PIP

GUIDE TO GOOD CROP PROTECTION PRACTICES

FOR AMARANTH (*AMARANTHUS* SPP.)

COLEACP is an international network promoting sustainable horticultural trade.

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In accordance with the Millennium Development Goals, the global objective is to: "Maintain and, if possible, increase the contribution made by export horticulture to the reduction of poverty in ACP countries".

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PIP

FOR SUSTAINABLE DEVELOPMENT OF THE ACP HORTICULTURAL INDUSTRY

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Note

The Guide to Good Plant Protection Practices details all plant protection practices regarding the production of the fruit or vegetables in question and recommends primarily the active substances supported by pesticides manufacturers in the framework of EU Regulation 1107/2009, which must comply with standards for pesticide residues. Most of these active substances have been tested through a field trials programme and the residue level of each active substance has been measured. The 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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Introduction

Amaranths of the genus *Amaranthus* are seasonal plants. Life cycle is from 2 to 3 months.

Many species exist and it is not always easy to identify them because they are often intercrossed. The main species cultivated are : *Amaranthus blitum*, *A. dubious, A. tricolor, A. viridis.*

Leaves and sprouts are cooked in sauces, soups or boiled. Old plants are a good forage for poultry.

1. Main pests and diseases

1.1. Extent and impact on the quantity and quality of produce

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: 0 = not on the crop, + = 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 quantity of leaves per plant, reduced size of leaves, lower quality product.

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

It is suggested that growers/exporters check periodically the web sites http://europa.eu/scadplus/leg/en/lvb/f85001.htm and http://www.eppo.org/QUARANTINE/quarantine.htm as pest status may vary in time.

INSECTS					
Importance	Organs attacked		Types of loss		
	Stems	Leaves	Number of plants	Size of plants	Quality of leaves at harvest
Coleoptera *Curculionidae* – *Gasteroclisus rhomboïdalis*					
+++	Larvae bore into	Perforated by adults			Branches destroyed, dried plants, holes in the leaves
Coleoptera *Curculionidae* – *Hypolixus nubilosus*					
++	Larvae bore into	Perforated by adults			Branches destroyed, dried plants, holes in the leaves
Coleoptera *Curculionidae* – *Cylas* sp.					
+	Larvae bore into	Perforated by adults			Holes in the leaves
Coleoptera *Chrysomelidae* – *Cassida liquefacta*					
+++		Gnawed by larvae and adults			Not edible leaves
Coleoptera *Chrysomelidae* – *Lema* spp.					
+		Gnawed by larvae and adults			Not edible leaves
Coleoptera *Chrysomelidae* – *Diabrotica* spp.					
		Gnawed by adults			Not edible leaves
The flea beetles : Coleoptera *Chrysomelidae* – *Altica nigrita*, *Podagrixina decolorata*, *Nisotra dilecta Dalman, Medithia quaterna*, *Disonycha* sp.					
+		Holes by adults			Holes in the leaves
The Galerucinae : Coleoptera *Chrysomelidae* – *Gallerucella funesta*, *Monolepta pauperata*, *M. elegans*, *Asbecesta verticalis*					
+		Gnawed by adults			Holes in the leaves
Coleoptera Coccinellidae* – *Chnootriba similis* ssp. *assimilis					
++		Gnawed by larvae and adults			Not edible leaves
Coleoptera *Tenebrionidae* – *Lagria villosa*, *Chrysolagria serricornis*					
++		Gnawed by adults			Holes in the leaves

INSECTS (continued)					
Importance	Organs attacked		Types of loss		
	Stems	Leaves	Number of plants	Size of plants	Quality of leaves at harvest
Various bugs (see 1.2. part of the Guide for description) – *Hemiptera*					
All bugs are individually of minor importance, since population are usually weak. However, in case of pullulation or when different species are present simultaneously , damages can be substantial.					
+	Adults and larvae suck the sap			Reduced by weakening of plants in case of pullulation	Drying of sprouts tips that eventually fall
Homoptera *Cicadellidae* – *Empoasca* spp.					
+	Adults and nymphs feed by piercing plant tissue with slender needle-like mouthparts and removing plant juices			A very heavy infestation affects the health, and vigor of the crop	Aesthetics of the crop affected
Lepidoptera *Pyralidae* – *Hymenia recurvalis* and *Spoladea recurvalis*					
+++		Larvae devour the leaves			Not edible leaves
Lepidoptera *Pyralidae* – *Psara basalis*					
++		Larvae devour the leaves			Not edible leaves
Lepidoptera *Noctuidae* – *Helicoverpa armigera*					
++		Larvae devour the leaves			Not edible leaves
Lepidoptera *Pyralidae* – Pyrale - *Herpetogramma bipunctalis*					
++		Caterpillars devour the leaves			Not edible leaves
Armyworms – Lepidoptera *Noctuidae* – *Spodoptera eridania* QO, *Spodoptera frugiperda* QO, *Spodoptera litura* QO, *Spodoptera exigua*					
++		Larvae devour the leaves			Not edible leaves
Looper moth – Lepidoptera *Noctuidae* – *Pseudoplusia includens.*					
+		Larvae devour the leaves			Not edible leaves
Orthoptera Pyrgomorphidae – *Zonocerus variegatus*					
+++		Larvae and adults devour the leaves			Not edible leaves
Aphids - Homoptera - *Aphis craccivora, Myzus persicae*					
++		They pierce the underside of leaves			Not edible leaves

MITES					
Importance	Organs attacked		Types of loss		
	Stems	Leaves	Number of plants	Size of plants	Quality of leaves at harvest
***Tetranychus* spp.**					
+	Adults and larvae suck the sap mainly on the underside of leaves			Adults and larvae suck the sap mainly on the underside of leaves	Aesthetics of the crop affected

FUNGI					
Importance	Organs attacked		Types of loss		
	Stems	Leaves	Number of plants	Size of plants	Quality of leaves at harvest
Powdery mildew - *Erysiphe cichoracearum*					
+		Mycelium develops on both surfaces of the leaf			Brownish lesions and yellowing of leaves that renders them unusable
Wet rot - *Choanephora cucurbitarum*					
++	Mycelium develops on all part of the plants		Wet rot of young stems may kill the plant		Wet rot (blight) of leaves that finally die
Damping off , root rots and stem lesions - *Pythium aphanidermatum, Rhizoctonia solani*					
++	Soil borne disease		Plants wilt and die	Stunted plants	Yellowish, smaller leaves of low quality
White rust - *Albugo bliti*					
+		Mycelium develops mainly on the underleaf surface		Plants may be stunted (shortened internodes)	Smaller, damaged leaves with low quality for consumption
Foliar spots - *Cercospora beticola, C. brachiata, Cladosporium variabile*					
+		Mycelium develops mainly on the upper side of leaves			Decrease quality of leaves, making them generally unusable

1.2. Identification and damage

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

INSECTS

COLEOPTERA

Weevils

Gasteroclisus rhomboïdalis

The adults are between 11 and 15 mm in length. Their body is covered by a yellow or white powder depending on the individual. A black patch and two more or less dark marks in the form of an inversed « V » can be made out on the back. The males and the females consume leaves and the females lay their eggs in the stems that are then bored by the larvae, making them dry out. In many cases, these stems break.

Adult

Hypolixus nubilosus

Smaller than *G. rhomboïdalis*, the 6 to 10 mm-long adults are brown coloured and dotted with whitish patches. They display the same behaviour as the previous species; they feed on leaves and their larvae bore the stems.

Adult

Cylas sp.

The adult is slender with a long rostrum. Completely black, it measures 6 mm in length. The larvae bore small branches but do not cause significant damage.

Chrysomelidae

Cassida liquefacta

The adults measure 4 mm in length approximately and are a light green colour all over. Known as "turtle beetles" because of their globular form that makes their legs invisible, as they are hidden by the elytra, they eat leaves. Their larvae, also green in colour, have several spiny protuberances on the circumference of their body. They also eat foliage.

Adult

Lema spp.

Three species can be found on the amaranths :

L. cephalotes : whose head, thorax and elytra are brick red in colour, the antennae and legs are uniformly black. The adults measure around 7 mm in length.

Lema sp. 1 : metallic blue all over, the antennae and the legs are black. The adults are smaller than the previous species, growing to around 5 mm.

Lema sp 2 : the largest of the three species, 9 mm completely black, it nevertheless has a greenish metallic tinge. The legs and antennae are completely black.

The adults of these three species bore holes in leaves.

Diabrotica spp.

The adults vary in size between 4 to 6 mm in length.

Galerucinae

Four species are present on the amaranths. In this group, only the adults are defoliators. The larvae live in the soil where they generally feed on plant roots. Pupation takes place at a shallow depth in the soil in a small shell that serves to protect them.

Asbecesta verticalis : the adults with green or blue coloured elytra with metallic tinges have an orange yellow head and thorax, and black legs and antennae. They measure between 6 and 7 mm. Relatively harmless on the amaranth, they are more commonly found on curcubitaceae where their damage is much more significant.

Adult

Gallerucella funesta : the adults measure between 6 and 7 mm, their body is parallel, the head and the antennae are a blackish brown, as are the elytra, each of which has an upward sinuous line in a yellow colour. The legs are yellow with sooty brown tibias.

Monolepta elegans : the adults measure between 6 and 7 mm in length and are red brown with four yellow circular patches. The antennae and the legs are also yellow. They devour leaves.

M. pauperata : a much smaller species (4 mm). The body, the legs and the antennae are yellowish white with four red brown bands in the form of a cross on the elytra. The population of this species is larger than that of the previous one.

Adult

The Flea Beetles

The adults can be recognised by the small jumps they make when they feel threatened.

Altica nigrita : The adults are between 3 and 5 mm in length excluding their antennae. They are a pretty metallic blue colour. They make holes in leaves. The larvae are present in the soil where they feed on small roots.

Adult

Nisotra dilecta : the adults are small in size, 2 to 3 mm and of a metallic blue colour. Their thorax and their head are orange red. They perforate foliage.

Adult

Medithia quaterna : the adults are small in size, 3 to 4 mm, their body is yellow and they have two longitudinal black bands on the elytra. They eat foliage. The females full of eggs have a disproportionate abdomen that extrudes on each side of the elytra.

Adult

Podagrixina decolorata : the adults between 3 and 4 mm in length, of a uniform orange red colour, perforate the foliage of the plants.

Adult

Disonycha sp.

Ladybirds

Chnootriba similis ssp. *assimilis*

This species of Ladybird is phytophagous. The adults are orange red in colour, as are the legs and antennae whose tips are black. The elytra are dotted with 12 black patches. The adults scrape the parenchyma of the leaves.

Tenebrionidae

Lagria villosa

The adults measure around 13 mm in length and are a metallic grey colour. Certain individuals can take on a violet or greenish tinge. They eat leaves and flowers.

Adult

Chrysolagria serricornis

The adults are blue metallic and eat the foliage. Their size is 7 to 11 mm.

HETEROPTERA

Pentatomidae

Agonocelis versicolor

The adults measure around 12 mm and their colours are highly variable. They can be multicoloured or yellow ochre all over. They pierce flowers and can make them fall over in the case of extensive pullulation.

Adult

Boerias ventralis

The light brown coloured adults measure 12 to 15 mm in length. They pierce all of the plant's organs, they are not very dangerous.

Mating

Nezara viridula

The adults, approximately 15 mm in length, are uniformly green in colour as are the legs. Some have yellow-edged heads and thoraxes. The females lay their eggs (sometimes around one hundred eggs) in a geometric form on the foliage. The larvae in the 1st, 2nd and 3rd stage are globular, black coloured and dotted with white. Grouped at the beginning of their life, they then disperse throughout the plant. Adults, larvae and nymphs pierce and suck the sap.

Adult

Aspavia armigera

Between 5 and 7 mm in length, the adults are of a brownish colour. They have three yellow points on their scutellum and two spines at the tip of the thorax. These rarely pullulating insects pierce the stems and flowers, making them fall.

Adult

Alydidae

Mirperus torridus

Completely reddish brown in colour, the underside of the body is lighter. The adults have a rather elongated shape around 15 mm long and 2 mm wide. Their legs are very long and the inside of the femurs are bulbous and denticulated. These are very agile individuals that pierce stems and flowers.

Miridae

Helopeltis sp.

