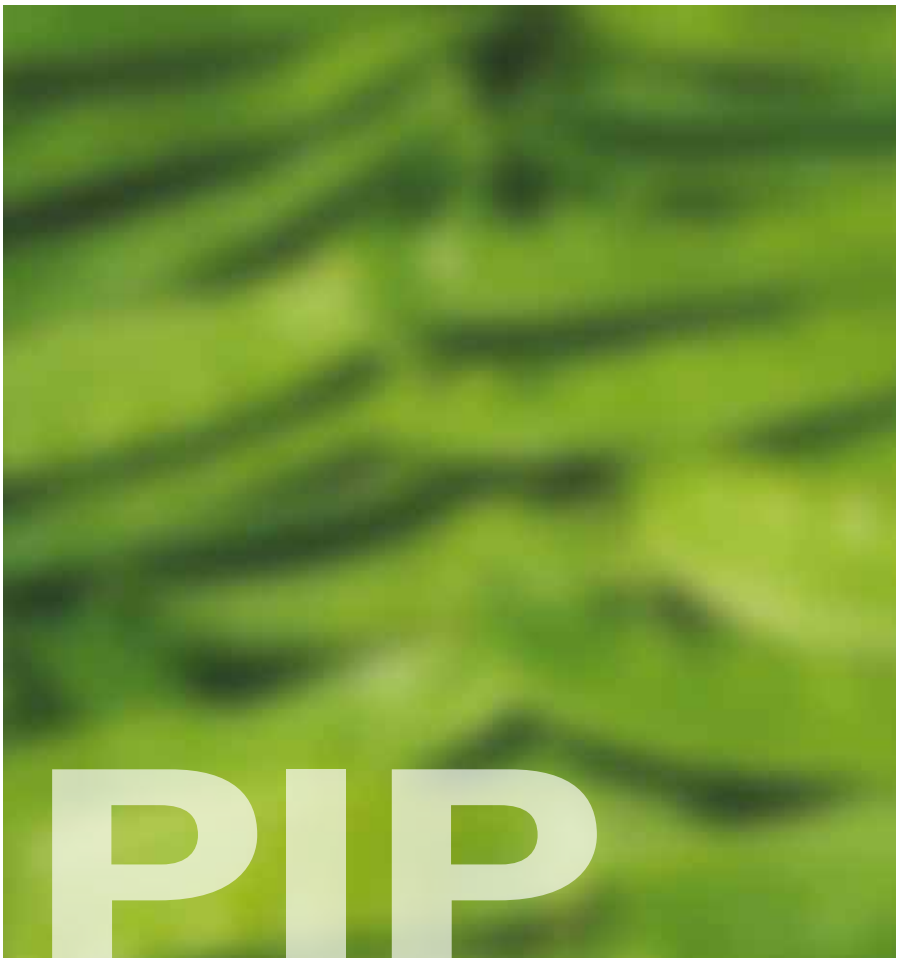

GUIDE TO GOOD CROP PROTECTION PRACTICES

FOR PRODUCTION OF CASSAVA (*MANIHOT ESCULENTA*)

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".

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PIP

FOR SUSTAINABLE DEVELOPMENT OF THE ACP HORTICULTURAL INDUSTRY

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Maladies et ravageurs des cultures de la région des grands lacs d'Afrique Centrale (No. 24). AGCD - Coopération Belge, 1989, 232 p.
Lutte contre les ravageurs du manioc - Guide de la pratique de lutte intégrée à l'usage des vulgarisateurs. Braima James, John Yaninek, Peter Neuenschwander, Anthony Cudjoe, Wester Modder, Nnamdi Echendu, Muaka Toko. IITA
Frank Peairs, Colorado State University, Bugwood.org
Disease Control in Cassava Farms – Weston Msikita, Braima James, Emmanuel Nnodu, James Legg, Kerstin Wydra, Francis Ogbe - IITA
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Notice

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

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

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

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FOR SUSTAINABLE DEVELOPMENT OF THE ACP HORTICULTURAL INDUSTRY

Table of content

1. Main pests and diseases

This guide is intended for plant protection practices on cassava grown for tubers and/or leaves.

1.1. Extent and impact on the yield and quality of the production

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

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

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

One should check the status of quarantine organisms on the websites
http://europa.eu/scadplus/leg/fr/lvb/f85001.htm;
http://www.eppo.org/QUARANTINE/quarantine.htm since regulation can change.

INSECTS						
Significance	Organs attacked				Types of loss	
	Leaves	Tubers	Number of plants	Number of tubers or leaves per plant	Size/weight of the tubers or leaves	Quality of the tubers or leaves
Lepidoptera						
Erynnis ello (Hesperidae) - America /Caribbean Islands						
++(+)	Defoliation by caterpillars			For tubers, possible reduction in case of heavy infestation before the seventh month of crop. For leaves at any time		
Coleoptera						
Tribolium castaneum (++) *(Tenebrionidae)* - Cosmopolite, *Sitophilus* sp. (++) *(Cucurlionidae)* - Cosmopolite, *Tenebrionides mauritanicus* (+) *(Ostomatidae)* - Cosmopolite, *Trogoderma granarium* (++) *(Dermestidae)* - Africa, *Araecerus fasciculatus* (+) *(Anthribidae)* - Africa, *Dinoderus* sp., *Carpophilus* sp., *Rhizopertha dominica, Prostephanus truncatus*						
+/++		Flour, chips, granules of tubers are eaten by larvae				Decrease commercial value of tubers after processing
Coelosternus spp. (+) (*Curculionidae*) - America/Africa *Lagocheirus* spp. (+) (*Cerambycidae*) - America/Africa						
+	Larva bore the stem		No significant losses			

INSECTS (continued)						
Significance	Organs affected		Type of losses			
	Leaves	Tubers	Number of plants	Number of tubers or leaves per plant	Size/weight of the tubers or leaves	Quality of the tubers or leaves
Orthoptera						
Zonocerus variegatus (*Pyrgomorphidae*) - Africa						
+/++	Eaten by larvae and adults			For tubers, possible reduction in case of heavy infestation before the seventh month of crop. For leaves at any time		
Thysanoptera (Thrips)						
Retithrips syriacus QO - Africa *Scirtothrips manihoti* - America						
+	Larvae and adults suck leaves and buds					Possible reduction for leaves
Homoptera						
Bemisia spp.						
Mainly important as vector of viruses						
+++	Larvae and adults suck the sap					Possible reduction for leaves
Scales on aerial part of the plant, *Phenacoccus manihoti* QO (+++) (*Pseudococcidae*) - Africa *Aonidomytilus albus* (+++) (*Diaspidae*) - America/Africa *Saissetia* spp. (+) (*Coccidae*) - America/Africa						
+++	Larvae present on leaves, stems and branches		Possible death of the plant due to early and heavy infestation	Tubers are few and small in case of heavy infestation before the seventh month of crop. For leaves possible reduction at any time		Quality of tubers and leaves may be reduced
Scales on underground part of the plant - *Stictococcus vayssierei (Sticiococcidae)*-Africa						
++		Larvae develop on roots and tubers		Infestation disturb the normal development of tubers		Tubers are distorted

