

PIP



GUIDE TO GOOD CROP PROTECTION PRACTICES FOR BABY CARROTS (*DAUCUS CAROTA*)

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".

www.coleacp.org/pip



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FOR SUSTAINABLE DEVELOPMENT OF
THE ACP HORTICULTURAL INDUSTRY

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Disclaimer

The document « Guide on Good Plant Protection Practices » (fruit or veg.) describes all the agricultural practices linked with the (fruit or veg.) and suggests control of pests and diseases based mainly on active substances supported by the pesticides manufacturers in the European Regulation 1107/2009 review and due to comply with pesticides residues limits . Most of these active substances have been tested through a field trials programme and the residue level of each active substance has been measured. The pests and diseases control suggested is however dynamic and will be adapted continuously integrating all information gathered by the PIP (see the web site www.coleacp.org/pip). Nevertheless, each grower has the possibility to select among the products listed a set of active substances of no concern regarding residues.

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

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



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1 – MAIN PESTS AND DISEASES

1.1. Importance and impact on yield and quality

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 roots 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 sized roots, lower quality of roots.

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

| INSECTS | | | | | |
|--|---|------|------------------|--|---|
| Importance | Part of the plant affected | | Type of loss | | |
| | Leave | Root | Number of plants | Size of the root | Quality of the root |
| Leafminer – <i>Liriomyza</i> spp. QO | | | | | |
| ++ | Bitten into by adults and mined by larvae | | | Losses can be considerable due to loss of photosynthetic tissue | |
| Aphids – various species | | | | | |
| ++ | Bitten into by adults and larvae | | | High infestations lead to weaken of plants and distorted leaves, reducing yield and quality. Sooty mould deposits disrupt photosynthesis | A significant problem if carrots sold with tops |
| Cutworms – <i>Agrotis</i> spp. | | | | | |
| +++ | | | | | Root zone losses can be significant |
| MITES | | | | | |
| Importance | Part of the plant affected | | Type of loss | | |
| | Leave | Root | Number of plants | Size of the root | Quality of the root |
| Red spider mites – <i>Tetranychus urticae</i> | | | | | |
| +++ | Eaten by adults and larvae | | | Reduced if attack is severe | |

NEMATODES

| Importance | Part of the plant affected | | Type of loss | | |
|--|----------------------------|------|------------------|---|---------------------|
| | Leave | Root | Number of plants | Size of the root | Quality of the root |
| Root knot nematodes – <i>Meloidogyne</i> spp. | | | | | |
| +++ | Deformed by galls | | | Significant reduction if growth is slowed by severe attack at early stage | Roots deformed |

DISEASES

| Importance | Part of the plant affected | | Type of loss | | |
|--|------------------------------------|---------------------------------------|--|---|--|
| | Leave | Root | Number of plants | Size of the root | Quality of the root |
| White mould – <i>Sclerotinia sclerotiorum</i> | | | | | |
| +++ | Development of mycelium on petiole | Development of mycelium on the collar | Loss of young plants through damping-off | | 25% of exportable yields may be lost under favourable conditions |
| Leaf spot – <i>Cercospora carotæ</i> | | | | | |
| +++ | Development of mycelium on leaves | | Young plants die if attacked severely | Can cause significant losses due to defoliation of plant | A significant problem if carrots sold with tops |
| Leaf Blight – <i>Alternaria dauci</i> | | | | | |
| +++ | Development of mycelium on leaves | | Loss of young plants if early appearance | Under favourable conditions, may reduce yields significantly due to loss of photosynthetic tissue, or cause complete loss when the canopy collapses disrupting harvesting | A significant problem if carrots sold with tops |
| Powdery mildew – <i>Erysiphe</i> sp. | | | | | |
| ++ | Development of mycelium on leaves | | | Causes harvesting problems due to weakening of the plant. Photosynthetic capacity affected. Yields can be reduced significantly | A significant problem if carrots sold with tops |

1.2. Identification and damage

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

INSECTS

Leafminer – *Liriomyza* spp.

Feeding punctures appear as white/yellow speckles between 0.13 and 0.15 mm in diameter. Mines are usually white with dampened black and dried brown areas, tightly coiled or irregular in shape, increasing in size as the larva matures.



Aphids – various species

Aphids colonies cluster around growing points of the plants. Some species give rise to twisted malformed foliage, which may be stunted or even killed. The production of honeydew encourages that growth of sooty mould which affects the photosynthetic capability of the plant. They also transmit viruses such as CMDD (Carrot motley dwarf disease).



Cutworms – *Agrotis* spp.

The pest has solitary habits. The seedling is cut at ground level by the soil dwelling larvae, at night. As the carrot matures holes are often bored into the side of the crown, as well as severe petiole damage and defoliation.



MITES

Red Spider Mites – *Tetranychus* spp.

Young and adult mites suck mainly the lower side of leaves by puncturing the epidermal cells with their stylets, resulting in chlorotic patches on the leaves. Leaves may become distorted, yellow and browning leading to premature leaf drop.

NEMATODES

Root knot nematodes – *Meloidogyne* spp.

Forms small discrete galls with related adventitious root proliferation. Carrot root becomes forked, stubby and bunched, with side shoots, constrictions and blunt ends. These symptoms lead to wilting.

DISEASES

White mould – *Sclerotinia sclerotiorum*

The initial symptoms are browning of petioles followed by tissue collapse. White mould containing black sclerotia develops on the base of the dead leaves which spreads to the shoulder of the carrot. The crowns develop brown water soaked lesions which lead to rotting of the carrot.



Cercospora Leaf spot – *Cercospora carotæ*

Initial symptoms are small, circular, brown spots on the leaves and leaf stems. The eye spots develop into lesions with straw coloured centre and dark brown edges. In serious cases the spots merge and cause the leaf to die off.

Often occurs in association with *Alternaria* leaf spot.



Leaf Blight – *Alternaria dauci*

Irregular, dark brown lesions with yellow borders. In prolonged, warm, moist weather the lesions enlarge causing the entire tops to turn yellowbrown, shrivel and die. Under ideal conditions, symptoms take 8 to 16 days to develop.



Powdery mildew – *Erysiphe* sp.

Infection first appears on the lower leaves, with mycelium and powdery spores covering the surface of the leaves, interfering with photosynthesis. Leaves often turn chlorotic. The weakening of foliage causes harvesting problems, as the crop is often handled by foliage.



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

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

| Stage | Length of stage | Nematodes | | Cutworms | | Leaf spots | | <i>Sclerotinia</i> | | Red spider mite | |
|-------------------------------------|---|-----------|--|----------|--|------------|--|--------------------|--|-----------------|--|
| Seed | | | | | | | | | | | |
| Germination | 1 – 2 weeks | | | | | | | | | | |
| Germination to first harvest | 6 weeks | | | | | | | | | | |
| From first harvest to peak harvest | 1 week to 10 days max (depending on time of year) | | | | | | | | | | |
| From peak harvest to end of harvest | | | | | | | | | | | |
| Post harvest | / | | | | | | | | | | |

Periods during which pests and pathogenic agents are potentially present

Periods during which the appearance of large numbers of pests or a serious case of disease can cause the greatest loss

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

Key:

0 = no damage

+ = light damage

++ = medium damage: control needed

+++ = serious damage: control essential

x = light damage but no information on evolution of importance during a year

xx = medium damage but no information on evolution of importance during a year

xxx = serious damage but no information on evolution of importance during a year

/ = no information available

TZ = Tanzania, KEN = Kenya, ZAM = Zambia

N.B. the inventory of pests and diseases has not been conducted exhaustively in all countries. The pest may be present, but has perhaps never been observed in the country on the crop, because it does not cause serious damage.

