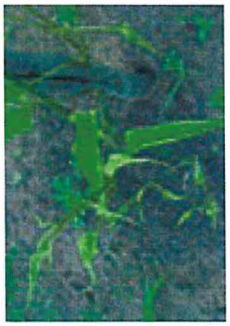
Green mould on a wound

Internal brown spot IBSV

This virus causes brown spots inside the flesh of the tuber. These attacks affect *D. alata* in particular.

Viruses: Yam mosaic
Yam mosaic potyvirus (YMV),
Yam mild mosaic potyvirus (YMMV),
Cucumber mosaic cucumovirus (CMV),
Dioscorea badnaviruses, potexviruses

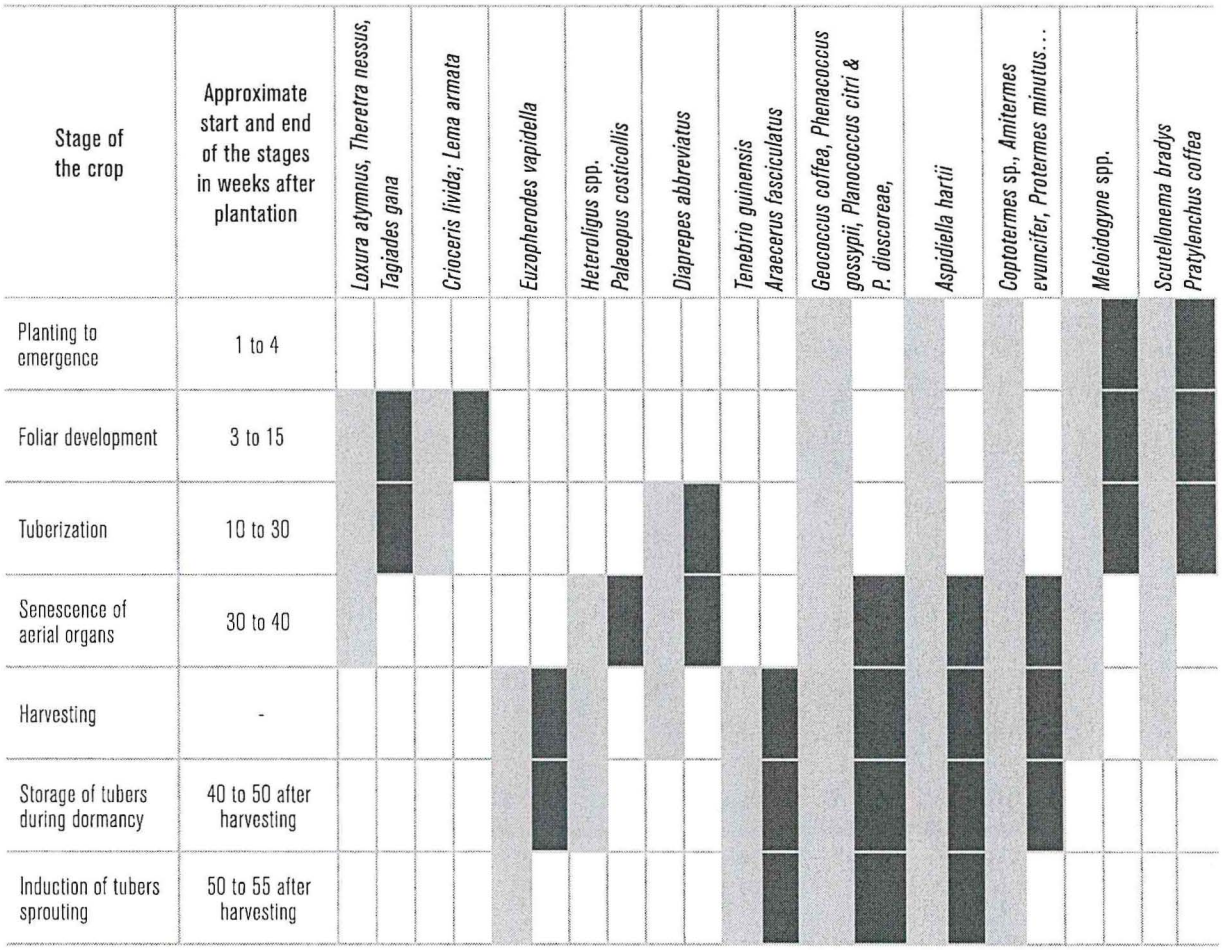
The different viruses which attack yam cause a wide range of symptoms on the leaves from the early stages of growth: chlorosis (greenish-yellow colour), mottle, mosaic, deformation (blistering) or reduction to a shoe-lace shape (photo on right). Severe and early attacks can cause stunting (dwarfism) of the entire plant until it practically disappears.



