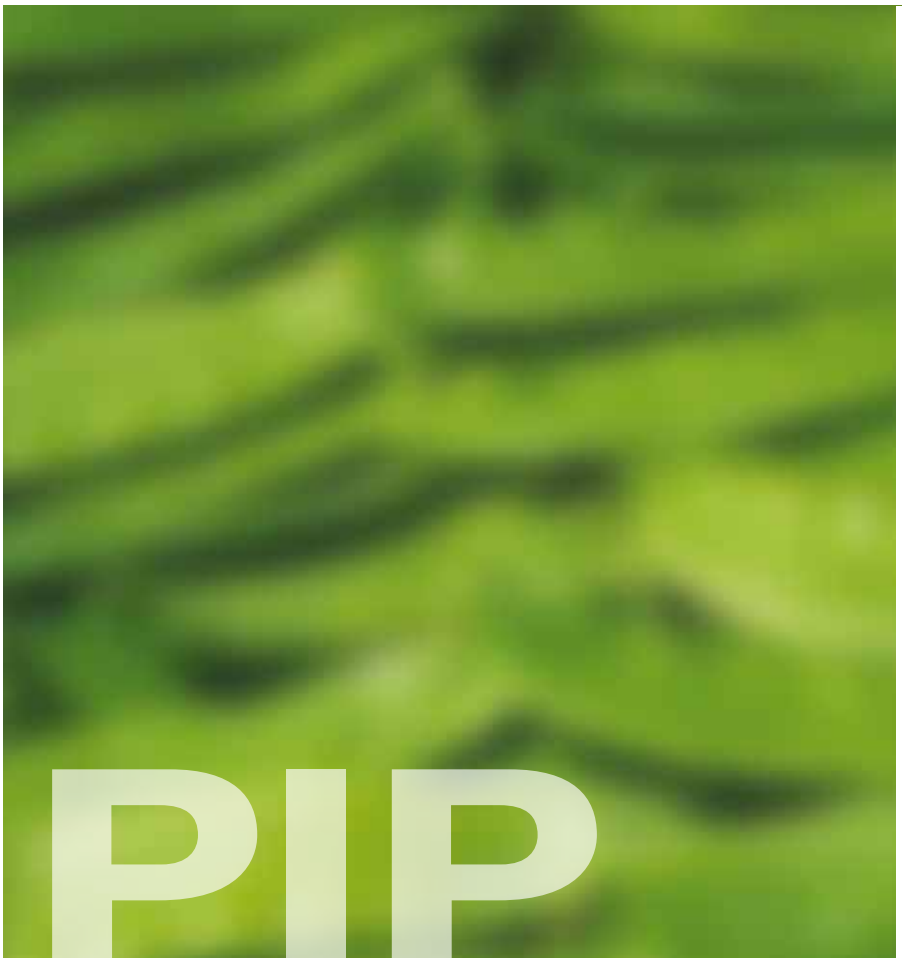


# GUIDE TO GOOD PLANT PROTECTION PRACTICES

## FOR ONIONS, (*ALLIUM CEPA*), GARLIC (*ALLIUM SATIVUM*) AND SHALLOTS (*ALLIUM ASCALONICUM* OR *ALLIUM CEPA* VAR. *AGGREGATUM*) IN ACP COUNTRIES

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".

PIP

FOR SUSTAINABLE DEVELOPMENT OF THE ACP HORTICULTURAL INDUSTRY

**www.coleacp.org/pip**

COLEACP

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## Notice

The Guide to Good Plant Protection Practices (fruit or vegetable) details all plant protection practices and recommends primarily the active substances supported by pesticides manufacturers in the framework of european Regulation 1107/2009, for organic production those allowed for usage by the EC Regulation 834/2007 and 889/2008, that must comply with standards for pesticide residues. Currently, these active substances have not been tested by PIP in ACP countries to check their conformity with MRLs. The information given on the active substances suggested is therefore changeable and will be adapted on an ongoing basis in accordance with the new information collected by PIP.

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

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

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FOR SUSTAINABLE DEVELOPMENT OF THE ACP HORTICULTURAL INDUSTRY

# Table of contents

# 1. Introduction

Information given in this guide is solely for productionof onion and shallots bulbs, and garlic cloves.

# 2. Main enemies and importance

## 2.1. Extent and impact on the quantity and quality of the production

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

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

Organisms listed in this guide are not quarantine organisms in Europe.

One should check the status of quarantine organisms on the websites: http://ec.europa.eu/food/plant/plant_health_biosafety/legislation/index_en.htm et http://www.eppo.org/QUARANTINE/quarantine.htm since regulation can change.

| FUNGI | | | | | | | |
|---|---|---|---|---|---|---|---|
| Extent | | | Organs affected | | Type of losses | | |
| Onion | Shallot | Garlic | Leaves and stems | Roots and bulbs | Number of plants | Bulb size | Bulb quality |
| **Purple blotch (*Alternaria porri*)** | | | | | | | |
| +++ | +++ | +++ | The fungus attacks the old leaves first before moving on the young ones. The presence of thrips, which pierce the epidermis of the leaves, makes it easier for the fungus to penetrate. | The bulbs are rarely attacked. | In cases of severe infection, the leaves wither and the plants die. | Reduced in the case of severe attack. | Infected bulbs rot during storage. |
| **Stemphylium leaf blight (*Stemphylium vesicarium*)** | | | | | | | |
| +++ | +++ | +++ | The leaves and stems are attacked. The onion flowering stem is also attacked. | | In the case of severe attack, the leaves wither and the plants die. | Reduced, resulting in yield loss. | |

| FUNGI (end) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Extent | | | Organs affected | | Type of losses | | |
| Onion | Shallot | Garlic | Leaves and stems | Roots and bulbs | Number of plants | Bulb size | Bulb quality |
| **Fusarium basal rot (*Fusarium oxysporum* f. sp. *cepae*)** | | | | | | | |
| +++ | +++ | +++ | | The fungus invades the basal plate of the stem and the roots. | Plants attacked severely at the seedling stage can wither. The pathogen causes damping off in the nursery. | | The losses are caused by bulbs rotting before harvest, but more frequently during storage. |
| **Botrytis Leaf Blight (*Botrytis squamosa*)** | | | | | | | |
| +++ | + | + | The fungus attacks the leaves. | | | Reduced, resulting in yield loss. | |
| **Onion downy mildew (P*eronospora destructor*)** | | | | | | | |
| +++ | +++ | +++ | The stems and leaves are attacked. In the case of systemic infection. | The bulbs are also affected. | The leaves turn yellow and die. For onion sets, broken onion flowering stems and poor seed filling cause seed yield losses. | Reduced, and causes major yield losses. | Rotting bulbs or their germination during storage causes losses. |
| **Pink root rot (*Phoma terrestris* ; syn. : *Pyrenochaeta terrestris*)** | | | | | | | |
| +++ | +++ | +++ | | Only the roots are attacked by the fungus. | The roots die, causing the leaves to turn yellow and then gradually wither. The plants rarely die. | Reduced, and causes major yield losses. | The bulbs are soft and unmarketable. |
| **White rot (*Sclerotiorum cepivorum*)** | | | | | | | |
| +++ | +++ | +++ | | The fungus causes the roots, crown and bulbs to rot. | Young seedlings can be attacked in the nursery. In this case, the seedlings die. In the field, the rotting roots cause the plant to die. | | Rotting bulbs before harvest or during storage cause significant losses. |
| **Onion smudge (*Colletotrichum circinans*)** | | | | | | | |
| ++ | ++ | + | The leaves are only attacked in exceptionally wet conditions. | This fungus mainly attacks the bulbs. | | | The presence of lesions on the outside scales tarnishes the appearance of the bulbs which can no longer be marketed. |
| **Rust (*Puccinia porri*)** | | | | | | | |
| +++ | +++ | +++ | The leaves and stems are attacked. | | The leaves become yellow and die. | Reduced, and causes yield loss. | |

## BACTERIA

| Extent | | | Organs affected | | Type of losses | | |
|---|---|---|---|---|---|---|---|
| Onion | Shallot | Garlic | Leaves and stems | Roots and bulbs | Number of plants | Bulb size | Bulb quality |
| **Soft rot (*Erwinia carotovora subsp. carotovora*)** | | | | | | | |
| +++ | +++ | +++ | | The bulbs are attacked. The bacterium enters the mature bulb through the crown (injuries or crown not closed) | The plants can sometimes die. | | The bulbs rot most frequently during storage, causing quality loss. |
| **Bulb rot (*Burkholderia cepacia*)** | | | | | | | |
| +++ | +++ | +++ | The leaves and bulbs are attacked. | | | | The bulbs rot during storage, causing losses. |

## INSECTS

| Extent | | | Organs affected | | Type of losses | | |
|---|---|---|---|---|---|---|---|
| Onion | Shallot | Garlic | Leaves and stems | Roots and bulbs | Number of plants | Bulb size | Bulb quality |
| **Thrips (*Thrips tabaci*, *Frankliniella* spp.)** | | | | | | | |
| +++ | +++ | +++ | Thrips pierce the leaves to feed. | The bulbs are also invaded by the larvae which live between the scales. | The plants wither if heavily infested. Thrips are vectors of several viruses (*Tomato spotted wilt virus and Irish yellow leaf spot*); they encourage the development of Stemphylium leaf blight and purple blotch. | It is often reduced, which causes yield losses. | The rotting of infested bulbs in storage due to the combined action of thrips and secondary pathogens cause significant losses. |
| **Armyworm (*Spodoptera exigua*)** | | | | | | | |
| ++ | ++ | ++ | The caterpillars cut the leaves and dig holes in them. | | An invasion of *Spodoptera* at the beginning of the season can cause a significant reduction in the number of plants. | | |

## 2.2. Damage identification

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

### FUNGI

#### Purple blotch (*Alternaria porri*)

The first symptoms appear on the leaves or the scape. They are formed of small damp lesions. The lesions grow and turn brown in the centre with concentric circles. They become crimson as they become larger. Several lesions can join together and cover the entire leaf which withers. Purple blotch lesions are surrounded by a yellowish halo. They turn black when colonised by secondary parasites.

Purple blotch symptoms

#### Stemphylium leaf blight *(Stemphylium vesicarium)*

The symptoms appear on the leaves and scapes exposed to the wind. They can easily be confused with purple blotch symptoms. At the beginning they are formed of small damp spots which elongate and become oval or taper. Their centre then turns slightly brownish with concentric circles. Several lesions can join together. The grouped lesions make the field look scorched. The lesions become olive-green or black after fructification of the fungus.

Stemphylium leaf blight lesions

#### Fusarium basal rot *(Fusarium oxysporum f.sp. cepae)*

The fungus penetrates the roots or the base of the plant directly and colonises the basal plate. The roots then turn brownish, but never pink. The above-ground symptoms resemble those of pink rot; a yellowing of the leaves that starts at the tip and works its way to towards the base.
The basal plate and the entire bulb will rot during storage. Whitish filaments (fungal mycelia) can be seen at the base of the plant.
The fungus causes crimson or reddish lesions on garlic.

Foliar symptoms of Fusarium basal rot

Symptoms on a stored bulb, with whitish filaments at the base of the bulb.

## Botrytis leaf blight *(Botrytis squamosa)*

The fungus forms elliptical flecks with a necrotic centre on the leaves. The lesions are initially surrounded by a pale halo which can disappear once the lesions expand. In very damp conditions, the lesions expand and group together, giving the leaves (or the entire field) a scorched appearance.

Onion leaf blight caused by *Botrytis squamosa*.

## Downy mildew (*Peronospora destructor*)

The symptoms consist of pale or whitish, elongated or oval spots on the leaves and the scape. These lesions are covered in a crimson down which is visible in the morning if humidity is high. The infected leaves become pale then yellow. The tips of the leaves shrivel. The lesions become much larger, sometimes up to 30 cm long, and encircle the leaf, the stem or the scape. The whole of the upper part of the plant may then collapse.

Downy mildew symptoms. Note the down on the leaf surface.

## Pink root rot (*Phoma terrestris*)

The roots become brown at first, then pink. They are very fragile and die. The infection does not reach the basal plate.
The above-ground symptoms are yellowing leaves, starting at the tip and moving towards the base (decrease). The entire above-ground part can wither. The symptoms on the above-ground parts are similar to those of the basal plate rot caused by *F. oxysporum* f.sp. *cepae*. The roots have to be observed, to distinguish between the two diseases in the field.

Infected shallot roots

## White rot (*Sclerotium cepivorum*)

The disease is rarely distributed uniformly in the field; isolated groups of plants are attacked. The infected plants are stunted, their leaves turn prematurely yellow and they die suddenly. Cottony filaments and (brown and black) sclerotia of the fungus are found at the base of the dead plants. The sclerotia are round, the size of poppy seeds.

Black sclerotia and *S. cepivorum mycelium* on onion bulbs.

## Anthracnose (*Colletotrichum circinians*)

Deep black lesions (stromata) appear on the external scales, usually in concentric circles. The internal scales are not affected.

Anthracnose lesions (*stromata*) on onion bulb.

## Rust (*Puccinia porri*)

The symptoms appear as small, whitish oval spots on the leaves and stem. Later, when the fungus starts to produce spores, the pustules become reddish or orange, and turn black towards the end of the season. The pustules grow and encircle the leaf or stem. The parts above this circle turn yellow and die.

Pustules and uredospores (note the red colour) on onion leaves infected by *P. porri.*

## BACTERIA

### Soft rot (*Erwinia carotovora subsp carotovora*)

The infected scales appear pale yellow at first, then brown or grey, but moist. The scales then become sticky and 'collapse'. The bulb fills with liquid and releases a nauseating smell. A spout comes out of both ends when the bulb is squeezed.

Bulb rot.

Symptoms on plants.

### Bulb rot (*Burkholderia cepacia*)

The infected leaves droop (yellowing and gradual death from the tip towards the base). The scales corresponding to the infected leaves rot whilst the adjacent ones seem healthy; the bulb neck is generally soft but the bulb seems normal.
The infected scales turn yellowish or slightly brown and produce a viscous substance.