Cutworms – *Agrotis* spp.

Favourable conditions: Warm dry conditions. Cool soil temperatures encourage feeding activity around the crop root zone.

| Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|-------|----|----|----|----|----|----|----|----|----|----|----|----|
| TZ | 0 | 0 | 0 | 0 | 0 | + | + | + | + | + | + | 0 |
| KEN | xx | xx | xx | xx | xx | xx | xx | xx | xx | xx | xx | xx |
| ZAM | 0 | 0 | 0 | + | ++ | ++ | ++ | + | 0 | 0 | 0 | 0 |

Aphids – Various species

Favourable conditions: Become a problem in hot and dry conditions.

| Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|-------|----|----|---|---|----|----|----|----|----|----|----|----|
| TZ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KEN | ++ | ++ | + | + | + | ++ | ++ | ++ | ++ | ++ | + | + |
| ZAM | 0 | 0 | 0 | + | ++ | ++ | ++ | + | 0 | 0 | 0 | 0 |

Leafminers – *Liriomyza* spp.

Favourable conditions: Optimal egg laying and development temperature 30 °C.

| Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|-------|----|----|---|---|----|----|----|----|----|----|----|----|
| TZ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KEN | ++ | ++ | + | + | + | ++ | ++ | ++ | ++ | ++ | + | + |
| ZAM | 0 | 0 | 0 | + | ++ | ++ | ++ | + | 0 | 0 | 0 | 0 |

Red Spider Mites – *Tetranychus* spp.

Favourable conditions: Optimal temperatures lie between 26 and 30°C. Mites flourish at relatively low humidity. Under optimal conditions eggs hatch after 3 -5 days, reaching adult stage in 10 to 14 days.

| Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|-------|---|---|---|---|---|----|----|----|-----|-----|----|----|
| TZ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KEN | 0 | + | 0 | 0 | 0 | ++ | ++ | ++ | ++ | 0 | 0 | 0 |
| ZAM | 0 | 0 | 0 | + | + | + | + | ++ | +++ | +++ | ++ | 0 |

Root knot nematodes – *Meloidogyne* sp.

Favourable conditions: Optimal egg laying and development temperature 30 °C.

| Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|-------|-----|-----|----|----|----|-----|-----|-----|-----|-----|-----|-----|
| TZ | 0 | 0 | 0 | 0 | 0 | +++ | +++ | +++ | +++ | +++ | +++ | 0 |
| KEN | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ |
| ZAM | +++ | +++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | +++ | +++ |

Powdery mildew – *Erysiphe heraclei*

Favourable conditions: Thrives in dry, warm weather, optimum temperature 26°C, but needs moisture (high humidity) early morning and night for spore germination.

| Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|-------|----|----|---|---|----|----|----|----|----|----|----|----|
| TZ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KEN | ++ | ++ | 0 | 0 | 0 | ++ | ++ | ++ | ++ | + | 0 | 0 |
| ZAM | 0 | 0 | 0 | 0 | ++ | ++ | ++ | ++ | ++ | ++ | + | + |

White mould – *Sclerotinia sclerotiorum*

Favourable conditions: Thrives in warm, moist condition, usually when foliage is dense and senescing.

| Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|-------|---|---|---|---|---|---|---|---|---|----|----|----|
| TZ | 0 | 0 | 0 | 0 | 0 | + | + | 0 | 0 | 0 | 0 | 0 |
| KEN | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ZAM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Leaf Spots – *Alternaria dauci*, *Cercospora carotæ*

Favourable conditions: Humid conditions(optimal 96%), moisture from dew or rain needed for spore germination, 20 - 30° (optimal 28° C) plus 24 hour leaf wetness will lead to severe infection.

| Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|-------|-----|-----|-----|-----|-----|---|---|---|---|-----|-----|-----|
| TZ | 0 | 0 | 0 | 0 | 0 | + | + | 0 | 0 | 0 | 0 | 0 |
| KEN | 0 | 0 | +++ | +++ | +++ | 0 | 0 | 0 | 0 | +++ | +++ | +++ |
| ZAM | +++ | +++ | +++ | ++ | 0 | 0 | 0 | 0 | 0 | ++ | +++ | +++ |

2 – MAIN CONTROL METHODS

2.1. Introduction

Carrots generally prefer cooler temperatures of 15 to 21° C. Growing carrots during colder times of the year will help to promote a healthier plant and improve shelf life. Carrots grow best in loose, deep, sandy or sandy loam soils that have good drainage and a pH of 6.0 is optimal.

Consider the positioning of early fields in relation to late fields so that prevailing winds do not carry spores of diseases and mobile insect stages onto young crops.

Keep the carrot plants healthy with a balanced fertility and irrigation programme that promote the plants' ability to defend against attack. Excessive Nitrogen may be partially responsible for splitting or forked roots, it also promotes foliage growth at the expense of root growth. Lush growth will also encourage insects such a leafminer, aphids and caterpillars. Carrots also respond well to boron and magnesium applications.

Fields should be kept clean of weeds, particularly those in the umbelliferae family (e.g. *Apium leptophyllum*, *Centella asiatica*).

Carrots should be planted in rotation with other nonumbelliferae crops, and must not follow a long term crop that has promoted the build up of nematodes, without a "nematicidal" crop planted in between (crucifer, marigold, sunhemp).

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

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

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

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

The second column of the table shows what actions should be taken to control the different stages of development of the pest or the disease shown in the first column.