MITES						
Significance	Organs affected		Type of losses			
	Leaves	Tubers	Number of plants	Number of tubers or leaves per plant	Size/weight of the tubers or leaves	Quality of the tubers or leaves
Mononychellus tanajoa QO (++(+)), *Oligonychus* spp. (+) and *Tetranychus* spp. (+) (*Tetranichidae*) - Africa/America						
++(+)	Larvae and adults suck the sap		Possible death of plants in case of heavy infestation on young plants	For tubers, possible reduction in case of heavy infestation before the seventh month of crop. For leaves at any time. Because of reduced plant growth, accumulation of starch in the storage roots is slowed, sometimes even reversed, and root yield losses in the absence of any control measures can reach 50%		Reduced quality of leaves

BACTERIA						
Significance	Organs affected		Type of losses			
	Leaves	Tubers	Number of plants	Number of tubers or leaves per plant	Size/weight of the tubers or leaves	Quality of the tubers or leaves
Xanthonomas spp.						
+++	Bacteria develop on leaves, stems and roots		Possible death of plants	Reduction		

FUNGUS						
Significance	Organs affected		Type of losses			
	Leaves	Tubers	Number of plants	Number of tubers or leaves per plant	Size/weight of the tubers or leaves	Quality of the tubers or leaves
Diseases on roots						
Dry root rot - *Rigidoporus lignosus* - Africa/America						
++		Mycelium develops on roots	Rot may induce death of the plant after progressive decaying			
Foliar diseases						
Anthracnose - *Glomerella cingulata f.* sp. *manihotis* - Cosmopolite						
+	Mycelium develops on leaves and stems			Possible reduction on susceptible varieties		
Blight leaf spot - *Cercospora* spp. - Cosmopolite						
+	Mycelium develops on leaves		A heavy defoliation may lead to death of the plant	Possible reduction on susceptible varieties		
Brown leaf spot - *Cercosporidium henningsii*						
+	Mycelium develops on both sides of leaves			Possible reduction on susceptible varieties if heavy defoliation		
Diseases on tubers						
Aspergillus sp. and *Penicillium* sp.						
+		Mycelium develops on chips				These infections depreciate the aspect of the tubers and produce aflatoxines which are toxic

VIROSIS						
Significance	Organs affected		Type of losses			
	Leaves	Tubers	Number of plants	Number of tubers or leaves per plant	Size/weight of the tubers or leaves	Quality of the tubers or leaves
Transmission by whiteflies						
African mosaic disease (+++) AMD - Africa - also transmitted through cuttings						
Epidemic conditions may result where there is a high incidence of severe AMD coupled with high whitefly populations. These conditions have been characteristic of the pandemic that has spread through East and Central Africa during the 1990s.						
+++	Viruses spread in the whole plant		Possible death of plants	Important losses if cuttings are infected		

Transmission through cuttings					
Cassava common mosaic disease QO (+) CCMD - America Cassava vein mosaic disease (++) CVMD - America					
+(+)	Viruses spread in the whole plant			Possible reduction	
Cassava brown streak virus QO (+++) CBSV - Africa					
+++	Viruses spread in the whole plant			Possible reduction	Reduced quality of tubers

1.2. Identification and damage

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

INSECTS

Defoliating insects

Erynnis ello

A large sphingid, grey-brown in colour. The female lays greenish eggs on the lower surfaces of leaves. The caterpillars vary in colour (green, yellow, black). They develop in 15 days and measure about 10 cm at the end of the process. Leaves are entirely consumed. Pupation occurs in the soil at the foot of the plant.

Caterpillar

Zonocerus variegatus

An Orthoptera that is easily recognisable by its colour: light green wings, yellow body with black and red markings. Damage caused essentially by larval bands is generally very localised and close to egg-laying areas. Defoliation is usually significant if a certain density of larval population is given.

Adult

Damage

Stem borers

Coelosternus spp. - *Lagocheirus* spp.

The females of these two pests lay their eggs on twigs in various places. The larvæ dig galleries that can go down to the tubers. These galleries cause shoots to break. The entry holes being invisible, twig rupture indicates the presence of the pest.

Piercing/sucking insects

Bemisia tabaci

This whitefly is wide-ranging, and host plants are numerous. Adults are small (1 mm), but can be easily observed on the undersides of leaves due to their white colouring. They are very mobile and fly away fast. Eggs are inserted into plant tissue. The very short biological cycle explains the high speed of infestation spread. Larvæ and adults feed on sap. The large number of insect holes and the toxicity of the saliva injected leads to leaf deformation that can cause leaf dryness in areas with high levels of infestation.

Adults

Thrips

Small insects identifiable by their elongated shape, and their narrow, elongated wings covered with hairs. Their attacks are localised in young shoots, causing deformations and stuntings which lead to a reduction in leaf surface area.

Damage

Phenacoccus manihoti

This cassava mealy bug is, as its name indicates, fully dependent on the cassava plant. It is ovoid in shape and pink in colour, with an easily visible abundant secretion of whitish-looking white wax. *P. manihoti* lives in colonies, especially on the young, tender parts of plants. Whilst feeding, the mealy bug injects a toxin into the plant which has a significant effect on plant development. The growing shoots look bushy, plant growth slows, internodes are shorter, and stems become twisted. In cases of severe infestation, plants die off completely from the crown downwards.
The female adult is 2 to 3 mm long.

Colonies of mealybugs

Bushy aspect

Distorted stem

Dessicated leaves

Aonidomytilus albus

Scale cover of adult female is elongated and mussel-shaped with 1.75-2.5 mm long. The carapace may be straight or curved, whitish to dark brown, with slightly darker terminal exuviæ. Scale cover of male similar to that of female but smaller (1.0-1.25 mm long) and narrower, with darker exuvia.