Symptoms on bulbs; the infected scales correspond to the infected leaves.

## INSECTS

### Thrips (*Thrips tabaci*, *Frankliniella* spp.)

The infestation very frequently starts on field borders. The leaves have silvery marks corresponding to the places pierced by the thrips who feed in colonies. As the leaf develops, these marks form more or less elongated whitish spots or stripes. Major infestations cause leaves to wither, especially during warm, dry weather. Small black dots, which are thrip droppings, can be seen. With a magnifying glass, it is easy to observe the thrip adults and larvae (which hide at the base of the plants between the leaf sheaths).

Damage to leaves.

Adult onion thrip.

Onion thrip larvae.

### Armyworm (*Spodoptera exigua*)

Attacks by the genus *Spodoptera* on onions, garlic and shallots take place mainly at the plant's early stages. The caterpillars are gregarious and devour the leaves by cutting them. They often dig holes and enter the tubular leaves; they always leave castings on the plant. Mature caterpillars can measure 30 mm in length. They measure about 5 mm on hatching and are a greenish or yellowish colour. Pale stripes appear on the back during the third stage. The dorsal surface becomes dark at the fourth stage and black lateral stripes appear. The mature caterpillars (fifth stage) vary in colour. The dorsal surface can be black or dark green with black spots; the ventral surface is yellow or pink; the flanks have white lateral stripes. A large breathing hole is to be found on the front part, surrounded by a whitish stripe. The caterpillars often have black spots on the back. The adult is 10-14 mm long. The wings are brown-grey, striped with dark lines with two yellowish brown spots. The female lays clutches of eggs on the plants. These egg masses are covered in scales and silk.

Adult.


Caterpillars with black spots on the back.

Fourth or fifth stage larva.

## 2.3. Appearance of pests or diseases based on plant growth stages

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

| Stage | Stage duration | Pink root rot | Basal plate rot | Alternaria | Stemphylium | Mildew | Botrytis Leaf Blight | Rust | White rot | Anthracnose | Soft rot | Bulb rot | Thrips | Armyworm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Seed | / | | | | | | | | | | | | | |
| Sowing to emergence | 14 days | | | | | | | | | | | | | |
| Emergence to pricking out | 30-40 days | | | | | | | | | | | | | |
| Pricking out to bulb maturity | 100-120 days | | | | | | | | | | | | | |
| Bulb maturity to harvest | 2-3 weeks | | | | | | | | | | | | | |
| Storage | / | | | | | | | | | | | | | |

Periods during which pest or pathogenic agent is potentially present

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

## 2.4 Importance per country (or large agri-ecological areas): period of the year and climatic conditions favouring crop enemies

SCWA=Sahelian countries of West Africa (Burkina Faso, Niger, Mali, Senegal); CAM=Cameroon; CHA=Chad; NGR=Nigeria; ETH=Ethiopia; SUD=Sudan; UGA=Uganda; KEN=Kenya; TAN=Tanzania; RDC= Democratic Republic of Congo; ANG=Angola; CAR= Caribbean; MAL=Malawi; ZAM=Zambia; GHA=Ghana; MAD=Madagascar.

/ = no information
+ = limited damage
++ = average damage: control necessary
+++ = heavy damage: control essential

In Niger, Mali, Senegal, Chad, Burkina Faso, Northern Cameroon and Nigeria, alliums are mainly cultivated in the cool, dry season between October and March. The climatic conditions are not generally favourable to the development of foliar diseases during this period. There are nevertheless specific conditions and/or growing practices which are favourable to the development of certain foliar diseases (purple blotch and Stemphylium leaf blight) even in the dry season:

- The position of the field in areas where dew can form on the plants during the night (like the flatlands and the seaside).
- Spray irrigation in the late afternoon inducing the formation of dew on the plants.

Area under cultivation for onion, garlic and shallot are not important in the rainy season, which is the favourable time to foliar diseases.

Madagascar has several regions with specific climates, which is why alliums are grown all year round on the Main Island. There is little information on allium diseases in Africa. Pests can be found in tropical environments all year round. In countries with a long dry season, such as the Sahelian countries, the development of irrigation and the use of varieties that tolerate high temperatures have exacerbated the pressure of some pests. Note that normally in the tropics, temperature is rarely a limiting factor in insect development (unlike Northern countries). The presence or absence of water (rain or irrigation) is the most important factor for insect development.

N.B.: The inventory of pests and diseases has not been carried out exhaustively in all countries. Little is known currently on allium crop pests in Africa, including garlic. A pest can vary in significance from one area to another inside a same country. It is also possible that the pest or disease is present, but has never been seen in the country on the crop, as it does not do major damage.

***Alternaria porri* & *Stemphylium vesicarium***

**Favourable conditions:** rainy weather followed by intense sunshine, high relative humidity, leaves covered in dew for several hours and temperatures no more than 30°C.

| Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCWA | + | + | + | + | + | + | +++ | +++ | +++ | ++ | + | + |
| CAM | + | + | + | + | + | +++ | +++ | +++ | +++ | ++ | + | + |
| CHA | + | + | + | + | + | +++ | +++ | +++ | +++ | ++ | + | + |
| NGR | + | + | + | + | + | + | +++ | +++ | +++ | ++ | + | + |
| ETH | / | / | / | / | / | / | / | / | / | / | / | / |
| SUD | / | / | / | / | / | / | / | / | / | / | / | / |
| UGA | / | / | / | / | / | / | / | / | / | / | / | / |
| KEN | +++ | +++ | +++ | ++ | +++ | +++ | ++ | ++ | ++ | ++ | ++ | +++ |
| TAN | +++ | +++ | +++ | +++ | +++ | +++ | ++ | ++ | ++ | ++ | ++ | +++ |
| RDC | + | + | + | + | + | + | + | + | + | + | + | + |
| ANG | / | / | / | / | / | / | / | / | / | / | / | / |
| CAR | / | / | / | / | / | / | / | / | / | / | / | / |
| MAL/ZAM | / | / | / | / | / | / | / | / | / | / | / | / |
| GHA | + | + | + | + | + | + | + | + | + | + | + | + |
| MAD | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ |

## Basal rot (*Fusarium oxysporum* f.sp. *cepae*)

**Favourable conditions:** soils that remain damp for a long time, with temperatures of more than 25°C.

| Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PSAO | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ |
| CAM | + | + | + | + | + | + | + | + | + | + | + | + |
| TCH | / | / | / | / | / | / | / | / | / | / | / | / |
| NGR | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ |
| ETH | / | / | / | / | / | / | / | / | / | / | / | / |
| SOU | / | / | / | / | / | / | / | / | / | / | / | / |
| OUG | / | / | / | / | / | / | / | / | / | / | / | / |
| KEN | + | + | + | + | + | + | + | + | + | + | + | + |
| TAN | + | + | + | + | + | + | + | + | + | + | + | + |
| RDC | + | + | + | + | + | + | + | + | + | + | + | + |
| ANG | / | / | / | / | / | / | / | / | / | / | / | / |
| CAR | / | / | / | / | / | / | / | / | / | / | / | / |
| MAL/ZAM | / | / | / | / | / | / | / | / | / | / | / | / |
| GHA | + | + | + | + | + | + | + | + | + | + | + | + |
| MAD | + | + | + | + | + | + | + | + | + | + | + | + |

## Botrytis Leaf Blight (*Botrytis squamosa*)

**Favourable conditions:** rainy weather followed by intense sunshine, high relative humidity, leaves covered in dew for several hours and temperatures no more than 30°C.

| Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCWA | + | + | + | + | + | + | + | + | + | + | + | + |
| CAM | + | + | + | + | + | + | + | + | + | + | + | + |
| CHA | + | + | + | + | + | + | + | + | + | + | + | + |
| NGR | + | + | + | + | + | + | + | + | + | + | + | + |
| ETH | / | / | / | / | / | / | / | / | / | / | / | / |
| SUD | / | / | / | / | / | / | / | / | / | / | / | / |
| UGA | / | / | / | / | / | / | / | / | / | / | / | / |
| KEN | + | + | + | + | + | + | + | + | + | + | + | + |
| TAN | + | + | + | + | + | + | + | + | + | + | + | + |
| RDC | + | + | + | + | + | + | + | + | + | + | + | + |
| ANG | / | / | / | / | / | / | / | / | / | / | / | / |
| CAR | / | / | / | / | / | / | / | / | / | / | / | / |
| MAL/ZAM | / | / | / | / | / | / | / | / | / | / | / | / |
| GHA | + | + | + | + | + | + | + | + | + | + | + | + |
| MAD | + | + | + | + | + | + | + | + | + | + | + | + |

## Mildew (*Peronospora destructor*)

**Favourable conditions:** the disease is encouraged by low temperatures (< 22°C), rainy weather or long dews, with high relative humidity (≥ 95%). In the tropics, mildew is found in high altitude areas where it is cool.

| Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCWA | + | + | + | + | + | + | + | + | + | + | + | + |
| CAM | + | + | + | + | + | + | + | + | + | + | + | + |
| CHA | + | + | + | + | + | + | + | + | + | + | + | + |
| NGR | + | + | + | + | + | + | +++ | +++ | +++ | ++ | + | + |
| ETH | / | / | / | / | / | / | / | / | / | / | / | / |
| SUD | / | / | / | / | / | / | / | / | / | / | / | / |
| UGA | / | / | / | / | / | / | / | / | / | / | / | / |
| KEN | + | + | + | + | + | + | + | + | + | + | + | + |
| TAN | + | + | + | + | + | + | + | + | + | + | + | + |
| RDC | +++ | +++ | +++ | +++ | + | + | + | + | + | + | + | +++ |
| ANG | / | / | / | / | / | / | / | / | / | / | / | / |
| CAR | / | / | / | / | / | / | / | / | / | / | / | / |
| MAL/ZAM | / | / | / | / | / | / | / | / | / | / | / | / |
| GHA | +++ | +++ | +++ | + | + | + | + | + | + | + | + | + |
| MAD | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ |

## Pink root rot (*Phoma terrestris*)

**Favourable conditions:** when the soil is infested and the alliums are planted, the disease can develop at any time as long as the soil temperature is more than 20°C. The resistance genes are 'ineffective' when the soil temperatures are high (≥ 29°C).

| Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCWA | ++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | ++ | ++ |
| CAM | ++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | ++ | ++ |
| CHA | ++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | ++ | ++ |
| NGR | ++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | ++ | ++ |
| ETH | / | / | / | / | / | / | / | / | / | / | / | / |
| SUD | ++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | ++ | ++ |
| UGA | / | / | / | / | / | / | / | / | / | / | / | / |
| KEN | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ |
| TAN | + | + | + | + | + | + | + | + | + | + | + | + |
| RDC | + | + | + | + | + | + | + | + | + | + | + | + |
| ANG | / | / | / | / | / | / | / | / | / | / | / | / |
| CAR | / | / | / | / | / | / | / | / | / | / | / | / |
| MAL/ZAM | / | / | / | / | / | / | / | / | / | / | / | / |
| GHA | + | + | + | + | + | + | + | + | + | + | + | + |
| MAD | + | + | + | + | + | + | + | + | + | + | + | + |

**White rot (*Sclerotiorum cepivorum*)**

**Favourable conditions:** low soil temperatures (14-18°C) encourage the germination of sclerotia and trigger the disease.

| Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCWA | + | + | + | + | + | + | + | + | + | + | + | + |
| CAM | + | + | + | + | + | + | + | + | + | + | + | + |
| CHA | + | + | + | + | + | + | + | + | + | + | + | + |
| NGR | + | + | + | + | + | + | + | + | + | + | + | + |
| ETH | / | / | / | / | / | / | / | / | / | / | / | / |
| SUD | / | / | / | / | / | / | / | / | / | / | / | / |
| UGA | / | / | / | / | / | / | / | / | / | / | / | / |
| KEN | + | + | + | + | + | + | + | + | + | + | + | + |
| TAN | + | + | + | + | + | + | + | + | + | + | + | + |
| RDC | + | + | + | + | + | + | + | + | + | + | + | + |
| ANG | / | / | / | / | / | / | / | / | / | / | / | / |
| CAR | / | / | / | / | / | / | / | / | / | / | / | / |
| MAL/ZAM | / | / | / | / | / | / | / | / | / | / | / | / |
| GHA | + | + | + | + | + | + | + | + | + | + | + | + |
| MAD | + | + | + | + | + | + | + | + | + | + | + | + |

**Anthracnose (*Colletotrichum circinans*)**

**Favourable conditions:** the disease is encouraged to develop by soils kept damp, with temperatures between 13 et 35°C.

| Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCWA | + | + | + | + | + | + | + | + | + | + | + | + |
| CAM | + | + | + | + | + | + | + | + | + | + | + | + |
| CHA | + | + | + | + | + | + | + | + | + | + | + | + |
| NGR | + | + | + | + | + | + | + | + | + | + | + | + |
| ETH | / | / | / | / | / | / | / | / | / | / | / | / |
| SUD | / | / | / | / | / | / | / | / | / | / | / | / |
| UGA | / | / | / | / | / | / | / | / | / | / | / | / |
| KEN | + | + | + | + | + | + | + | + | + | + | + | + |
| TAN | + | + | + | + | + | + | + | + | + | + | + | + |
| RDC | + | + | + | + | + | + | + | + | + | + | + | + |
| ANG | / | / | / | / | / | / | / | / | / | / | / | / |
| CAR | / | / | / | / | / | / | / | / | / | / | / | / |
| MAL/ZAM | / | / | / | / | / | / | / | / | / | / | / | / |
| GHA | + | + | + | + | + | + | + | + | + | + | + | + |
| MAD | + | + | + | + | + | + | + | + | + | + | + | + |

**Rust (*Puccinia Porri*)**

**Favourable conditions:** non-rainy weather combined with a high relative humidity (≥ 97%) for at least four hours and temperatures between 10 et 24°C.

| Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PSAO | + | + | + | + | + | + | + | + | + | + | + | + |
| CAM | + | + | + | + | + | + | + | + | + | + | + | + |
| TCH | + | + | + | + | + | + | + | + | + | + | + | + |
| NGR | + | + | + | + | + | + | +++ | +++ | +++ | ++ | + | + |
| ETH | / | / | / | / | / | / | / | / | / | / | / | / |
| SOU | / | / | / | / | / | / | / | / | / | / | / | / |
| OUG | / | / | / | / | / | / | / | / | / | / | / | / |
| KEN | + | + | + | + | + | + | + | + | + | + | + | + |
| TAN | + | + | + | + | + | + | + | + | + | + | + | + |
| RDC | +++ | +++ | +++ | +++ | + | + | + | + | + | + | + | +++ |
| ANG | / | / | / | / | / | / | / | / | / | / | / | / |
| CAR | / | / | / | / | / | / | / | / | / | / | / | / |
| MAL/ZAM | / | / | / | / | / | / | / | / | / | / | / | / |
| GHA | +++ | +++ | +++ | + | + | + | + | + | + | + | + | + |
| MAD | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ |

**Soft rot (*Erwinia carotovora subsp. carotovora*)**

**Favourable conditions:** injuries caused to bulbs during harvest and poor storage conditions (uncontrolled temperatures over 0°C and lack of ventilation).

| Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PSAO | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | ++ | ++ |
| CAM | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | ++ | ++ |
| TCH | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | ++ | ++ |
| NGR | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | ++ | ++ |
| ETH | / | / | / | / | / | / | / | / | / | / | / | / |
| SOU | / | / | / | / | / | / | / | / | / | / | / | / |
| OUG | / | / | / | / | / | / | / | / | / | / | / | / |
| KEN | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ |
| TAN | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ |
| RDC | + | + | + | + | + | + | + | + | + | + | + | + |
| ANG | / | / | / | / | / | / | / | / | / | / | / | / |
| CAR | / | / | / | / | / | / | / | / | / | / | / | / |
| MAL/ZAM | / | / | / | / | / | / | / | / | / | / | / | / |
| GHA | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ |
| MAD | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ |

N.B.: Soft bulb rot is certainly prevalent in all countries without exception.