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

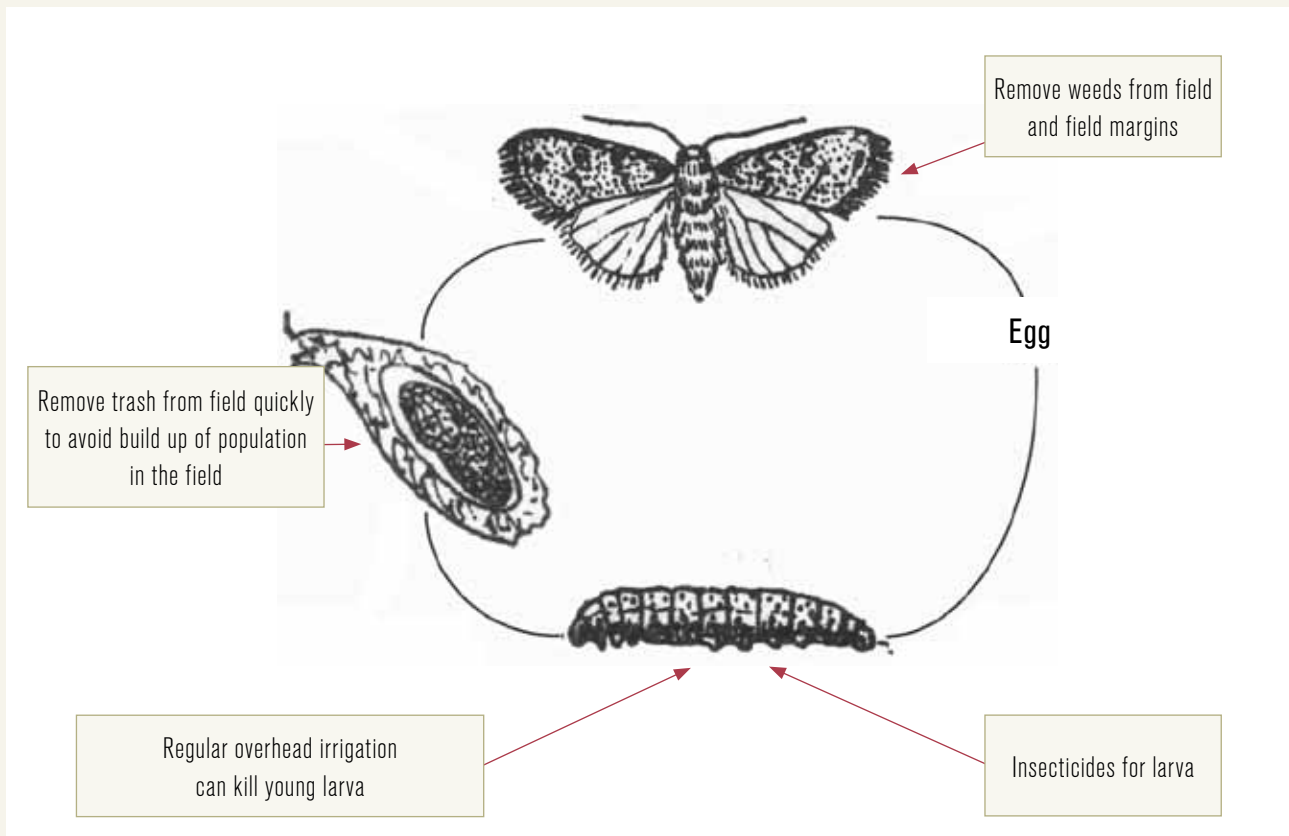
Cultivation practices

Application of plant protection product

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

CUTWORM - *Agrotis* spp.

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



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

During first weeks

- Spray insecticide to kill young larva.
- Regular overhead irrigation can kill larva

During all plant cycle

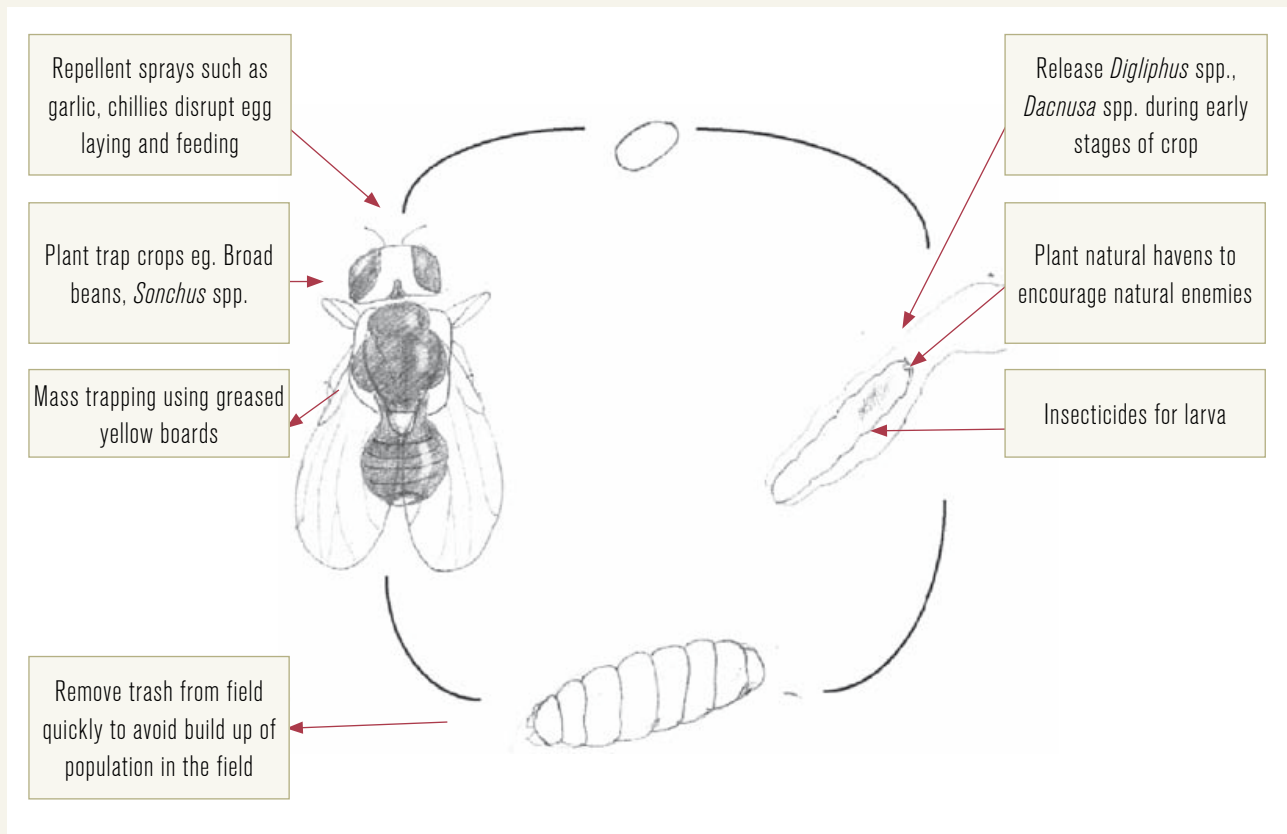
- Weed control in the field and around the margins is important to suppress population build up on alternative host sites.

After last harvesting

- Remove trash from field quickly to avoid build up of population in the field.

LEAFMINER - *Liriomyza* spp.

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



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

At field preparation

- Leafminers are attracted to nitrogen levels in leaves, therefore beans can be used as trap crops near carrot fields.
- Plant natural havens to encourage natural enemies.