On cassava, *A. albus* coats the stems, side shoots and even sometimes the leaf petioles with scales. Heavy infestation causes desiccation of the stems, causing them to become thin and weak, and break in the wind; death of the plant may result. Breakage of stems leads to profuse branching, and infested plants often appear bushy. Close planting encourages development and spread of infestations; wide spacing of plants and use of clean planting materials, reduce the risk of serious infestation. Infested cuttings often do not root. Root development in infested plants is poor, and the roots become unpalatable.

Infected stem

Saissetia spp.

Mealy bug, strongly convex blackish shield. Attacks can significantly decrease the viability of cuttings.

Stictococcus vayssierei

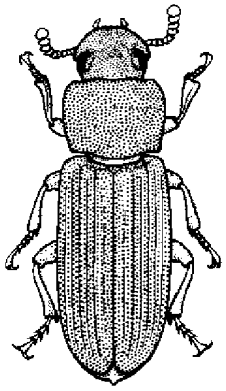
Ovoid in shape, red-purple or brown in colour, this scale looks like a tick and lives only in the soil and on tubers.

Scales on the underground part of a cassava stem

On stored processed cassava

Flour beetle (= rust-red flour beetle), Tribolium castaneum

Adults are about 3.5 mm long. They range in colour from rust-red to reddish. Larvæ are yellowish in colour. This species strongly resembles the rice flour *Tribolium*.



Adult of *Tribolium* sp.

MITES

Mononychellus tanajoa

This mite seems to be strongly dependent on the cassava plant. It is very small and green in colour. The mite bores holes into the lower surface of young leaves, causing the appearance of yellow spots and deformations. In case of water stress, the ends of stems turn brown, with progressive drying and death of the plant from crown to root.

Most mites are generally found on the upper third or the cassava plant. Leaves damaged by this green mite may also show mottled symptoms which causes confusion with symptoms of cassava mosaic virus disease (CMD).

Severely damaged leaves dry out and fall off, which can cause a characteristic candlestick appearance. Reduced growth and stunting of the tips is also responsible for contorted and thin stems, thus affecting the planting material to be used for the next season.

Cassava green mite eggs and active stages

Yellow spots on leaves

Adults

Candlestick appearance

Tetranychus spp.

Several species of red spider mites also occur on cassava, mostly on the older leaves. Adults are about 0.6 mm long. Initial symptoms are yellowish pinpricks along the main vein of mature leaves. Spider mites produce protective webbing that can be readily seen on the plant. Attacked leaves turn reddish, brown or rusty in colour. Under severe mite attack, leaves die and drop beginning with older leaves.

BACTERIA

Xanthomonas campestris pv. *manihotis*

Young plant grown from infected material shows withering of young leaves followed by death of plant.

Older plant infected with the bacterium via stomata shows angular marks that grow in size and turn brown, with circular burnt area. The leaves become weak and droopy. Vascular infection is characterised by gum exudates on petioles and young stems.

The attack progresses through the stems to the roots, ending in the death of the plant.

Bacterial blight

Xanthomonas campestris pv. *cassavae*

On leaves, the bacterium causes angular marks filled with water which become necrotic. These marks are spread out along leaf blades or along primary and secondary leaf veins. This is similar to the effect of *X. c.* pv. *manihotis*. Unlike fire blight, leaf burn areas are rare, and the disease does not become systemic. Apex parts may wilt due to stem cortical tissue being attacked, usually due to plant injury. The result is ring necrosis that can spread over a few centimetres. Gum exudate is not abundant.
The disease usually arises in soils rich in coarse sand and fine granitic gravel. It is rare in young, vigorous plants, and is only indicated by a few leaf symptoms. Attacks on stems are more frequent at the start of the flowering period, when plant growth is slowed down.

FUNGUS

Rigidoporus lignosus

Dry rot affecting the roots of young plants. A cottony white mycelium, turning cream to orange, covers the roots. The infected tissues of tubers dry out, and give a characteristic rotting odour. Infected areas are clearly marked in the field.

Glomerella cingulata f. sp. *manihotis*

The fungus mainly attacks stems. The first symptoms are visible on green portions as discoloured areas that range from oval to round in shape. They are distinct, and range in length from 1 to 2 cm. Lesions are dark brown in colour, and often have a greasy border. As they grow, lesions become dry necrotic areas that are light brown in colour. As stem lignification takes place, lesions change into cankers of varying depth. The dry epidermis persists in the form of lacerated stripes covered in small black spots made up of fungal fructification (acervulus). Lesions are usually found at the insertion points of petioles, where drops of water remain after rainfall. In sensitive cultivars, anthracnosis can lead to peripheral death by the longitudinal development of lesions or their transverse development, which leads to stem strangulation. Strong attacks cause a reduction in the capacity of cuttings to germinate.

Symptoms on a stem

Cercosporidium henningsii

The disease starts with greyish-green rounded marks less than 1 cm in diameter, visible on both sides of the leaf limb. These marks become necrotic and turn greyish-brown in colour on the lower surface, being light brown with a reddish-brown border on the upper surface. They are often bounded by a secondary vein or the primary vein, which gives them a partially angled appearance. Some lesions are surrounded by a diffuse chlorotic halo, or they evolve into irregular necrotic areas several centimetres wide. The stromatic base of fungal fructification is visible as a series of small black spots on both sides of old leaves.
The disease affects plants over 5 months old. It begins by attacking older leaves, which turn yellow, dry up, and fall off prematurely.

Symptoms: brown marks on leaves

Cercospora vicosae

Yellowish, irregular, diffuse marks visible on the upper surface of the blade. They develop as reddish-brown necrotic areas that may cover almost the whole leaflet. Older leaves are most severely attacked, and fall off prematurely.

Spots on a leaf

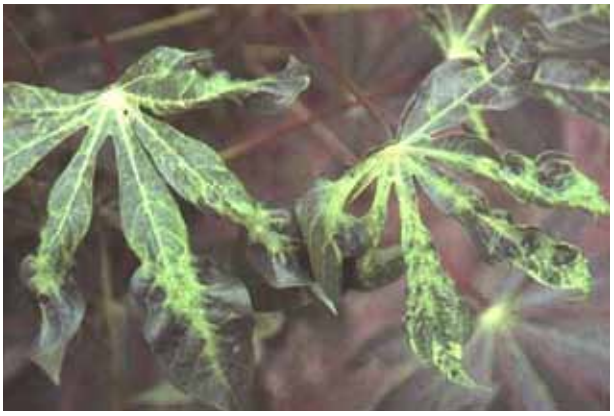
Aspergillus sp. - *Penicillium* sp.