The adults, 6 to 8 mm long, with very long and fine legs, are vermilion red in colour and have a needle-like growth that protrudes from the thorax. The antennae are long and black. The larvae are also slender but orange yellow in colour. They pierce the stems and flowers.

Adult

Lygaeidae

Spilostethus festivus

The adults measure around 10 mm and are orange red in colour. The top of the thorax has a black patch in the form of a "H" that ends at the posterior half with two broad bands that are also black. Their scutellum is bordered by a black band in the form of a « V ». The hind part of the hemi elytra is black, the front part orange red with a black patch on each of them. The legs and the antennae are brownish red. They pierce and suck all parts of the plant.

Aspilocoryphus fasciativentris

A much smaller species (5 to 6 mm) than the previous one, the colouring of the individuals is almost similar, with the exception of a black triangular patch on the head. Like the previous species they suck the sap from the plants.

Taylorilygus vosseleri

Very small species (4 mm) of a yellow colour with rather globular black eyes.

Les *Pyrrhocoridae*

Dysdercus völkeri

The adults differ considerably in size, varying between 11 and 18 mm. Mainly orange yellow, the posterior part of the body is black. The abdomen is circled with white and red bands. The larvae are red and striped with white bands on the abdomen. Although commonly found on cotton and on the malvaceae, larvae and adults weaken the plant by piercing it and making its flowers fall.

Adult

Scutelleridae

Sphaerocoris annulus

The adults are globular, often grouped. They measure 10 mm in length and their body seems to be patterned with green circular shapes circled with black, which themselves are surrounded with green patches. They pierce plants and feed on their sap.

Adult

HOMOPTERA

Aphididae

Aphis craccivora and *Myzus persicae*

Following the piercing and the injection of toxic saliva, the leaves become crimped, roll downwards and are deformed. The colonies of aphids are to be found on the underside of the leaves or on the young stems.

Deformed leaves

Colonies on the underside of leaves

Cicadellidae

Empoasca spp.

Adult leafhoppers are about 3mmlong, slender bodied and shiny green in colour. Eggs are oviposited in stems or leaf ribs. Nymphs are bright green and feed on the underside of the leaf where they run about. Linear yellow etchings on the leaf surface result from feeding.

LEPIDOPTERA

Pyralidae

Hymenia recurvalis

The adults, 15 mm in length, have a brown to black body with a white band that crosses the anterior wings. Two white patches are also present on the tips of the anterior wings. The very agile caterpillars are a translucent green colour with two lengthwise white bands on the body. At the beginning of the attack, they devour the interior face of the leaves, only leaving a fine transparent membrane. In the event of a heavy attack, they only leave the veins of the leaves.

Adult

Damages

Psara basalis

The adults are entirely yellow ochre, finely dotted with black. They measure between 16 and 20 mm in size. The caterpillars, a greenish white colour, devour the parenchemy of the leaves under a fold that they have already made. Pupation mostly takes place in the inflorescence. Often present with *H. recurvalis*, this species has caterpillars that are much less agile and that are more stocky. Less dangerous than the previous species, it can nevertheless cause relatively considerable damage.

Caterpillar

Adult

Damages

Herpetogramma bipunctalis

Colour of larvae vary from pale cream, light green to yellowish. The maximal length is 20 mm. Caterpillars are often in silken nests hidden in inflorescences or sheaths of leaves. Chrysalides can be found on the plant or in the soil.

Noctuidae

Helicoverpa armigera

The adults measure around 35 mm in size. The light brown-coloured male and the female, which has a more greenish tinge, are nocturnal. It lays isolated eggs on the leaves of the top part of the plant. The caterpillars vary in colour, ranging from brown to green but in all cases, they have two darker lines on the sides and the ventral part of their body is lighter. Pupation takes place at shallow depth in the soil. The caterpillars have a solitary character and devour foliage and flowers.

Caterpillar

Spodoptera eridania, Spodoptera frugiperda, Spodoptera litura, Spodoptera exigua

The *Spodoptera* larvae, such as those of other Noctuidae, are gregarious and remain grouped on the leaf during the first two stages. During the 3rd stage it disperses and becomes more solitary and nocturnal. It hides during the day in the litter or in the foliage and comes out at night to feed on the leaves. The caterpillars can behave like armyworms by regrouping and migrating towards adjacent fields when food becomes scarce. Sometimes, the large larvae behave like grey worms.
Pupation takes place in the soil in a fragile cell dug in the earth and lasts for 9 to 12 days. The adults have a nocturnal behaviour.

Soybean Looper - *Pseudoplusia includens*

The larvae are of a green colour with green and white longitudinal lines on the side and the back. They are generally to be found on the inferior surface of the leaves. The maximum length of the caterpillar is 30 mm. Pupation takes place on the plant in a fine cocoon of white silk.

ORTHOPTERA

Zonocerus variegatus

This species is part of the group of grasshoppers, crickets that do not form swarms. The adults can reach 50 mm and are very colourful. The head and thorax are yellow, the wings entirely green. Some black, red and white patches are visible on the head, the antennae are black. The legs are dotted with white, red and black. The femur of the hind legs has white stripes on a black background. The segments of the abdomen are yellow with patches of black.
The larvae are of a blacker colour with yellow patches present on the entire body and legs. They are always grouped during the young stages. Adults and larvae devour foliage, generally only leaving the veins.

Adult

Damages

MITES

Tetranychus spp.

Adult mites are 0.3-0.4mm and globular. They are a dull red colour, eight-legged, with an oval body sparsely covered with spines. Two dark spots show through the transparent body wall. The mites feed on the lower surface of the leaves causing yellowing and speckling. A heavy infestation causes silvering of the leaf, 'silver back' and ultimately leaf abscission. The nymphs are similar to adults but have only six legs. Eggs are spherical, translucent and laid on the underside of leaves attached to the leaf surface by a web spun by the mite. All stages of the mite can be found on a single leaf where they form a colony.

FUNGI

Powdery mildew - *Erysiphe cichoracearum*

Powdery mildew is an easily recognizable plant disease. The disease appears with pale green spots on leaves that are covered by a powdery whitish growth (fungal mycelium) forming patches. As disease progresses, leaves turn yellow and necrotise. It is most commonly observed on the upper side of the leaves but can also be present on the under side.

Wet rot - *Choanephora cucurbitarum*

The disease appears as blighted leaves and as dieback of shoot tips.
Sporulation of the fungus occurs on the surface of necrotic tissue.

Blighted leaves

Damping off - *Pythium aphanidermatum*

Pythium is a soil borne plant pathogen which, among others, can cause the disease known as damping off.
For the so called post-emergence damping off, roots of seedlings that have already emerged are usually attacked, possibly up to the soil line. The invaded tissue becomes water soaked, discoloured, followed by rapid collapse of the cells. Basal parts of the stems become thinner and softer than the above, causing loss of firmness and subsequent falling of the seedlings over the soil. Fungal invasion continues, causing the seedlings to wither and die.
Pythium can be one of the causes of deficient seed germination. In this case, germinated seeds may be killed before emerging from the soil (pre-emergence damping off) killing the growing tip of the seedling.

Damping off - *Rhizoctonia solani*

Rhizoctonia solani is a soil borne pathogen causing damping off, among other diseases.
Very young seedlings may be killed soon after emergence (post-emergence), by making the basal portion of the stem water soaked, soft and incapable of supporting the seedlings which fall and die.
Rhizoctonia can be one of the causes of deficient seed germination. In this case, germinated seeds may be killed before emerging from the soil (pre-emergence damping off) killing the growing tip of the seedling.

Root rot and stem lesion – *Pythium aphanidermatum* and *Rhizoctonia solani*

In the field, after the seedling stage, *P. aphanidermatum* can cause root rot and/or stem lesions. Rootlets turn brown and stop functioning, possibly resulting in stunting, wilting and killing of the plant. Stem lesions can girdle the stem and retard plant growth, leaf size and quality considerably.

Stem canker caused by *Pythium* on amaranth

White rust – *Albugo bliti*

Circular to elongated and usually no larger than 0.4 mm in diameter white blister-like pustules appear on the lower side of the leaf, rarely on the upper side and on the petioles. The pustules can be scattered or grouped, and the tissue around them gradually turns brown and dies. When disease is severe entire leaves may coalesce.

Foliar spots - *Cercospora beticola, C. brachiata*

Infected leaves show rounded, brown to red delimited spots with ash-en-grey centre about 0.5 cm in diameter. Spots can coalesce causing complete leaf collapse. The older the leaf the greater number of lesions with larger spot diameter. The disease is more severe on red type amaranth.

Foliar spots

Foliar spot – *Cladosporium variabile*

The disease appears as whitish leaf spots which are more notorious on the upper surface of the leaf. The earlier the appearance of the disease the more threatening. It usually appears on the lower leaves and advances to upper younger leaves.

Other fungal pathogens are reported in the literature, but these can not be considered as causing diseases of economical importance or of general distribution. *Curvularia* sp., Volutella sp., *Alternaria* sp., *Macrophoma* sp. and *Phomopsis amaranthicola* have been reported causing foliar and/or stem lesions on leafy amaranth. However it is expected that disease problems may develop as the acreage of amaranth increases.

It is suggested that growers become familiar with symptoms caused by viruses on plants and be able to recognize potential vectors of plant viruses, as aphids, whiteflies and leafhoppers. If viral symptoms are recognized proceed for sampling and submission to the local responsible authorities.

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

The following table shows the stages of cultivation during which crop enemies are potentially present and the stages during which their presence can do the most harm. 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.

Insects and mites

Stage	Length of stage	Weevils	Chrysomelidae with larval stage on the plants	Chrysomelidae with larval stage in the soil	Ladybirds and Tenebrionidae	Lepidoptera	Orthoptera	Heteroptera	Homoptera	Mites
Seeds										
Germination and seedlings	1 week									
From emergence to two weeks after emergence	2 weeks	■	■	■	■	■	■	■	■	■
From two weeks after emergence to the first harvest	2 to 3 weeks	■	■	■	■	■	■	■	■	■
Harvesting	1 to 6 weeks	■	■	■	■	■	■	■	■	

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

Fungal diseases

Stage	Length of stage	Powdery mildew *Erysiphe cichoracearum*	Wet rot *Choanephora cucurbitarum*	Damping off *Pythium aphanidermatum, Rhizoctonia solani*	Root rots and stem lesions *P. aphanidermatum, R. solani*	White rust *Albugo bliti*	Foliar spots *Cercospora beticola, C. brachiata*	Foliar spot *Cladosporium variabile*
Seeds				■	■		■	
Germination and seedlings	1 week	■	■	■	■	■	■	■
From emergence to two weeks after emergence	2 weeks	■	■	■	■	■	■	■
From two weeks after emergence to the first harvest	2 to 3 weeks	■	■	■	■	■	■	■
Harvesting	1 to 6 weeks	■	■	■	■	■	■	■

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

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

Key:
BEN = Benin, CON = Congo, GAB = Gabon, DOR = Dominican Republic, JAM = Jamaica
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.

Gasteroclisus rhomboïdalis, Hypolixus nubilosus

Favourable conditions : Present during dry and rainy season.

Month	1	2	3	4	5	6	7	8	9	10	11	12
BEN	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
CON	++	++	++	++	++	++	++	++	++	++	++	++
GAB	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/
JAM	/	/	/	/	/	/	/	/	/	/	/	/

Cylas sp.

Favourable conditions: No information available.

Mois	1	2	3	4	5	6	7	8	9	10	11	12
BEN	/	/	/	/	/	/	/	/	/	/	/	/
CON	/	/	/	/	/	/	/	/	/	/	/	/
GAB	/	/	/	/	/	/	/	/	/	/	/	/
RDO	/	/	/	/	/	/	/	/	/	/	/	/
JAM	/	/	/	/	/	/	/	/	/	/	/	/

Lema spp.

Favourable conditions: No information available.

Month	1	2	3	4	5	6	7	8	9	10	11	12
BEN	/	/	/	/	/	/	/	/	/	/	/	/
CON	/	/	/	/	/	/	/	/	/	/	/	/
GAB	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/
JAM	/	/	/	/	/	/	/	/	/	/	/	/

Diabrotica spp.

Favourable conditions: No information available.