During all plant cycle

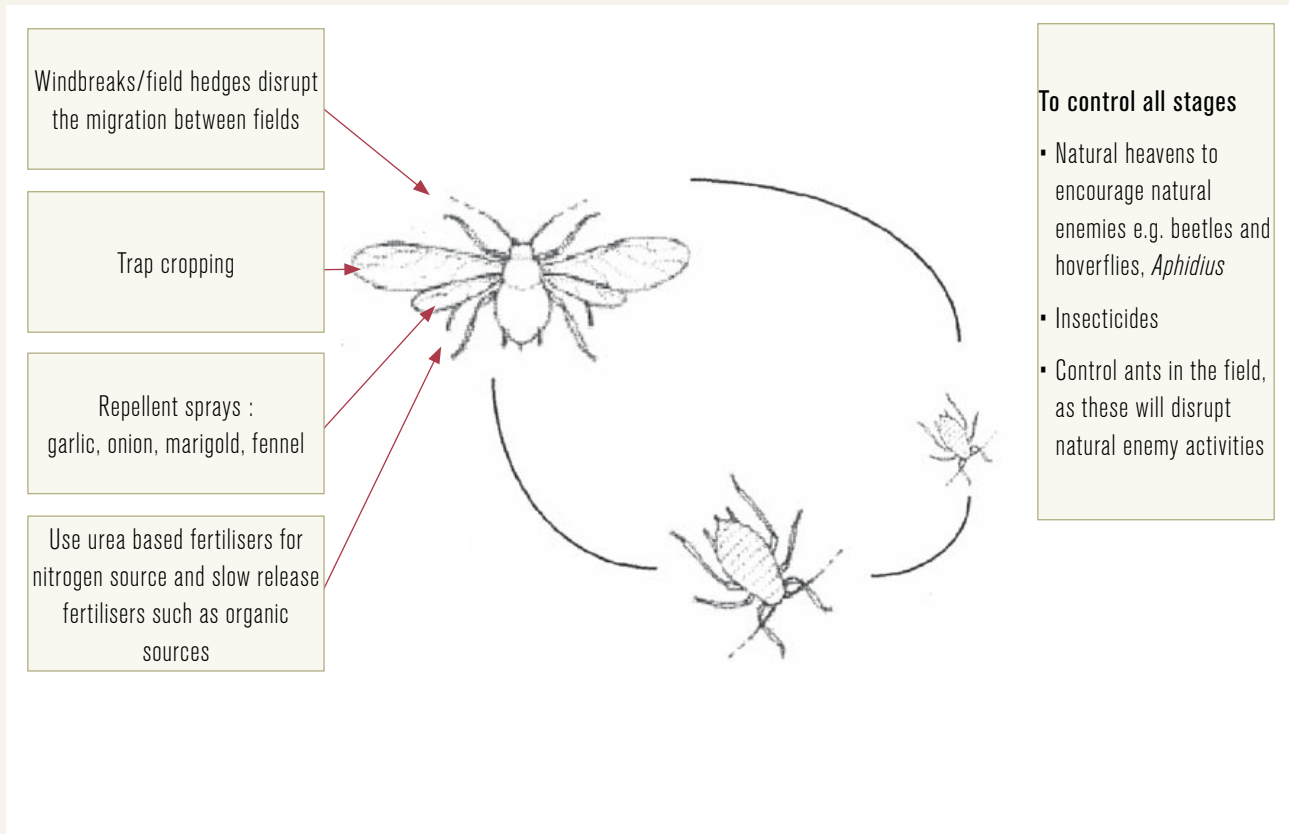
- Repellent sprays such as garlic, chillies disrupt egg laying and feeding.
- *Diglyphus* spp. and *Dacnusa* spp. are very effective parasitoids of leafminer larva. Providing chemicals to not disturb them, natural populations of parasitoids can significantly reduce leafminer populations below economic thresholds. In addition these natural enemies can be harvested and released into the crop at critical stages of growth.
- Spray specific insecticides to kill larva in the leaves.
- During peak adult flight activity, the leafminer adults can be mass trapped by moving through the crop with big yellow boards coated with white grease. The plants are gently disturbed in front of the board, and when the leafminer adults take flight they get attracted to and then stick on the board

After last harvesting

- Remove trash from field quickly to avoid build up of population in the field.

APHIDS

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



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

At field preparation

- Natural havens can be planted within or on the edges of fields to encourage natural enemies to establish and move into the crop and to attract aphids away from crop. Species such as coriander, dill, mustard, sonchus weeds (milk weed).
- Windbreaks and field hedges help to disrupt the migration of adults between fields, by suppressing airflow carry adults and acting as a physical barrier.
- Aphids are attracted to nitrogen levels in plants, the use of slow release nitrogen based fertilisers can reduce plant's attractiveness.

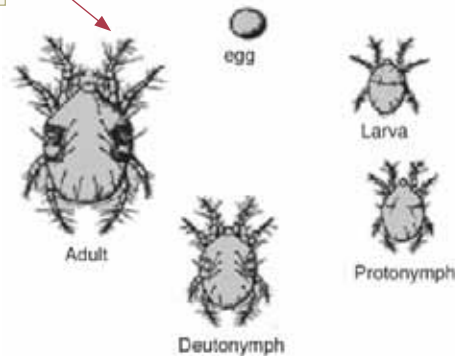
During all plant cycle

- Repellent sprays such as garlic, onion and marigold teas, helps to deter aphid colonisation.
- Control ants in the field, as these will disrupt natural enemy activities.
- Spray specific insecticides to target both nymphs and adults.

RED SPIDER MITES - *Tetranychus* spp.

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

Windbreaks/field hedges disrupt the migration between fields



To control all stages

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

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

At field preparation

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

During all plant cycle

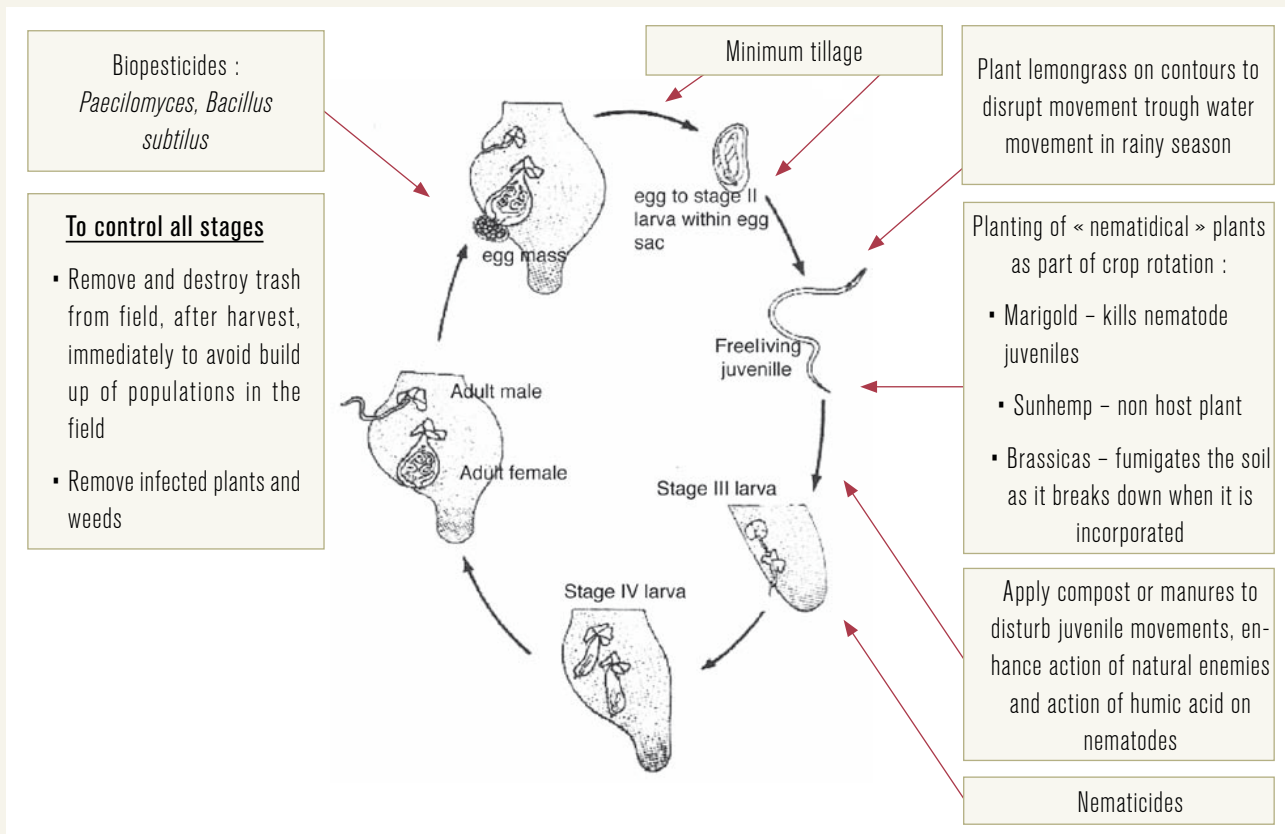
- Red spider mites thrive in dry conditions. Applying overhead irrigation on a regular basis will increase the microclimate humidity. This will lead to an unfavourable environment for mite development. The application of overhead also washes off a significant number of mites.
- Dust from farm tracks can get blown onto the webbing created by mites, further protecting them from pesticide control. In addition the photosynthetic capability of the plant is reduced. Any road close to the crop should be dowsed in water on a regular basis to reduce dust.
- Predatory mites, such as *Phytoseiillus persimilis* can be used to suppress populations.
- Products such as starch, milk and oil can be used as sprays to help suppress mite populations.
- Apply acaricides during early development of populations, before webbing formation.