This fungus causes rot that develops on badly dried products or in warehouses that are damp or badly ventilated.

VIROSIS

African mosaic disease - AMD

This viral disease is characterised by a pale green to yellowish mosaic on the leaf, which becomes deformed and blistered, and which goes on to grow asymmetrically due to a stop of growth in the infected areas. When the infection is precocious and severe, this affects the development of the whole plant: internodes become shorter, growth is slowed or stopped, deformed and discoloured leaves are undersized, the base of some leaflets is reduced to primary vein with a border made of a little discoloured parenchyma, and the plant becomes stunted and shaggy. The disease does not always affect all the stems of a plant. Symptoms may weaken or even disappear under the effect of heat in growing periods and at the end of the cassava cycle.



Typical symptoms of mosaic

Cassava common mosaic disease - CCMD

Symptoms are analogous to the previous disease.

Cassava vein mosaic disease - CVMD

Vein chlorosis.

Cassava brown streak virus - CBSV

All plant organs are affected with symptoms of varying acuteness depending on the variety / clone. Developed leaves turn yellow. Stems show brown or black streaks with necrotic lesions. Tubers show fissures of varying depth that may lead to root rot.

Pale chlorotic patches on leaves

Streaks on a stem

Browning inside tubers

1.3 Appearance of pests and diseases according to 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. It is especially during the latter stages that they must be monitored and controlled if necessary. The purpose is to show that the presence of a pest, disease or pathogenic agent is not always harmful to the crop.

The length of the crop cycle for cassava varies according to varieties considered and can be influenced by the cultural practices and the climatic conditions. It is in general 12 months but cassava can produce for 24 months with decreasing during the periods of dry season.

Usually, the youngest plant of cassava suffer more of pests and diseases than the older one. For the majority of varieties, 3 to 4 months after plantation, the roots start to form tubers because of accumulation of nutrients. Approximately 7 months after propagation by cutting, the plants will have formed the appropriate number of tubers. This number will increase very shortly after this period, but the tubers will continue to grow bigger until harvest. Consequently, the losses will be higher if the attack of the pests and diseases occurs in 7 months or less, than if the infestation occurred later.

Insects and mites

Stage		Start and end of stage (approx.) in weeks after planting	*Erynnis ello*	Beetles on stored tubers	*Coelosternus* spp., *Lagocheirus* spp.	*Zonocerus variegatus*	*Retithrips syriacus*, *Sciryothrips manihoti*	*Phenacoccus manihoti*, *Aonidomytilus albus*, *Saissetia* spp.	*Stictococcus vayssierei*	*Bemisia tabaci*	*Mononychellus tanajoa*, *Oligonychus* spp., *Tetranychus* spp.
Planting to first leave		1 to 2									
Foliar development		2 to 12									
Establishing of tubers	Harvest of leaves	12 to 28									
Growth of tubers	Harvest of leaves	28 to 44									
Harvest of tubers		-									
Storage		-									

- Periods during which pest or pathogenic agent is potentially present
- Periods during which the appearance of a serious infestation can cause the greatest loss on tubers
- Periods during which the appearance of a serious infestation can cause the greatest loss on leaves

Bacterial, fungal and viral diseases

Stage		Start and end of stage (approx.) in weeks after planting	*Xanthomonas* spp.			*Rigidoporus lignosus*			*Aspergillus* sp. *Penicillium* sp.			Foliar fungal diseases			African mosaic disease Common mosaic disease Vein mosaic disease			Cassava brown streak virus		
Planting to first leave		1 to 2																		
Foliar development		2 to 12																		
Establishing of tubers	Harvest of leaves	12 to 28																		
Growth of tubers	Harvest of leaves	28 to 44																		
Harvest of tubers		-																		
Storage		-																		

- Periods during which pest or pathogenic agent is potentially present
- Periods during which the appearance of a serious infestation can cause the greatest loss on tubers
- Periods during which the appearance of a serious infestation can cause the greatest loss on leaves

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

UGA = Uganda, valid also for east of Africa; GHA = Ghana and BEN = Benin, valid also for West Africa; DOR = Dominican Republic
0 = no damage or not reported in the country
+ = limited damage
++ = moderate damage: control necessary
+++ = heavy damage: control essential
X = generally limited damage but evolution of damage level over the year is not known
XX = damage can be moderately important, but evolution of damage level over the year is not known
XXX = damage can be heavy, but evolution of damage level over the year is not known
/ = no information available
N.B. the inventory of pests and diseases has not been conducted exhaustively in all countries. The pest may be present, but has perhaps never been observed in the country on the crop, because it does not cause serious damage.

Erynnis ello

Favourable conditions: Most important damages are at the beginning of rainy season.

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
BEN	0	0	0	0	0	0	0	0	0	0	0	0
DOR	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX

Zonocerus variegatus

Favourable conditions: This pest occurs mainly in humid area. In West and Central Africa many locusts appear in this type of area usually between March and May. Hatching of eggs start at the beginning of the great dry season, usually between October and November.

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
BEN	/	/	/	/	/	/	/	/	/	/	/	/
DOR	0	0	0	0	0	0	0	0	0	0	0	0

Coelosternus spp. and – *Lagocheirus* spp.

Favourable conditions: No information.

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

Bemisia tabaci

Favourable conditions: Dry seasons.

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

Thrips

Favourable conditions: Develops more in case of hydric stress, so infestation will be more severe during dry periods.

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

Phenacoccus manihoti

Favourable conditions: Infestations are more severe in dry season.

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
BEN	/	/	/	/	/	/	/	/	/	/	/	/
DOR	0	0	0	0	0	0	0	0	0	0	0	0

Aonidomytilus albus

Favourable conditions: The severity of attack becomes worse in drought conditions, aggravating drought stress.

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

Saissetia spp.

Favourable conditions: No information.

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

Stictococcus vayssierei

Favourable conditions: Pest impact is more severe in the dry season than in the wet season.

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
BEN	X	X	X	X	X	X	X	X	X	X	X	X
DOR	0	0	0	0	0	0	0	0	0	0	0	0

Mononychellus tanajoa, Oligonychus spp.

Favourable conditions: Moderate rainfall.

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

Tetranychus spp.

Favourable conditions: Dry periods.

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
BEN	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/

Xanthomonas spp.