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

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

Crop cycle on yams depends on species, varieties and growing conditions (temperature ...). Crop cycle (from germination to complete senescence of the plant) is between 8 and 11 months. The dormancy period of the tuber is the complement of the cycle in the field to achieve 12 months of cycle. If the cycle in the field is 8 months the dormancy period will be more or less 4 months, if the field cycle is 11 months the dormancy period will be only 1 month.



Periods during which pest or pathogenic agent is potentially present.

Periods during which the appearance of a serious infestation can cause the greatest loss.

1. Main enemies and significance

Stage of the crop	Approximate start and end of the stages in weeks after plantation	Anthracnose	Other leaf-spot diseases *Alternaria* , *Curvularia, Cercospora* , *Sclerotum.*. *Sclerotum rolfsii; Rhizoctonia* spp.	Tuber wet rot	Tuber dry rot	Green rot: *Penicillium* spp.	Internal brown spot virus	Yam mosaic (YMV, YMMV, CMV,...)
Planting to emergence	1 to 4							
Foliar development	3 to 15							
Tuberization	10 to 30							
Senescence of aerial organs	30 to 40							
Harvesting	-							
Storage of tubers during dormancy	40 to 50 after harvesting							
Induction of tubers sprouting	50 to 55 after harvesting							

Periods during which pest or pathogenic agent is potentially present.

Periods during which the appearance of a serious infestation can cause the greatest loss.

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

UGA = Uganda, GHA = Ghana, JAM = Jamaica, DOR = Domenican Republic
0 = no damage
+ = limited damage
++ = average damage: control necessary
+++ = heavy damage: control essential
X = generally limited damage but evolution of damage level over the year is not known
XX = damage can be average, but evolution of damage level over the year is not known
XXX = damage can be heavy, but evolution of damage level over the year is not known
/ = no information available
N.B. the inventory of pests and diseases has not been conducted exhaustively in all countries. The pest may be present, but has perhaps never been observed in the country on the crop, because it does not cause serious damage.

Leaf eater caterpillar: *Loxura atymnus, Theretra nessus; Tagiades gana*

Favourables conditions: Moderate rains.

Month	1	2	3	4	5	6	7	8	9	10	11	12
UGA	/	/	/	/	/	/	/	/	/	/	/	/
GHA	/	/	/	/	/	/	/	/	/	/	/	/
JAM	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/

Yam Leaf Beetle: *Crioceris livida; Lema armata*

Favourables conditions: Moderate rains.

Month	1	2	3	4	5	6	7	8	9	10	11	12
UGA	/	/	/	/	/	/	/	/	/	/	/	/
GHA	X	X	X	X	X	X	X	X	X	X	X	X
JAM	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/

Yam moth: *Euzopherodes vapidella*

Favourables conditions: Dry season, mainly for *D. alata* storage during first 4 months of storage.

Month	1	2	3	4	5	6	7	8	9	10	11	12
UGA	/	/	/	/	/	/	/	/	/	/	/	/
GHA	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
JAM	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/

Yam "tuber" beetle: *Heteroligus* spp.; *Palaeopus costicollis*

Favourables conditions: Humid area close to yam fields.

Month	1	2	3	4	5	6	7	8	9	10	11	12
UGA	/	/	/	/	/	/	/	/	/	/	/	/
GHA	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
JAM	0	0	0	0	0	0	0	0	0	0	0	0
DOR	0	0	0	0	0	0	0	0	0	0	0	0

1. Main enemies and significance

Coffee/cocoa Weevil: *Araecerus fasciculatus, Diaprepes abbreviatus*

Favourables conditions: Not well ventilated storage.

Month	1	2	3	4	5	6	7	8	9	10	11	12
UGA	/	/	/	/	/	/	/	/	/	/	/	/
GHA	X	X	X	X	X	X	X	X	X	X	X	X
JAM	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/

Maruca - *Diaprepes abbreviatus, D. famelicus*

Favourables conditions: No information available.

Month	1	2	3	4	5	6	7	8	9	10	11	12
UGA	0	0	0	0	0	0	0	0	0	0	0	0
GHA	0	0	0	0	0	0	0	0	0	0	0	0
JAM	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
DOR	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX

Mealybug: *Geococcus coffea, Phenacoccus gossypii, Planococcus citri* & *P. dioscoreae*, Yam scale (with carapace): *Aspidiella hartii*

Favourables conditions: Humid air.

Month	1	2	3	4	5	6	7	8	9	10	11	12
UGA	/	/	/	/	/	/	/	/	/	/	/	/
GHA	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
JAM	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
DOR	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX

Termites: *Coptotermes* sp., *Amitermes evuncifer, Protermes minutus*

Favourables conditions: No information available.