Month	1	2	3	4	5	6	7	8	9	10	11	12
BEN	/	/	/	/	/	/	/	/	/	/	/	/
CON	/	/	/	/	/	/	/	/	/	/	/	/
GAB	/	/	/	/	/	/	/	/	/	/	/	/
DOR	X	X	X	X	X	X	X	X	X	X	X	X
JAM	/	/	/	/	/	/	/	/	/	/	/	/

Galerucinae - *Asbecesta verticalis, Gallerucella funesta, Monolepta elegans, M. pauperata*

Favourable conditions: More frequent during dry season.

Month	1	2	3	4	5	6	7	8	9	10	11	12
BEN	+	+	+	+	+	+	+	+	+	+	+	+
CON	X	X	X	X	X	X	X	X	X	X	X	X
GAB	X	X	X	X	X	X	X	X	X	X	X	X
DOR	/	/	/	/	/	/	/	/	/	/	/	/
JAM	/	/	/	/	/	/	/	/	/	/	/	/

Flea beetles - *Altica nigrita, Medithia quaterna, Podagrixina decolorata, Nisotra dilecta, Disonycha* spp.

Favourable conditions: More frequent during dry season.

Month	1	2	3	4	5	6	7	8	9	10	11	12
BEN	+	+	+	+	+	+	+	+	+	+	+	+
CON	X	X	X	X	X	X	X	X	X	X	X	X
GAB	X	X	X	X	X	X	X	X	X	X	X	X
DOR	/	/	/	/	/	/	/	/	/	/	/	/
JAM	X	X	X	X	X	X	X	X	X	X	X	X

Chnootriba similis* ssp. *assimilis

Favourable conditions: No information available.

Month	1	2	3	4	5	6	7	8	9	10	11	12
BEN	/	/	/	/	/	/	/	/	/	/	/	/
CON	/	/	/	/	/	/	/	/	/	/	/	/
GAB	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/
JAM	/	/	/	/	/	/	/	/	/	/	/	/

Lagria villosa

Favourable conditions: No information available.

Month	1	2	3	4	5	6	7	8	9	10	11	12
BEN	/	/	/	/	/	/	/	/	/	/	/	/
CON	/	/	/	/	/	/	/	/	/	/	/	/
GAB	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/
JAM	/	/	/	/	/	/	/	/	/	/	/	/

Chrysolagria serricornis

Favourable conditions: No information available.

Month	1	2	3	4	5	6	7	8	9	10	11	12
BEN	/	/	/	/	/	/	/	/	/	/	/	/
CON	/	/	/	/	/	/	/	/	/	/	/	/
GAB	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/
JAM	/	/	/	/	/	/	/	/	/	/	/	/

Heteroptera - *Agonocelis versicolor, Boerias ventralis, Nezara viridula, Aspavia armigera, Mirperus torridus, Helopeltis* sp., *Spilostethus festivus…*

Favourable conditions: More frequent during dry season.

Month	1	2	3	4	5	6	7	8	9	10	11	12
BEN	+	+	+	+	+	+	+	+	+	+	+	+
CON	X	X	X	X	X	X	X	X	X	X	X	X
GAB	X	X	X	X	X	X	X	X	X	X	X	X
DOR	/	/	/	/	/	/	/	/	/	/	/	/
JAM	/	/	/	/	/	/	/	/	/	/	/	/

Dysdercus volkerii

Favourable conditions: More frequent during dry season and where cotton is grown.

Month	1	2	3	4	5	6	7	8	9	10	11	12
BEN	++	++	++	++	++	++	++	++	++	++	++	++
CON	X	X	X	X	X	X	X	X	X	X	X	X
GAB	X	X	X	X	X	X	X	X	X	X	X	X
DOR	/	/	/	/	/	/	/	/	/	/	/	/
JAM	/	/	/	/	/	/	/	/	/	/	/	/

Aphis craccivora

Favourable conditions: No information available.

Month	1	2	3	4	5	6	7	8	9	10	11	12
BEN	/	/	/	/	/	/	/	/	/	/	/	/
CON	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
GAB	/	/	/	/	/	/	/	/	/	/	/	/
RDO	/	/	/	/	/	/	/	/	/	/	/	/
JAM	/	/	/	/	/	/	/	/	/	/	/	/

Myzus persicae

Favourable conditions: No information available.

Month	1	2	3	4	5	6	7	8	9	10	11	12
BEN	/	/	/	/	/	/	/	/	/	/	/	/
CON	/	/	/	/	/	/	/	/	/	/	/	/
GAB	/	/	/	/	/	/	/	/	/	/	/	/
DOR	X	X	X	X	X	X	X	X	X	X	X	X
JAM	/	/	/	/	/	/	/	/	/	/	/	/

Empoasca spp.

Favourable conditions: No information available.

Month	1	2	3	4	5	6	7	8	9	10	11	12
BEN	/	/	/	/	/	/	/	/	/	/	/	/
CON	/	/	/	/	/	/	/	/	/	/	/	/
GAB	/	/	/	/	/	/	/	/	/	/	/	/
DOR	X	X	X	X	X	X	X	X	X	X	X	X
JAM	X	X	X	X	X	X	X	X	X	X	X	X

Hymenia recurvalis

Favourable conditions: Present all the year round.

Month	1	2	3	4	5	6	7	8	9	10	11	12
BEN	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
CON	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
GAB	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
DOR	/	/	/	/	/	/	/	/	/	/	/	/
JAM	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX

Psara basalis

Favourable conditions: More frequent during rainy season.

Month	1	2	3	4	5	6	7	8	9	10	11	12
BEN	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
CON	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
GAB	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/
JAM	/	/	/	/	/	/	/	/	/	/	/	/

Helicoverpa armigera

Favourable conditions: More frequent during dry season and where cotton is grown.

Month	1	2	3	4	5	6	7	8	9	10	11	12
BEN	++	++	++	++	++	++	++	++	++	++	++	++
CON	++	++	++	++	++	++	++	++	++	++	++	++
GAB	++	++	++	++	++	++	++	++	++	++	++	++
DOR	/	/	/	/	/	/	/	/	/	/	/	/
JAM	/	/	/	/	/	/	/	/	/	/	/	/

Herpetogramma bipunctalis

Favourable conditions: No information available.

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

Spodoptera eridania

Favourable conditions: Essentially a subtropical species, a temperature of 20-25°C is preferable for the development; the reproduction could be continuous.

Month	1	2	3	4	5	6	7	8	9	10	11	12
BEN	/	/	/	/	/	/	/	/	/	/	/	/
CON	/	/	/	/	/	/	/	/	/	/	/	/
GAB	/	/	/	/	/	/	/	/	/	/	/	/
DOR	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
JAM	/	/	/	/	/	/	/	/	/	/	/	/

Spodoptera frugiperda

Favourable conditions: The optimal temperature for development of larval stage is 28°C, but it is lower for pupation and eggs laying. Under tropical conditions, the reproduction could be continuous with four to six generations per year.

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

Spodoptera litura

Favourable conditions: No information available.

Month	1	2	3	4	5	6	7	8	9	10	11	12
BEN	/	/	/	/	/	/	/	/	/	/	/	/
CON	/	/	/	/	/	/	/	/	/	/	/	/
GAB	/	/	/	/	/	/	/	/	/	/	/	/
RDO	/	/	/	/	/	/	/	/	/	/	/	/
JAM	/	/	/	/	/	/	/	/	/	/	/	/

Spodoptera exigua

Favourable conditions: No information available.

Month	1	2	3	4	5	6	7	8	9	10	11	12
BEN	/	/	/	/	/	/	/	/	/	/	/	/
CON	/	/	/	/	/	/	/	/	/	/	/	/
GAB	/	/	/	/	/	/	/	/	/	/	/	/
DOR	X	X	X	X	X	X	X	X	X	X	X	X
JAM	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX

Pseudoplusia includens

Favourable conditions: No information available.

Month	1	2	3	4	5	6	7	8	9	10	11	12
BEN	/	/	/	/	/	/	/	/	/	/	/	/
CON	/	/	/	/	/	/	/	/	/	/	/	/
GAB	/	/	/	/	/	/	/	/	/	/	/	/
DOR	X	X	X	X	X	X	X	X	X	X	X	X
JAM	/	/	/	/	/	/	/	/	/	/	/	/

Zonocerus variegatus

Favourable conditions: Present during dry and rainy season.

Month	1	2	3	4	5	6	7	8	9	10	11	12
BEN	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
CON	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
GAB	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
DOR	/	/	/	/	/	/	/	/	/	/	/	/
JAM	/	/	/	/	/	/	/	/	/	/	/	/

Tetranychus spp.

Favourable conditions: No information available.

Month	1	2	3	4	5	6	7	8	9	10	11	12
BEN	/	/	/	/	/	/	/	/	/	/	/	/
CON	/	/	/	/	/	/	/	/	/	/	/	/
GAB	/	/	/	/	/	/	/	/	/	/	/	/
DOR	X	X	X	X	X	X	X	X	X	X	X	X
JAM	X	X	X	X	X	X	X	X	X	X	X	X

Powdery mildew – *Erysiphe cichoracearum*

Favourable conditions: The pathogen is capable of causing disease in cool or warm, humid areas, but it is more severe under warm and dry climate. Powdery mildew is favoured by alternating humid (but rain-free) and dry periods. It is favoured by warm weather (24 to 30°C), no rain, with relative humidity between 50 and 90%. Very high humidity is needed for spore germination with no need of film of water on the leaf surface.

Month	1	2	3	4	5	6	7	8	9	10	11	12
BEN	/	/	/	/	/	/	/	/	/	/	/	/
CON	/	/	/	/	/	/	/	/	/	/	/	/
GAB	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/
JAM	/	/	/	/	/	/	/	/	/	/	/	/

Wet rot – *Choanephora cucurbitarum*

Favourable conditions: A high incidence of disease is correlated with periods of high relative humidity and excessive rainfall. Conidia spores can germinate on free water.

Month	1	2	3	4	5	6	7	8	9	10	11	12
BEN	/	/	/	/	/	/	/	/	/	/	/	/
CON	/	/	/	/	/	/	/	/	/	/	/	/
GAB	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/
JAM	/	/	/	/	/	/	/	/	/	/	/	/

Damping off or root rot and stem lesion – *Pythium aphanidermatum*

Favourable conditions: Favoured by heavy, poorly drained soils under wet conditions, preferably above 90% soil moisture. Incidence increases as pH increases from 4.5 to 8.0. Usually most severe at low temperatures unfavourable for the host.

Month	1	2	3	4	5	6	7	8	9	10	11	12
BEN	/	/	/	/	/	/	/	/	/	/	/	/
CON	/	/	/	/	/	/	/	/	/	/	/	/
GAB	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/
JAM	/	/	/	/	/	/	/	/	/	/	/	/

Damping off or root rot and stem lesion – *Rhizoctonia solani*

Favourable conditions: Favoured by moderately wet soils (50-70% saturation) and acid pH about 5. Usually most severe at low temperatures unfavourable for the host.

Month	1	2	3	4	5	6	7	8	9	10	11	12
BEN	/	/	/	/	/	/	/	/	/	/	/	/
CON	/	/	/	/	/	/	/	/	/	/	/	/
GAB	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/
JAM	/	/	/	/	/	/	/	/	/	/	/	/

White rust – *Albugo bliti*

Favourable conditions: The disease is favoured more by prolonged dews or fogs than by heavy rains, with epidemics occurring during or following moist cool weather. The fungus is very sensitive to temperature changes. Spore germination is favoured by temperatures ranging from 10 to 13.5°C. Swarm spores produce germ tubes and penetrate the leaf when temperature is between 15.5 to 25°C, with an optimum of 20°C. Disease develops most rapidly at 22°C.

Month	1	2	3	4	5	6	7	8	9	10	11	12
BEN	/	/	/	/	/	/	/	/	/	/	/	/
CON	/	/	/	/	/	/	/	/	/	/	/	/
GAB	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/
JAM	/	/	/	/	/	/	/	/	/	/	/	/

Foliar spots - *Cercospora beticola, C. brachiata*

Favourable conditions: Disease development is favoured by wet conditions originated by frequent rain or sprinkle irrigation, and by optimum temperatures ranging from 25 to 29°C.

Month	1	2	3	4	5	6	7	8	9	10	11	12
BEN	/	/	/	/	/	/	/	/	/	/	/	/
CON	/	/	/	/	/	/	/	/	/	/	/	/
GAB	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/
JAM	/	/	/	/	/	/	/	/	/	/	/	/

Foliar spot – *Cladosporium variabile*

Favourable conditions: Disease development is favoured by high relative humidity above 85% up to a 100%, and by optimum temperatures about 23°C and pH of 5.5.