After last harvesting

- Remove and destroy trash from field, after harvest, immediately to avoid build up of populations in the field.

ROOT KNOT NEMATODES - *Meloidogyne* spp.

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



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

Before field preparation

- Planting marigolds and sunhemp before the crop, will help suppress the build up of nematodes, particularly if carrots are following a crop that has supported the increase in nematodes in the soil.
- Leafy brassicas can be used as part of a rotation, when the brassicas are turned into the soil they breakdown release glucosinolates and isothiocyanates products. These products fumigate the soil.
- Lemongrass can be used as a barrier for nematode migration when planted on the contours of a slope between fields.

At field preparation

- The practice of minimum tillage will help to reduce the spread of nematodes through the field.
- Apply nematicides before or at planting.
- Apply compost or manures to the soil to improve the organic matter content.

During all plant cycle

- Both *Paecilomyces* and *Bacillus subtilis* can be incorporated into the soil to control nematodes eggs. However, as they do not control mobile juveniles they need to be used as part of a long term nematode control maintenance programme.
- Good sanitation practices should be adopted, removing infected plants and weeds.

After last harvesting

- Remove crop trash from the field immediately after harvest, to reduce build up of populations.

LEAF SPOTS - *Alternaria dauci*, *Cercospora carotæ*

Major elements of the control strategy:

- Use healthy seeds
- Remove crop residues
- Equilibrated nitrogen fertilization

| Stages of the disease cycle | Action to be undertaken | Stages of the crop cycle | | | | | | |
|------------------------------|---|--------------------------|-------------------|------------------------|---------------------------|-------------------------------|--------------------------------|-----------------------|
| | | Choice of piece of land | Field preparation | Sowing and germination | From emergence to harvest | First harvest to peak harvest | Peak harvest to end of harvest | After last harvesting |
| Germination on carrot plant | Irrigate in the morning only to ensure that the leaves are dry during the night | | | | X | | | |
| | Apply fungicides to prevent germination | | | | X | | | |
| Development in carrot plant | Apply fungicides to prevent mycelium development | | | | | X | X | |
| Transport by wind or water | Sow in raised well drained beds | | X | | | | | |
| | Wind breaks and in field hedges will help suppress the spread, by reducing the ability of wind to carry the disease | X | X | X | X | | | |
| Development on crop or weeds | Remove all weeds particularly from the <i>Umbelliferae</i> family | | X | X | X | X | X | X |
| Maintaining in the soil | Crop rotations should not include other members of <i>Umbelliferae</i> family | X | X | | | | | |
| | Crop trash should be removed quickly from the field | | | | | | | X |

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

WHITE MOULD - *Sclerotinia sclerotiorum*

Major elements of the control strategy:

- Crop rotation
- Avoid too much humidity by appropriate agricultural practices.

| Stages of the disease cycle | Action to be undertaken | Stages of the crop cycle | | | | | | |
|---------------------------------------|--|--------------------------|-------------------|------------------------|---------------------------|-------------------------------|--------------------------------|-----------------------|
| | | Choice of piece of land | Field preparation | Sowing and germination | From emergence to harvest | First harvest to peak harvest | Peak harvest to end of harvest | After last harvesting |
| Germination on carrot plant | Irrigate in the morning only to ensure that the leaves are dry during the night | | | | X | X | X | |
| | Apply fungicides to prevent germination | | | X | X | X | X | |
| | Avoid overcrowding of plants | | X | X | | | | |
| Development in carrot plant | Avoid overcrowding of plants | | X | X | | | | |
| | Apply fungicides to prevent mycelium development | | | X | X | X | X | |
| Sclerotinia production on host plants | Refrigerate rapidly after harvest | | | | | | | X |
| Transport by wind or water | Sow in raised well drained beds | X | X | | | | | |
| | Wind breaks and in field hedges will help suppress the spread, by reducing the ability of wind to carry the disease | X | X | X | X | X | | |
| Development on crop or weeds | Remove all weeds particularly from the Umbelliferae family | | X | X | X | X | X | X |
| Maintaining in the soil | Crop rotations should not include other members of <i>Umbelliferae</i> family. Carrots should also not follow susceptible crops such as beans. | X | X | | | | | |
| | Crop trash should be removed quickly from the field | | | | | | | X |

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

POWDERY MILDEW - *Erysiphe* spp.