Month	1	2	3	4	5	6	7	8	9	10	11	12
UGA	/	/	/	/	/	/	/	/	/	/	/	/
GHA	X	X	X	X	X	X	X	X	X	X	X	X
JAM	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/

Root-knot nematodes – *Meloidogyne* spp. - Yam/lesion nematodes: *Scutellonema bradys, Pratylenchus coffea*

Favourables conditions: Sandy soils with high humidity and poor in organic matter.

Month	1	2	3	4	5	6	7	8	9	10	11	12
UGA	/	/	/	/	/	/	/	/	/	/	/	/
GHA	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
JAM	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
DOR	/	/	/	/	/	/	/	/	/	/	/	/

Anthracnose and other leaf spot diseases

Favourables conditions: High humidity and temperatures. Heavy rains (spores dispersal).

Month	1	2	3	4	5	6	7	8	9	10	11	12
UGA	/	/	/	/	/	/	/	/	/	/	/	/
GHA	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
JAM	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
DOR	/	/	/	/	/	/	/	/	/	/	/	/

Tuber wet rot

Favourables conditions: Rains and sunstroke on tubers after harvesting.

Month	1	2	3	4	5	6	7	8	9	10	11	12
UGA	/	/	/	/	/	/	/	/	/	/	/	/
GHA	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
JAM	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
DOR	/	/	/	/	/	/	/	/	/	/	/	/

Tuber dry rot

Favourables conditions: No information available.

Month	1	2	3	4	5	6	7	8	9	10	11	12
UGA	/	/	/	/	/	/	/	/	/	/	/	/
GHA	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
JAM	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
DOR	/	/	/	/	/	/	/	/	/	/	/	/

Tuber green rot: *Penicillium* spp.

Favourables conditions: No information available.

Month	1	2	3	4	5	6	7	8	9	10	11	12
UGA	/	/	/	/	/	/	/	/	/	/	/	/
GHA	/	/	/	/	/	/	/	/	/	/	/	/
JAM	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/

Yam mosaic virus and others virus

Favourables conditions: No information available.

Month	1	2	3	4	5	6	7	8	9	10	11	12
UGA	/	/	/	/	/	/	/	/	/	/	/	/
GHA	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
JAM	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
DOR	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX

2 Main control methods

2.1 Introduction

Yams are tropical plants adapted to hot, humid climates. Below 20°C, growth slows. These plants reproduce via vegetative multiplication, which in agriculture is done by replanting part of the vegetative body, bypassing the production of seeds. Growers use a tuber or fraction of a tuber which includes at least one piece of epidermis capable of producing a sprout. This sprout will produce a stem and then an entire plant.

From a health point of view, the cuttings are possible carriers of practically all pests and diseases. The choice and preparation of planting material is therefore extremely important for maintaining the crops in a satisfactory state of health. When the necessary precautions are not taken, very quickly in a few generations there will be a high pest and disease load, particularly nematodes and viruses.

In traditional food crop systems, the growing techniques used minimize the risks of proliferation: slash and burn cultivation, long fallow periods, sometimes intervals of several decades before recultivation, isolation and small size of fields. In traditional plots there is generally strong agro-biodiversity (inter- and intra-species) – i.e. a mix of several cultivated species, with each species having several varieties, often with different behavior (resistance to disease, cycle, etc). These conditions slow the multiplication and dissemination of pests and pathogens.

When cultivation becomes more intensive, with shorter fallow periods, planting of larger plots and weaker genetic diversity, pressure from pests and diseases increases. If the planting material is not selected and produced cautiously, the health of the crops can deteriorate significantly, compromising the profitability and even the preservation of these crops. While in the major producer countries potato seeds undergo a specific multiplication process which is extremely meticulous and carefully separated (including geographically) from the production itself, to avoid the proliferation of viruses and other pathogens, with yams the planting material is generally produced by the farmers themselves, simply by selecting cuttings from their own yield. Under these conditions it is even more important to use good agricultural practices (crop rotation, elimination of unhealthy plants, rigorous selection of cuttings and seeds, preservation of strong agro-biodiversity, etc) to minimize the health risks.

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

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

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

The control methods for pests or diseases whose cycle is not illustrated are presented in a table.
The second column of the table shows what actions should be taken to control the different stages of development of the pest or the disease shown in the first column.

In the second column, actions that can be referred to as "cultivation practices" are shown in green boxes, and actions that can be referred to as "application of plant protection products", in pink boxes.

- Cultivation practices.
- Application of plant protection product.

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

Defoliating caterpillar: *Loxura atymnus, Theretra nessus, Tagiades gana*
Chrysomelids: *Crioceris (= Lilioceris) livida; Lema armata*

Major elements of the control strategy

- Monitoring of plots.