Month	1	2	3	4	5	6	7	8	9	10	11	12
BEN	/	/	/	/	/	/	/	/	/	/	/	/
CON	/	/	/	/	/	/	/	/	/	/	/	/
GAB	/	/	/	/	/	/	/	/	/	/	/	/
DOR	/	/	/	/	/	/	/	/	/	/	/	/
JAM	/	/	/	/	/	/	/	/	/	/	/	/

2. Main control methods

2.1. Introduction

A successful disease control program depends on a crop production system which is closely aligned with the goals of integrated disease management. Growers must start with the selection of appropriate varieties, an irrigation system that minimizes leaf wetness, and a fertilizer program that results in optimum plant growth. Also, bed preparation, plant density, and canopy management that affords optimum air circulation and pesticide coverage. Important to consider a transplant program which minimizes transplant shock, a clean seedling production program, effective pest monitoring during the season, and a harvest and shipping procedure which maximizes shelf life and produce quality.

The management of diseases requires an integrated approach of cultural, physical, biological and chemical (pesticide) practices. General management consider the development of economical measures for control based on knowledge of the specific disease, the pathogen life cycle, the time and the method of infection, the plant parts affected, causal agent dissemination, and certain other agronomic and economic considerations. Certain principles must be kept in mind, including:

1. The cost of the measure must be less than the expected return;
2. The measure must not be too complicated and dangerous to use;
3. The measure must not aggravate other pest problems in the operation, and when possible, should complement other production practices.

A monitoring disease program should be strictly implemented for the application of control measurements at the best moment. An appropriate implementation of a monitoring program will determine the effective management of diseases and, will incite in obtaining a good yield and a high quality produce.

The short term nature of amaranth does not always allow the build up of disease problems over a crop cycle. As well, the regular harvest of foliage can affect considerably the dissemination of foliar diseases, caused by a decrease of inoculum and limited availability of host tissue. However, in the case of soil borne pathogens, as *Pythium aphanidermatum* and *Rhizoctonia solani*, inoculum could build up in soil over time and could cause considerable damage to amaranth during a growing season.

There is very limited amount of epidemiological information on diseases of amaranth which makes decision taking a matter of "good guessing" on when to apply and how frequent the control measures, as in the case of pesticide applications. For this reason, the prevalence will remain for growers to take a decision on spraying for diseases when conditions seem favourable for disease development, when first symptoms are observed and/or based on a calendarized program (routine spraying).

Plant Protection Products

Diseases must be controlled to ensure good yield and marketable quality. As far as possible use mechanical, cultural and biological control measures. Chemical pesticides should be used as protective-preventive and as systemic-therapeutic when conditions for occurrence of disease prevail. Choose pesticides that have short persistence, i.e., the effects last only a few days. Closely follow pesticide labels to assure appropriate and effective use.

Physical control

Heat, recommended as steam, is usually implemented under greenhouse production. Steam eliminates pathogens, pests and weed seeds when applied to the soil or growing mixture. It is recommended to pasteurize the soil without reaching sterilizing temperatures. Pasteurizing will preserve some beneficial microorganisms and needs less energy than sterilization, making it less expensive.

Solarization, the practice of naturally heating and pasteurizing the soil by sun rays, reduces the pathogen populations present in the soil, as well as insects and weeds. Tarps or strips of plastic are placed on moist soil for the solarization process to take place.

Rotation

Rotation of crops is directed to reduce the primary inoculum that will be responsible for starting disease when a host crop is planted. However, rotation is not always a feasible measure, due to biological and economical considerations. Possible rotation will be determined by appropriate climatic and soil conditions that will allow the rotating crop to grow commercially.

Amaranth is a suitable plant for crop rotation because it is affected by a limited number of diseases. In South America rotations used are: potato (*Solanum tuberosum*)-amaranth-cereals-mung bean *(Vigna radiata)*; potato-cereals-amaranth-mung bean; potato-corn *(Zea mays)*-amaranth; alfalfa *(Medicago sativa)*-potato-amaranth-cereals; corn-tomato *(Lycopersicon esculentum)*-amaranth-beans *(P. vulgaris)*.

Tillage

Tillage is an important measure to avoid the presence of alternate hosts while no crops on the ground.

Burial of crop residue is beneficial in reducing pathogen survival and inoculum for the succeeding crops. The burial of infested debris facilitates rotting and deprives pathogens and pests of a food base. This measure is of limited effectiveness for soil inhabitant pathogens that can survive on crop debris and remain in the soil for some years. Burial of infested debris, however, may not provide an effective means of reducing some disease inoculum if the practice is not implemented in surrounding areas where a source of inoculum may be maintained.

Nutrition Management

In general, a good nutrition management program that will allow a high yield and a good quality produce should be implemented. Avoidance of excessive nitrogen fertilization is recommended to evitate excessive tender tissue that generally increases tissue susceptibility to diseases.

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.

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

The control methods for pests or diseases whose cycle is not illustrated are presented in a table.
The 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.

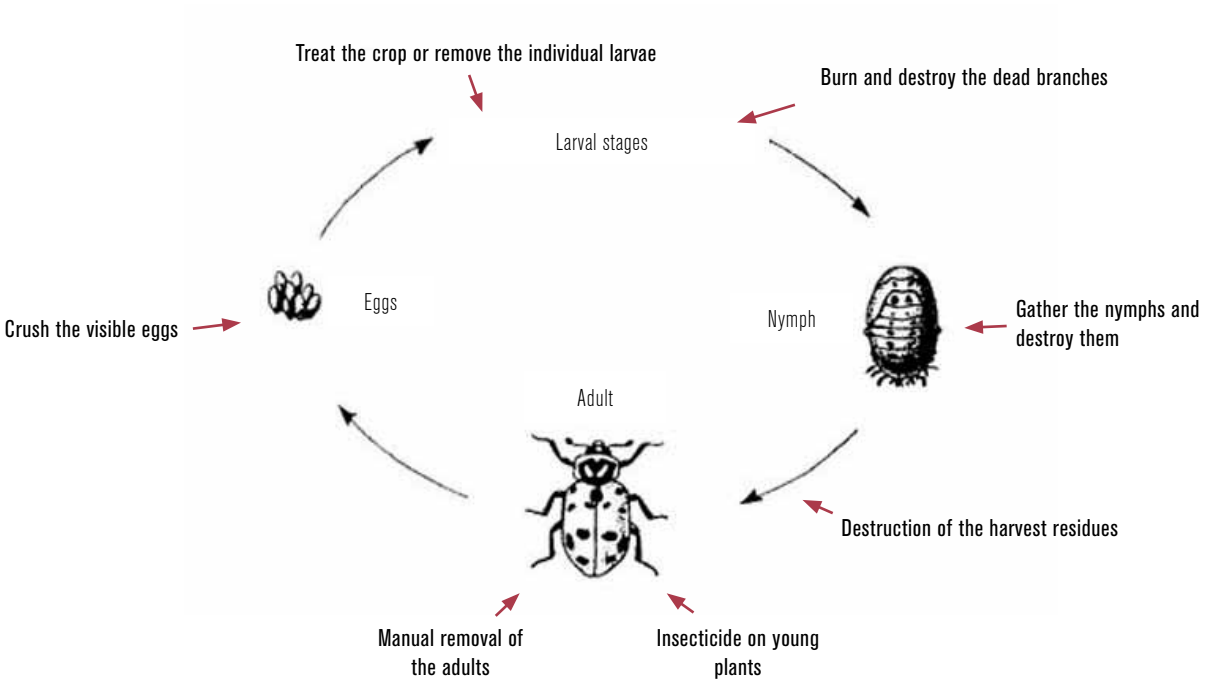
In the second column, actions that can be referred to as "cultivation practices" are shown in green boxes, and actions that can be referred to as "application of plant protection products", in pink boxes.

- Cultivation practices
- Application of plant protection product

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

Coleoptera with larval stage on the plants
Curculionidae, Coccinellidae, Cassida liquefacta, Lema spp.

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



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

During the production cycle

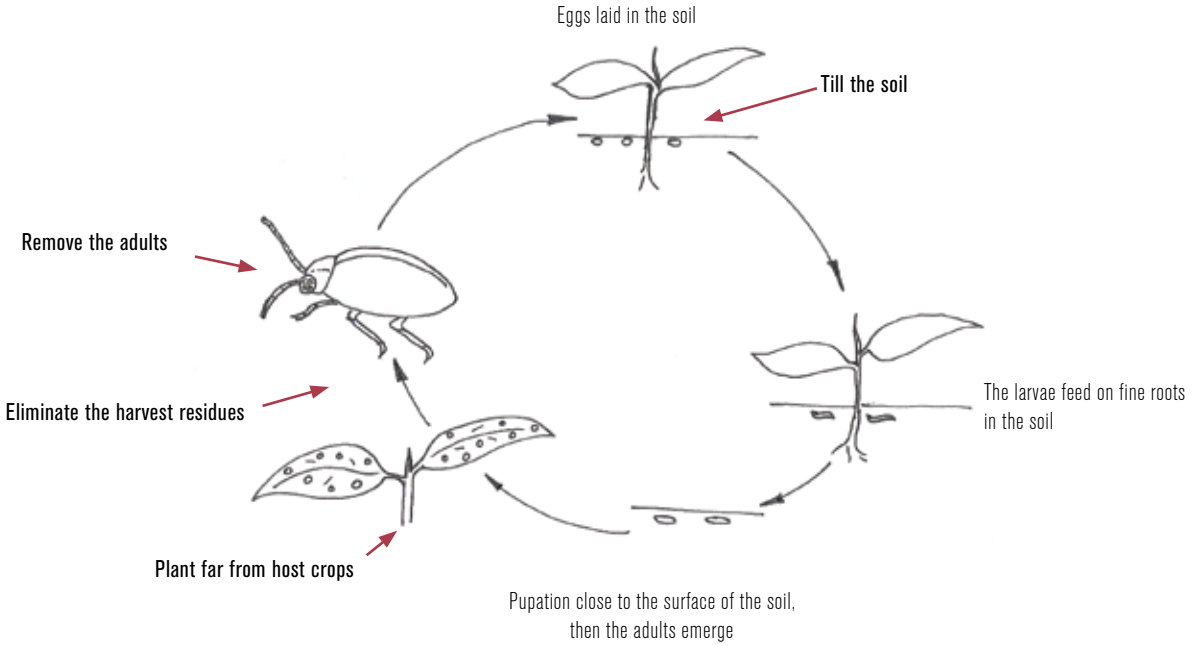
- The removal of the adults and of the visible stages is often enough to avoid a proliferation of the populations of these insects.
- We must urgently burn or destroy the dead branches that are often the symptom of the presence of Curculionidae larvae.
- Insecticide on young plants in the event of heavy infestation.

After the last harvests

- Destruction of the harvest residues.

Coleoptera with larval stage in the soil
Flea beetles, *Galerucinae*, *Diabrotica* spp. and ténébrionides

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



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

When preparing the soil

Avoid planting close to host crops to reduce potential parasitic pressure.