Favourable conditions: Humid period. Projections of soil particles, by strong winds before heavy rains, could induce superficial injuries to the plants and foster entering of the bacteria.

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

Rigidoporus lignosus

Favourable conditions: No information.

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

Glomerella cingulata f. sp. *manihotis*

Favourable conditions: No information.

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

Cercosporidium henningsii

Favourable conditions: No information.

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

Cercospora spp.

Favourable conditions: No information.

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

Aspergillus sp. and *Penicillium* sp.

Favourable conditions: No information.

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

African mosaic disease - AMD

Favourable conditions: No information.

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

Cassava common mosaic disease - CCMD

Favourable conditions: No information.

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

Cassava common mosaic disease - CCMD

Favourable conditions: No information.

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

Cassava vein mosaic disease - CVMD

Favourable conditions: No information.

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

Cassava brown streak virus - CBSV

Favourable conditions: Symptoms are most pronounced during the dry season and aboveground symptoms may not be apparent during periods of wet weather.

CBSV occurs most commonly along the coastal strip of East Africa, from Kenya in the North to Mozambique to the South. Incidence is greatest at low altitude, and the disease is rarely observed above 800 m.a.s.l. CBSV also occurs along the shores of Lake Malawi in both Malawi and Tanzania, and has been reported from some locations in Uganda and Zambia.

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

2. Main control methods

2.1. Introduction

Cassava is a tropical plant adapted to hot, humid climates. At temperatures below 20 °C growth is slow. Cassava is a plant which shows also vegetative multiplication. Agricultural reproduction proceeds by replanting a portion of the vegetative parts without using seed. Plants are regularly grown from cuttings.

How to control cassava pests

From a sanitary point of view, cuttings are possible vectors for several ests, in particular viruses and bacteria.
The best way of dealing with pests and diseases is to plant healthy cuttings, rather than simply trying to destroy them. In order to obtain healthy cassava, one should combines production aspects with plant protection techniques.

Integrated Pest Management practices on cuttings

A large number of Integrated Pest Management (IPM) practices can be done against cassava pests when cuttings are used. These practices cover the choice of site, soil conditioning, choice of varieties and choice of the right plant material.

Several cassava pests and diseases are transmitted during transport and plantation of contaminated cuttings. The main insects transmitted by stems are the cassava mealy bug, the green cassava mite, whitefly and the white scale. These pests survive on cassava stems and leaves, which means that they are easily carried into new fields.

In order to take healthy cuttings, seek out cassava plants with strong stems and branches, luxuriant foliage and showing a minimum of damage. Avoid taking material for planting from cassava plants showing signs of pest presence or infestation. The white scale only appears on some plants in fields planted with cassava. During the development phase of the cassava plant and after roots have been harvested, try to destroy contaminated stems. Do not retain stems that carry harmful insects. Remove such stems from plant storage areas.

If you find it difficult to find enough healthy stems to plant, treat the cuttings to protect them against certain pests. For example, you can plant infected cuttings horizontally, by setting them flat and burying them completely, in order to kill insects living on cuttings (horizontally-planted sticks produce tubers at each node, but lodging of the aerial part is increased and yields reduced). With vertical or inclined planting, the roots penetrate more deeply and tubers may be formed at intervals along the planted portion, but in areas of low rainfall, desiccation of the cuttings may occur. You can also soak cuttings in a dilute solution of recommended pesticide. This solution will kill harmful insects. If pesticides are used, follow the user guide and other instructions to avoid any danger to the field worker and to the environment that may arise from such use.

When taking cassava cuttings to be planted, choose central areas with a brown coating. These portions will give strong growth, and plants which are more vigorous than those grown from the upper green portions of stems. The upper green portions dry out quickly and are extremely vulnerable to pest damage.

Cassava pests are more numerous and cause more damage in dry periods than in the rainy season. It is therefore advisable to plant early in the rainy season. Early rather than late planting will result in vigorous plants with better resistance to pests during the dry season.

Integrated Pest Management practices after plantation

Current Integrated Pest Management practices after cuttings have been planted include biological, microbiological and growth-related techniques.

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 (first column), 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. After failing to obtain precise information on the cycles of various pests in the countries concerned, the presentation of control methods is given 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" are in pink boxes.

Cultivation practices
Application of plant protection product

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

Erynnis ello

Main control methods

Development stages of the pest	Action	Cultivation stages						
		Choice of the field	Preparation of the field	Planting	From planting to complete setup of tubers in number	Growth of tubers	Harvest of tubers	Storage of tubers
Caterpillar	Eliminate visible caterpillars by hand				X			
	Spray a contact insecticide				X			

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

Coleoptera: stored tubers, chips, flour

Tribolium castaneum, Sitophilus sp., *Tenebrionides mauritanicus, Trogoderma granarium, Araecerus fasciculatus, Dinoderus* sp., *Carpophilus* sp., *Rhizopertha dominica, Prostephanus truncatus*

Main control methods

Development stages of the pest	Action	Cultivation stages						
		Choice of the field	Preparation of the field	Planting	From planting to complete setup of tubers in number	Growth of tubers	Harvest of tubers	Storage of tubers
Larva and adult	Sorting tubers; check cassava chips for being free of attacks and/or pests						X	X
	Check warehouses or storage areas before building up stocks. Cleaning and disinfecting							X
	Treating tubers or sacs before placing in storage						X	
	Surface treatment of tubers or sacs (repeat treatment)							X

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

Zonocerus variegatus

Main control methods

Development stages of the pest	Action	Cultivation stages						
		Choice of the field	Preparation of the field	Planting	From planting to complete setup of tubers in number	Growth of tubers	Harvest of tubers	Storage of tubers
Egg	Pay attention on egg-laying areas. Egg pods should be destroyed by hoeing the soil *		X	X	X			
Larva and adult	Spray insecticide on first larval stages				X			
	Hand pick grasshoppers. This is feasible in small plots				X			

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

* However, egg pods destruction has to be done over a wide area in the wet season in order to be effective. This will require the participation of farmers on many neighbouring farms. If only one neighbour destroys the eggs on his/her farm, the grasshoppers will later invade that farm from neighbouring farms and from the bush. In egg-laying areas vegetation always exists which blocks the sun and keeps the site damp and cool, making it suitable for egg laying. Egg-laying sites are often small in size and usually found near cassava fields.