**Bulb rot (*Burkholderia cepacia*)**

**Favourable conditions:** temperatures over 30°C and poor storage conditions (uncontrolled temperatures and lack of ventilation).

| Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| All countries | / | / | / | / | / | / | / | / | / | / | / | / |

N.B.: This disease is certainly prevalent in all countries; however, it may be confused with soft bulb rot which is very well known.

**Thrips (*Thrips tabaci*, *Frankliniella* spp.)**

**Conditions favorables:** thrips develop when the environment is dry and warm.

| Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PSAO | ++ | +++ | +++ | +++ | +++ | +++ | + | + | ++ | ++ | ++ | ++ |
| CAM | ++ | +++ | +++ | +++ | +++ | +++ | + | + | ++ | ++ | ++ | ++ |
| TCH | ++ | +++ | +++ | +++ | +++ | +++ | + | + | ++ | ++ | ++ | ++ |
| NGR | ++ | +++ | +++ | +++ | +++ | +++ | + | + | ++ | ++ | ++ | ++ |
| ETH | / | / | / | / | / | / | / | / | / | / | / | / |
| SOU | / | / | / | / | / | / | / | / | / | / | / | / |
| OUG | / | / | / | / | / | / | / | / | / | / | / | / |
| KEN | ++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | ++ | ++ | ++ |
| TAN | ++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | ++ | ++ | ++ |
| RDC | + | + | +++ | +++ | +++ | +++ | +++ | +++ | + | + | + | + |
| ANG | / | / | / | / | / | / | / | / | / | / | / | / |
| CAR | / | / | / | / | / | / | / | / | / | / | / | / |
| MAL/ZAM | / | / | / | / | / | / | / | / | / | / | / | / |
| GHA | / | / | / | / | / | / | / | / | / | / | / | / |
| MAD | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ |

**Armyworm (*Spodoptera exigua*)**

**Favourable conditions:** it is found all year round in tropical countries.

| Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PSAO | + | + | + | + | + | +++ | + | + | + | +++ | +++ | +++ |
| CAM | + | + | + | + | + | +++ | + | + | + | +++ | +++ | +++ |
| TCH | + | + | + | + | + | +++ | + | + | + | +++ | +++ | +++ |
| NGR | + | + | + | + | + | +++ | + | + | + | +++ | +++ | +++ |
| ETH | / | / | / | / | / | / | / | / | / | / | / | / |
| SOU | / | / | / | / | / | / | / | / | / | / | / | / |
| OUG | / | / | / | / | / | / | / | / | / | / | / | / |
| KEN | + | + | + | + | + | +++ | + | + | + | + | +++ | ++ |
| TAN | + | + | + | + | + | +++ | + | + | + | + | +++ | +++ |
| RDC | ++ | ++ | +++ | +++ | +++ | +++ | +++ | +++ | ++ | ++ | ++ | ++ |
| ANG | / | / | / | / | / | / | / | / | / | / | / | / |
| CAR | / | / | / | / | / | / | / | / | / | / | / | / |
| MAL/ZAM | / | / | / | / | / | / | / | / | / | / | / | / |
| GHA | + | + | + | + | + | + | + | + | + | + | + | + |
| MAD | + | + | + | + | + | + | + | + | + | + | + | + |

# 3. Main control methods

## 3.1 Introduction

Onions, shallots and garlic are three alliums grown primarily for their bulbs. The onion is the only crop which produces seeds. Shallots and garlic are propagated from bulbs. There are however some varieties of shallot which produce flowers and seeds, but their use is still very limited (they are not used for commercial production).

The onion is a biennial plant. The first year, the 'mother' bulbs are produced from seed. These bulbs are planted in the second year to produce the seeds. Nevertheless, a few plants can be seen to flower in the first year (early flowering). A good commercial onion variety must have a very low early flowering rate (10% at most). Early flowering encourages the development of bulb rot, as the crown is not closed, representing a gateway for the secondary pathogens.

In practical terms, the shallot differs from the onion, in that it produces several bulbs to the onion's single bulb. Shallots are mainly grown in damp regions where it may prove difficult to store onions. It is important to realise that all these crops respond to the photoperiod: the formation of bulbs is totally dependent on the length of the day. Onions are therefore classed as long-day, short-day and intermediate onions. Only short-day onions are grown in West Africa, for example.

The same growing techniques are used for onions, shallots and garlic.

Alliums prefer loamy soil with good drainage and a neutral pH (6.5-7.0). The pH must be raised by a lime- or chalk-based additive if the soil is acid. Alliums are demanding in terms of nutrients. The farmer must provide an adequate input of mineral fertilisers. In general, all the phosphate is applied as bottom dressing. Nitrogen and potassium are, on the other hand, applied in fractions. It is highly inadvisable to plant or sow before the fertilisers have broken down fully: they must be spread uniformly and incorporated into the soil when the field is being prepared. It is extremely important to control weeds both in and around the fields, given their potential harm and the fact that they represent centres of infection (diseases) and infestation (pests).

The plants need a lot of water during the period when bulbs form and grow. Any form of hydric stress during this period will have a negative effect on yields. Prostrate stems and leaves indicate that the bulbs are mature. It is recommended to stop irrigating when 50% of the plants are prostrate. The bulbs must be dried for two to three weeks after harvesting, before storing them. The storage shed must be cool, well ventilated, clean and disinfected.

### General comments on disease and pest management

The same diseases and pests are found more or less in all three crops. Thrips are the insects which cause the most damage, whilst pink root rot is the most damaging disease. Purple blotch also causes major damage in damp regions. Certain diseases are much more frequent in cold or temperate regions, for example white rot (*S. cepivorum*) and mildew (*P. destructor*).

Any disease and pest control programme must take account of four essential components:

1. The correct identification of the disease or pest. Indeed, effective control methods for one pest can prove totally ineffective for another.
2. Regular monitoring of fields to identify the pests present and their population levels. Monitoring also includes recording other parameters such as the type of fertilisers/pesticides and the dose used, the previous crop, the variety planted, the diseases appearing in past seasons and monitoring climatic conditions. Meteorology is a major factor in disease development. Disease forecasting is mainly based on the following factors: rain, temperature, how long the dew lasts, relative humidity and period of sunshine.
3. Decision-making, which must be based on intervention thresholds depending on the crop development stage.
4. Control methods: when it is decided to act, the specific methods to be used must be chosen. There must be a coherent control programme that takes account of the profitability of the production and the agroecosystem. An ideal control programme must be able to become part of the production system without endangering the sustainability and profitability of the system. There are several actions that can be combined coherently (the appropriate measures for each case are specified in the following section):

- Choice of the variety: this is a basic action by the grower. A good variety must be tolerant or resistant to one or more major diseases in the area, with a high yield potential. Varietal resistance is one of the least expensive control methods, both for the farmer and for the environment.
- Sowing date: it can influence the development of certain diseases and insects.
- The use of certified seeds, especially for vegetatively propagated plants such as shallots and garlic. This certification can slow down the propagation of several diseases, including systemic infections, such as diseases caused by viruses. The use of vigorous seed can help control damping-off.
- Crop rotation reduces the residual population of a pest. It plays a vital role in the control of several fungi and insects which attack alliums. Rotation also re-establishes soil fertility.
- Protecting nurseries: it is always advisable to set up nurseries away from old fields and on healthy soil. Nursery sowing can be in cells or boxes filled with pasteurised compost. If sowing directly into the ground, the soil can be pasteurised by burning straw on boards or by solarisation using transparent plastic. The ground must also drain well. This avoids damping off and several other diseases. Success in the nursery dictates how the entire season unfolds. When the young plants have emerged, the nurseries must be protected from insects, diseases and sunlight by using screens and applying plant protection products.
- Other growing techniques, which almost all have an impact on the diseases or pests. Weeding the fields and surrounding areas will eliminate sources of infection or infestation formed by the weeds. Destroying harvest residues before sowing is an important measure, as is letting the organic matter decompose before sowing, thus reducing potential infection by several soil pathogens linked to an abundance of non-decomposed organic matter. Proper fertilisation of the soil is essential: too few or too many certain fertilising elements can prove detrimental. Plant nutrition must be suitable/balanced.
- Apply Plant Protection Products, if necessary. There is no positive resistance for certain diseases or pests, and Plant Protection Products therefore remain the main control method. They can quickly reduce a major pest population to a non-harmful level.
- Seed treatment: this is an inexpensive technique which protects the seedlings and gives an optimum density of plants in the field.

## 3.2. Pest or disease cycle ; positionning of control methods and factors influencing the development of the cycle

Indicated below are the applicable control methods for the development stages of each pest or disease and the effects of natural factors, other than climate, indicated in part 1.4 of this guide. The ranking of control methods in relation to the life cycle of the plant is then indicated.

For the insects, an illustration of their biological cycles has been provided. The cycle illustrations represent the various development stages, but they cannot under any circumstances be used as a means of identifying pests or diseases. Please refer to part 1.2 of this guide for the identification.

The control methods for diseases are described in the tables. The second column in the table gives the actions to be undertaken to control the various development stages of the disease indicated in the first column. In the second column, 'growing practice' actions are in green boxes and 'Plant Protection Product application' actions are in orange boxes:

- Growing practice
- Plant Protection Product application

The third column shows the crop stage, during which these actions should be planned.

## PINK ROOT ROT DISEASES (*PHOMA TERRESTRIS*; SYN.: *PYRENOCHAETA TERRESTRIS*)

Factors favourable to the development of the disease

Use of non-vigorous seeds, lack of water, unbalanced soil fertilisation, compact and poorly-drained soils are factors favourable to the disease. Although the pathogen has a large number of hosts (over forty), pink root rot is much more severe when onions are grown as a single crop. The fungus survives in the soil, plant debris or roots of host plants in the form of spores, microsclerotia or mycelium. It is virtually impossible to eradicate this fungus once the soil has been contaminated.

Major control measures

- If possible, the production season must be shifted to the cool periods in the year. Resistant varieties and healthy and vigorous seedlings and seed must be used (treating seeds or the soil with a fungicide has never been effective).
- The solarisation of the soil during the hottest periods of the year can sanitise the soil. Combining solarisation with a fumigant is more effective than just solarisation or just fumigation.
- Crop rotation (four to six years) can reduce the inoculum present in the soil and/or the infectivity of the pathogen. The inclusion in the rotation of tall cereal crops such as maize must be avoided; barley, however, is recommended.
- The soil must be ploughed to make it loose and ideal for root growth. The plants must be thoroughly irrigated and well fertilised.

**Ranking of control methods in relation to the life cycle**

| Fungus development stage | Action to be undertaken | Crop development stages | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Preparing the nursery substrate and environment | Sowing | Preparing the soil for pricking out | Pricking out | Vegetative phase: pricking out to bulb maturity | Harvest | Post-harvest period |
| Survival of the pathogen | Crop rotation with non-host plants for four to six years | | | | | | | X |
| | Heat pasteurisation of the substrate: solarisation of the soil for four to eight weeks with plastic film during the hottest periods of the year. | X | | X | | | | X |
| | If possible, combine solarisation with a fumigant such as metham sodium | X | | X | | | | X |
| Contact with the plant | Move the sowing date towards the coolest seasons of the year (soil temperature < 28°C) | | X | | X | | | |
| Penetration | Use certified seeds or healthy and vigorous seedlings for pricking out | | X | | X | | | |
| Plant colonisation | Cultivate and apply a bottom dressing | | | X | | | | |
| | Suitable irrigation and fertilisation in vegetative phase | | | | | X | | |
| | Use of resistant varieties | | X | | X | | | |
| | Incorporation of *Trichoderma* spp. into the soil | | | X | | | | |

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

## BASAL PLATE ROT (*F. OXYSPORUM* F.SP. *CEPAE*)

Factors favourable to the development of the disease

The fungus lives in the soil; it survives by producing chlamydospores which are structures resistant to extreme climatic conditions. The presence of soil insects causing injuries increases the incidence of the disease. Poor ventilation in the storage sheds encourages bulb rot.

Major control measures

- The use of resistant varieties is the best control measure.
- Soaking mother bulbs or seedlings in a fungicide solution before sowing or pricking out reduces the incidence of the disease.
- Good ventilation of storage sheds.
- Control of soil insects and nematodes which favour entrance of the fungus in the plant.