During the production cycle

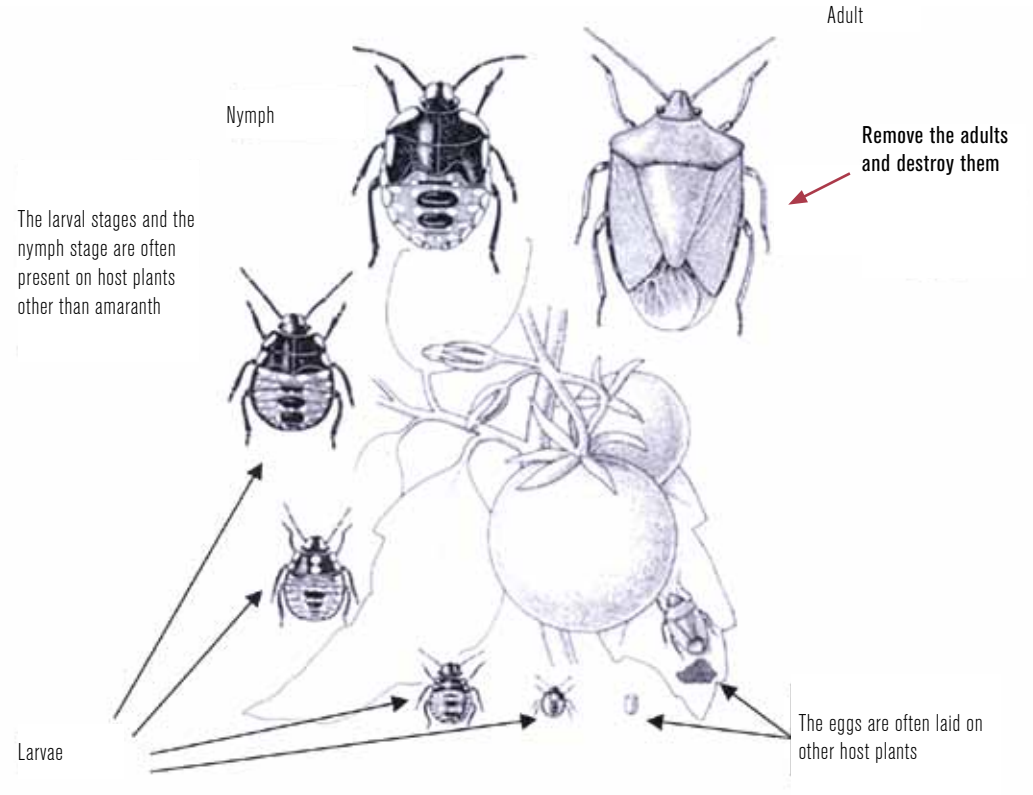
- Till the soil at the foot of the plants to expose the larvae to natural enemies.
- On small surfaces, removing the adults is often sufficient.
- The damage caused by the adults of these beetles is not that significant and usually does not require the application of insecticides.

After the last harvests

- Destruction of the harvest residues.

Hémiptera - bugs

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



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

For many species, the amaranth is a secondary host plant and only the adults are present.

When preparing the soil

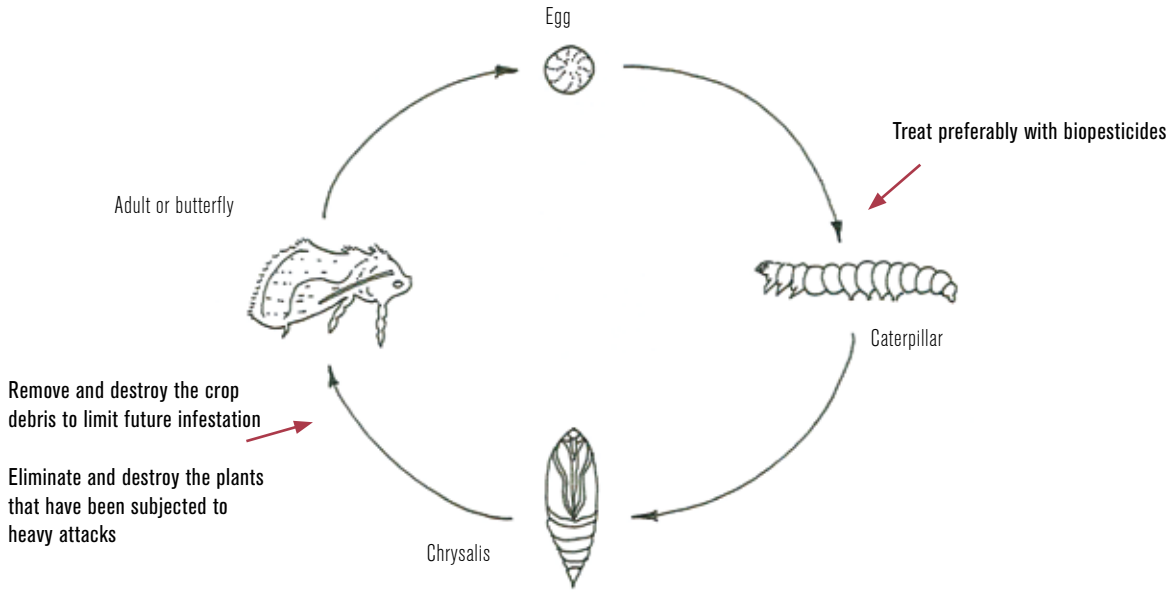
- If possible, avoid planting near host crops to reduce potential parasitic pressure.

During the production cycle

- The adults of all these species of "Bugs" are never very dangerous and only very rarely need insecticidal treatment.
- On small surfaces, the removal and destruction of the adults is often sufficient.

Caterpillars

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



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

During the production cycle

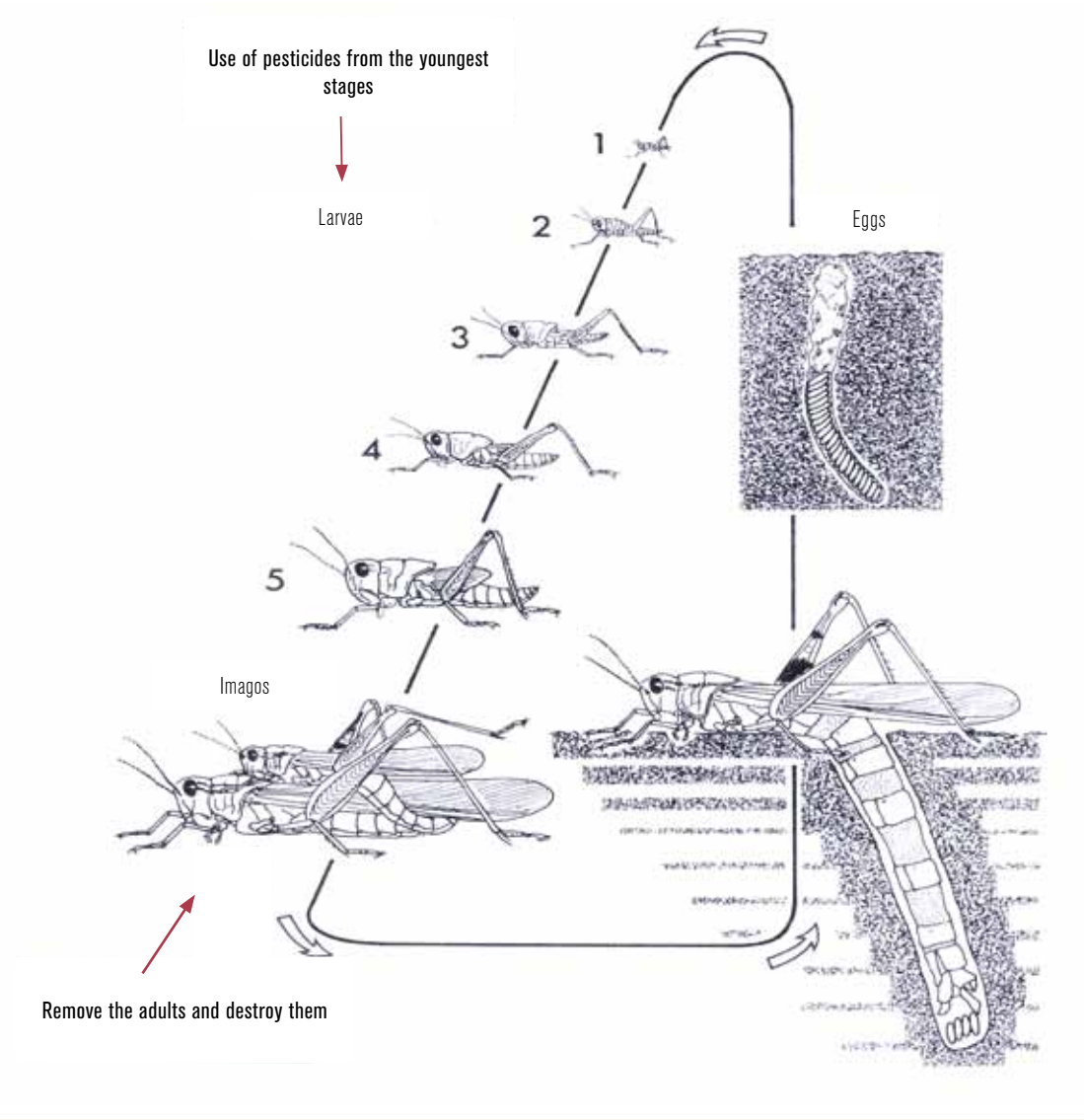
- Always fight the larvae stages by using a series of insecticides if the populations are significant. Bacillus thuringiensis is the product to be used for the pyralis, but products must be alternated to avoid resistance. Apply only at night to avoid burns on the foliage.
- Eliminate the plants that have been attacked too much and destroy them in order to limit future pullulations.

After the last harvests

- Destruction of the harvest residues.

Grasshopper – *Zonocerus variegatus*

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



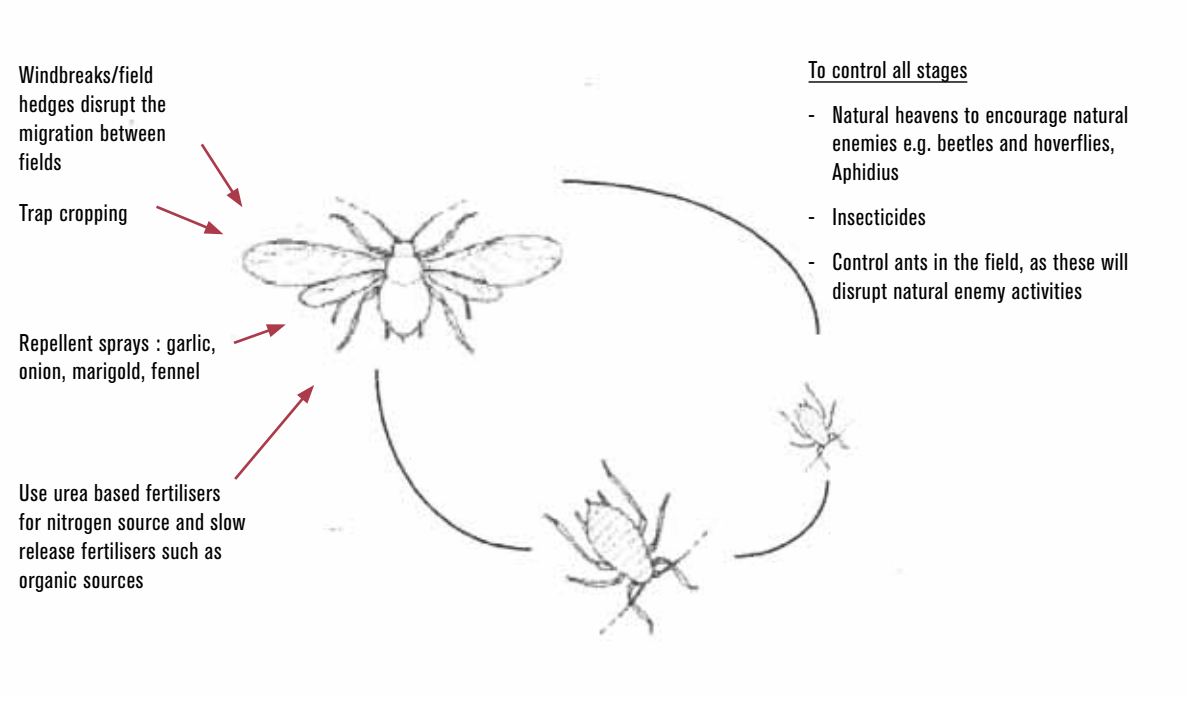
Positioning of control methods in terms of the development cycle of the plant

During the production cycle

- From the first appearance of young larvae, insecticides must be applied.
- It is worth mentioning the effectiveness of a biopesticide on the basis of a species of entomopathogenic mushroom, (*Metarhizium anisopliae*) used against the larvae and the adults.

APHIDS - *Aphis craccivora, Myzus persicae*

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



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

At field preparation

- Natural havens can be planted within or on the hedges of fields to encourage natural enemies, for example coriander, dill, mustard and Sonchus weed.
- Plants can be planted to trap aphids away from crop. These trap crops may be sprayed to control the build up of populations.

During all plant cycle

- Remove weeds that are alternate notes for aphids and harbour certain viruses.
- Aphids are attracted to nitrogen levels in plants, use slow release nitrogen based fertilisers to reduce plant attractiveness.
- Repellent sprays such as garlic, onion, chilli and marigolds help to deter aphids from the crop.

