Crop Walkers' Guide

AHDB

Bedding and Pot Plants

HORTICULTURE

Bedding and pot plant growers can encounter a wide range of problems that can quickly render crops unmarketable unless they are identified and dealt with promptly. Often, such problems are linked to pests and diseases, but nutritional and cultural disorders may also be encountered.

This AHDB Horticulture Crop Walkers' Guide has been created to assist growers, supervisors and technical nursery staff in the vital task of monitoring crops. It is designed for use directly on the nursery to help with the accurate identification of many of the economically important pests, diseases and disorders as well as providing background information on the range of biological control agents that may be applied to protected ornamentals crops. Images of the key stages of each pest or pathogen, and the typical plant symptoms produced, have been included, together with succinct bullet point comments to assist with identification.

The bedding and pot plant sectors produce a wide range of crops and it is clearly impossible to show every problem associated with each crop. The guide therefore presents the most commonly occurring issues, listed alphabetically within each section, on a range of important crops.

Although covering some of the key biological control agents that may be used in protected ornamentals production, this guide does not attempt to offer advice on the available control measures as these frequently change. Instead, having identified a particular pest, disease or disorder, growers should acquaint themselves with the currently available control measures.

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Pests

Aphid (Glasshouse potato)

Aulacorthum solani

- A shiny, pale green or yellowish-green aphid with darker green patches at the base of siphunculi (the tubes extending from the rear of the body).
- Siphunculi have distinct black tips along with black markings on the leg joints and antennae.
- The aphids also have an indentation between their antennae.
- Infests many host plants including *Fuchsia*, *Nicotiana*, *Pelargonium* and *Verbena* and can lead to severe leaf distortion.

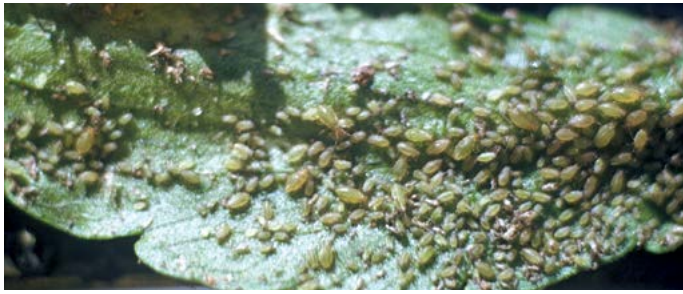
Aphid (Melon-cotton)

Aphis gossypii

- A small aphid, pale green to olive, dark or mottled green or black in colour. Siphunculi (the tubes extending from the rear of the body) are short and black.
- The aphids have antennae that are shorter than their body with no indentation at the base of them.
- A major pest of *Chrysanthemum*, *Cyclamen* and *Fuchsia* causing leaf distortion and leading to the development of sooty moulds.
- Resistant to the active ingredient pirimicarb and can be resistant to other insecticides.

Aphid (Peach-potato)

Myzus persicae



- The peach-potato aphid is pale green, yellowish-green, or pink/red in colour and pear-shaped.
- The long siphunculi (the tubes extending from the rear of the body) have dusky black tips.
- The aphids also have a pronounced indentation between the base of their antennae.
- They can form large colonies on leaf undersides and on young shoots, causing distortion.
- Infests many host plants, including *Chrysanthemum*, *Fuchsia*, *Impatiens*, *Nicotiana*, *Petunia*, *Viola* and *Primula*.
- Most UK strains are resistant to certain insecticides.

Aphid (Potato)

Macrosiphum euphorbiae

- A long, pear-shaped aphid, green or pink in colour, often with a longitudinal stripe running down the back.
- Possesses long, slender siphunculi (the tubes extending from the rear of the body) with no black tips.
- Antennae are longer than their body, with a indentation between the base of them.
- Can form colonies in shoot tips, causing distortion.
- Infests *Dahlia*, *Dianthus*, *Fuchsia*, *Pelargonium* and *Petunia*.

Caterpillars – Leaf holing

Autographa gamma, *Laconobia oleracea*, etc

- Caterpillars, of various butterfly and moth species, that vary in colour from green to pale brown.
- When small, caterpillars may be hard to find as they often hide under foliage, trays and pots during the day and emerge at night to feed.
- Damage symptoms include leaf 'windowing' (where only the leaf underside is removed) and leaf holing. Droppings may also be visible on the plants.
- *Chrysanthemum*, *Cyclamen*, ornamental cabbage/kale, *Primula* and *Viola* (especially pansy) are often attacked.

Caterpillars – Leaf rolling

Cacoecimorpha pronubana, etc

- Caterpillars, of mainly moth species, are small and pale green with a brown head.
- They roll up the growing points or leaves of plants and spin them together with silk to form a shelter in which they feed.
- When disturbed, tortrix caterpillars wiggle backwards.
- Populations can breed continuously during the summer months, causing serious damage.
- Host plants include *Cyclamen*, *Dianthus*, *Diascia*, *Fuchsia* and *Pelargonium*.