Development stages of the pest	Action	Cultivation stages						
		Choice of parcel	Preparation of parcel	Planting to germination	Leaf development	Senescence of aerial organs	Tubers harvesting	Tubers storage
Adult	Alternate yam species and varieties on a single plot of land.		X	X				
Larva	Manually eliminate the first damaged leaves.				X			
	Spraying of a contact insecticide for caterpillars, systematically for Crioceris because of its protective mucus.				X			

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

Yam beetle - *Heteroligus* spp. - Yam weevil - *Palaeopus costicollis*

Major elements of the control strategy

Development stages of the pest	Action	Cultivation stages						
		Choice of parcel	Preparation of parcel	Planting to germination	Leaf development	Senescence of aerial organs	Tubers harvesting	Tubers storage
Larva	Avoid locating yam fields too close to swampy areas where larvae reproduce.	X	X					
Adult	Treatment of seeds with insecticides*.			X				

X = action to be taken at the cultivation stage shown in the corresponding column.
* Treatments of planting material reduce the incidence on tubers but are not always economically gainful.

Coffee bean weevil - *Araecerus fasciculatus*; Weevil - *Tenebrio guinensis*; Maruca - *Diaprepes abbreviatus* Yam moth - *Euzopherodes vapidella*; Moth - (undetermined species)

Major elements of the control strategy

- Avoid injuries on tubers at harvesting.
- Sorting tubers.

Development stages of the pest	Action	Cultivation stages						
		Choice of parcel	Preparation of parcel	Planting to germination	Leaf development	Senescence of aerial organs	Tubers harvesting	Tubers storage
Larva	Sorting of injured or damaged tubers, separate storage.						X	X
	Cleaning and disinfection of storehouses.						X	
	Treatment of stored tubers with insecticide spray before storage.						X	
	Repeat the treatment one month later on damaged tubers (after sorting).							X

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

Mealybug scale - *Geococcus coffea, Phenacoccus gossypii, Planococcus citri & P. dioscoreae* Yam scale (with carapace) - *Aspidiella hartii*

Major elements of the control strategy

- Use healthy seeds.

Development stages of the pest	Action	Cultivation stages						
		Choice of parcel	Preparation of parcel	Planting to germination	Leaf development	Senescence of aerial organs	Tubers harvesting	Tubers storage
Larva/adult	Mechanical brushing of tubers or immersion in hot water (50° C for 20 min) against mealybug.						X	
	Insecticide treatment of immersion for 10 mins in an insecticide solution before storage.			X			X	

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

Termites: *Coptotermes* sp., *Amitermes evuncifer, Protermes minutus*...

Major elements of the control strategy

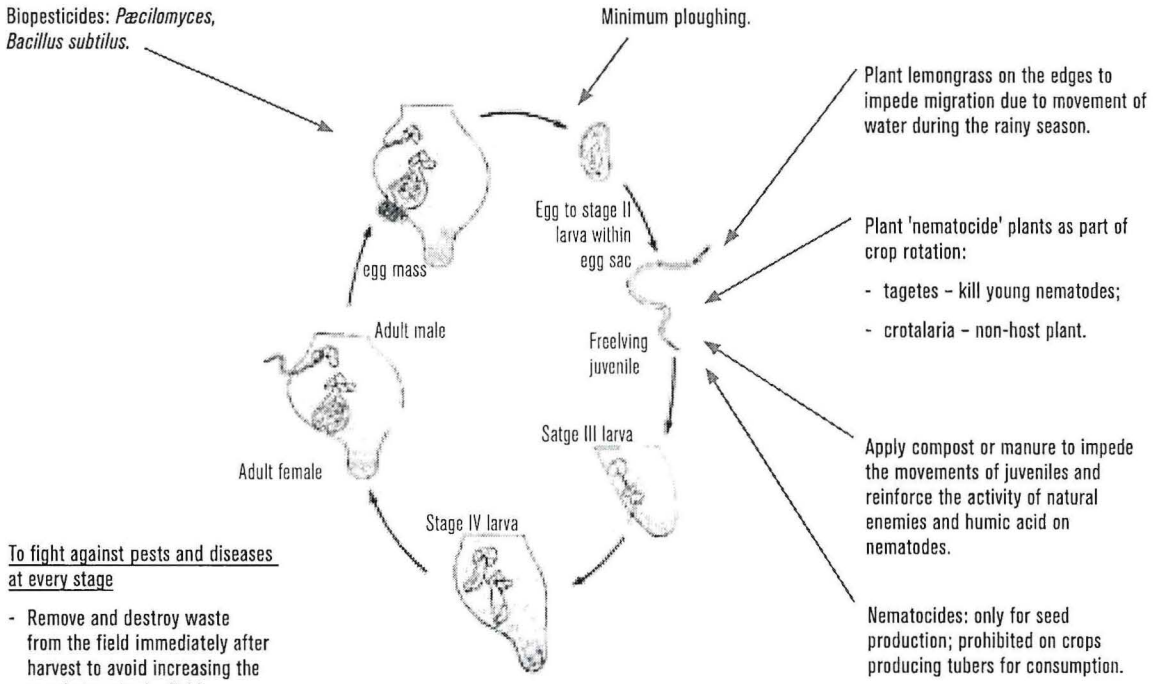
- Damage on tubers are usually due to presence of termites in the wood structure of garners. Therefore, the control should be done on termites attacking the wood.