Thrips

Main control methods

Development stages of the pest	Action	Cultivation stages						
		Choice of the field	Preparation of the field	Planting	From planting to complete setup of tubers in number	Growth of tubers	Harvest of tubers	Storage of tubers
Larva and adult	Before planting, cuttings can be treated with hot water by immersing them in heated water (mixing equal volumes of boiling and cold water) for 5-10 minutes			X				
	Plant the cuttings horizontally and completely underground			X				
	Soak the cuttings in an insecticide solution			X				

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

Bemisia tabaci

Main control methods

Development stages of the pest	Action	Cultivation stages						
		Choice of the field	Preparation of the field	Planting	From planting to complete setup of tubers in number	Growth of tubers	Harvest of tubers	Storage of tubers
Larva and adult	Keep the plantation in a water and mineral balance	X	X		X			
	Plant the cuttings horizontally and completely underground			X				
	Before planting, cuttings can be treated with hot water by immersing them in heated water (mixing equal volumes of boiling and cold water) for 5-10 minutes			X				
	Spray a systemic insecticide				X			

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

Mealy bugs and scales - *Phenacoccus manihoti, Aonidomytilus albus, Saissetia* spp.

Main control methods

Development stages of the pest	Action	Cultivation stages						
		Choice of the field	Preparation of the field	Planting	From planting to complete setup of tubers in number	Growth of tubers	Harvest of tubers	Storage of tubers
Egg	Do not take cuttings from infested fields			X				
Larva and adult	Before planting, cuttings can be treated with hot water by immersing them in heated water (mixing equal volumes of boiling and cold water) for 5-10 minutes			X				
	Separate and limit the size of plots of cassava to prevent dispersal of young larvae that are easily blown away	X	X					
	Plant the cuttings horizontally and completely underground			X				
	Use less sensitive cultivars			X				
	Avoid placing sensitive plants in proximity to one another *	X	X					
	Damage can be limited by using growth-related practices that encourage rapid and vigorous growth in plants	X	X	X	X			
	Soak the cuttings in an insecticide solution			X				

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

* *Aonidomytilus albus* has been recorded on species of: *Atriplex, Carica papaya, Chrysanthemum, Flourensia, Harrisia, Malvaceæ, Malvastrum, Mangifera indica, Manihot* spp., *Mimosa, Sechium, Solanum, Suaeda* and *Ziziphus*.

Mites

Main control methods

Development stages of the pest	Action	Cultivation stages						
		Choice of the field	Preparation of the field	Planting	From planting to complete setup of tubers in number	Growth of tubers	Harvest of tubers	Storage of tubers
Larva and adult	Do not take cuttings from infested fields			X				
	Before planting, cuttings can be treated with hot water by immersing them in heated water (mixing equal volumes of boiling and cold water) for 5-10 minutes			X				
	Separate and limit the size of plots of cassava to prevent dispersal of young larvae that are easily blown away	X	X					
	Plant cuttings horizontally and completely underground			X				
	Use less sensitive cultivars			X				
	Practice intercropping*		X	X	X			
	Soak cuttings in an acaricide solution			X				

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

* Cassava intercropped with pigeon pea has been reported to suffer less damage from cassava green mites than those grown on a pure stand in Nigeria. Higher tuber yields were obtained when cassava was intercropped with pigeon pea in triple and double rows than those alternated in a single row or in a pure stand.

Xanthomonas spp.

Main control methods

Development stages of the disease	Action	Cultivation stages						
		Choice of the field	Preparation of the field	Planting	From planting to complete setup of tubers in number	Growth of tubers	Harvest of tubers	Storage of tubers
Conservation in cuttings	Take cuttings from healthy plants *			X				
	When taking cuttings, use clean or disinfected tools			X				
	Choice of tolerant / resistant plants			X				
Dispersion	Keep cassava plots separate and of limited size	X	X					
	Intercrop cassava with maize or melon. This has been reported to reduce cassava bacterial blight significantly		X	X	X			
Persistance in the soil	Crop rotation: allow several years to pass between 2 cassava crops	X						
	Remove and burn all infected plant debris and weeds. Alternatively, plough them into the soil				X	X	X	

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

* In case of sporadic occurrence of the disease, collect cuttings only from healthy plants and from the most lignified portion of the stem, up to 1 m from the base. Check visually the cuttings for vascular browning.

Rigidoporus lignosus - Dry rot

Main control methods

- If the cassava is planted in a soil occupied beforehand by a jungle or forest crops, all the roots must be uprooted and burned.
- In the fields of cassava, the infected zone must be marked and the crop residues must be pull out and burned.
- The level of inoculum in the soil can be reduced by rotations with herbaceous cultures which have less woody and less persistent roots or with cereals.
- Tolerant varieties have been selected.

Cercosporidium henningsii, *Cercospora* spp. and *Glomerella cingulata* f. sp. *manihotis*

Main control methods

Pest management is essentially growth-related: choice of less sensitive cultivars in areas where the disease is endemic, well-spaced plots to encourage fast drying out of crops after rainfall. Also, remove and burn all infected plant debris and weeds. Alternatively, plough them into the soil.

Aspergillus sp. and *Penicillium*

Main control methods

- Check tubers before storage: eliminate damaged tubers, splitted tubers, or tubers that show the first signs of rot.
- Use well-ventilated and dry storage areas.

Virosis

Main control methods

- An essential aspect of pest management is to take cuttings from cassava plants that have shown no symptoms of mosaic disease during development. In fields dedicated to production of cuttings, it is advisable to uproot diseased plants as soon as symptoms appear.

Development stages of the disease	Action	Cultivation stages						
		Choice of the field	Preparation of the field	Planting	From planting to complete setup of tubers in number	Growth of tubers	Harvest of tubers	Storage of tubers
Conservation in cuttings	Take cuttings from healthy plants			X				
	When taking cuttings, use clean or disinfected tools			X				
	Choice of tolerant / resistant plants			X				
Dispersion	Keep cassava plots separate and of limited size	X	X					
	Avoid planting in proximity to an infected plot	X						
	Where virus spread is not rapid, the disease may also be controlled through the removal of diseased plants shortly after sprouting (roguing)				X			
Persistance in the soil	Crop rotation: allow several years to pass between 2 cassava crops	X						

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

2.3 Tolerant and resistant varieties

Such varieties are numerous, and often adapted / developed specifically for the countries concerned.
When selecting resistant varieties you may also wish to consider other desired characteristics.

Mealy bugs
TMS 60142 appears resistant.

Green mites
The following varieties are resistant: Cameroon: IITA TMS 30572, as well as 8017 and 8034; Nigeria: MS6 and NR 8082.