**Ranking of control methods in relation to the life cycle**

| Fungus development stage | Action to be undertaken | Crop development stages | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Preparing the nursery substrate and environment | Sowing | Preparing the soil for pricking out | Pricking out | Vegetative phase: pricking out to bulb maturity | Harvest | Post-harvest period |
| Survival of the pathogen | Crop rotation with non-host plants for four years | | | | | | | X |
| | Destruction of harvest debris by deep ploughing | | | | | | | X |
| | Heat pasteurisation of the substrate (solarisation of the soil during hot periods) | X | | X | | | | X |
| Contact with the plant and germination | Use of vigorous, certified seeds | | X | | | | | |
| | Soak the cloves (garlic), mother bulbs (onions, shallots) or transplants in a fungicide solution | | | | X | | | |
| Development on the plant | Use of resistant varieties if available | | X | | X | | | |
| | Store the onion bulbs at a temperature close to 4°C and ventilate the store well | | | | | | | X |
| | Good irrigation and fertilisation to encourage rapid root growth | | | X | | | | |

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

## PURPLE BLOTCH (*ALTERNARIA PORRI*) AND STEMPHYLIUM LEAF BLIGHT (*STEMPHYLIUM VESICARIUM*)

Factors favourable to the development of the disease

Stress caused by or lack of water or nitrogen makes the plants vulnerable to the disease. The injuries caused by strong winds carrying grains of sand, and by thrips that pierce the surface of leaves, make it easier for the fungus to get a hold. The spores are dispersed by the wind.

Major control measures

No commercial variety appears to have a high resistance level against purple blotch and Stemphylium leaf blight. Growing techniques and chemical control remain the only alternatives.

- The field must be well drained to discourage the formation of dew.

The effectiveness of the rotation must be tested, as the spores can be carried by the wind over long distances.

**Ranking of control methods in relation to the life cycle**

| Fungus development stage | Action to be undertaken | Crop development stages | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Preparing the nursery substrate and environment | Sowing | Preparing the soil for pricking out | Pricking out | Vegetative phase: pricking out to bulb maturity | Harvest | Post-harvest period |
| Survival of the fungus | Destruction of the harvest residues | | | | | | | X |
| | Rotation with plants that do not belong to the *Alliaceae* family | | | | | | | X |
| Germination and penetration | Plant preferably in the dry season; if possible, avoid flatlands where there is extensive dew | | X | | X | | | |
| | Use vigorous/certified seeds or transplants | | X | | X | | | |
| | Use seeds or transplants treated with a suitable fungicide | | X | | X | | | |
| | Irrigate before the afternoon to prevent dew forming on the leaves. Use drip irrigation | | | | | X | | |
| | Control the thrips (see section on thrips) | | | | | X | | |
| Development on the plant and sporulation | Monitor the field. As soon as the first symptoms appear, start a fungicide spraying programme. Rotate products to avoid the emergence of resistant strains | | | | | X | | |
| | Fertilise the plants to keep them vigorous and to avoid early ageing of leaves | | | | | X | | |

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

## MILDEW (*PERONOSPORA DESTRUCTOR*)

Conditions favourable to the development of the disease

The pathogen survives in the infected bulbs left in the field, the perennial alliums and the harvest residues. The spores are produced at night and are disseminated in the morning by the wind. The disease has a short cycle – eleven to fifteen days; mildew can therefore quickly cause severe problems.

Major control measures

There are no mildew-resistant varieties. It is controlled by growing methods and chemical methods:

- Offsetting the sowing date to avoid period favourable to the disease.
- Separation in time and space between the old and new fields.
- The use of certified seeds.
- Not using (potentially) infected bulbs to produce seedlings.
- Moderate use of nitrogen.
- Destruction of plants and weeds in the *Alliaceae* family and destruction of the harvest residues.
- Crop rotation for two to four years with plants not belonging to the *Alliaceae* family.
- Monitoring the field to detect the first symptoms and then instigating a fungicide application programme.

**Ranking of control methods in relation to the life cycle**

| Fungus development stage | Action to be undertaken | Crop development stages | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Preparing the nursery substrate and environment | Sowing | Preparing the soil for pricking out | Pricking out | Vegetative phase: pricking out to bulb maturity | Harvest | Post-harvest period |
| Survival of the fungus | Destruction of harvest residues, self-seeding and volunteer *allium* plants | | | | | | | X |
| | Crop rotation for two to five years with plants not belonging to the *Alliaceae* family. | | | X | | | | |
| Dispersion, contact | Establish the nurseries and new fields away from the old ones | X | | X | | | | |
| | Remove and burn the seemingly infected seedlings | | | | X | X | | |
| Germination, penetration and sporulation | Use vigorous/certified seeds or transplants | | X | | X | | | |
| | Use seeds or transplants treated with a suitable fungicide | | X | | X | | | |
| | If possible, plant when the temperature is > 25°C | | X | | X | | | |
| | Plant on well-drained land and avoid excessive water | | X | | X | X | | |
| | Do not surround the field with wind-breakers and remove weeds in the surrounding fields to avoid dew | | | | | X | | |
| | Use corrugation or drip irrigation | | | | | X | | |
| Development in the plant | Avoid excessive fertilisers, especially nitrogen, which makes the leaves vulnerable to attack from the pathogen | | | | | X | | |
| | Monitor the field constantly. Commence a fungicide application programme as soon as the first symptoms appear at the tips of leaves; alternate the active substances to avoid the emergence of resistant strains. Contact fungicides must be applied at eight- to ten-day intervals and repeated after a rainfall. Prefer treatment equipment with a hollow cone nozzle that can cover the entire plant. | | | | | X | | |

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

## BOTRYTIS LEAF BLIGHT (*BOTRYTIS SQUAMOSA*)

Conditions favourable to the development of the disease

The fungus survives in plant debris and the soil in the form of sclerotia or mycelium. Continuous cultivation of alliums increases the inoculum level of soils. An epidemic can quickly develop, as the disease is polycyclic.

Major control measures

There is no commercial variety resistant to Botrytis squamosa. The most suitable control method is still spraying fungicides. Rotation reduces the inoculum load.

**Ranking of control methods in relation to the life cycle**

| Fungus development stage | Action to be undertaken | Crop development stages | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Preparing the nursery substrate and environment | Sowing | Preparing the soil for pricking out | Pricking out | Vegetative phase: pricking out to bulb maturity | Harvest | Post-harvest period |
| Survival of the fungus | Destruction of harvest residues and self-seeding allium plants | | | | | | | X |
| | Crop rotation of one to two years | | | | | | | X |
| Dispersion, contact | Establish the nurseries and new fields away from the old ones | | X | | X | | | |
| Germination and penetration | Use vigorous/certified seeds or transplants | | X | | X | | | |
| | Use seeds or transplants treated with a suitable fungicide | | X | | X | | | |
| | Avoid high densities when sowing, so that air can circulate between the plants | | | | X | | | |
| Development on the plant | Monitor the field. Apply a fungicide spraying programme if the weather is rainy or if the dew lasts more than six hours | | | | X | | | |

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

## RUST (*PUCCINIA PORRI*)

Conditions favourable to the development of the disease

The fungus survives in the form of teliospores or uredospores in the onion, garlic or other allium plants, which are the main sources of infection.

Major control measures

No resistant variety is known. The only alternatives are growing methods and the use of fungicides:

- Crop rotation (two to four years) with plants not belonging to the Alliaceae family.
- Weeding in allium crops.
- Monitoring fields to detect the first symptoms and applying fungicides.

**Ranking of control methods in relation to the life cycle**

| Fungus development stage | Action to be undertaken | Crop development stages | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Preparing the nursery substrate and environment | Sowing | Preparing the soil for pricking out | Pricking out | Vegetative phase: pricking out to bulb maturity | Harvest | Post-harvest period |
| Survival of the fungus | Destruction of harvest residues and self-seeding allium plants | | | | | | | X |
| | Crop rotation. | | | | | | | X |
| Contact with the plant | Keep onions, garlic and shallots away from leeks | | | | X | | | |
| Germination and penetration | Use vigorous/certified seeds or transplants | | X | | X | | | |
| | Use seeds or transplants treated with a suitable fungicide | | X | | X | | | |
| Development on the plant | Treat the nurseries with a suitable fungicide | | | | X | | | |
| | Monitor the field. If the relative humidity is very high (97% for four hours) and the first pustules have been observed, start the fungicide application programme (maneb, zineb, etc.) | | | | | X | | |

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

## ONION SMUDGE (*COLLETOTRICHUM CIRCINANS*)

Conditions favourable to the development of the disease

It is a soil pathogen which only attacks white onions. The fungus survives in the soil on scale debris or as a saprophyte. It can live in the soil for several years.

Major control measures

Only the red and yellow varieties are resistant to the disease; using them is the main control method.

**Ranking of control methods in relation to the life cycle**

| Fungus development stage | Action to be undertaken | Crop development stages | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Preparing the nursery substrate and environment | Sowing | Preparing the soil for pricking out | Pricking out | Vegetative phase: pricking out to bulb maturity | Harvest | Post-harvest period |
| Survival of the fungus | Destruction of the harvest residues | | | | | | | X |
| Germination and development in the plant | Plant the red/yellow onions in the infested soils and the white onions in the healthy soils | | X | | X | | | |

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

## WHITE ROT (*SCLEROTIORUM CEPIVORUM*)

Conditions favourable to the development of the disease

The pathogen survives in the form of sclerotia which can remain in the soil for twenty years. Sclerotia germination is stimulated by substances containing sulphur emitted by the host plants.

Major control measures

No resistant variety to this disease is known. The main control method is to avoid planting in an infested field. It is strongly advisable to destroy all harvest residues and to prohibit soil or plants from being transported away from an infested field. Chemical treatments are used.

**Ranking of control methods in relation to the life cycle**

| Fungus development stage | Action to be undertaken | Crop development stages | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Preparing the nursery substrate and environment | Sowing | Preparing the soil for pricking out | Pricking out | Vegetative phase: pricking out to bulb maturity | Harvest | Post-harvest period |
| Survival of the fungus | Destruction of the harvest residues | | | | | | | X |
| | Solarisation of the soil during hot periods of the year with incorporation of plant residues from the crucifer family | X | | X | | | | |
| | Combine fumigation with solarisation/incorporation of residues | X | | X | | | | |
| | Treat the garlic cloves or mother onion or shallot bulbs with hot water (115°C) to kill the sclerotia | | X | | X | | | |
| | Induce suicidal germination of sclerotia by incorporating allium plant extracts or residues in the soil when the temperature is favourable to germination of sclerotia and in the absence of any host plant | | | | | | | |
| Dispersion | Do not transport harvest residues or soil away from infested fields. Clean all work tools before entering another field | X | X | X | X | X | X | X |
| Contact with the plant and germination | Avoid planting on an infested plot | | X | | X | | | |
| | Plant when temperatures are above 25°C | | X | | X | | | |
| Development on the plant | Treat the soil with a fungicide | | X | | X | | | |
| | Incorporate a biopesticide based on *Trichoderma* spp. or *Coniothyrium minitans* into the soil | | | X | | | | |

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

Relevance

The effectiveness of biopesticides must be tested and validated, for the soil environment plays a major role in the survival and success of the organisms introduced.

The effectiveness of suicidal germination by incorporating garlic extracts or onion residues must also be tested and validated.

## SOFT BULB ROT (*ERWINIA CAROTOVORA* SUBSP. *CAROTOVORA*)

Conditions favourable to the development of the disease

The injuries caused during the harvest, spray irrigation or heavy rain after bulb maturity and infestation of bulbs by soil insects are factors that encourage infection.

Major control measures

There are no resistant varieties to E. *Carotovora* subsp. *Carotovora*. It is therefore important to:

- Harvest when the plants are prostrate.
- Stop irrigating once the plants have reached maturity.
- Avoid injuring the bulbs during harvest.
- Dry the bulbs well before storing them.
- Store bulbs at 0°C and 70% relative humidity. The shed must be ventilated and kept clean; if possible, disinfect the shed before storing the bulbs.

**Ranking of control methods in relation to the life cycle**

| Bacterium development stage | Action to be undertaken | Crop development stages | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Preparing the nursery substrate and environment | Sowing | Preparing the soil for pricking out | Pricking out | Vegetative phase: pricking out to bulb maturity | Harvest | Post-harvest period |
| Contact with the bacterium | Use varieties with a low rate of early flowering (≤ 10%) | | X | | X | | | |
| | Let the above-ground parts lie prostrate before harvest; in this way, the bulb neck is closed and the bacteria cannot penetrate | | | | | X | X | |
| | Stop irrigating when 50% of the plants are prostrate | | | | | X | X | |
| | Avoid injuring the bulbs during harvest | | | | | X | X | |
| | Dry the bulbs before storing them | | | | | | | X |
| | Avoid excessive nitrogen which makes the plants sensitive | | | | | | | |
| Development on the plant | Store the bulbs in a well-ventilated location and at a temperature of no more than 3°C | | | | | | | X |

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

## BULB ROT (*BURKHOLDERIA CEPACIA*)

Conditions favourable to the development of the disease

This bacterium attacks both plants and humans (such as mucoviscidosis patients). The bacterium lives in the soil and in water courses. Spray irrigation using contaminated water and rains accompanied by high winds are the main dissemination methods for the bacterium. Mechanical injuries (especially at the crown) when tending the field or during harvest is the bacterium's main way in. The plants become more sensitive after the bulb initiation stage. An excessive use of nitrogen also makes the plants more sensitive. When the leaf is infected, the bacterium can propagate in the plant and reach the bulb.