Development stages of the pest	Action	Cultivation stages						
		Choice of parcel	Preparation of parcel	Planting to germination	Leaf Development	Senescence of aerial organs	Tubers harvesting	Tubers storage
Adult	Avoid wood in the storage area and prefer concrete or stones. Use wood not sensible to termites.							X
	Treat wood structure in the storage area.							X

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

Root-knot nematodes (*Meloidygyne* spp.) and lesion nematodes - *Pratylenchus* spp., *Scutellonema* spp.

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



<u>To fight against pests and diseases at every stage</u>

- Remove and destroy waste from the field immediately after harvest to avoid increasing the populations in the field.
- Remove infected plants and weeds.

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

Since the yam is a bio-concentrator with an active substance, the use of chemical nematocide will be prohibited, except when producing seeds in perfectly controlled conditions, if local legislation allows it.

<u>Before preparing the ground</u>

- Rotate crops, avoiding cultivating yams two years in a row. Avoid first crops encouraging the development of nematodes (solanaceae for Meloidogyne).
- Plant cover crops with a nematode suppressant/nematocide effect as a first crop, enabling the reduction of nematode populations in the soil. A number of plant species with a nematocide effect may be recommended but must be validated locally since their antagonist action is often limited to certain species of nematode (Meloidogynes or Pratylenchus) and their effectiveness also depends on the variety of plant species used.

Species available as a first crop with nematode-suppressant action:

Scientific name	French/English name	Remarks
1. Tagetes erecta *2. T. patula* *3. T. minuta*	1. Tagète africaine/African marigold 2. Œillet d'Inde/ french marigold 3. Tagète des parfumeurs / mexican marigold *	Cover crop as first or associated crop. * notably the Nemanon ® variety
Arachis hypogea	Arachide/groundnut	Crop
Cajanus cajan	Pois d'angol/pigeon pea	Crop
Calopogonium sp.	*Calopogon* sp.	Cover crop, leguminous
Crotalaria juncea	Crotalaire/Crotalaria	Cover crop. Strong action against *Pratylenchus coffea* as first crop or associated crops
Macroptilium atropurpureus	*Siratro*	Cover crop, leguminous, antagonist of *Meloidogyne* sp.
Mucuna atterrima (syn. *Styzolobium atterrimum)*	Mucuna noire/black mucuna	Cover crop
Panicum maximu. var. *trichoglume*	Herbe de Guinée/ Guinea or Buffalo grass	
Sesamia indica	Sésame/sesame	Crop
Vigna unguiculata	Niébé/cowpea	Crop

Cover crops may be used as fallow crops cultivated in a mixture (cocktail) or as a pure crop. The cocktail has the benefit of a broader spectrum anti-nematode effect. The disadvantage is that it is more difficult to manage, to avoid a natural self-sowing of the seeds of the different species with different cycles.

A pure crop avoids these disadvantages if cutting is done before seed production, but the spectrum of antagonist action on nematode species is more narrow. The crop must be cut before seeds are produced and buried in the soil.

When preparing the ground

- Ploughing with solarisation (sterilisation of the soil under the effect of the sun's rays) under transparent plastic sheet; disinfection of the soil with steam may, on restricted surfaces, constitute an adapted solution to limit nematode populations in plots of land.
- An increase in the organic matter content via manure or compost helps to limit nematodes.

When planting

- Rigorous choice of seeds. Eliminate all contaminated material (nematode galls, lesions or splits).
- Apply nematocides by dipping tubers and as soil treatment when planting for seed production only.

Throughout the plant cycle

- Eliminate weeds – potential hosts for nematodes.

After the harvest

- Sort and separate the infected tubers from those that appear healthy. Keep them separate.
- For the tubers destined for planting: possible hot water therapy (immersing the seeds for 20 mins. at 52-53°C, dry thoroughly in the shade). Beware, delicate treatment: do not exceed the time and maximum temperature or there is a risk of killing the germination capacity.

Foliar spots - Anthracnose: fungus complex including *Colletotrichum gloeosporioides* *Alternaria* spp., *Curvularia eragroistides*, *Cercospora* spp., *Sclerotum rolfsii*, *Rhizoctonia* spp.

Major elements of the control strategy

- Use seeds collected from healthy plots.
- Resistant varieties.
- Crop rotation.
- Alternate varieties and species of yam in the plots (discontinuity).
- Separate yam plots and limit their size.
- Equilibrate nitrogen fertilization.