Cassava brown-streak virus
Varieties have been identified in southern Tanzania and Malawi which are either resistant to infection by CBSV or express very mild symptoms which do not have an effect on yield.

AMV
Use resistant/tolerant varieties (e.g. SS 4, TMS 60142, TMS 30337 and TMS 30572).

2.4 Using natural enemies

Natural enemies feed on other insects, including cassava pests such as mites, caterpillars, bark beetles and whiteflies. Natural enemies often found in cassava plantations among them several types of coleoptera, predator mites and very small “wasps”. These "wasps" are sometimes “parasitoids”. There are also microbes that cause diseases in pests.

Natural enemies do not eliminate pests. They reduce pest populations to levels that are less harmful to plants. When pest populations decrease in numbers, so do the populations of their natural enemies; the reverse is also true. Thus, a balance is observed between pest and natural enemy in a locality.

Phenacoccus manihoti
Parasitoids *(Epidinocarsis lopezi)* and predators from South America are introduced and released in order to improve the natural regulation of mealy bug populations.

Epidinocarsis lopezi is the most effective natural enemy for use against the cassava mealy bug. It has proved itself capable of dealing with the pest in most African regions.

Epidinocarsis lopezi prefers large-size mealy bugs attacking healthy cassava plants. The biological approach of dealing with mealy bugs is strengthened by using soil-conditioning techniques that favour vigorous cassava growth.

Predatory ladybirds can also help in dealing with cassava mealy bugs or white mealy bugs.

Green mites
The main agents as Biological Control against cassava mites are predators called “Phytoseiids”. On cassava plants, phytoseiids look like green mites but they have a shinier body surface, and they run faster than the pest. Amongst mite predators, *Typhlodromalus aripo* is most effective against green mites. This predator mainly attacks young leaves at shoot tips. It is spread by wind and by transport of contaminated cuttings. Field workers can improve the survival rate and the spread of predators by cultivating cassava varieties with fresh leaves arising in bouquet form at shoot tips. These

varieties will attract more predators than varieties where young leaves are spread out. Even if these varieties are not planted for personal use or for sale, the mere fact of growing a few of these plants is enough to attract predators.

Growers can use certain types of wild plant in their cassava plots, e.g. *Euphorbia heterophylla* and *Mallotus oppositifolius*, in order to attract phytoseiids. Predators can survive on these wild plants if they do not find enough nutrition on the cassava plants; thus ensuring that as soon as green mites return, the predators are present in order to play their role in Biological Control. Growers can cultivate wild plants as border plants or in other parts of the field. But wild plants should not be grown in large numbers to avoid any competition with cassava. These growth-related practices are particularly useful in sites where cassava is cultivated on a continuous basis with little or no fallow land.

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

No information available.

4. Plant protection products and treatment recommendations

Introduction

For each pest or disease, proposals of the strategy for the use of Plant Protection Products (PPP) are indicated hereafter. It should however be noted that practically no PPP is applied to cassava crops in ACP countries. Most of the time the recommendations of treatment are limited to the treatment of the cuttings and/or the soil.

When available, the critical GAP, which allows compliance with European MRLs currently in force on tubers of cassava or spinach and similar for cassava leaves, is also shown. At this stage, however, it is worth noting that no tests have been carried out on cassava 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 or elsewhere. It is nevertheless worth noting that there are very few PPP registered on these crops in ACP countries and that not all the growers contacted provided information on the PPP used.

In the case of a production for the tubers, if the attack of the pest or disease occurs in 7 months or less, the losses will be all the more high than if the infestation occurred later. The application of PPP should thus be done more particularly at the beginning of the plant cycle.

To avoid infestation at the start of the crop, preventive treatment of cuttings could be done by dipping them in a solution of insecticide and/or fungicide. For instance:
- to control insects and mites: dimethoate (0.1 to 0.25 g of a.i. per 100 litres of water) ;
- to control fungal diseases: 5 g of a formulation at 80 % of mancozeb per litre of water.

On the other hand, foliar spraying are generally not very useful and nonprofitable.
Since the use of PPPs in cassava crop is not frequent, this part of the guide will not be presented as in the other Guides of the same collection.

Erynnis ello

Some usable insecticides

Active substance	Recommended GAP*				
	Dosage g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days) for tubers production	Pre-harvest interval (days) for leaves production
Deltamethrin	12.5	2	15	15	3 (at least 30 days for non detectable residues)
Lambda-cyhalothrin	15	3	30 between 1st and 2nd application; 15 between 2nd et 3rd application	15	3 (at least 30 days for non detectable residues)
Spinosad	120	2	15	15	3 (at least 30 days for non detectable residues)

* The elements of the recommended GAP shown here allow to comply with the harmonised European MRL (see part 6 of this guide). They are given as an indication on the basis of tests carried out on sweet potato.

Zonocerus variegatus

Some usable insecticides

Active substance	Recommended GAP*				
	Dosage g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days) for tubers production	Pre-harvest interval (days) for leaves production
Deltamethrin	12.5	2	15	15	3 (at least 30 days for non detectable residues)
Lambda-cyhalothrin	15	3	30 between 1st and 2nd application; 15 between 2nd et 3rd application	15	3 (at least 30 days for non detectable residues)

* The elements of the recommended GAP shown here allow to comply with the harmonised European MRL (see part 6 of this guide). They are given as an indication on the basis of tests carried out on sweet potato.

- When available, use biopesticides. There is an environmental friendly biopesticide that can be used. It is based on a naturally occurring fungus strain indigenous to Africa (*Metarhizium anisopliae*) which is deadly to locusts and grasshoppers but does not damage other insects, plants, animals, or people. Typically 70 to 100 percent mortality rates were obtained after 8 to 28 days after applications. This bioinsecticide is effective in grasshopper management in outbreak situations. However, it is costly and currently only available in South Africa and West Africa.
- Use neem extracts. Neem protects cassava from grasshopper damages. It acts as antifeedant (grasshoppers stop feeding when exposed to neem products) and affects development of the grasshoppers. In Nigeria, the following neem products have given good control of *Z. variegatus* on cassava: 1- emulsifiable concentrate of neem oil at 0.5% to 2% applied at 8-day intervals or at 3-4% at 10-day intervals, 2- Aqueous neem kernel water extracts (NSKE) at 7-10% applied every 12 days and aqueous neem leaf water extracts (NLWE) at 50% applied every 6 days. Aqueous extracts from neem leaves were less effective than neem seeds extracts.