Major elements of the control strategy:

- Optimal fertilization programme
- Implement good sanitation in and around the field.

| Stages of the disease cycle | Action to be undertaken | Stages of the crop cycle | | | | | | |
|------------------------------|---|--------------------------|-------------------|------------------------|---------------------------|-------------------------------|--------------------------------|-----------------------|
| | | Choice of piece of land | Field preparation | Sowing and germination | From emergence to harvest | First harvest to peak harvest | Peak harvest to end of harvest | After last harvesting |
| Germination on carrot plant | Keep the crop strong and healthy by ensuring optimal nutrient programme | | X | X | X | | | |
| | Mulch plants to promote retention of soil moisture | | | | X | | | |
| | Apply fungicides to prevent germination | | | | X | | | |
| Development in carrot plant | Plant resistant varieties | | | X | | | | |
| | Apply fungicides to prevent mycelium development | | | | X | | | |
| Transport by wind or water | Sow in raised well drained beds | X | X | | | | | |
| | Wind breaks and in field hedges will help suppress the spread, by reducing the ability of wind to carry the disease | X | X | X | X | | | |
| Development on crop or weeds | Remove all weeds particularly from the <i>Umbelliferae</i> family. | | X | X | X | X | X | X |
| Maintaining in the soil | Crop trash should be removed quickly from the field | | | | | | | X |

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

2.3. Cultivar resistance or tolerance

| Company | Cultivar | <i>Alternaria</i> tolerance |
|-----------|----------|-----------------------------|
| Hygrotech | Tyna-F1 | X |

2.4. Importance and use of natural enemies

Natural enemies such as certain beetles, green lacewing and *syrphus* fly larvae can play the role of auxiliaries, preventing and limiting population explosions of certain pests. Broadspectrum insecticides should therefore be avoided as much as possible. The use of selective active substances, when available, is preferred as a means of protecting natural enemies.

Explanations of the importance of natural enemies and ways of encouraging their presence can be found in documents especially dedicated to this matter.

3 – Crop monitoring and intervention thresholds

20 stations should be selected across the field in a zig zag pattern. At each station a one metre square should be sampled. For each problem the number of plants affected in the selected area should be counted. This number should be recorded on the scouting sheet.

Nematodes

If nematodes are suspected, the plant should be carefully pulled up with the soil around the roots, so as not to disturb any nodules.

Cutworm

The damage from cutworms is not directly related to the number of larva present. The larva only feed during the night. If severed seedlings are observed, the soil around the plants should be scratched to find larva buried in the soil. Pheromone traps can be used to monitor adult flight dynamics. This data can be correlated with rainfall and temperature to assist with predicting irrigation and spray application timing.

Aphids, Leafminer

Yellow sticky traps and water traps can be used to monitor flight activity of mobile stages of insects.

Suggested threshold levels based on scouting procedure described:

| Problem | Stage of crop | Threshold level % plants affected |
|---------------------|---------------|-----------------------------------|
| Cutworms | Seedling | 25 % |
| Red Spider mite | All | 10 % |
| Aphids | All | 50 % |
| Leafminer | All | 50 % |
| Root knot nematodes | All | 20 % |
| <i>Alternaria</i> | All | 20 % |
| <i>Sclerotinia</i> | All | 10 % |

4 – Active substances and treatment recommendations

Introduction

For each pest or disease, proposals of the strategy for the use of Plant Protection Products (PPP) are indicated below. A list of active substances is suggested for each pest or disease. When available, the critical GAP which allows compliance with European MRLs currently in force is also shown. 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.

At this stage, however, it is worth noting that no tests have been carried out in ACP production environments to check compliance of MRLs with the GAPs indicated.

N.B.: Obviously, this is not a timetable for treatments to be applied as such since the producer will have to treat crops in terms of levels of attacks or real risks.

The list of active substances proposed has been drawn up taking into account the products used by ACP producers and the products registered in ACP countries and in Europe. It is nevertheless worth noting that not all the ACP producers contacted provided information on the PPP used. The products mentioned by producers have been underlined in the tables. The active substances are classified by resistance risk group (FRAC and IRAC classification and codes). In practice, it is important to alternate active substances belonging to different groups.

The most appropriate development stages of the crop (green boxes) for the application of each active substance are also suggested, taking into account the pre-harvest interval to be respected so as to comply with MRLs, the modes of action of the active substances and the effects on natural enemies. Since cucurbits depend on bees for pollinisation, it is recommended that the use of insecticides be kept to a strict minimum during the flowering period.

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

Commercial soap-based PPPs (to control aphids, spider mites, whitefly, etc.) also exist and are not listed in the following tables because they pose no problems in terms of residues.

Cutworms – *Agrotis* spp.

Strategy: Treat before planting and seedling stage. Repeat if scouting records indicate damage to carrot.

| Active substance | Recommended GAP* | | | | Proposed application period | | | |
|---|------------------|-----------------------------|---------------------------------------|-------------|-----------------------------|------------------------|----------------------------|------------|
| | Dosage g/ha | Maximum number applications | Minimum interval between applications | PHI in days | Soil preparation | Sowing and germination | Emergence to first harvest | Harvesting |
| Group 3 – Pyrethroids (sodium channel modulators) | | | | | | | | |
| Cypermethrin | 70 | 2 | 10 | 20 | | | | |
| <u>Lambda cyhalothrin</u> | / | 2 | / | 7 | | | | |
| <u>Deltamethrin</u> | | 3 | / | 3 | | | | |
| Group 1 – Organophosphates and carbamates | | | | | | | | |
| Dimethoate | 400 | 3 | / | 21 | | | | |
| Diazinon | 5,100 | 1 | / | 90 | | | | |
| Chlorpyrifos-ethyl** | 2,000 | 1 | / | 45 | | | | |
| Group 18 – Ecdysone agonists/moulting disruptors | | | | | | | | |
| Azadirachtin | 150 | / | / | / | | | | |
| Group 11 – Microbial disruptors of insect midgut membranes | | | | | | | | |
| <i>Bacillus thuringiensis</i> | / | / | / | 1 | | | | |

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

** Possible phytotoxicity

/ elements of the recommended GAP not available

Aphids – various

Strategy: Apply treatment when thresholds are reached and repeat as necessary.

| Active substance | Recommended GAP* | | | | Proposed application period | | | |
|--|------------------|-----------------------------|---------------------------------------|-------------|-----------------------------|------------------------|----------------------------|------------|
| | Dosage g/ha | Maximum number applications | Minimum interval between applications | PHI in days | Soil preparation | Sowing and germination | Emergence to first harvest | Harvesting |
| Group 18 – Ecdysone agonists/moulting disruptors | | | | | | | | |
| Azadirachtin | 150 | / | / | 3 | | | | |
| Group 4 – Nicotinic Acetylcholine receptor agonists/antagonists | | | | | | | | |
| Imidacloprid | / | / | / | / | | | | |
| Thiamethoxam | 30 | 2 | / | 21 | | | | |
| Group 3 – Pyrethroids (sodium channel modulators) | | | | | | | | |
| <u>Lambda cyhalothrin</u> | 10 | 2 | / | 7 | | | | |
| Pyrethrin | / | / | / | 2 | | | | |
| <u>Deltamethrin</u> | / | 3 | / | 7 | | | | |
| Tau-fluvalinate | / | / | / | / | | | | |
| Bifenthrin | 30 | / | / | / | | | | |
| Group 1 – organophosphates and carbamates | | | | | | | | |
| <u>Pirimicarb</u> | 375 | / | / | 7 | | | | |
| Dimethoate | 200 | 4 | / | 21 | | | | |
| Group 9 | | | | | | | | |
| Pymetrozine | / | / | / | / | | | | |
| Group 21 | | | | | | | | |
| Rotenone | / | / | / | / | | | | |

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

** Possible phytotoxicity

/ elements of the recommended GAP not available

Red Spider Mite – *Tetranychus* spp.