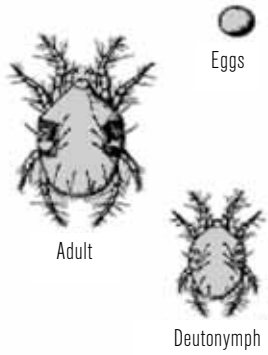
CICADELLIDAE - Ampoasca spp.

Empoasca feeding behaviour is similar to that of aphids and therefore main strategies adopted to control them also have an impact on the former.

RED SPIDER MITES

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

Plant hedges around field to reduce dust build up and migration of adults between fields



To control all stages

- Encourage and release natural enemies such as predatory mites
- Apply specific acaricides to control larva, nymph and adult (someone are also ovicide)
- Apply products such as starch, milk and oil to suppress mite populations
- Dowse dirt track with water
- Apply overhead irrigation to increase microclimate humidity
- Remove and destroy trash from field, after harvest, immediately to avoid build up of populations in the field

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

At field preparation

- Where practical, hedges can be planted around the field to help reduce dust reaching the crop.

During all plant cycle

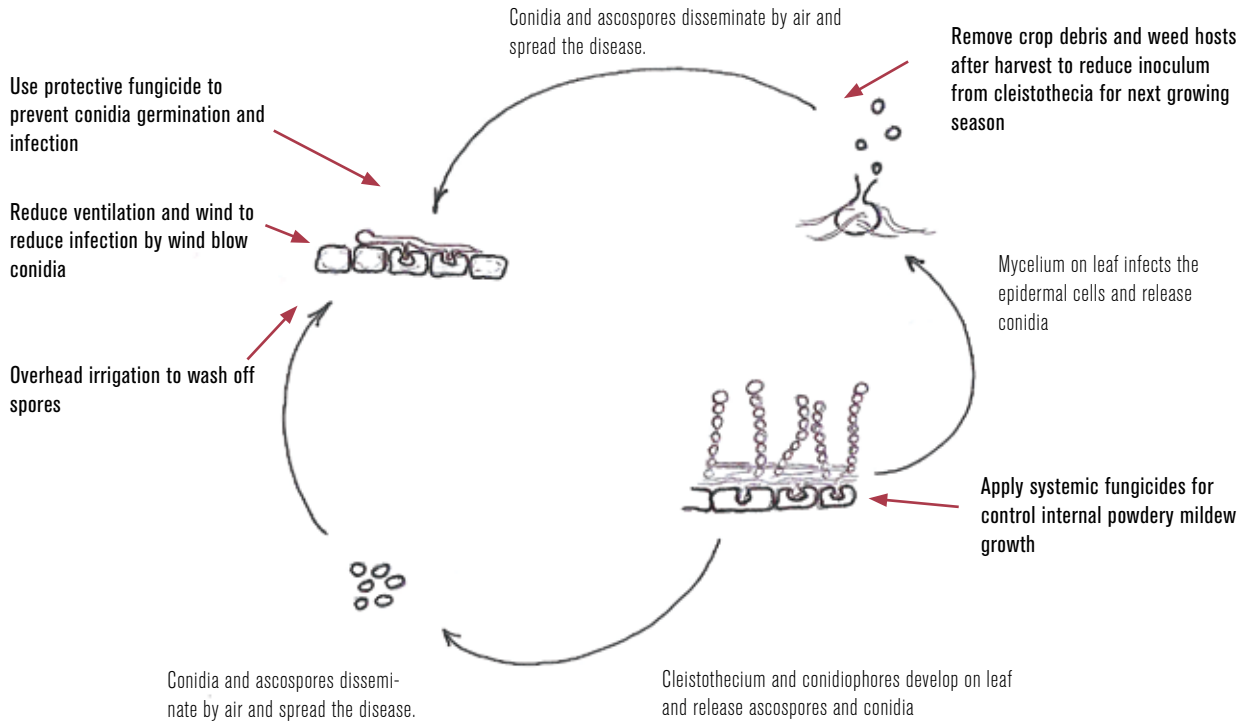
- Red spider mites thrive in dry conditions. Applying overhead irrigation on a regular basis will increase the microclimate humidity. This will lead to an unfavourable environment for mite development. The application of overhead also washes off a significant number of mites.
- Dust from farm tracks can get blown onto the webbing created by mites, further protecting them from pesticide control. In addition the photo-synthetic capability of the plant is reduced. Any road close to the crop should be dowsed in water on a regular basis to reduce dust.
- Weeding around the field during the crop cycle is not advisable as the mite on these plants will move into the crop.
- Predatory mites, such as *Phytoseuillus persimilis* can be used to suppress populations.
- Products such as starch, milk and oil can be used as sprays to help suppress mite populations.
- Apply acaricides during early development of populations, before webbing formation.

After last harvesting

- Remove and destroy trash from field, after harvest, immediately to avoid build up of populations in the field.
- Removal of the weeds once the crop is removed will help suppress mites moving to alternative hosts.

POWDERY MILDEW

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



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

Before sowing and during crop development

- Avoid irrigation systems that don't wet leaf. However, take into consideration that this may favour other foliar diseases.

During sensible stage of the plant (see 1.3.)

- Reduce ventilation in the field to avoid further arrival of conidia.
- Apply protective fungicides when conditions are expected to encourage powdery mildew infections, such as the dry season.
- Apply systemic fungicides for control of internal powdery mildew growth. To be done at early stage of disease development.

After last harvesting

- Burial of plant residues to decrease primary inoculums for next growing season.
- Maintain area free of hosts of the pathogen, i.e., weed amaranth.

Wet rot - *Choanephora cucurbitarum*

Development stage of the fungus	Control Action	Cultivation stages							
		Nursery substrate and environment preparation	Sowing	Nursery	Selection of land	Field preparation	Transplanting	From transplanting to harvest	After last harvest
Germination of propagules on plant	Avoid over population on seedbeds and in the field to maintain plants well aerated		X	X			X		
	Avoid excessive shading by providing adequate plant and row spacing								
	Water plants in the morning to allow wet foliage to dry (depends on irrigation system in use)			X				X	
	Avoid sprinkle irrigation	X		X				X	
Development in plant	Apply protective fungicides at the appearance of disease			X				X	
Dissemination	Apply protective fungicides							X	
	Harvest at proper stage of leaf maturity and avoid injuries							X	
	Selection of healthy seedlings						X		
	Eliminate potential undesirable hosts, i.e., weeds							X	
Survival	Destroy plant residues after harvest								X
	Maintain area free of alternate hosts of the pathogen, i.e., weed amaranth								X

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

Damping off, root rot and stem lesions – *Pythium aphanidermatum* and *Rhizoctonia solani*

Development stage of the fungus	Control Action	Cultivation stages							
		Nursery substrate and environment preparation	Sowing	Nursery	Selection of land	Field preparation	Transplanting	From transplanting to harvest	After last harvest
Germination on Plant	Seedbed conditions should not be too moist	X		X					
	Regulate irrigation programme to avoid over watering or stress			X				X	
	Space rows and/or seedlings in the seedbed to maximize air movement. Do not over populate		X	X					
	Avoid water logging areas when planting. Planting on raised bed and providing good drainage			X	X	X	X		
	Plant resistant or tolerant seeds if available		X						
	Apply fungicides as seed treatment		X						
Development in plant	Apply fungicides as spraying or drenching	X		X			X	X	
Dissemination	Apply fungicides as spraying or drenching							X	
	Avoid irrigation water movement							X	
	Selection of healthy seedlings						X		
Development on crop or weeds	Remove and destroy infected plants			X			X		
Survival in the soil	Steam, heat (65°C for 30 minutes) and solar treatment of soil and growing media will help to kill the pathogens	X				X			
	Use clean and/or sterile soil	X		X	X				
	Rotation with cereals may reduce pathogen *Rhizoctonia* in soil				X	X			X
	Apply fungicides to the soil	X				X			

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

White rust – *Albugo bliti*

Development stage of the fungus	Control Action	Cultivation stages							
		Nursery substrate and environment preparation	Sowing	Nursery	Selection of land	Field preparation	Transplanting	From transplanting to harvest	After last harvest
Germination of propagules on plant	Avoid windbreaks and eliminate weeds to hasten drying of dew			X				X	
	Avoid sprinkle irrigation	X							
Development in plant	Apply protective fungicides if moist, cool weather prevail and at the appearance of disease (stop spraying during hot weather)			X				X	
Dissemination	Spraying of fungicides							X	
	Eliminate potential undesirable hosts, i.e., weeds							X	
	Selection of healthy seedlings						X		
Dissemination	Crop rotation								X
	Burial of crop residues after harvest to decrease mycelial inoculum								X
	Maintain area free of hosts of the pathogen, i.e., weed amaranth							X	X
	Steam (pasteurization) or solarization	X				X			

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

Foliar spots - *Cercospora beticola* and *C. brachiata*

Development stage of the fungus	Control Action	Cultivation stages							
		Nursery substrate and environment preparation	Sowing	Nursery	Selection of land	Field preparation	Transplanting	From transplanting to harvest	After last harvest
Germination on Plant	Seedbed conditions should not be too moist			X					
	Regulate irrigation programme to avoid over watering or stress								
	Appropriate nutrition (N, P, K, B and Na)			X				X	
	Plant resistant or tolerant varieties if available		X						
	Avoid overhead irrigation	X						X	
	Apply fungicides as seed treatment		X						
Development in plant	Spraying of fungicides			X				X	
Dissemination	Spraying of fungicides							X	
	Avoid overhead irrigation							X	
	Selection of healthy seedlings						X		
	Eliminate potential undesirable hosts, i.e., weeds							X	
Survival in the soil	Plow down of crop debris					X			X
	Eliminate potential undesirable hosts, i.e., weeds								X

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

2.3. Cultivar resistance or tolerance

There are no cultivars that are resistant or tolerant to the various attacks by pests.

The low monetary yield of these crops has never made it possible to initiate selection programmes against the resistance of the pests, except on the organoleptic or agronomic values, especially in the Congo.

Disease-resistant and tolerant varieties are the easiest and most efficient way to reduce disease losses. The availability of certified seed of resistant varieties of amaranth is limited.

Some possible suppliers of leafy amaranth seeds are listed below:

Eden Organic Nursery Services Inc.
www.eonseed.com

Johnny's Selected Seeds.
www.johnnyseeds.com

Native Seeds/Search.
www.nativeseeds.org

Seeds Blum.
www.saveseeds.org

JTS Les Semences du jardin Tropical
http://www.jtssemences.com/index.php

2.4. Utility and use of the natural enemies

Few natural enemies are present in any large quantities on all these species of pests, with the exception of a species of Braconide (*Hymenoptera*) that is regularly found on the populations of *H. recurvalis* and of *P. basalis* caterpillars. Despite their rather common presence, they do not seem to efficiently regulate the caterpillars.

Difficult to quantify, as often generalist, several predators (spiders, *Hymenopterae, Coleopterae, Hemipterae*. . .), are present on the crops and intervene in the natural regulation of certain plots. This group of natural enemies species is not to be overlooked in an agro-ecological balance.

For the *Spodoptera*, the natural attacks of certain parasitic *Hymenoptera* and *Tachinidae* seem to be efficient.

A large number of parasitic Hymenopterae of the larvae have been bred from *S. frugiperda*, and several predators are also pointed out : biological control methods can therefore be of significant importance. The natural levels of larvae parasitism are often very high (20-70%), more often by braconidae. The pathogens also kill 10-15% of them.

3. Crop monitoring and intervention threshold

3.1. Guidelines for pest monitoring

The unfortunate shortage of knowledge about the biology and the identification of pests and the absence of help at crop level, except for some advice from local NGOs, do not allow producers to introduce any kind of monitoring of the phytosanitary condition of the crop in order to have an exact idea of what an intervention threshold is. It is however advisable to check the condition of the crop and to intervene in the event of heavy attacks.

3.2. Guidelines for disease monitoring

For routine disease monitoring, it is suggested that the field be monitor once per week; however, keep in mind that time intervals for monitoring may be conditioned by weather conditions and disease development. It is recommended to follow up weather conditions of the zone to determine if a protective fungicide spray is necessary.