Development stages of the fungus	Action	Cultivation stages						
		Choice of parcel	Preparation of parcel	Planting to germination	Leaf Development	Senescence of aerial organs	Tubers harvesting	Tubers storage
Conservation in seeds	Treatment of seeds with fungicide.			X				
Germination on yam plants	Application of fungicide.				X			
Development on leaves	Application of fungicide.				X			
Transportation by wind and water	Avoid sprinkler irrigation in case of wind.				X			
Persistence in the soil	Crop rotation, leave several years between 2 yam crops.	X						
	Destroy creepers after attacks.						X	
	Avoid close first crops of yam.	X						

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

Tuber wet rot: *Botryodiplodia theobromae, Rhizopus nodosus* and others fungi *Erwinia carotovora* and others bacteria

Dry rot: *Fusarium, Aspergillus* spp. and others fungi Green rot: *Penicillium* spp.

Major elements of the control strategy

- Crop rotation.
- Harvest carefully to avoid injuries on tubers.
- Sort and separate injured tubers at harvest.
- Disinfection of storage areas.

Development stages of the fungus	Action	Cultivation stages						
		Choice of parcel	Preparation of parcel	Planting to germination	Leaf Development	Senescence of aerial organs	Tubers harvesting	Tubers storage
Conservation in seeds	Use healthy seeds.			X				
Germination on tubers	Avoid injuries during harvest.						X	
	Sort and separate injured tubers.						X	X
	Apply wood ash to tuber injuries.						X	
Development on tubers	Treatment of tubers with fungicide before storage.							X
Infection and persistance in storage areas	Disinfection of storage areas.							X
	Aeration and ventilation.							X
Persistence in the soil	Crop rotation, leave several years between 2 yam crops.	X						

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

Viruses: Yam mosaic and other viruses

Major elements of the control strategy

- Resistant varieties.
- Use seeds collected from healthy plants.
- Increase biodiversity within the plots.
- Practice of double harvesting.

Development stages of the fungus	Action	Cultivation stages						
		Choice of parcel	Preparation of parcel	Planting to germination	Leaf Development	Senescence of aerial organs	Tubers harvesting	Tubers storage
Conservation in seeds	Use of healthy seeds.			X				
Primary infection on young plant	Avoid the presence of vector insects on the crop (aphids, mealybugs, etc).				X			
Development of symptoms	Elimination of plants presenting symptoms.				X			
Development of late symptoms	Identification of infected and stunted plants to eliminate replanting material.					X		
	Double harvesting.						X	
Dissemination to others tubers	Elimination of mealybugs - carriers of badnaviruses.						X	X

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

Symptoms of viral infections generally appear at the beginning of the cycle. They can then be masked if plant growth is vigorous, while still remaining infected. It is important to identify early on any plants presenting symptoms (mosaic, shoestring, deformities, etc) and eliminate them from the field so as to limit the further dissemination of the virus by the carriers.

The practice of double harvesting (on early *D. rotundata* varieties) enables the partial elimination of unhealthy plants that do not have the strength to form tubers a second time, when the tubers will be used as seeds.

Double harvesting, or 'weaning', consists of initially harvesting still immature tubers without destroying the rest of the plant. The plant then forms tubers a second time, which are used as seeds. This technique is mostly used in West Africa on *Dioscorea rotundata*. The tubers from the first harvest are highly prized for making foutou (pounded yam).

3. Active substances and treatment recommendations

Introduction

For each pest or disease, proposals of the strategy for the use of Plant Protection Products (PPP) are indicated below.

A list of active substances is suggested for each pest or disease. When available, the critical GAP which allows compliance with European MRLs currently in force on yams is also shown, or the highest national MRL when no harmonised European MRL exists. At this stage, however, it is worth noting that no tests have been carried out in ACP production environments to check compliance of MRLs with the GAPs indicated. Any change in one or more elements of these GAPs (increase in the doses, frequency of application and number of applications, last application before harvest not respecting the recommended pre-harvest interval) can result in residues in excess of the MRL in force. These GAPs does not represent a treatment calendar to be applied as such. In practice, the frequency of treatments must take account locally of the severity of attacks and the real risks of damage.

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

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

Defoliating caterpillars - *Loxura atymnus, Theretra nessus, Tagiades gana*
Chrysomelids - *Crioceris (= Lilioceris) livida, Lema armata*

Strategy: Use of insecticides rarely necessary. In case of heavy infestation an insecticide could sprayed: contact insecticides to control caterpillars, systemic to control chrysomelids (contact insecticides are not efficient to control larvae of chrysomelids since they are protected by a viscous blackish mucus). Alternate active substances in case of repeated treatments.