Strategy: Apply acaricides as soon as first symptoms appear, and when conditions are optimal for population development. Apply at 5 to 7 day intervals when necessary to ensure new generations are targeted.

| Active substance | Recommended GAP* | | | | Proposed application period | | | |
|---|------------------|-----------------------------|---------------------------------------|-------------|-----------------------------|------------------------|----------------------------|------------|
| | Dosage g/ha | Maximum number applications | Minimum interval between applications | PHI in days | Soil preparation | Sowing and germination | Emergence to first harvest | Harvesting |
| Group 6 - Avermectines | | | | | | | | |
| Abamectin | / | / | / | / | | | | |
| Group 3 - Pyrethroids | | | | | | | | |
| Bifenthrin | 50 | / | / | / | | | | |
| Not classified | | | | | | | | |
| Petroleum oil | / | / | / | 1 | | | | |
| Sulphur | 4,000 to 6,000 | 2 | 14 | 1 | | | | |
| Group 12 | | | | | | | | |
| Tetradifon | / | / | / | / | | | | |
| Propargite | / | / | / | / | | | | |
| Group 19 - Octopaminergic agonists | | | | | | | | |
| Amitraz | 400 | 1 | / | 14 | | | | |

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

/ elements of the recommended GAP not available

Leaf blight – *Alternaria dauci*, *Cercospora carotae*

Strategy: If present, treat disease during early stages of disease establishment, repeat at regular intervals when conditions are conducive to disease development.

| Active substance | Recommended GAP* | | | | Proposed application period | | | |
|--------------------------------------|------------------|-----------------------------|---------------------------------------|-------------|-----------------------------|------------------------|----------------------------|------------|
| | Dosage g/ha | Maximum number applications | Minimum interval between applications | PHI in days | Soil preparation | Sowing and germination | Emergence to first harvest | Harvesting |
| Group 11 : QoI fungicides | | | | | | | | |
| <u>Azoxystrobin</u> | 250 | 2 | 7 | 10 | | | | |
| Trifloxystrobin | / | / | / | / | | | | |
| Pyraclostrobin | 27 | 2 | / | 14 | | | | |
| Boscalid | 200 | 3 | 7 | 28 | | | | |
| Group 3 : DMI - fungicides | | | | | | | | |
| Difenoconazole | 125 | 3 | 14 | 14 | | | | |
| <u>Tebuconazole</u> | 250 | 3 | 14 | 21 | | | | |
| Group 2 : Dicarboximides | | | | | | | | |
| <u>Iprodione</u> ** | 750 | 4 | 10 | 27 | | | | |
| Group M : Multi-site activity | | | | | | | | |
| Mancozeb | 1,600 | 4 | 14 | 14 | | | | |
| <u>Chlorothalonil</u> | 1,250 | 3 | 10 | 7 | | | | |
| <u>Copper oxychloride</u> | 1,500 | 3 | 14 | 4 | | | | |

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

/ elements of the recommended GAP not available

** : can be used also for seeds treatment at the dose of 500 g active substance/100 kg seeds

Powdery Mildew – *Erysiphe heraclei*

Strategy: Apply at early stage of disease development before infection spreads to new crop growth, repeat treatments at regular intervals when conditions are optimal for disease development.

| Active substance | Recommended GAP* | | | | Proposed application period | | | |
|--------------------------------------|------------------|-----------------------------|---------------------------------------|-------------|-----------------------------|------------------------|----------------------------|------------|
| | Dosage g/ha | Maximum number applications | Minimum interval between applications | PHI in days | Soil preparation | Sowing and germination | Emergence to first harvest | Harvesting |
| Group M : Multi-site activity | | | | | | | | |
| <u>Sulphur</u> | 4,000 to 6,000 | 6 | 5 | 7 | | | | |
| Group 11 : Qol fungicides | | | | | | | | |
| <u>Azoxystrobin</u> | 250 | 2 | 7 | 10 | | | | |
| | / | 2 | 14 | 14 | | | | |
| Group 3 : DMI - fungicides | | | | | | | | |
| <u>Difenoconazole</u> | 125 | 3 | 14 | 14 | | | | |
| <u>Penconazole</u> | | 4 | 7 | / | | | | |
| <u>Myclobutanil</u> | 62,5 | 2 | / | 14 | | | | |
| <u>Tebuconazole</u> | 250 | 3 | 14 | 21 | | | | |

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

/ elements of the recommended GAP not available

White mould – *Sclerotinia sclerotiorum*

Strategy: Apply when conditions are suitable for infection especially in wet weather. First application must be done early, this mean before the canopy has covered space between line.

| Active substance | Recommended GAP* | | | | Proposed application period | | | |
|--|---|-----------------------------|---------------------------------------|-------------|-----------------------------|------------------------|----------------------------|------------|
| | Dosage g/ha | Maximum number applications | Minimum interval between applications | PHI in days | Soil preparation | Sowing and germination | Emergence to first harvest | Harvesting |
| Group 2 : dicarboximides | | | | | | | | |
| <u>Iprodione</u> | / | 4 | / | / | | | | |
| Group M : Multi-site activity | | | | | | | | |
| <u>Copper oxychloride</u> | / | / | / | / | | | | |
| Group 11 : QoI fungicides | | | | | | | | |
| Pyraclostrobine | 67 | 2 | / | 14 | | | | |
| Boscalid | 267 | 2 | 7 | 26 | | | | |
| Group 4: PhenylAmide fungicides | | | | | | | | |
| Metalaxyl-M | 240 (soil application) + 68 (foliar application) | 1 + 1 | / | 30 | | | | |
| Group 1: MBC fungicides | | | | | | | | |
| Carbendazime | / | / | / | / | | | | |

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

/ elements of the recommended GAP not available

Root knot nematodes

Strategy: Apply treatment pre-planting as a drench.

| Active substance | Recommended GAP* | | | | Proposed application period | | | |
|------------------|------------------|-----------------------------|---------------------------------------|-------------|-----------------------------|------------------------|----------------------------|------------|
| | Dosage g/ha | Maximum number applications | Minimum interval between applications | PHI in days | Soil preparation | Sowing and germination | Emergence to first harvest | Harvesting |
| Azadirachtin | 150 | / | / | 3 | | | | |
| Oxamyl | 2,500** | 1 | n.a. | 75 | | | | |
| Fenamifos | 720 | 1 | n.a. | / | | | | |

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

** In furrow application

/ elements of the recommended GAP not available

n.a. = not applicable

5 – Existing registrations in ACP countries

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

Registration of PPP in Zambia

Zambia does not have a proper registration process and any pesticide registered elsewhere is basically allowed into Zambia

Registration of PPP in Tanzania

Following actives substances listed in part 4 of this Guide have PPP registered on vegetables in general or various crops.

Various crops: cypermethrin, dimethoate

Vegetables: carbendazim, chlorothalonil, copper, deltamethrin, diazinon, imidacloprid, iprodione, lambda-cyhalothrin, mancozeb, penconazole, sulphur, tau-fluvalinate, tetradifon

Registration of PPP in Kenya

Following actives substances listed in part 4 of this Guide have PPP registered on carrots, vegetables or various crops.