Know the diseases that affect your crop, their life cycles, symptoms and the conditions that favour their development to take accurate control measures and to avoid unnecessary expenses.

Number of samplings within a field should be according to field size, topography and soil factors (for soil borne pathogens). It is important that results give a good approximation of field sanitary condition. Keep in mind that foliar diseases tend to randomly scatter through the field due mostly to dissemination by air, and soil borne pathogens propagate as foci due mostly to propagation by water from infected plant to adjacent healthy plant.

A simple monitoring process for disease in amaranth is to evaluate the incidence of the disease (% of plants showing symptoms of a particular disease). For damping off, root rot and stem lesions, incidence is evaluated. For foliar pathogens, incidence and number of diseased leaves on plants (severity) can be recorded.

Monitor the field in a W pattern, remembering that it is a random process.

Indicative thresholds proposed :
The thresholds proposed are not based on epidemiological work. These are recommended as safe for disease control, but could influence the number of fungicide applications and consequently, production cost and competitivity. It is important that growers have their data from monitoring well organized to compare previous years data and results of measures taken, to be able to consider or not accurately a decision of spraying. It is up to the grower and his observations and experiences with the diseases to use other thresholds.

Powdery mildew:	Protectant/Therapeutic fungicide spray when first seen.
Damping off:	Protectant/Therapeutic fungicide spray when first seen.
Root and stem cankers:	Therapeutic fungicide when first seen.
Wet rot:	Protectant/therapeutic fungicide spray when first seen.
White rust:	Protectant/therapeutic fungicide when first seen.
Leaf spots:	Protectant/Therapeutic spray when first seen.

If accurate environmental conditions (precipitation, relative humidity and temperature) of the field or agricultural zone are available, and the diseases of amaranth are known, it is recommended to also follow the weather information for taking a decision of spraying.

The selection of pesticide, protectant, systemic-therapeutic, to spray will depend on the days before harvest that the fungicide can be used. Also, spraying or not spraying close to harvest will depend on the incidence-severity and the disease. Always follow pesticide label instructions.

Guidelines on completion of the weekly summary sheets

On a weekly basis, transfer the data from the field monitoring forms to the weekly summary.

Indicate day monitored in the column provided. It is important to remember that these are figures per field and specific disease.

Graphs of weekly changes against incidence and/or severity of diseases versus time to plot progress can be made manually or in computer.

Enter all sprays and any other management measure applied to the crop. This can provide knowledge related to the response of the disease to the management measure implemented. Keep in mind that disease development is affected by environmental conditions.

Sample of a disease monitoring form:

Sampling site	Powdery mildew	Wet rot	Damping off	Root rot	Stem lesion	White rust	Foliar spot
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
Incidence							
Diseased leaves / pt.							
Average. diseased leaves / pt.							

Other observations: (distribution of problem, other symptoms, waterlogging, drip lines, hotspots, etc.)

4. Plant Protection Products and treatment recommendations

Introduction

For each pest or disease, proposals for the strategy on 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 Good Agricultural Practice (GAP) is also shown.

This PHIs (Pre-harvest interval) are indicated for:

- Compliance with the European Maximum Residue Limits (MRLs) currently in force on spinach including amaranthus spinach (on products exported into the EU).
- Compliance with the CODEX MRL (for products sold in the countries where the CODEX MRLs are relevant).
- Special private standards, who allow to cultivate only without any quantifiable residues i.e. with "0" residues taking into account European LOQ..

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 into account the severity of attacks and the real risks of local 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. It is nevertheless worth noting that not all the ACP producers contacted provided information on the PPP used. The products mentioned by producers have been underlined in the tables.

When there is intrinsically no residues issue for an active substance or a biological agent (highlighted in blue in the tables) the PHI is fixed by default to 3 days.

Some GAPs (marked in the following tables in yellow) have been evaluated at tropical level by the PIP on amaranthus spinach in Ghana in 2009.

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 if high risk for resistance is possible.

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 impact on natural enemies.

Other PPPs not shown in the following tables can be effective, for example, neem extract (to control caterpillars, beetles, etc.), wood ash (to control flea beetles, etc.). The effectiveness of this type of PPP depends in large measure on the origin of the raw materials used, so efficacy needs to be checked locally.

Others substances act as a physical trap on some small insects, nematodes and fungus and are not considered like conventional Plant Protection Products. For instance propylene glycol alginate can trap aphids, mites and leafhopers as well as powdery mildews when applied correctly. This substance as no pesticide resistance and no residues of concern but one should check locally authorization for use on crops.

PIP updates quarterly on its website the compilation of GAPs (Good Agricultural Practice) taking into account changes in EU or Codex MRLs.

Coleoptera								
Strateg: Scout at least once per week, use pesticides with short PHIs as crop is short term when problem first seen.								
Active substance	Recommended GAP*						Proposed application period	
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)			Before sowing	From emergence to harvest
				EU MRL	Codex MRL	LOQ		
Group 3 - Pyrethroids								
Cypermethrin	40	3	14	7	7	21		
Deltamethrin	12,5	4	14	3	3	21		
Lambda cyhalothrin	20	2	14	7	21	21		
Pyrethrin	75 - 100	/	/	/	/	/		
Group 1 – Organophosphates and carbamates								
Diazinon	550	2	14	21	21	21		
Group 4 – Nicotinic Acethylcholine receptor agonists/antagonists								
Acetamipride	65	2	14	14	/	/		
Imidacloprid	/	/	/	/	/	/		
Thiacloprid	/	/	/	/	/	/		
Thiamethoxam	100	2	14	10	10	10		

* The elements of the recommended GAP shown here allow to comply with the harmonised European MRL the Codex MRL or the LOQ (0 residues) (see part 6 of this guide).
/ elements of the recommended GAP not available

Bugs, aphids and cicadellidae								
Strategy: Scout at least once per week, use pesticides with short PHIs as crop is short term.								
Active substance	Recommended GAP*						Proposed application period	
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)			Before sowing	From emergence to harvest
				EU MRL	Codex MRL	LOQ		
Group 3 - Pyrethroids								
Cypermethrin	40	3	14	7	7	21		
Bifenthrin	12	/	/	/	/	/		
Deltamethrin	12,5	4	14	3	3	21		
Lambda cyhalothrin	20	2	14	7	21	21		
Pyrethrin	75-100	/	/	/	/	/		
Tau-fluvalinate	/	/	/	/	/	/		
Group 1 – Organophosphates and carbamates								
Dimethoate	/	/	/	/	/	/		
Diazinon	550	2	14	21	21	21		
Pirimicarbe (only on aphids)	/	/	/	/	/	/		
Pirimiphos-methyl	/	/	/	/	/	/		
Group 9								
Pymetrozine	200	3	7	7	/	/		
Group 4 – Nicotinic Acethylcholine receptor agonists/antagonists								
Acetamipride	65	2	14	14	/	/		
Imidacloprid	/	/	/	/	/	/		
Thiacloprid	/	/	/	/	/	/		
Thiamethoxam	100	2	14	10	10	10		
Group 18 – Ecdysone aganists/moulting disruptors								
Azadiractin	15-60	Sans limite	7	3	3	3		
Groupe 21								
Rotenone	/	/	/	/	/	/		

* The elements of the recommended GAP shown here allow to comply with the harmonised European MRL the Codex MRL or the LOQ (0 residues) (see part 6 of this guide).
/ elements of the recommended GAP not available

Caterpillars								
Strategy: Scout at least once per week, crop young crops completely with fleece/netting, use pesticides with short PHIs as crop is short term. Target should be small larvae who are easier to control with insecticides.faciles à contrôler avec des insecticides.								
Active substance	Recommended GAP*						Proposed application period	
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)			Before sowing	From emergence to harvest
				EU MRL	Codex MRL	LOQ		
Group 3 - Pyrethroids								
Cypermethrin	40	3	14	7	7	21		
Bifenthrin	/	/	/	/	/	/		
Deltamethrin	12,5	4	14	3	3	21		
Lambda cyhalothrin	20	2	14	7	21	21		
Pyrethrin	75-100	/	/	/	/	/		
Group 5 - Spynosines								
Spinosad	96	3	7	3	3	10		
Group 11 – Microbial disruptors of insect midgut membranes								
Bacillus thuringiensis var. kurstaki	/	Not restricted	7	3	3	3		
Group 18 – Ecdysone aganists/moulting disruptors								
Methoxyfenozide	/	/	/	30	/	/		
Group 22 – Voltage-dependent sodium channel blockers								
Indoxacarbe	375	3	14	10	/	/		
Group 6 - Avermectins								
Emamectin benzoate	5,7	4	14	3	3	3		

* The elements of the recommended GAP shown here allow to comply with the harmonised European MRL the Codex MRL or the LOQ (0 residues) (see part 6 of this guide).
/ elements of the recommended GAP not available

Grasshopper								
Strategy: One should start applications at appearance of young larval stages.								
Active substance	Recommended GAP*						Proposed application period	
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)			Before sowing	From emergence to harvest
				EU MRL	Codex MRL	LOQ		
Group 3 - Pyrethroids								
Cypermethrin	40	3	14	7	7	21		
Deltamethrin	12,5	4	14	3	3	21		
Lambda-cyhalothrin	20	2	14	7	21	21		
Pyrethrin	/	/	/	/	/	/		
Not classified								
Metarhizium anisopliae	96	3	7	3	3	10		

* The elements of the recommended GAP shown here allow to comply with the harmonised European MRL the Codex MRL or the LOQ (0 residues) (see part 6 of this guide).
/ elements of the recommended GAP not available

Mites

Strategy: Selective acaricides should be used, with an alternation to limit risks of resistance and to minimise the negative impact on auxiliaries, including predator acarids (*phytoseidae*).

As soon as the first symptoms have been detected, and if the attack starts to spread, treatments should be envisaged, either with specific acaricides having ovicide and/or larvicide action, or with insecticides having an acaricide effect (abamectin, pyrethroids with acaricide action). Pyrethroids with acaricide action can control most insects present at the time of treatment.

To the extent that attacks are limited in space, it is sometimes possible and useful to concentrate applications on the infested areas.

Active substance	Recommended GAP*						Proposed application period	
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)			Before sowing	From emergence to harvest
				EU MRL	Codex MRL	LOQ		
Group 6 - Avermectins								
Abamectin	12 à 18	/	/	/	/	/		
Group 3 - Pyrethroids								
Acrinathrin	45	/	/	/	/	/		
Bifenthrin	40	/	/	/	/	/		
Group 10								
Clofentezine	200	/	/	/	/	/		
Hexythiazox	50	/	/	/	/	/		
Group 12								
Fenbutatin oxyde	495	/	/	/	/	/		
Group 21								
Tebufenpyrad	200	/	/	/	/	/		
Fenpyroximate	/	/	/	/	/	/		
Group 25 – Neuronal inhibitor								
Bifenazate	/	/	/	/	/	/		
Group 23 – Inhibitors of lipids synthesis								
Spiromesifen	/	/	/	/	/	/		

* The elements of the recommended GAP shown here allow to comply with the harmonised European MRL the Codex MRL or the LOQ (0 residues) (see part 6 of this guide).
/ elements of the recommended GAP not available

Powdery Mildew – *Erysiphe cichoracearum*

Strategy: Scout at least once per week; use pesticides with short PHIs as crop is short term when problem first seen. Application of sulphur to leaf surface before the onset of disease when environmental conditions are favourable can effectively inhibit disease development.