Active substance	Recommended GAP*				Proposed application period			
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)	Preparation of soil	Seeds	Foliar development	Harvest and storage
Group 3 - Pyrethroids								
Cypermethrin	70	2	15	60			1 to 5 months after emergence	
Deltamethrin	/	2	/	60				
Esfenvalerate	/	2	/	60				
Group 1 - Organophosphates and carbamates								
Carbaryl	/	/	/	/			1 to 5 months after emergence	
Dimethoate	400	2	/	/				
Group 18 - Ecdysone aganists/moulting disruptors								
Azadirachtine	150	/	/	2			1 to 5 months after emergence	
Group 11 - Microbial disruptors of insect midgut membranes								
Bacillus thuringiensis subsp. *Kurstaki* To control caterpillars	/	/	/	2			1 to 5 months after emergence	
Bacillus huringiensis subsp. *tenebrionis* To control chrysomelids	/	/	/	2				

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

Yam beetle - *Heteroligus* spp.
Yam weevil - *Palaeopus costicollis*

Strategy: Treat seeds wit an insecticide, possibly with two associated actives substances.

Active substance	Recommended GAP*				Proposed application period			
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)	Preparation of soil	Seeds	Foliar development	Harvest and storage
Group 3 – Pyrethroids								
Deltamethrin	/	1	n.a.	n.a.		powder application or dipping following manufacturer recommen-dation		
Group 1 – Organophosphates and carbamates								
Pyrimiphos-methyl	/	1	n.a.	n.a.		powde application or dipping following manufacturer recommen-dation		

Coffee bean weevil - *Araecerus fasciculatus*, Weevil - *Tenebrio guinensis*
Maruca - *Diaprepes abbreviatus*, Yam moths - *Euzopherodes vapidella*, Moth (undetermined species)

Strategy: Treatment of stored tubers by spraying with two mixed actives substances. The first time at harvest before storage. Repeat the treatment after one month on damaged tubers (after sorting).

Active substance	Recommended GAP*				Proposed application period			
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)	Preparation of soil	Seeds	Foliar development	Harvest and storage
Group 3 – Pyrethroids								
Deltamethrin	10	2	30	n.a.				Subject to test com-pliance with European MRL in force
Group 1 – Organophosphates and carbamates								
Pyrimiphos-methyl	25	2	30	n.a.				Subject to test com-pliance with European MRL in force

* The elements of the recommended GAP shown here allow to comply with the harmonised European MRL or the highest national MRL (see part 6 of this guide).
/ elements of the recommended GAP not available.
n.a.: not applicable.

Mealy bugs - *Geococcus coffea, Phenacoccus gossypii, Planococcus citri* et *P. dioscoreae*,
Yam scale (with carapace) - *Aspidiella hartii*

Strategy: treatments should be done on tubers immediately after harvest before storage by dipping during 10 min in a solution of 2 actives substances in eventual addition to a mechanical brush (mealy bugs) or to a dipping in hot water (50° C during 20 minutes).

Active substance	Recommended GAP*				Proposed application period			
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)	Preparation of soil	Seeds	Foliar development	Harvest and storage
Group 3 - Pyrethroids								
Deltamethrin	2.5	1	n.a.	n.a.				Subject to test compliance with European MRL in force
Group 1 - Organophosphates and carbamates								
Pyrimiphos-methyl	25	1	n.a.	n.a.				Subject to test compliance with European MRL in force
Diazinon	/	1	n.a.	n.a.				
Malathion	/	1	n.a.	n.a.				

* The elements of the recommended GAP shown here allow to comply with the harmonised European MRL or the highest national MRL (see part 6 of this guide).
/ elements of the recommended GAP not available.
n.a.: not applicable.

Foliar spots

Anthracnose: fungus complex including *Colletotrichum gloeosporioides*.

***Alternaria* spp., *Curvularia eragroistides*, *Cercospora* spp., *Sclerotum rolfsii*, *Rhizoctonia* spp.**

Strategy: Foliar application from symptoms appearance paying attention in humid period. The quantity of water to apply per hectare to wet properly the foliage should be adapted to foliar development.

Active substance	Recommended GAP*				Proposed application period			
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)	Preparation of soil	Seeds	Foliar development	Harvest and storage
Group 11: QoI fungicides								
Azoxystrobine	200 - 250	2	15	30				
Group M: Multisite activity								
Copper	1,000 - 2,200	3	/	30				
Mancozeb	1,000 - 2,200	3	/	30				
Group 1: MBC fungicides								
Benomyl	/	/	/	/				

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

/ elements of the recommended GAP not available.

n.a.: not applicable.

Tubers wet rot - *Botryodiplodia theobromae, Rhizopus nodosus* and others fungi
Erwinia carotovora and others bacteria
Dry rot - *Fusarium, Aspergillus* spp. and others fungi
Green rot - *Penicillium* ssp.