**Ranking of control methods in relation to the life cycle**

| Bacterium development stage | Action to be undertaken | Crop development stages | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Preparing the nursery substrate and environment | Sowing | Preparing the soil for pricking out | Pricking out | Vegetative phase: pricking out to bulb maturity | Harvest | Post-harvest period |
| Survival | Rotation for at least three years with small cereals like barley or other crops. Avoid using maize | | | | | | | X |
| Dispersion, contact | Use corrugation or drip irrigation. Do not use wastewater for irrigation. Stop irrigating when 50% of the plants are prostrate | | | | | X | | |
| Penetration | Harvest when the bulbs reach maturity (more than 50% of plants are prostrate) | | | | | | X | |
| | Avoid applying too much nitrogen | X | | X | | X | | |

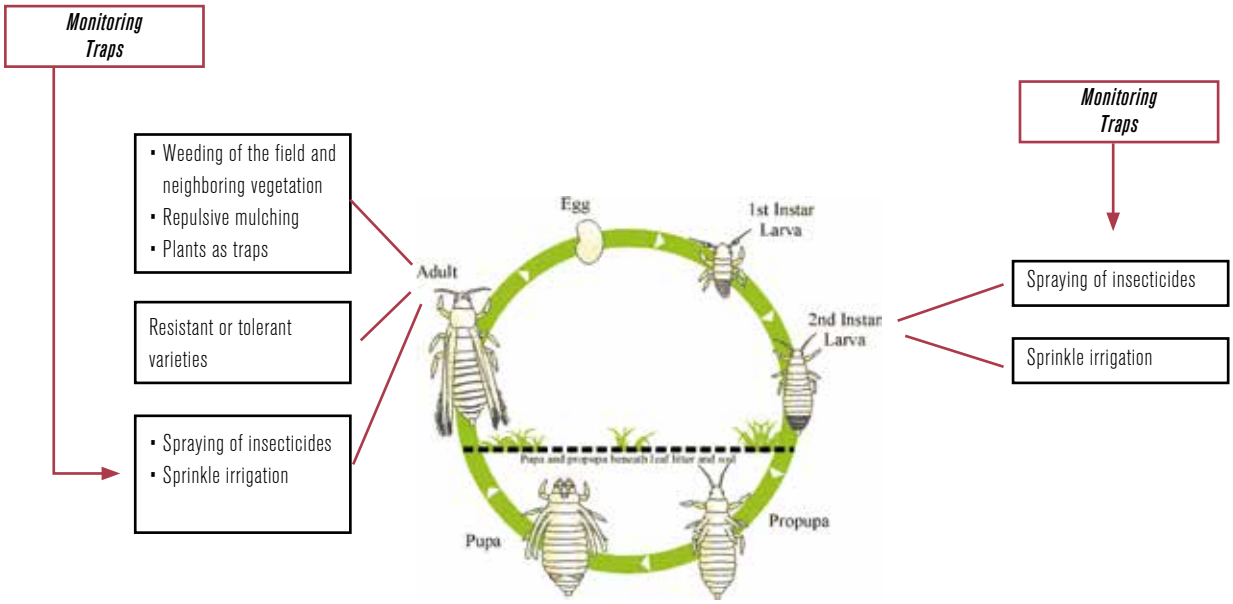
X = action to be taken at the cultivation stage shown in the corresponding column

## THRIPS (*THRIPS TABACI, FRANKLINIELLA* SPP.)

Thrips are small, elongated insects (generally 1 to 2 mm long). They attack numerous wild and cultivated plant species belonging to several families. They tend to develop more in hot, dry weather. The first infestations are almost always seen along field borders. Failure to remove weeds on plots and their surrounding areas encourages the infestation of fields from weeds and other self-seeding plants. Although winged, the adults are more usually carried by the wind and land on the crops. The females lay the eggs inside the plant's tissues. The nymphs have four development stages before reaching adulthood: stage I and II nymphs, prepupae and pupae. A generation lasts two to three weeks, depending on the temperature. There can therefore be several generations in any one season. Thrips populations can thus rapidly reach damage-potential thresholds if no control measure is taken. The damage is caused by the stage I and II nymphs and the adults. The prepupae and pupae develop in the soil at the base of plants.

Thrips have several natural enemies (bugs, beetles, predatory mites, spiders, hoverfly larvae, etc.). However, early in the season, these beneficial insects do not manage to keep the thrip population down, as the stages I and II nymphs are protected: they settle between the leaf sheaths at the base of the plants or in the leaf folds. Rain is a major factor in thrip mortality for adults, pupae and prepupae alike.

**Positionnement des méthodes de lutte par rapport au cycle du ravageur**




**Biological cycle of thrips**

Définition des termes en anglais

| Anglais | Français |
|---|---|
| Adult | Adulte |
| Egg | Œuf |
| 1st instar larva | Larve de 1er Stade |
| 2nd Instar larva | Larve de 2ème stade |
| Prepupa | Prépupe |
| Pupa | Pupe |

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

### * Nurseries

- Install nurseries away from old fields.
- Monitor the nurseries and treat (with an insecticide) as soon as thrips are seen.

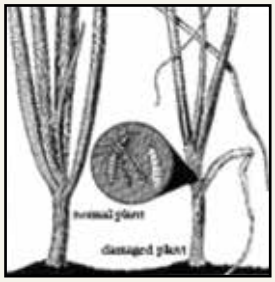
### * Fields

These measures are valid for the entire growing period:

- Remove weeds in the field and surrounding areas, as they provide refuge for the thrips.
- Use a tolerant/resistant variety if possible.
- Install repellents in the field.
- Use trap cropping.
- Monitor the field constantly during the entire production period. Take samples to determine the number of thrips per plant. For example, take five to ten plants at random from four different locations and count the number of thrips on each plant. If the average number of thrips per plant is above the treatment threshold defined for your location, spray with an insecticide. Insecticides are only justified when the thrip population reaches the intervention threshold. Resistance to pesticides is a serious problem. Use different families of insecticides (with different modes of action) in rotation to avoid developing resistance. Good coverage of the base of plants ensures that the treatment is effective.
- Use spray irrigation to clean the plants of adult thrips.

### Where do you look for thrips?

It is important to know where to find the thrips to estimate their population correctly. Most stage I and II nymphs live between the leaf sheaths which are intertwined at the base of the plant. The image below shows where most nymphs are found:




### Validity and relevance to be verified in local conditions.

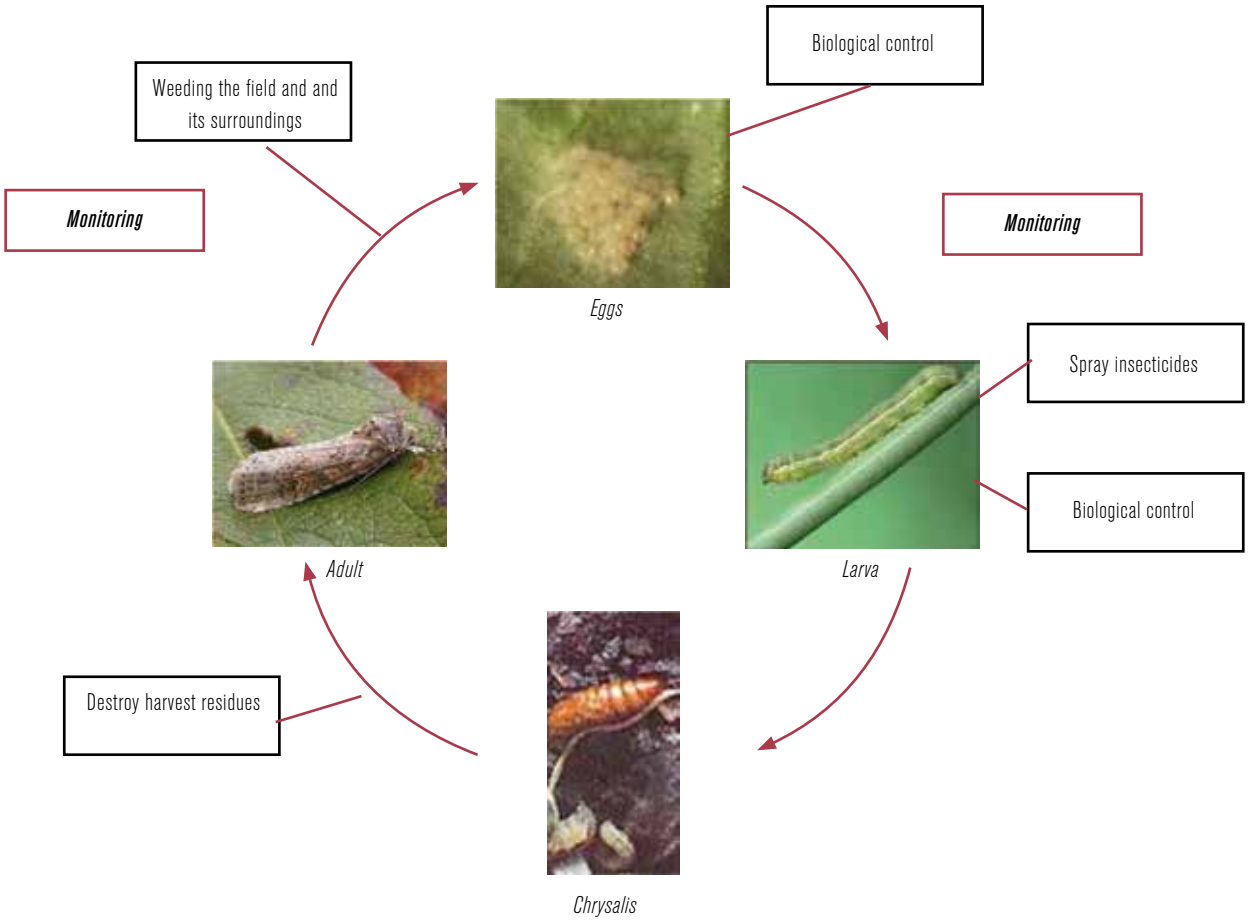
Spray irrigation can be effective, but it can encourage the development of foliar diseases. A holistic approach to plant protection is recommended, as there is never a lone enemy on the plant and the method for controlling one enemy can encourage the emergence of another.

The use of repellents and trap crops to control thrips and the practice of using garlic and hot pepper extracts is not very widespread on the whole, although several people mention these methods.

## BEET ARMYWORM (*SPODOPTERA EXIGUA*)

The adult lays eggs in a clump on the plants in the field but most frequently in the grass surrounding the crops. A single female can lay one thousand eggs during her lifetime. The eggs hatch two to three days after laying. The young caterpillars then disperse through the fields. The damage is much greater early in the season when the plants are young. There is little damage to old plants. The larva (or caterpillar) moults five times before turning into a chrysalis. The larval stage lasts approximately two weeks. Pupation takes place in the soil and lasts about seventeen days.
There can be several generations in the tropics. The adults migrate from hot regions to colder countries in April and May.

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




**Cycle of *S. exigua***

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

Start of season

- Weed the field and its surroundings to reduce the number of caterpillars entering the field.
- Monitor the field and its surroundings. Shake the plants to make the young caterpillars drop off so that they can be seen. Pheromone or luminous traps can be used to monitor changes in adult populations.
- In large holdings, sexual pheromones can be used to prevent Spodoptera from mating.
- Spray a plant protection product when the number of caterpillars or adults reaches the intervention threshold. Only the young caterpillars are sensitive to the protection products, which makes early detection essential.

During the season

Damage is often minimal. Generally, therefore, there is no need to intervene. However, the harvest residues must be destroyed at the end of the season.

## 3.3. Resistant or tolerant varieties

Varietal resistance is an ideal method for controlling diseases and pests. Even if the resistance level is not very high, it can reduce the cost of control measures (such as the number of pesticide sprayings).

It is impossible to list all the resistant varieties to the diseases and insects affecting onions, shallots and garlic. Note that only resistant varieties of onions seem to be known (this is perhaps due to the difficulty in improving garlic/shallot varieties by hybridisation).

List of a few resistant varieties:

| CROPS | | | Fusarium | Pink root rot | Thrips |
|---|---|---|---|---|---|
| Shallot | Garlic | Onion | | | |
| | - | Texas Early Grano 502 | 0 | + | - |
| - | - | Milky way (F 1) | 0 | + | - |
| - | - | Alabaster (F1) | 0 | + | - |
| - | - | Cometa (F1) | + | + | - |
| - | - | Excel1104 (F1) | 0 | + | - |
| - | - | Granero F1 | 0 | + | - |
| - | - | Yaakar (F1) | - | - | + |
| - | - | Texas Grano | - | - | + |
| - | - | Md Guadeloupe(F1) | - | - | + |
| - | - | Oignon Md Gelma (F1) | - | - | + |
| - | - | Md Campo Lindo (F1) | - | - | + |
| - | - | Constanza (F1) | + | - | + |

+ means that the variety is resistant, 0 means a lack of resistance and - is not known.

There are no varieties resistant to *Botrytis squamosa, Alternaria porri, Puccinia porri, Stemphylium vesicarium, Sclerotium cepivorum, Erwinia carotovora subsp. carotovora, Burkholderia cepacia* or *Spodoptera exigua*. All red and yellow onion varieties are resistant to *Colletotrichum circinans*.

NB: the fact that a variety is reported as resistant in one locality does not necessary imply that it will be resistant elsewhere. The resistance is always determined in relation to the dominant strain of the pathogen in a given region. Before a variety is broadcast, its resistance to local strains of the pathogen must therefore always be tested for confirmation.

## 3.4 Advantage and use of beneficial insects

Most pests have natural enemies which control their populations. The abusive use of broad-spectrum synthetic pesticides also decimates the natural enemy populations. Thus certain minor pests can become a serious problem. Using beneficial insects can maintain the balance of the ecological system, reduce the number of pesticide applications (and related costs), reduce the potential emergence of resistant strains to the active substances and keep the environment, humans and animals healthy. Any beneficial insect which adapts well to its new conditions can provide a lasting solution to a problem.

*Spodoptera exigua* has several so-called parasitoid enemies: the hymenoptera *Chelonus insularis, Cotesia marginiventris* and *Meteorus autographae* and the *diptera Lespsia archippivora*. Other enemies (predators) attack the eggs and/or the young caterpillars: *Orius* spp., *Geocoris* spp., *Nabis* spp. and *Podisus maculiventris. Erynia* sp. and *Nomurea rileyi* are fungi that attack the larvae. The nuclear polyhedrosis virus and the bacterium *Bacillus thuringiensis* are major factors in caterpillar mortality.