Bemisia tabaci

Some usable insecticides

Active substance	Recommended GAP*				
	Dosage g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days) for tubers production	Pre-harvest interval (days) for leaves production
Deltamethrin	12.5	2	15	15	3 (at least 30 days for non detectable residues)
Imidacloprid	100	2	14	58	46
Lambda-cyhalothrin**	15	3	30 between 1st and 2nd application ; 15 between 2nd et 3rd application	15	3 (at least 30 days for non detectable residues)
Spirotetramat	52 to 88	2	7	7	/
Thiamethoxam**	30	3	30 between 1st and 2nd application ; 15 between 2nd et 3rd application	15	3 (at least 30 days for non detectable residues)

* The elements of the recommended GAP shown here allow to comply with the harmonised European MRL (see part 6 of this guide). They are given as an indication on the basis of tests carried out on sweet potato excepted for spirotetramat.

** lambda-cyhalothrin + thiamethoxam associated

Mealy bugs and scales - *Phenacoccus manihoti, Aonidomytilus albus, Saissetia* spp.

The use of broad spectrum insecticides must be avoided in order to not eliminate the natural enemies controlling generally sufficiently this pest. The use of insecticide will be limited at the first stages of the crop.

Some usable insecticides

Neem

Young cassava mealybugs are sensitive to neem kernel water extract. Thus, mobile stages (first instar nymphs) of the cassava mealybug were repelled by leaves treated with a 10% neem kernel water extract, and those that settled and started feeding died in the second instar. Treatment of cassava plants with neem extracts at concentration of between 1 and 25 % provided good protection against the cassava mealybug. However, some phytotoxicity, manifested as yellow spots on the leaves, was observed on plants treated with neem extracts. Phytotoxic damage was slight in plants treated with lower concentrations (1 to 10%).

Soap spray

When necessary, spray with soapy solutions (1 to 2%) or insecticidal soaps. Spraying with a soap and water solution is reported to control mealybugs. Whenever possible, spray only infested plants (spot spraying).

Oils

Oils such as vegetable oils (e. g. rape oil, neem oil) and mineral oils are useful for control of mealybugs.

Good spray coverage and good timing is important when using soapy solutions and oils. To be effective they must come in contact with the mealybugs. Mobile nymphs are the easiest to kill, since they are more susceptible and are more exposed than eggs, older nymphs and adults. As they grow, the wax covering their bodies becomes thicker, rendering them more resistant to insecticides. Use with caution soapy solutions and oils. These products may be toxic to some plants causing discoloration or burning of foliage. Prior to applying them extensively, apply to a small, inconspicuous branch or to a few plants and after 48 hours check for adverse reactions. Apply them when the air temperature is cool. Make sure your plants were watered well the day before you apply your control - never spray wilted plants.

Mites

Some usable insecticides

Active substance	Recommended GAP*				
	Dosage g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days) for tubers production	Pre-harvest interval (days) for leaves production
Bifenazate	/	1	/	/	/
Spiromesifen	120 to 144	2	7	7	/

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

Coleoptera on stored tubers, chips, flour

Tribolium castaneum, *Sitophilus* sp., *Tenebrionides mauritanicus*, *Trogoderma granarium*, *Araecerus fasciculatus*, *Dinoderus* sp., *Carpophilus* sp., *Rhizopertha dominica*, *Prostephanus truncatus*

Some usable insecticides

Use botanicals or plant parts to protect stored cassava. In Kenya it is reported that the larger grain borer (*Prostephanus truncatus*) can be effectively repelled by storing cassava or grains with a fairly large amount of dried lantana or eucalyptus leaves. Neem is also reported to be effective.

5. Existing registrations in ACP countries

To our knowledge, no PPP is registered for a use on this crop in the countries quoted in this Guide (Uganda, Ghana, Benin, Dominican Republic).

6. Regulations and pesticide residues

Status of the active substances in EU Regulation 1107/2009 and MRLs in September 2011.
There are no MRLs Codex for cassava tubers. For cassava leaves Codex MRLs on leafy vegetables apply. For active substances listed below, only one MRL is set on leafy vegetables,it is 10 mg/kg for spinosad.
Caution: the information contained in this table is subject to change by future directives of the Commission of the European Communities and Codex decisions.

MRLs for cassava tubers, spinach and other similar crops *

Active substance	Status in REG 1107/2009	European MRL	
		Cassava tubers	Spinach and similar
Azadirachtin	Approved	1	1
Deltamethrin	Approved	0.05**	0.5
Dimethoate	Approved	0.02**	0.02**
Imidacloprid	Approved	0.5	0.05**
Lambda-cyhalothrin	Approved	0.02**	0.5
Mancozeb	Approved	0.05**	0.05**
Spinosad	Approved	0.02**	10
Spiromesifen	New substance - pending	0.02**	0.02**
Spirotetramat	New substance - pending	0.1**	7
Thiamethoxam	Approved	0.05**	0.05**

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

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

Note on MRLs:

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

MRLs in the EU

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

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

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

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

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

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

How are MRLs applied and monitored in EU?

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

MRLs in ACP countries

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

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

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

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

Annexes

1. References and useful documents

- Maladies et ravageurs des cultures de la région des grands lacs d'Afrique Centrale (No. 24). AGCD - Coopération Belge, 1989, 232 p.
- Lutte contre les ravageurs du manioc - Guide de la pratique de lutte intégrée à l'usage des vulgarisateurs. Braima James, John Yaninek, Peter Neuenschwander, Anthony Cudjoe, Wester Modder, Nnamdi Echendu, Muaka Toko. IITA
- Disease Control in Cassava Farms – Weston Msikita, Braima James, Emmanuel Nnodu, James Legg, Kerstin Wydra, Francis Ogbe - IITA
- Cassava growers' guide – National Agricultural Research Organization – 1994 – Uganda
- Growing Cassava Commercially in Nigeria – an illustrated guide – A.A. Adelunke, A. Dixon, J. Ojurongbe, P. Ilona, L. Muthada, S. Adisa – IITA
- Le manioc – P. Silvestre et M. Arraudeau – Techniques agricoles et productions tropicales

2. Useful websites

http://www.cassavabiz.org/production/pathology.htm
http://www.infonet-biovision.org/default/ct/114/crops

CROP PRODUCTION PROTOCOLS

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

GUIDES TO GOOD PLANT PROTECTION PRACTICES

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

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