Strategy: Before storage or packing, dipping clean and sorted tubers during 10 - 15 seconds in an aqueous solution. Dry tubers accurately after treatment. Disinfect regularly areas of packing and storage.

Active substance	Recommended GAP*				Proposed application period			
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)	Preparation of soil	Seeds	Foliar development	Harvest and storage
Group 1: MBC fungicides								
Thiabendazole	200	1	n.a.	n.a.				Dipping during 2 minutes
Thiophanate-methyl	50	1	n.a.	n.a.				
Group 11: QoI fungicides								
Azoxystrobine	/	1	n.a.	n.a.				
Group 12								
Fludioxonyl	/	1	n.a.	n.a.				
Group 14								
Dicloran	/	1	n.a.	n.a.				
Group 3: DMI fungicides								
Imazalil	50-100	1	n.a.	n.a.		Dipping during 5 seconds		
Not classified								
Sodium hypochlorite (Chlorine/Javel) at 14,4 % of active chlorine (or 48°chl)	1.25 litre	1	n.a.	n.a.				

* The elements of the recommended GAP shown here allow to comply with the harmonised European MRL or the highest national MRL (see part 6 of this guide).
/ elements of the recommended GAP not available.
n.a.: not applicable.

4. Existing registrations in ACP countries

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

Uganda
No information available.

Ghana
Following actives substances listed in part 4 of this guide have PPP registered on various crops: cypermethrin, lambda-cyhalothrin, deltamethrin, pirimiphos-methyl, dimethoate, mancozeb.

Jamaica
Imazalil for post harvest to control *Rhizopus* spp.
Fludioxonyl for post harvest to control *Fusarium* and *Penicilium*
Dicloran for post harvest to control *Rhizopus* spp.

Dominican Republic
No information available.

5. European regulations and pesticide residues

Status of the active substances in Directive 91/414; European and national MRLs in European countries in March 2008.

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

	LMR on yam* in Europe																			
Active substance	European regulations		National MRLs of European countries																	
	Status DIR 91/414	European MRL	DE	AT	BE	DK	ES	FI	FR	IT	LU	NL	UK	SE	PT	SI	PL	SK	EE
Azadiractine	Notified List 4C	/																		
Azoxystrobine	Annex 1	0.05[2]																		
Bacillus thuringiensis	Notified List 4A	/																		
Benomyl	Withdrawn	0.1																		
Carbaryl	Withdrawn	0.05[1]																		
Copper	Notified List 3A	5																		
Cypermethrin	Annex 1	0.05																		
Deltamethrin	Annex 1	0.05																		
Dicloran	Notified List 3A	0.1																		
Dimethoate	Annex 1	0.02																		
Esfenvalerate	Annex 1	0.02																		
Fludioxonyl	Notified List 3A	0.05[2]																		
Imazalil	Annex 1	0.02[2]																		
Mancozeb	Annex 1	0.05[2]																		
Pyrimiphos-methyl	Annex 1	0.05																		
Thiabendazole	Annex 1	15[1]																		
Thiophanate-methyl	Annex 1	0.1																		

* The MRL in this table are valid for the all group of roots and tubers vegetables. If a specific MRL exist on yam, this is clearly indicated by [1].
For tropical roots or tubers vegetables by [2].

6. References and useful documents

Sauphanor, B., D. Bordat, G. Delvare, and A. Ratnadass. 1987. Les insectes des ignames stockées de Côte d'Ivoire. Inventaire faunistique et éléments biologiques. L'Agronomie Tropicale 42:305-312.

Quénéhervé, P. 1998. Les nématodes de l'igname, p. 193-204, In J. Berthaud, et al., eds. L'igname, plante séculaire et culture d'avenir. Actes du séminaire international Cirad-Inra-Orstom-Coraf, 3-6 juin 1997, Montpellier, France. CIRAD, Montpellier, France.

Kenyon L et al, Poster on Diseases and pests of yam. NRI.
http://www.gre.ac.uk/~kl04/posters.pdf.

Checklists of insects and mites recorded on crops in Ghana.
http://ghana.ipm-info.org/list_diseases.htm.

Marigolds as cover crops. K. E. Dover, R. McSorley, K. -H. Wang, Department of Entomology & Nematology, University of Florida. 2003
http://agroecology.ifas.ufl.edu/Marigoldsbackground.htm.

Récolte mécanique de l'igname en Nouvelle-Calédonie. Vernier P., Varin D., 1996. Agriculture et Développement, n. 10, p. 56-60

Vernier P., 2002. L'igname, In : Agriculture spéciale. Les plantes comestibles : les autres amylacées. Mémento de l'agronome. Montpellier, France, CIRAD, p. 831-878.