# 4. Monitoring the plant health of crops and intervention thresholds

Timely detection of diseases and pests is one of the keys to a successful control programme. This early detection means that the grower has time to prepare, treat at the correct moment and thus avoid yield losses. Unfortunately, there is not yet a pest development forecast model for most diseases (and insects). The growers must therefore monitor their fields regularly, be capable of identifying the most significant diseases and pests for their crops (directly or indirectly via their symptoms) and pay attention to the weather conditions. They must then judge whether or not the intervention threshold has been reached.

The intervention thresholds are usually defined by the research institutions. They are based on several factors, including the environment, the variety (sensitive, tolerant or resistant?), the plant's growth stage (a foliar disease at the end of the cultivation cycle has no effect on the yield) and the plant organ attacked.

The intervention thresholds given below are an indication only. The producer must consult the technical supervisors in his locality for further information. In general, note that there is no real intervention threshold for diseases. The disease control measures are more preventive.

### Purple blotch (*A. porri*) and Stemphylium leaf blight (S. *vesicarium*)

Both these diseases generally become apparent in rainy weather, high relative humidity or when there is dew. The grower must monitor the field to detect the first symptoms. The disease can be controlled in its early stages. The threshold is normally the presence of symptoms when the conditions are favourable to fungi.

### Basal rot *(F. oxysporum* f.sp. *cepae*)

There is no intervention threshold for basal rot. If a plot is liable to basal rot, the pathogen is in the field and can cause damage if a sensitive variety is grown.

### Pink root rot (*P. terrestris*)

There is no intervention threshold. The pathogen remains the soil for a very long time. The farmer has to move his sowing/pricking out date towards the cool seasons in the year and use the other protection measures quoted previously.

### Anthracnose (C. *circinans*)

This disease has no intervention threshold. If the soil is infested, the farmer must plant a red or yellow variety.

### White rot (*S. cepivorum*)

No intervention threshold has been defined for this disease.

### Rust (*P. porri*)

No threshold has been defined for this disease. The farmer must monitor his field by looking at the leaf tips to detect the first symptoms. If the environment is favourable to the disease (non-rainy weather accompanied by high relative humidity and temperatures no higher than 24°C), he must commence treatments with an appropriate fungicide.

### Botrytis Leaf Blight (*B. squamosa*)

Mathematical models can predict the development of the existing disease. Electronic programmes (*Botcast* and *Blight alert*) based on these models can determine the probability of sporulation and infection by *B. squamosa* and therefore the development of the disease depending on meteorological factors. As a result, they can judge whether or not spraying with a fungicide is necessary. The farmers who have computers can therefore use these programmes. For growers without these means, the fields must be monitored regularly to detect the first symptoms; given the 'explosive' nature of this disease in favourable weather, treatment must start rapidly.

### Downy mildew *(P. destructor*)

The forecasts are based on meteorological factors: if there is rain, if the dew lasts a long time, if the leaves remain damp for a long time, if the relative humidity is ≥ 95% and if the temperature is less than 20°C, then there is a very strong chance of infection. The downy mildew forecasting programme (*Downcast*) is also based on mathematical models which forecast the progress of the disease based on meteorological factors. The farmers who do not have many resources can rely on the daily weather bulletins in their regions (paying special attention to the cool and damp weather periods). They must also observe the fields to detect the first symptoms quickly.

### Bulb rot (*E. carotovora* subsp. *carotovora* and *B. cepacia*)

There is no intervention threshold for either of these bacterial diseases which are mainly storage diseases.

### Thrips

Thrips are cosmopolitan. Allium intervention thresholds vary from one country to the next and sometimes from one region to the next in the same country. The farmer must use the threshold defined by the agricultural research services in his region or country. For example, in California, the threshold is thirty thrips per plant for adult plants; the threshold at the start of the season is less than thirty individuals, but more than thirty thrips per plant at the end of the season. In Texas, the intervention threshold for the first plant protection treatment is 1 thrip per seedling; the threshold becomes five individuals per plant for adult plants.

The farmer must therefore monitor the thrip population. Blue or pink sticky traps can be used. Samples must also be taken from plants and the average number of thrips per plant counted, as explained earlier. An insecticide must be sprayed when the average number of thrips/plant is higher than or equal to the intervention threshold.

### Armyworm (*S. exigua*)

The intervention threshold for the onion is not known. But, on average, one caterpillar for five plants at the start of the season seems to indicate a severe infestation. The farmers must monitor their fields to detect the eggs or young larvae. Luminous or pheromone-based traps can be installed to note the changes in the adult population. A plant protection treatment should be applied when the caterpillars are young. Adult caterpillars are resistant to insecticides.

# 5 Active substances and treatment recommendations

## Introduction

For each pest or disease, proposals of the strategy for the use of Plant Protection Products (PPP) are indicated. Then a list of active substances or biocontrol agents is suggested and when available, the recommended critical GAP (Good Agricultural Practice) is also shown. Information given is about production of onions and shallots bulbs, and garlic gloves.

PHI (Pre Harvest Interval) are indicated to:
- either comply to EU MRL for production exported to EU;
- either comply to Codex MRL (for products consumed in countries referring to Codex MRLs);
- either produce without quantifiable residues and so to comply with private standards requiring « 0 » residues.

Any change in one or more elements of these GAPs (increase in the doses, frequency of application and number of applications, last application before harvest not respecting the recommended pre-harvest interval) can result in residues in excess of the MRL in force. These GAPs does not represent a treatment calendar to be applied as such. In practice, the frequency of treatments must take account locally of the severity of attacks and the real risks of damage.

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.

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

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, as well as the active substances' modes of action and effects on natural enemies.

Others products, not listed in the tables of this section due to lack of registration in ACP countries for these crops, are known to be effective; for instance :
- *Bacillus subtilis* to control *Botrytis squamosa*;
- *Trichoderma* sp. applied in the soil to control pink roots;
- *Coniothyrium minitans* applied in the soil 3 months before sowing/transplanting to control Sclerotinia rot.

Others substances act as a physical trap or repellent on some small insects and fungus and are not considered like conventional Plant Protection Products. For instance propylene glycol alginate, paraffin oil and maltodextrin can trap thrips when applied correctly.

Calcined kaolin can repel various insects, included thrips. Extract of Citrus can control various insects and fungus by dessicating their cuticule. These substances have no possible resistance and no residues of concern but one should check locally authorization for use on crops.

There are no risks of resistance or residues with substances liste before but one should check locally the authorisations for use on these crops.

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

In any case, it is important to read carefully pesticide's label prior to any phytosanitary treatment and / or consult officers from supervisory services in your area.

**Purple blotch & stemphylium blight (*Alternaria porri*, *Stemphylium vesicarium*)**

**Strategy:** Fields should be monitored regularly. From the appearance of first symptoms, a spraying program of fungicides should begin. Beyond that stage, it is almost impossible to control purple blotch or stemphylium blight. If conditions are favorable for disease development, it is recommended to spray every 7-10 days. It is important to make a rotation of fungicides or use mixtures of products with different modes of action (from different groups). A mixture, with one broad-spectrum substance (eg. mancozeb, chlorothalonil), is preferable.

| Active substance | Recommended GAP* | | | | | | Proposed application period | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Pre-harvest interval (days) | | | | | | | | |
| | Dose (g/ha) | Maximum number of applications | Minimum interval between application (days) | EU MRL | Codex MRL | LOQ** | Soil preparation | Sowing | Nursery | Trabsplanting | Vegetative phase | Flowering (oignon for seeds |
| **Group M – Multi site action fungicides (dithiocarbamates, chloronitriles and inorganics)** | | | | | | | | | | | | |
| Mancozeb1[1] | 1,600 | 4 | / | 28 onion and shallot<br>42 garlic | 20 onion | / | | | | ■ | ■ | ■ |
| Chlorothalonil | 1,000 | 2 | 7 | 14 | / | / | | | | ■ | ■ | |
| Copper hydroxyde (+ mancozeb)[1] | 2,500 | / | / | 20 | / | / | | | | ■ | ■ | |
| **Group 3 – DMI Fungicides (DeMethylation Inhibitors; sterol biosynthesis inhibitor)** | | | | | | | | | | | | |
| Difenoconazole | 125 | 4 | 7 | 14 | / | / | | | | ■ | ■ | |
| Tebuconazole | 250 | 4 | / | 14 onion<br>21 shallot | 14 onion | / | | | | ■ | ■ | |
| **Group 11 – QoI Fungicides (Quinone outside Inhibitors; respiration disruptor)** | | | | | | | | | | | | |
| Azoxystrobin | 250 | 3 | / | 14 | 14 | / | | | | ■ | ■ | |
| Trifloxystrobin (+ tebuconazole)[1] | / | 3 | / | 21 | 21 | 21 | | | | ■ | ■ | ■ |

1 mixtures are recommended. Formulations of such mixtures are sold under several trade names.

* the elements of the recommended GAP is the critical case that allow to meet the European MRL, the Codex MRL or the LOQ (cf. chapter 6 of this guide for value of MRLs). One should check on label of the product which dose fit to the targeted pest or disease.

** PHI based on the EU LOQ value.

/ elements of the recommended GAP not available.

## Basal plate rot (*Fusarium oxysporum* f.sp. *cepae*)

**Strategy:** Chemical treatments are generally ineffective for the control of this fungus. All the benzimidazole fungicides (eg. benomyl, carbendazim) can be used.

| Active substance | Recommended GAP* | | | | | | Proposed application period | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Pre-harvest interval (days) | | | | | | | | |
| | Dose (g/ha) | Maximum number of applications | Minimum interval between application (days) | EU MRL | Codex MRL | LOQ** | Soil preparation | Sowing | Nursery | Trabsplanting | Vegetative phase | Flowering (oignon for seeds |
| **Groupe 1 – Fongicides MBC (Méthyl Benzimidazole Carbamates; perturbateurs de la mitose/division cellulaire)** | | | | | | | | | | | | |
| Thiophanate-methyl | Soil application *** Seed tratment (2 g/ kg of seeds) Dipping of bulbs (630 g/100 litres) | 1 | n.a. | n.a. | n.a. | n.a. | | | | | | |
| Carbendazime | Solution at 0.1% | 1 | n.a. | n.a. | n.a. | n.a. | | | | | | |
| **Group M – Multi site action fungicides (dithiocarbamates, chloronitriles and inorganics)** | | | | | | | | | | | | |
| Thiram | Seed treatment : 2 g/kg of seeds | 1 | n.a. | n.a. | n.a. | n.a. | | | | | | |

* the elements of the recommended GAP is the critical case that allow to meet the European MRL, the Codex MRL or the LOQ (cf. chapter 6 of this guide for value of MRLs). One should check on label of the product which dose fit to the targeted pest or disease.

** PHI based on the EU LOQ value.

*** spot applicationat planting in the holes or the furrow of transplanting. The dose of a product at 70,4 % can be modulated from 2.5 kg/ha in case of medium or light pressure to 6 kg/ha in case of high pressure.

/ elements of the recommended GAP not available.

n.a. not applicable.

## Leaf blight (*Botrytis squamosa*)

**Strategy:** When the environment is favorable to the fungus, phytosanitary treatments must be started as soon as first symptoms are detected. If the environment is not too favorable, the time interval between two treatments can be lengthened. You have to rotate fungicides to reduce the risk of emergence of resistant strains. Bacillus subtilis should work to control this disease.

| Active substance | Recommended GAP* | | | | | | Proposed application period | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Pre-harvest interval (days) | | | | | | | | |
| | Dose (g/ha) | Maximum number of applications | Minimum interval between application (days) | EU MRL | Codex MRL | LOQ** | Soil preparation | Sowing | Nursery | Trabsplanting | Vegetative phase | Flowering (oignon for seeds |
| **Groupe M – Fongicides à activités multi-sites (dithiocarbamates, chloronitriles et inorganiques)** | | | | | | | | | | | | |
| Mancozeb1[1] | 1,600 | 4 | / | 28 onion and shallot 42 garlic | 20 onion | / | | | | ■ | ■ | ■ |
| Chlorothalonil | 1,000 | 2 | 7 | 14 | 14 onion | / | | | | ■ | ■ | ■ |
| Copper (hydroxyde) (+ mancozeb)[1] | 2,500 | / | / | 20 | / | / | | | | ■ | ■ | |
| **Group 11 – QoI Fungicides (Quinone outside Inhibitors; respiration disruptor)** | | | | | | | | | | | | |
| Azoxystrobin | Traitement de semence : 2 g/kg de semences | 250 | 3 | / | 14 | 14 | | | | ■ | ■ | |
| Trifloxystrobin (+ tebuconazole)[1] | Solution à 0,1 % | / | 3 | / | 21 | 21 | | | | ■ | ■ | ■ |
| **Group 1 – MBC Fungicides (Methyl Benzimidazole Carbamates; mitosis and cell division disruptor)** | | | | | | | | | | | | |
| Thiophanate-methyl | 700 | 2 | / | 28 | 28 | 28 | | | | ■ | ■ | |
| Carbendazim | 250 | 2 | / | 28 | 28 | 28 | | | | ■ | ■ | |
| **Group 3 – DMI Fungicides (DeMethylation Inhibitors; sterol biosynthesis inhibitor)** | | | | | | | | | | | | |
| Tebuconazole | 250 | 4 | / | 14 onion 21 shallot | 14 onion | / | | | | ■ | ■ | |

1 mixtures are recommended. Formulations of such mixtures are sold under several trade names.

* the elements of the recommended GAP is the critical case that allow to meet the European MRL, the Codex MRL or the LOQ (cf. chapter 6 of this guide for value of MRLs). One should check on label of the product which dose fit to the targeted pest or disease.

** PHI based on the EU LOQ value

/ elements of the recommended GAP not available.