Active substance	Recommended GAP*						Proposed application period	
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)			Before sowing	From emergence to harvest
				EU MRL	Codex MRL	LOQ		
Group 1 - Benzimidazoles								
Thiabendazole	/	/	/	/	/	/		
Thiophanate-methyl	/	/	/	/	/	/		
Group 3 - DMI – fungicides								
Myclobutanil	/	/	/	/	/	/		
Bitertanol	/	/	/	/	/	/		
Triadimenol	/	/	/	/	/	/		
Triadimefon	/	/	/	/	/	/		
Group M - Multisite activity								
Captan	/	1	n.a.	seeds treatment				
Thiram	/	1	n.a.	seeds treatment				
Sulfur	/	/	/	/	/	/		
Group 7 - Carboximides								
Carboxin	/	1	n.a.	seeds treatment				
Boscalid	/	/	/	/	/	/		
Group 11 - QoI fungicides								
Pyraclostrobin	/	/	/	/	/	/		

* The elements of the recommended GAP shown here allow to comply with the harmonised European MRL the Codex MRL or the LOQ (0 residues) (see part 6 of this guide).
/ elements of the recommended GAP not available
n.a. : not applicable

Wet rot – *Choanephora cucurbitarum*								
Strategy: Scout at least once per week; use pesticides with short PHIs as crop is short term when problem first seen.								
Active substance	Recommended GAP*						Proposed application period	
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)			Before sowing	From emergence to harvest
				EU MRL	Codex MRL	LOQ		
Groupe M - Activité multisite								
Fixed coppers	/	/	/	/	/	/		

* The elements of the recommended GAP shown here allow to comply with the harmonised European MRL the Codex MRL or the LOQ (0 residues) (see part 6 of this guide).
/ elements of the recommended GAP not available

White rust – *Albugo bliti*								
Strategy: Soon after the first symptoms appear, apply several fungicide sprays. Usually spraying applications should continue at 7- to14-day intervals as long as the weather is cool and moist. Omit the sprays in hot weather.								
Active substance	Recommended GAP*						Proposed application period	
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)			Before sowing	From emergence to harvest
				EU MRL	Codex MRL	LOQ		
Group M - Multisite activity								
Maneb	/	/	/	/	/	/		
Fixed copper	/	/	/	/	/	/		
Group 4 - PhenylAmide fungicides								
Mefenoxam	/	/	/	/	/	/		
Group 11 - QoI fungicides Group								
Azoxystrobin	250	1	n.a.	7	/	/		
Group 33 - Phosphonate								
Fosetyl	/	/	/	/	/	/		

* The elements of the recommended GAP shown here allow to comply with the harmonised European MRL the Codex MRL or the LOQ (0 residues) (see part 6 of this guide).
/ elements of the recommended GAP not available
n.a. : not applicable

Leaf spots – *Cercospora beticola, C. brachiata*								
Strategy: Scout at least once per week, use pesticides with short PHIs as crop is short term when problem first seen.								
Active substance	Recommended GAP*						Proposed application period	
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)			Before sowing	From emergence to harvest
				EU MRL	Codex MRL	LOQ		
Group 1 - Benzimidazoles								
Thiabendazole	/	/	/	/	/	/		
Thiophanate-methyl	/	/	/	/	/	/		
Group 3 - DMI – fungicides								
Difenoconazole	175	/	/	/	/	/		
Triademefon	/	/	/	/	/	/		
Propiconazole	/	/	/	/	/	/		
Group M - Multisite activity								
Mancozeb	1600	/	/	/	/	/		
Maneb	/	/	/	/	/	/		
Captan	/	1	n.a.	seeds treatment				
Thiram	/	1	n.a.	seeds treatment				
Group 7 - Carboximides								
Carboxin	/	1	n.a.	seeds treatment				
Propineb	2000	/	/	/	/	/		
Group 11 - QoI fungicides								
Azoxystrobin	250	1	n.a.	7	/	/		
Trifloxystrobin	/	/	/	/	/	/		
Group 28 - Carbamates								
Propamocarb	/	/	/	/	/	/		

* The elements of the recommended GAP shown here allow to comply with the harmonised European MRL the Codex MRL or the LOQ (0 residues) (see part 6 of this guide).
/ : elements of the recommended GAP not available
n.a. : not applicable

Damping off, root rot and stem lesion - *Pythium aphanidermatum*								
Strategy: Treat seeds if expected infection is high.								
Active substance	Recommended GAP*						Proposed application period	
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)			Before sowing	From emergence to harvest
				EU MRL	Codex MRL	LOQ		
Group M – Multisite activity								
Mancozeb	/	/	/	/	/	/		
Captan	/	1	n.a.	seeds treatment				
Thiram	/	1	n.a.	seeds treatment				
Group 7 – Carboximides								
Carboxin	/	1	n.a.	seeds treatment				
Group 28 – Carbamates								
Propamocarb	/	/	/	/	/	/		
Group 33 – Phosphonate								
Fosetyl	/	/	/	/	/	/		
Group 4 – PhenylAmide fungicides								
Mefenoxam	/	/	/	/	/	/		

* The elements of the recommended GAP shown here allow to comply with the harmonised European MRL the Codex MRL or the LOQ (0 residues) (see part 6 of this guide).
/ : elements of the recommended GAP not available
n.a. : not applicable

Damping off, root rot and stem lesion – *Rhizoctonia solani*								
Strategy: Treat seeds if expected infection is high.								
Active substance	Recommended GAP*						Proposed application period	
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)			Before sowing	From emergence to harvest
				EU MRL	Codex MRL	LOQ		
Group M – Multisite activity								
Mancozeb	/	/	/	/	/	/		
Captan	/	1	n.a.	seeds treatment				
Thiram	/	1	n.a.	seeds treatment				
Group 7 – Carboximides								
Carboxin	/	1	n.a.	seeds treatment				
Group 28 – carbamates								
Propamocarb	/	/	/	/	/	/		

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

Foliar spot – *Cladosporium variabile*								
Strategy: Scout at least once per week, use pesticides with short PHIs as crop is short term when problem first seen.								
Active substance	Recommended GAP*						Proposed application period	
	Dose g/ha	Maximum number applications	Minimum interval between applications (days)	Pre-harvest interval (days)			Before sowing	From emergence to harvest
				EU MRL	Codex MRL	LOQ		
Group M – Multisite activity								
Mancozeb	1600	/	/	/	/	/		
Maneb	/	/	/	/	/	/		
Chlorothalonil	/	/	/	/	/	/		
Captan	/	1	n.a.	seeds treatment				
Thiram	/	1	n.a.	seeds treatment				
Group 7 – Carboximides								
Carboxin	/	1	n.a.	seeds treatment				

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

Sources of GAP validated by PIP trials (boxes highlighted in yellow in previous pages)

Active substance	Commercial product tested	Pesticide company	Trials	
			Year	Country
Deltamethrin	Decis 2.5 EC	Bayer CropScience	2009	Ghana
Cypermethrin	Cypercal 50 EC	Arysta Life Science	2009	Ghana
Diazinon	Diazol 50 EW	Makteshim Agan	2009	Ghana
Emamectin-benzoate	Attack 1.9 EC	IPROCHEM	2009	Ghana
Lambda-Cyhalothrin	Karate 5 EC	Syngenta	2009	Ghana
Spinosad	Tracer 480 SC	DOW Agroscience	2009	Ghana
Thiamethoxam	Actara 25 WG	Syngenta	2009	Ghana

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

5. Existing registrations in ACP countries

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

Regarding **Dominican Republic, Benin, Congo Republic and Gabon** we have not yet information on what is registered.

For CILSS countries, the registrations issued by the Sahelian Pesticides Committee (CSP) apply. Following active substances listed in part 4 of this guide have a Trade name registered for use on vegetables:

- For use on seeds: imidacloprid, thiram, thiamethoxam, mefenoxam, difenoconazole
- Insecticides: acetamiprid, cypermethrin, lambda-cyhalothrin
- Fungicides : mancozeb, myclobutanil

In Jamaica, following active substances listed in part 4 of this guide have a Trade name registered for use on vegetables, one PPP is registered on amaranth (calaloo).

Active substance	Registered in Jamaica on
Bacillus thuringiensis	Calaloo
Thiamethoxam	vegetables
Lambda-cyhalothrin	vegetables
Deltamethrin	vegetables
Diazinon	vegetables

6. Regulations and pesticide residues

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

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

Substance active	European regulations		LMR CODEX sur amarante ou légumes feuilles
	Statuts Reg 1107/2009	LMR européenne pour l'amarante	
Abamectin	Approved	0.01**	0.01**
Acetamiprid	Approved	3	/
Acrinathrin	Approved	0.05**	/
Alpha-cypermethrin	Approved	0.7	0.7 (leafy vegetables)
Azadirachtin	Approved	1	/
Azoxystrobin	Approved	0.05**	0.01**
Bacillus thuringiensis	Approved	0.05	/
Bifenazate	Approved	0.01**	0.01**
Bifenthrin	Not approved	0.05**	0.05**
Bitertanol	Not approved	0.05**	0.01**
Boscalid	Approved	30	0.05**
Captan	Approved	0.1	0.01**
Carboxin	Approved	0.5	/
Chlorothalonil	Approved	0.01**	0.01**
Clofentezine	Approved	0.02**	0.05**
Copper	Approved	20	/
Cypermethrin	Approved	0.7	0.7 (leafy vegetables)
Deltamethrin	Approved	0,5	2 (leafy vegetables)
Diazinon	Not approved	0.01**	0.5 (spinach)
Difenoconazole	Approved	2	0.02**
Dimethoate	Approved	0.02**	0.05**
Emamectin-benzoate	Pending	0.01**	/
Fenbutatin-oxide	Approved	0.05**	0.05**
Fenpyroximate	Approved	0.05**	0.01**
Fosetyl-Al	Approved	75	/
Hexythiazox	Approved	0.5	0.01**
Imidacloprid	Approved	0.05**	0.05**
Indoxacarbe	Approved	2	0.02**
Lambda-cyhalothrin	Approved	0.5	/
Mancozeb	Approved	0.05**	/
Maneb	Approved	0.05**	/

Substance active	European regulations		LMR CODEX sur amarante ou légumes feuilles
	Statuts Reg 1107/2009	LMR européenne pour l'amarante	
Mefenoxam (Metalaxyl-M)	Approved	0.05**	2 (spinach)
Metarhizium anisopliae	Approved		/
Methoxyfenozide	Approved	0,02**	0.02**
Myclobutanil	Approved	0,02**	0.01**
Propamocarbe	Approved	30	40 (spinach)
Pymetrozin	Approved	0,4	/
Pyraclostrobine	Approved	0,5	0.02**
Pyrethrins	Approved	1	0.05**
Pirimiphos-methyl	Approved	0.05**	0.01**
Propiconazole	Approved	0.05**	0.02**
Pirimicarb	Approved	2	0.01**
Rotenone	Not approved	0.01**	/
Spinosad	Approved	10	10 (leafy vegetables)
Spiromesifen	Pending	0.02**	/
Sulfur	Approved	Not required	/
Tau-fluvalinate	Approved	0.01**	/
Tebufenpyrad	Approved	0.05**	/
Thiabendazole	Approved	0.05**	0.05**
Thiacloprid	Approved	0.02**	0.02**
Thiamethoxam (+ Clothianidin)	Approved	0.05**	/
Thiophanate-methyl	Approved	0,1**	/
Thiram	Approved	0.1**	/
Triadimefon	Not approved	0,1**	0.05**
Triadimenol	Approved	0,1**	0.05**
Trifloxystrobine	Approved	0,02**	0.02**

** MRL indicates a lower limit of analytical determination (LOQ)
n.a. not applicable

Note on the status of active substances in EU

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

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

Note on MRLs:

The quantities of pesticide residues found in food must be safe for consumers and remain as low as possible.

The maximum residue limit (MRL) is the maximum concentration of pesticide residue legally permitted in or on food or feed.

MRLs in the EU

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

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

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

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

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

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

How are MRLs applied and monitored in EU?

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

MRLs in ACP countries – Codex

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

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

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

References, websites and useful documents

1. References and useful documents

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H. Dupriez, P. de Leener (1987) – Jardins et vergers d'Afrique. Terres et vie, CTA, Wageningen, Pays Bas

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Sherf, A.F. and A. A. Macnab. 1986. Vegetable diseases and their control. Second Edition. Published by John Wiley & Sons, Inc. 728 pp.

2. Useful websites

UR-Horticulture, CIRAD-Persyst : http://www.cirad.fr/ur/horticulture
Lettuce. UC IPM Pest Management Guidelines–University of California's
Integrated Pest Management. http://www.ipm.ucdavis.edu/PMG/selectnewpest.lettuce.html
Documents. http://www.inia.org.uy/publicaciones/documentos/lb/ad/2004/ad_352.pdf
CaribPesticides.net. http://www.caribpesticides.net
European Plant Protection Organization. http://www.eppo.org/quarantine/quarantine.htm
FRAC Links. http://www.frac.info/frac/index.htm
Plant Viruses Online. Descriptions and lists from VIDE Database. http://www.agls.uidaho.edu/ebi/vdie//
Vegetable Amaranth. http://www.island.wsu.edu/CROPS/VEGETABL.htm

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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