Carrots: Mancozeb

Vegetables: Abamectin, *Bacillus thuringiensis*, bifenthrin, chlorpyrifos-ethyl, copper, cypermethrin, deltamethrin, diazinon, dimethoate, iprodione, lambda-cyhalothrin, metalaxyl-m, pymetrozine, pyrethrin, sulphur, tebuconazole, tetradifon, thiamethoxam.

Various crops: Azadirachtin

6 – European regulations and pesticide residues

Status of the active substances in Directive 91/414; European harmonised MRLs in March 2009

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

| Active substance | Status DIR 91/414 | European MRL |
|-------------------------------|-------------------|--------------|
| Abamectin | Annex 1 | 0.01 |
| Amitraz | Withdrawn | 0.05 |
| Azadirachtin | Not included* | 1 |
| Azoxystrobin | Annex 1 | 0.2 |
| <i>Bacillus thuringiensis</i> | Annex 1 | / |
| Bifenthrin | Notified List 3A | 0.05 |
| Boscalid | Annex 1 | 1 |
| Carbendazim | Annex 1 | 0.1 |
| Chlorothalonil | Annex 1 | 1 |
| Chloryriphos-ethyl | Annex 1 | 0.1 |
| Copper | Notified List 3A | 5 |
| Cypermethrin | Annex 1 | 0.05 |
| Deltamethrin | Annex 1 | 0.05 |
| Diazinon | Withdrawn | 0.01 |
| Difenoconazole | Annex 1 | 0.3 |
| Dimethoate | Annex 1 | 0.02 |
| Fenamiphos | Annex 1 | 0.5 |
| Imidacloprid | Annex 1 | 0.05 |
| Iprodione | Annex 1 | 0.5 |
| Lambda-cyhalothrin | Annex 1 | 0.02 |
| Mancozeb | Annex 1 | 0.2 |
| Mefenoxam (Metalaxyl-M) | Annex 1 | 0.1 |
| Myclobutanil | Not included* | 0.2 |
| Oxamyl | Annex 1 | 0.01 |
| Penconazole | Notified List 3B | 0.05 |
| Petroleum oil | Notified List 4H | / |
| Propargite | Not included* | 0.01 |
| Pymetrozine | Annex 1 | 0.02 |
| Pyraclostrobin | Annex 1 | 0.1 |
| Pyrethrin | Annex 1 | 1 |

* Not included in Annex 1 for the time being and the EU Member States have the possibility to maintain authorisations until 31 December 2010

| Active substance | Status DIR 91/414 | European MRL |
|------------------|-------------------|--------------|
| Pirimicarbe | Annex 1 | 0.5 |
| Rotenone | Notified List 4C | 0.01 |
| Sulphur | Annex 1 | 50 |
| Tau-fluvalinate | Not included* | 0.02 |
| Tebuconazole | Annex 1 | 0.5 |
| Tetradifon | Withdrawn | 0.02 |
| Thiamethoxam | Annex 1 | 0.1 |
| Trifloxystrobin | Annex 1 | 0.05 |

* Not included in Annex 1 for the time being and the EU Member States have the possibility to maintain authorisations until 31 December 2010

Note on the European MRL harmonisation:

The DG Health and Consumers (DG SANCO) has undertaken an MRL harmonisation process on the European level and has established a new EC MRL regime under EC Regulation 396/2005 and its annexes, which was published afterward as separate Regulations.

A list of national MRL was gathered by DG SANCO in June 2005 and submitted to EFSA (European Food Safety Authority) for verification and approval.

When no specific MRL exists for a crop, a default MRL is set at 0,01 mg/kg. These default EU MRLs as well as the EU MRLs based on measured residues could only be set after the publication of Annex I to the Regulation, establishing the list of food and feed products (Regulation (EC) No 178/2006 of 1st February 2006).

Towards the end of 2007 EFSA submitted the conclusion report of the MRL evaluation and recommendation to the Commission for final decision on the setting of harmonised EU MRLs.

These EU MRLs are listed in the annexes ,II,III and IV of the EC Regulation which were established by the Regulation (EC) No 149/2008 of 29 January 2008. The annexes were updated for the first time in March 2008 and the MRLs were entered into force on September 1st, 2008 and are available on the website http://ec.europa.eu/sanco_pesticides/public/index.cfm

References, web sites and useful documents

Bejo, Major carrot pests and diseases, Pub Bejo Zaden B.V, Netherlands

Ellis, B.W & Bradley, F.M, The Organic Gardener's Handbook of natural Insect and Disease control, Pub. Rodale Press, USA

Web sites:

European Food Safety Agency.

<http://www.efsa.europa.eu>

European and Mediterranean Plant Protection Organisation.

www.eppo.org

Department for Environment Food and Rural Affairs, Plant Health, quarantine pests and diseases information.

www.defra.gov.uk/planth

Cornell University. Vegetable MD online.

<http://vegetablemdonline.ppath.cornell.edu/cropindex.htm>

UC IPM online. Provides information on IPM guidelines for various pests on

www.ipm.ucdavis.edu/index.html

Oregon state university extension: An online guide to Plant disease control

<http://plant-disease.ippc.orst.edu>

Crop knowledge master: Information on insect pests

www.extento.hawaii.edu

Ontario Ministry of Agriculture Food and Rural Affairs: Fact sheets on managing crop pests.

www.omafra.gov.on.ca

Glossary:

APPC – Asia and Pacific Protection Commission

CMDD – Carrot motley dwarf disease

CPPC – Caribbean Plant Protection Commission

EFSA – European Food Safety Agency

EPPO – European and Mediterranean Plant Protection Organisation

IAPSC – Interacfrican Phytosanitary Council

IPPC – International Plant Protection Convention

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 annum*, *Capsicum chinense*) and sweet peppers (*Capsicum annum*)
Citrus (*Citrus* sp.)
Coconut (*Cocos nucifera*)
Cucumber (*Cucumis sativus*), zucchini and pattypan (*Cucurbita pepo*) and other cucurbitaceae with edible peel of the genus *Momordica*, *Benincasa*, *Luffa*, *Lagenaria*, *Trichosanthes*, *Sechium* and *Coccinia*
Dasheen (*Colocasia esculenta*) and macabo (*Xanthosoma sagittifolium*)
Eggplants (*Solanum melongena*, *Solanum aethiopicum*, *Solanum macrocarpon*)
Garlic, onions, shallots (*Allium sativum*, *Allium cepa*, *Allium ascalonicum*)
Ginger (*Zingiber officinale*)
Guava (*Psidium catteyanum*)
Lettuce (*Lactuca sativa*), spinach (*Spinacia oleracea* and *Basella alba*), leafy brassica (*Brassica* spp.)
Lychee (*Litchi chinensis*)
Melon (*Cucumis melo*)
Organic Avocado (*Persea americana*)
Organic Mango (*Mangifera indica*)
Organic Papaya (*Carica papaya*)
Organic Pineapple (*Ananas comosus*)
Potato (*Solanum tuberosum*)
Sweet potato (*Ipomea batatas*)
Tamarillo (*Solanum betaceum*)
Water melon (*Citrullus lanatus*) and butternut (*Cucurbita moschata*)
Yam (*Dioscorea* spp.)