## Downy mildew (*Peronospora destructor*)

**Strategy:** When the environment is favorable to the fungus, phytosanitary treatments must be started as soon as first symptoms are detected. You have to rotate fungicides or use formulations that contain a mixture of two products with different modes of action.

| Active substance | Recommended GAP* | | | | | | Proposed application period | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Pre-harvest interval (days) | | | | | | | | |
| | Dose (g/ha) | Maximum number of applications | Minimum interval between application (days) | EU MRL | Codex MRL | LOQ** | Soil preparation | Sowing | Nursery | Trabsplanting | Vegetative phase | Flowering (oignon for seeds |
| **Group M – Multi site action fungicides (dithiocarbamates, chloronitriles and inorganics)** | | | | | | | | | | | | |
| Mancozeb[1] | 1,600 | 4 | / | 28 onion and shallot<br>42 garlic | 20 onion | / | | | | ■ | ■ | ■ |
| Chlorothalonil | 1,000 | 2 | 7 | 14 | 14 onion | / | | | | ■ | ■ | ■ |
| Copper (hydroxyde) (+ mancozeb)[1] | 2,500 | / | / | 20 | / | / | | | | ■ | ■ | |
| Propineb (+ cymoxanil of the FRAC Group 27)[1] | 1,400 (+ 120) | / | 7 | 14 onion | 14 onion | / | | | | ■ | ■ | ■ |
| **Group 4 – PA Fungicides (PhenylAmides; disruptor of acid nucleic synthesis)** | | | | | | | | | | | | |
| Benalaxyl (+ mancozeb) [1] | 100 (+ 1,625) | 3 | / | 28 onion and shallot | 28 onion and shallot | / | | | | ■ | ■ | ■ |
| Mefenoxam (+ mancozeb)[1] | 100 (+ 1,600) | 3 | 7 | 14 onion and shallot<br>28 garlic | 14 onion<br>28 garlic and shallot | / | | | | ■ | ■ | ■ |
| **Group 33 – Phosphonates (unknown mode of action)** | | | | | | | | | | | | |
| Foséthyl-Al | 2,240 | / | / | 7 onion and garlic | / | / | | | | ■ | ■ | |
| **Group 11 – QoI Fungicides (Quinone outside Inhibitors; respiration disruptor)** | | | | | | | | | | | | |
| Azoxystrobine | 250 | 3 | / | 14 | 14 | / | | | | ■ | ■ | |
| Famoxadone (+ cymoxanil du Groupe 27 du FRAC) [1] | 90 (+ 120) | 4 | 7 | 28 | 28 | 28 | | | | ■ | ■ | ■ |
| Trifloxystrobine (+ tebuconazole) [1] | / | 3 | / | 21 | 21 | 21 | | | | ■ | ■ | ■ |

1 mixtures are recommended. Formulations of such mixtures are sold under several trade names.

* the elements of the recommended GAP is the critical case that allow to meet the European MRL, the Codex MRL or the LOQ (cf. chapter 6 of this guide for value of MRLs) One should check on label of the product which dose fit to the targeted pest or disease.

** PHI based on the EU LOQ value.

/ elements of the recommended GAP not available.

## Onion pink root disease (*Phoma terrestris*)

**Strategy:** Chemical treatments have generally been ineffective in controlling pink root disease. The severity of the disease can be reduced by treating the seeds. Seeds or bulbs (garlic) or transplants (onion and shallot) treatments are made by soaking in a solution of 1.5 to 2.0 ‰. Then they are dried on thin layer. For more information, thank you to consult the package label. Treatment of soil or seeds with Trichoderma sp. are known to control this disease.

| Active substance | Recommended GAP* | | | | | | Proposed application period | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dose (g/ha) | Maximum number of applications | Minimum interval between application (days) | Pre-harvest interval (days) | | | Soil preparation | Sowing | Nursery | Trabsplanting | Vegetative phase | Flowering (oignon for seeds) |
| | | | | EU MRL | Codex MRL | LOQ** | | | | | | |
| **Group 1 – MBC Fungicides (Methyl Benzimidazole Carbamates; mitosis and cell division disruptor)** | | | | | | | | | | | | |
| Thiophanate-methyl | Soil application *** Seed tratment (2 g/kg of seeds) Dipping of bulbs (630 g/100 litres) | 1 | n.a | Seed treatment or transplanting | | | ■ | ■ | ■ | ■ | | |
| **Group M – Multi site action fungicides (dithiocarbamates, chloronitriles and inorganics)** | | | | | | | | | | | | |
| Thiram | Seed treatment : 2 g/kg of seeds / | 1 | n.a. | Seed treatment | | | | ■ | | | | |

* the elements of the recommended GAP is the critical case that allow to meet the European MRL, the Codex MRL or the LOQ (cf. chapter 6 of this guide for value of MRLs). One should check on label of the product which dose fit to the targeted pest or disease.

** PHI based on the EU LOQ value.

*** spot applicationat planting in the holes or the furrow of transplanting. The dose of a product at 70,4 % can be modulated from 2.5 kg/ha in case of medium or light pressure to 6 kg/ha in case of high pressure.

/ elements of the recommended GAP not available.

n.a. not applicable.

## White rot (*Sclerotiorum cepivorum*)

**Strategy:** There are two possible strategies: (i) induce a "suicidal" germination of the fungus sclerotia by injecting some extracts of garlic or synthetic stimulants (diallyl sulfides) in the soil ; the application must be done 6 months before sowing or transplanting and in the absence of any host plant ; the incorporation of crop residues is also recommended (ii) treat seeds or bulbs or soil with a fungicide, then treat during the growth/vegetative phase. The application of the fungicide in the soil must be done in the sowing / transplanting furrow in a band of 10-15cm wide. During the growing season, 1-3 treatments will be carried out on average. Soil application of *Coniothyrium minitans* can control this disease.

| Active substance | Recommended GAP* | | | | | | Proposed application period | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Pre-harvest interval (days) | | | | | | | | |
| | Dose (g/ha) | Maximum number of applications | Minimum interval between application (days) | EU MRL | Codex MRL | LOQ** | Soil preparation | Sowing | Nursery | Trabsplanting | Vegetative phase | Flowering (oignon for seeds) |
| **Group 3 – DMI Fungicides (DeMethylation Inhibitors; sterol biosynthesis inhibitor)** | | | | | | | | | | | | |
| Tebuconazole | 250 | 4 | / | Oignon : 14<br>Echalote : 21 | Oignon : 14 | / | | | | ■ | ■ | |
| **Group 1 – MBC Fungicides (Methyl Benzimidazole Carbamates; mitosis and cell division disruptor)** | | | | | | | | | | | | |
| Thiophanate-methyl | Soil application ***<br>Seed tratment (2 g/kg of seeds)<br>Dipping of bulbs (630 g/100 litres) | 1 | n.a. | n.a. | n.a. | n.a. | ■ | ■ | ■ | ■ | | |
| Carbendazime | Solution at 0.1% | 1 | n.a. | n.a. | n.a. | n.a. | | | | ■ | | |

* the elements of the recommended GAP is the critical case that allow to meet the European MRL, the Codex MRL or the LOQ (cf. chapter 6 of this guide for value of MRLs). One should check on label of the product which dose fit to the targeted pest or disease.

** PHI based on the EU LOQ value.

*** spot applicationat planting in the holes or the furrow of transplanting. The dose of a product at 70,4 % can be modulated from 2.5 kg/ha in case of medium or light pressure to 6 kg/ha in case of high pressure.

/ elements of the recommended GAP not available.

n.a. not applicable.

## Rust (*Puccinia porri*)

**Strategy:** When the environment is favorable to the fungus, it is necessary to begin treatments as soon as the first symptoms are detected. If the environment is less favorable, the time interval between two treatments can be lengthened. It is important to rotate fungicides.

| Active substance | Recommended GAP* | | | | | | Proposed application period | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Pre-harvest interval (days) | | | | | | | | |
| | Dose (g/ha) | Maximum number of applications | Minimum interval between application (days) | EU MRL | Codex MRL | LOQ** | Soil preparation | Sowing | Nursery | Trabsplanting | Vegetative phase | Flowering (oignon for seeds) |
| **Group M – Multi site action fungicides (dithiocarbamates, chloronitriles and inorganics)** | | | | | | | | | | | | |
| Maneb | 1,600 | 4 | / | 28 onion and shallot 42 garlic | 20 onion | / | | | | ■ | ■ | |
| Mancozeb | 1,600 | 4 | / | 28 onion and shallot 42 garlic | 20 onion | / | | | | ■ | ■ | |
| Chlorothalonil | 1,000 | 2 | 7 | 14 | 14 onion | / | | | | ■ | ■ | |
| **Group 11 – QoI Fungicides (Quinone outside Inhibitors; respiration disruptor)** | | | | | | | | | | | | |
| Azoxystrobine | 250 | 3 | / | 14 | 14 | / | | | | ■ | ■ | |
| Trifloxystrobine (+ tebuconazole) [1] | / | 3 | / | 21 | 21 | 21 | | | | ■ | ■ | |
| **Group 3 – DMI Fungicides (DeMethylation Inhibitors; sterol biosynthesis inhibitor)** | | | | | | | | | | | | |
| Tébuconazole | 250 | 4 | 7 | 14 onion 21 shallot | 14 onion | / | | | | ■ | ■ | |
| Difénoconazole | 125 | 4 | 7 | 14 | / | / | | | | ■ | ■ | |
| Myclobutanil | / | / | / | / | / | / | | | ■ | | | |

1 mixtures are recommended. Formulations of such mixtures are sold under several trade names.

* the elements of the recommended GAP is the critical case that allow to meet the European MRL, the Codex MRL or the LOQ (cf. chapter 6 of this guide for value of MRLs). One should check on label of the product which dose fit to the targeted pest or disease.

** PHI based on the EU LOQ value.

/ elements of the recommended GAP not available.

## Thrips (*Thrips tabaci, Frankliniella* spp.)

**Strategy:** Monitor thrips population by the use of traps and by counting them on onion plants (the sample of plants of must be representative of the field). If the threshold is reached, apply a treatment.

| Active substance | Recommended GAP* | | | | | | Proposed application period | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Pre-harvest interval (days) | | | | | | | | |
| | Dose (g/ha) | Maximum number of applications | Minimum interval between application (days) | EU MRL | Codex MRL | LOQ** | Soil preparation | Sowing | Nursery | Trabsplanting | Vegetative phase | Flowering (oignon for seeds) |
| **Group 3 – Pyrethroids (sodium channel modulators)** | | | | | | | | | | | | |
| Alpha-cypermethrin | 40 | 2 | 7 | 14 | / | / | | | | ■ | ■ | |
| Beta-cyfluthrin | 15 | / | 7 | 21 | 21 | 21 | | | | ■ | ■ | |
| Bifenthrin | 20 | / | / | 14 | / | / | | | | ■ | ■ | |
| Cypermethrin | 50 | 2 | 7 | 14 | / | / | | | | ■ | ■ | |
| Deltamethrin | 12,5 | 3 | 7 | 7 | 14 | / | | | | ■ | ■ | |
| Etofenprox | 28 | / | / | 7 garlic<br>14 onion | / | / | | | | ■ | ■ | |
| Lambda-cyhalothrin | 10 | 3 | 10 | 7 | 7 | / | | | | ■ | ■ | |
| Pyrethrins | / | / | / | 7 onion and shallot | / | / | | | | ■ | ■ | |
| **Group 1 – Organophosphates (acetylcholine esterase inhibitor)** | | | | | | | | | | | | |
| Acephate | / | / | / | / | / | / | | | ■ | | | |
| Chlorpyriphos-methyl | 400 | / | / | 21 | 21 | 21 | | | ■ | ■ | ■ | |
| Dimethoate | 300 | 2 | / | 14 | 14 | 14 | | | ■ | ■ | ■ | |
| Malathion | 1,125 | / | / | / | 7 | / | | | ■ | ■ | ■ | |
| Methomyl | 450 | / | / | 14 onion and shallot | 7 onion | / | | | ■ | ■ | ■ | |
| **Group 5 – Spynosins** | | | | | | | | | | | | |
| Spinetoram | 72 | 2 | 7 | 7 | 7 | 7 | | | | ■ | ■ | |
| Spinosad | 96 | 2 | 7 | 7 onion and shallot | 7 onion | / | | | | ■ | ■ | |
| **Group 23 – Inhibitors of acetyl CoA carboxylase** | | | | | | | | | | | | |
| Spirotetramate | 75 | 4 | 7 | 14 onion and shallot | 14 onion | / | | | ■ | ■ | ■ | |
| **Group 6 – Avermectins** | | | | | | | | | | | | |
| Abamectin | 18 | 3 | 7 | 14 | 14 | 14 | | | | ■ | ■ | |
| **Group UN – Unknown or uncertain mode of action** | | | | | | | | | | | | |
| Neem extract (azadirachtin) | / | / | / | 7 | 7 | 7 | | | | ■ | ■ | |
| **Group 4 – Nicotinic Acetylcholine receptor agonists/antagonists** | | | | | | | | | | | | |
| Acetamiprid | 100 | 2 | 7 | 7 | 7 | 7 | | | ■ | ■ | ■ | |
| Imidacloprid | 78 | 3 | 7 | Oignon : 7 | Oignon : 7 | / | | | ■ | ■ | ■ | |
| Thiacloprid | 125 | 2 | 7 | 14 | 14 | 14 | | | ■ | ■ | ■ | |
| Thiamethoxam | 50 | 2 | 7 | / | / | / | | | ■ | | | |
| **Group 2 - GABA-gated chloride channel antagonists** | | | | | | | | | | | | |
| Fipronil | / | / | / | / | / | / | | | ■ | | | |
| **Not classified** | | | | | | | | | | | | |
| Oxymatrine | / | 3 | 7 | 7 | 7 | 7 | | | | ■ | ■ | |

* the elements of the recommended GAP is the critical case that allow to meet the European MRL, the Codex MRL or the LOQ (cf. chapter 6 of this guide for value of MRLs). One should check on label of the product which dose fit to the targeted pest or disease.

** PHI based on the EU LOQ value.

/ elements of the recommended GAP not available.