Caterpillars – Stem feeding

Agrotis pronuba, etc

- Caterpillars are pale brown, and when small, feed on leaves and shoots, but later burrow into the growing medium to feed on stem bases, sometimes severing them.
- Damage usually occurs from late June onwards, being more common in hot, dry summers. Damage can be mistaken for that caused by mice.
- *Primula* and *Viola* (especially pansy) are sometimes affected.

Flea beetles

Altica lythri and *Phyllotreta cruciferae*

- Adult flea beetles are metallic bright blue, green or black in colour. They jump or fly actively when disturbed.
- Large numbers can build up, causing many small leaf pits or 'shot-holes' and even defoliate plants.
- Larvae are caterpillar-like in appearance and also feed on leaves.
- The pest overwinters as adults.
- The large blue flea beetle is a common pest of *Fuchsia* during the summer months. Other flea beetle species, such as the turnip flea beetle, also attack ornamental cabbage, stocks and wallflowers.

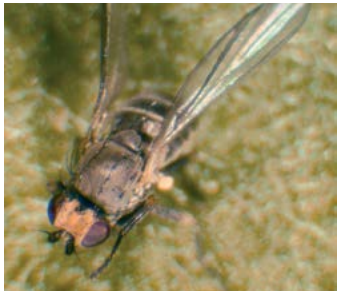
Leafhoppers

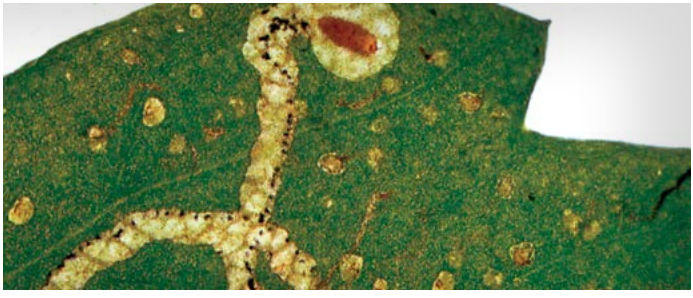
Hauptidia maroccana, Eupteryx melissae, etc

- Adults of the glasshouse leafhopper are whitish-yellow, with two grey, chevron-shaped marks on the wings. Nymphs are whitish without any markings.
- Leafhoppers cause indistinct white or pale yellow spots or flecks on the leaves, which often coalesce to form bleached areas that later turn brown.
- Cast skins can also be found on leaves.
- The main species damaging bedding plants is the glasshouse leafhopper, which is common on *Primula*, but also found on *Chrysanthemum*, *Fuchsia*, *Nicotiana* and *Salvia*.

Leaf miners

Chromatomyia syngenesiae, Liriomyza huidobrensis, etc





- Adult leaf miners are small, robust flies, like miniature houseflies. They have a grey or black body, *Liriomyza* species are characterised by a yellow spot on their backs (top left).
- Adult feeding causes a fine white/yellow leaf spotting.
- Larvae feed within the leaf causing whitish mines in plants such as *Argyranthemum*, *Brachycome*, *Chrysanthemum* and *Cineraria*.
- Pupation can occur in the tunnel, or the pupae can fall to the ground to pupate, depending upon species.
- The most common species on bedding plants is the native chrysanthemum leaf miner (top right). There is a risk of introducing non-indigenous quarantine species on imported plants.

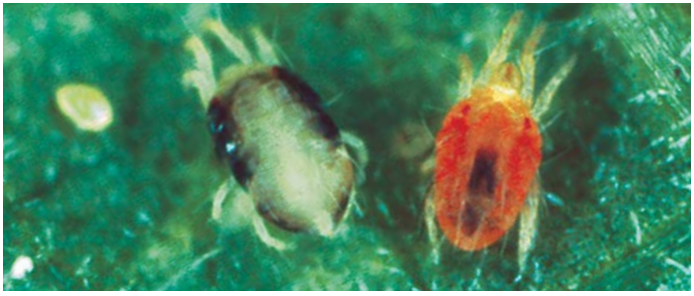
Mites (Tarsonemid)

Phytonemus pallidus and *Polyphagotarsonemus latus*

- Broad and cyclamen mites are very small translucent mites that can only be seen with the aid of a powerful hand lens.
- The mites occur on the underside of young, expanding leaves or within growing points.
- Symptoms can include plant stunting, leaf scarring, thickening, distortion and discolouration and flower flecking.
- Host plants include *Antirrhinum*, *Begonia*, *Celosia*, *Cyclamen*, *Dahlia*, *Fuchsia* and New Guinea impatiens.