## Armyworm (*Spodoptera exigua*)

**Strategy:** Monitor the population of adults and inspect the plants to detect eggs or early stages larvae. The young larvae (1st and 2nd stages) are more sensitive to pesticides than the older caterpillars. At the beginning of culture and if the number of larvae is very high, a synthetic short-acting insecticide can be applied. For subsequent sprayings, a biopesticide or neem extracts can be used.

| Active substance | Recommended GAP* | | | | | | Proposed application period | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Pre-harvest interval (days) | | | | | | | | |
| | Dose (g/ha) | Maximum number of applications | Minimum interval between application (days) | EU MRL | Codex MRL | LOQ** | Soil preparation | Sowing | Nursery | Trabsplanting | Vegetative phase | Flowering (oignon for seeds) |
| **Groupe 3 – Pyréthrinoïdes (perturbateurs du canal sodique)** | | | | | | | | | | | | |
| Alpha-cypermethrin | 40 | 2 | 7 | 14 | / | / | | | | ■ | ■ | |
| Beta-cyfluthrin | 15 | / | 7 | 21 | 21 | 21 | | | | ■ | ■ | |
| Bifenthrin | 20 | / | / | 14 | / | / | | | | ■ | ■ | |
| Cypermethrin | 25 | 2 | 7 | 14 | / | / | | | | ■ | ■ | |
| Deltamethrin | 12.5 | 3 | / | 7 | 14 | / | | | | ■ | ■ | |
| Etofenprox | 28 | / | / | 7 garlic<br>14 onion | / | / | | | | ■ | ■ | |
| Lambda-cyhalothrin | 10 | 3 | 10 | 7 | 7 | / | | | | ■ | ■ | |
| Pyrethrins | / | / | / | 7 onion and shallot | / | / | | | | ■ | ■ | |
| **Group 5 – Spynosins** | | | | | | | | | | | | |
| Spinetoram | 72 | 2 | 7 | 7 | 7 | 7 | | | | ■ | ■ | |
| Spinosad | 96 | 2 | 7 | 7 onion and shallot | 7 onion | / | | | | ■ | ■ | |
| **Group 1 – Organophosphates (acetylcholine esterase inhibitor)** | | | | | | | | | | | | |
| Chlorpyrifos-methyl | 400 | / | / | 21 | 21 | 21 | | | | ■ | ■ | |
| **Group UN – Unknown or uncertain mode of action** | | | | | | | | | | | | |
| Neem extract (azadirachtin) | / | / | / | 7 | 7 | 7 | | | | ■ | ■ | |
| **Group 11 – Microbial disruptors of insect midgut membranes** | | | | | | | | | | | | |
| *Bacillus thuringiensis* | / | / | / | 7 | 7 | 7 | | | | ■ | ■ | |
| **Group 18 – Ecdysone receptor agonists** | | | | | | | | | | | | |
| Tebufenozide | 120 | / | / | / | / | / | | | ■ | | | |
| **Group 28 : Ryanodine receptor modulators** | | | | | | | | | | | | |
| Chlorantraniliprole | 25 | 4 | 7 | / | / | / | | | ■ | | | |
| **Not classified** | | | | | | | | | | | | |
| Oxymatrine | / | 3 | 7 | 7 | 7 | 7 | | | | ■ | ■ | |
| **Group 22 - Voltage-dependent sodium channel blockers** | | | | | | | | | | | | |
| Indoxacarbe | 37.5 | 3 | 7 | | | | | | ■ | | | |

* the elements of the recommended GAP is the critical case that allow to meet the European MRL, the Codex MRL or the LOQ (cf. chapter 6 of this guide for value of MRLs). One should check on label of the product which dose fit to the targeted pest or disease.

** PHI based on the EU LOQ value.

/ elements of the recommended GAP not available.

# 6. Existing registrations in ACP countries

**Remarks:** Since lists of registered products change, this information should be tallied with the legislation in force locally in each area of production.

As an example, in the tables below are listed the active substances which are included in products registered for use on vegetables or specifically on Allium, onion, shallot or garlic in Kenya, Côte d'Ivoire, Ghana, Ethiopia and by CSP (Sahelian Committee on Pesticides) for Burkina, Cabo Verde, Chad, Guinea-Bissau, Mali, Mauritania, Niger, Senegal, The Gambia.

## Insecticides

| Active substance | Kenya | CSP | Côte d'Ivoire | Ghana | Ethiopia |
|---|---|---|---|---|---|
| Abamectin | Vegetables - onions | Vegetables | Vegetables | Vegetables | / |
| Acetamiprid | Onions | Vegetables | Vegetables | Vegetables | / |
| Alpha-cypermethrin | Onions | / | / | Vegetables | / |
| Azadirachtin | / | / | / | / | Onions |
| Bacillus thuringiensis var. kurstaki | Vegetables | / | Vegetables | Vegetables | / |
| Beta-cyfluthrin | / | / | / | Vegetables | / |
| Bifenthrin | Vegetables | / | Vegetables | / | / |
| Chlorantraniliprole | / | All crops | / | / | / |
| Chlorpyrifos-methyl | / | Vegetables | / | / | / |
| Cypermethrin | Vegetables | Vegetables | Vegetables | Vegetables | / |
| Deltamethrin | Vegetables | / | Vegetables | Vegetables | / |
| Dimethoate | / | | / | Vegetables | / |
| Etofenprox | / | / | Vegetables | / | / |
| Imidacloprid | Onions | / | Vegetables | Vegetables | / |
| Indoxacarbe | / | / | Vegetables | / | / |
| Lambda-cyhalothrin | Vegetables | Vegetables | Vegetables | Vegetables | Onions |
| Malathion | Vegetables | / | Vegetables | / | / |
| Maltodextrin | / | / | / | Vegetables | / |
| Methomyl | Vegetables | Vegetables | / | / | / |
| Oxymatrine | / | / | / | Vegetables | / |
| Pyrethrin | Vegetables | / | / | / | / |
| Spinetoram | / | / | / | / | Onions |
| Spinosad | Vegetables | / | / | / | / |
| Spirotetramate | / | / | / | Vegetables | / |
| Thiacloprid | Vegetables | / | / | / | / |
| Thiamethoxam | Vegetables | / | Vegetables | Vegetables | / |
| Fipronil | / | / | / | Onions | / |
| Acephate | Onions | / | / | / | / |
| Tebufenozide | Onions | / | / | / | / |

## Fungicides

| Active substance | Kenya | CSP | Côte d'Ivoire | Ghana | Ethiopia |
|---|---|---|---|---|---|
| Azoxystrobine | / | Vegetables | Vegetable | Vegetable | / |
| Benalaxyl-M | Onions | / | / | / | / |
| Carbendazim | / | / | Vegetable | Vegetable | / |
| Chlorothalonil | / | / | Vegetable | / | / |
| Copper | Vegetables | / | Vegetable | Vegetable | / |
| Cymoxanil | Vegetables - Onions | / | / | / | / |
| Difenoconazole | / | / | / | Vegetable | / |
| Famoxadone | Onions | / | / | / | / |
| Fosetyl-Al | Onions | / | / | Vegetable | / |
| Mancozeb | Vegetables – Onions | Vegetables | Vegetable | Vegetable | Onions |
| Manèbe | / | / | Vegetable | Vegetable | / |
| Metalaxyl-M | Vegetables - onions | All crops (on seeds) | Vegetable | Vegetable | Onions |
| Myclobutanil | / | Vegetables | / | / | / |
| Propineb | Vegetables - onions | / | / | Vegetable | / |
| Tebuconazole | Vegetables | / | Vegetable | Vegetable | / |
| Thiophanate-methyl | / | / | / | Vegetable | / |
| Thiram | / | For seeds | / | For seeds | / |
| Trifloxystrobine | / | / | Vegetable | Vegetable | / |

# 7. Regulations and pesticides residues

**Status of the active substances in Regulation 1107/2009; European MRL and Codex MRL in February 2015**

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

| Active substance | European regulation | | | | Codex MRL (mg/kg) | | |
|---|---|---|---|---|---|---|---|
| | Status Reg 1107/2009 | EU MRL (mg/kg) | | | | | |
| | | Onion | Shallot | Garlic | Onion | Shallot | Garlic |
| Abamectin | Approved | 0.01* | 0.01* | 0.01* | / | / | / |
| Acephate | Not approved | 0.02* | 0.02* | 0.02* | / | / | / |
| Acetamiprid | Approved | 0.02 | 0.01* | 0.02 | 0.02 | / | 0.02 |
| Alpha-cypermethrin | Approved | 0.1 | 0.1 | 0.1 | 0.01* | / | / |
| Azadirachtin | Approved | 1 | 1 | 1 | / | / | / |
| *Azoxystrobin* | Approved | 10 | 10 | 10 | 10 | 10 | 10 |
| *Bacillus thuringiensis* var. *kurstaki* | Approved | / | / | / | / | | |
| Benalaxyl-M | Approved | 0.2 | 0.05* | 0.05* | 0.02* | / | / |
| Beta-cyfluthrin | Approved | 0.02* | 0.02* | 0.02* | / | / | / |
| Bifenthrin | Approved | 0.05* | 0.05* | 0.05* | / | / | / |
| Carbendazim | Not approved | 0.1* | 0.1* | 0.1* | / | / | / |
| Chlorantraniliprole | Approved | 0.01* | 0.01* | 0.01* | / | / | / |
| Chlorothalonil | Approved | 0.5 | 0.5 | 0.5 | 0.5 | / | / |
| Chlorpyrifos-methyl | Approved | 0.05* | 0.05* | 0.05* | / | / | / |
| Copper | Approved | 5 | 5 | 5 | / | / | / |
| Cymoxanil | Approved | 0.5 | 0.05* | 0.05* | | / | / |
| Cypermethrin | Approved | 0.1 | 0.1 | 0.1 | 0.01* | / | / |
| Deltamethrin | Approved | 0.1 | 0.1 | 0.1 | 0.05 | / | / |
| Difenoconazole | Approved | 0.5 | 0.5 | 0.5 | / | / | 0.02* |
| Dimethoate | Approved | 0.02* | 0.02* | 0.02* | / | / | / |
| Emamectin benzoate | Approved | 0.01* | 0.01* | 0.01* | / | / | / |
| Etofenprox | Approved | 0.5 | 0.5 | 0,01* | / | / | / |
| Famoxadone | Approved | 0.02* | 0.02* | 0.02* | / | / | / |
| Fipronil | Approved | 0.02 | 0.02 | 0.005* | / | / | / |
| Fosetyl-Al | Approved | 50 | 2 | 50 | / | / | / |
| Imidacloprid | Approved | 0.1 | 0.05* | 0.05* | 0.1 | / | / |
| Indoxacarbe | Approved | 0.02* | 0.02* | 0.02* | / | / | / |
| Lambda-cyhalothrin | Approved | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Malathion | Approved | 0.02* | 0.02* | 0.02* | 1 | / | / |
| Maltodextrin | Approved | NO MRL REQUIRED | | | / | / | / |
| Mancozeb | Approved | 1 | 1 | 0.6 | 0.5 | / | 0.5 |

*Non inclue dans l'Annexe 1 : les Etats membres de l'EU ont la possibilité de maintenir l'autorisation jusqu'au 31 décembre 2010.

| Active substance | European regulation | | | | Codex MRL (mg/kg) | | |
|---|---|---|---|---|---|---|---|
| | Status Reg 1107/2009 | EU MRL (mg/kg) | | | | | |
| | | Onion | Shallot | Garlic | Onion | Shallot | Garlic |
| Maneb | Approved | 1 | 1 | 0.6 | 0.5 | / | 0.5 |
| Mefenoxam (Metalaxyl-M) | Approved | 0.5 | 0.5 | 0.5 | 2 | / | / |
| Methomyl | Approved | 0.02* | 0.02* | 0.02* | 0.2 | / | / |
| Myclobutanyl | Approved | 0.02* | 0.02* | 0.02* | / | / | / |
| Oxymatrine | Not listed | / | / | / | / | / | / |
| Propineb | Approved | 1 | 1 | 0.6 | 0.5 | / | 0.5 |
| Pyrethrins | Approved | 1 | 1 | 1 | / | / | / |
| Spinetoram | Approved | 0.05* | 0.05* | 0.05* | 0.01* | / | / |
| Spinosad | Approved | 0.2 | 0.1 | 0.1 | 0.1 | / | / |
| Spirotetramat | Approved | 0.4 | 0.4 | 0.1 | 0.4 | / | / |
| Tebuconazole | Approved | 0.1 | 0.05 | 0.1 | 0.1 | / | / |
| Tebufenozide | Approved | 0.05* | 0.05* | 0.05* | / | / | / |
| Thiacloprid | Approved | 0.02* | 0.02* | 0.02* | / | / | / |
| Thiamethoxam | Approved | 0.1 | 0.05* | 0.05* | / | / | / |
| Thiophanate-methyl | Approved | 0.1* | 0.1* | 0.1* | 0.2 | / | / |
| Thiram | Approved | 1 | 1 | 0.6 | 0.5 | / | 0.5 |
| Trifloxystrobin | Approved | 0.02* | 0.02* | 0.02* | / | / | / |

L* = LOQ
/ MRL not set : in this case one can take the default 0.01 mg/kg MRL

### 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/pesticides/index_en.htm. Current status of active substances can be checked at http://ec.europa.eu/sanco_pesticides/public/index.cfm?event=activesubstance.selection&language=EN .
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

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?event=pesticide.residue.selection&language=EN

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.

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.

# Annexes

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## 2. Useful websites

http://www.caribpesticides,net/cp_pes_info.asp?iID-9
http://www.pmra_publications@hc-sc.gc.ca
www.syngenta-crop.co.uk
http://www.agproducts.basf.com
http://www.agsolutions.com
http://www.dupont.com/product_Agriculture/en_US/assets/downloads/pdfs/
http://www.elliotchemicals.co.nz/documents/nautile-leaflet.pdf
http://news.agropages.com./news/NewsDetail---2826.htm 12/5/2010
http://prpv.org/index.php/fr/rotection_des_cultures/raisonner_1_usage_des_pestici..12/5/2010

## 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 mays*)
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 (*Ipomoea batatas*)
Tamarillo (*Solanum betaceum*)
Water melon (*Citrullus lanatus*) and butternut (*Cucurbita moschata*)
Yam (*Dioscorea* spp.)

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