Mite (Two-spotted spider)

Tetranychus urticae



- Adult mites are small and usually found on leaf undersides. The young mites and summer adults are green with two black patches on their backs (top left). In the autumn, the females turn brick-red prior to over-wintering (top right).
- Feeding damage causes fine yellow speckling on leaves, which later develops into necrotic patches.
- In severe infestations webbing, produced by the mites, can be observed on plants (bottom right).
- Common host plants include *Chrysanthemum*, *Dahlia*, *Fuchsia*, *Impatiens* and *Rosa*.

Sciarid fly

Bradysia difformis

- Adults are small, grey-black, gnat-like insects with long legs and antennae, often seen walking on, or flying just above, the growing medium surface.
- They do not feed on plants, but can transport the spores of pathogens such as *Pythium*.
- Larvae are off-white with a black head and no legs. They live in the growing medium, feeding on fungi and plant roots. Root damage by the larvae can cause plant wilting.
- Young seedlings, cuttings and slow-rooting species are particularly vulnerable, especially in damp environments.

Shore fly

Scatella tenuicosta

- Adults are small, stout-bodied, black flies with short antennae and pale spots on their wings.
- They are often seen sitting on plants and the surface of growing media. They can be more numerous on slow-growing plants.
- Larvae are brown with no obvious head. They feed on algae, not on the crop plants.
- The flies can leave black faecal spots on the foliage of plants (bottom right), which may lead to quality issues on seedling crops.

Thrips

Frankliniella occidentalis, Thrips tabaci, etc

- Western flower thrips adults are small and narrow-bodied, yellow or pale brown. Larvae are yellow (top images).
- Onion thrips are slightly smaller and greyish-yellow to brown.
- Damage symptoms include small white or silvery flecks on leaves and petals, leaf necrosis, leaf curling and leaf or flower distortion.
- Host plants include *Brachycome*, *Chrysanthemum*, *Cyclamen*, *Fuchsia*, *Primula* and *Verbena*.
- Western flower thrips can also spread a number of important viruses including tomato spotted wilt virus and impatiens necrotic spot virus.

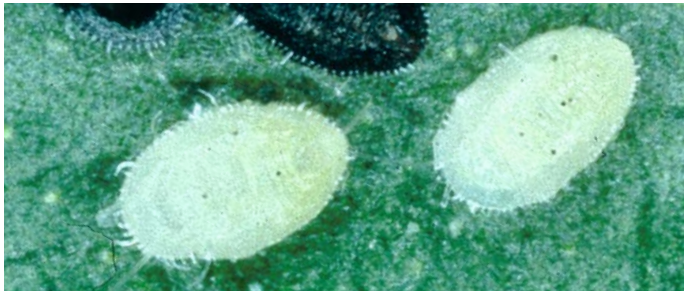
Vine weevil

Otiorhynchus sulcatus

- Adults are large, wingless, slow-moving, black weevils with pale yellowish/orange flecks on their backs. They are nocturnal, feeding at night on foliage, causing notching of leaf edges, usually between late June and September.
- Larvae are legless, cream or white with a pale brown head, often lying in a 'C' shape within the growing medium.
- They feed on roots, stem bases and corms between July and September, causing plant stunting and collapse.
- Common host plants are *Cyclamen*, ferns and *Primula*.

Whitefly (Glasshouse)

Trialeurodes vaporariorum



- Adults are small, white and moth-like and tend to hold their wings flat across the back when at rest.
- The scales are white in colour, oval in shape, with a visible depth to them, and have short hairs around the edge.
- Scales often develop in clusters on leaves.
- All stages are found on leaf undersides, with adults usually concentrated on growing points or young shoots and older scales on lower leaves.
- The honeydew excreted by the whiteflies allows the growth of sooty moulds.
- Common host plants include *Abutilon*, *Datura*, *Fuchsia* and *Pelargonium*.

Whitefly (Tobacco)

Bemisia tabaci

- Adults are slightly smaller than the glasshouse whitefly and tend to hold their wings slightly apart, exposing the yellow body beneath.
- Adults tend to fly less actively and more directly from plant to plant within the crop than glasshouse whitefly adults.
- The larger, older scales are yellow rather than white (as in the glasshouse whitefly) flatter, with few or no hairs and are pointed at one end.
- This species is a non-indigenous quarantine pest and there is a risk of importing it on plants or cuttings of poinsettia and a number of pot plant and patio plant species.

Beneficials

INTRODUCED

Amblyseius, *Neoseiulus* and *Transeius* species

For the control of thrips and other pests

- *Neoseiulus (Amblyseius) cucumeris* (image) is the most commonly used, but *A. swirskii* and *Transeius montdorensis* are also available.
- Small, oval shaped, straw-coloured predatory mites found on leaf undersides, growing points, buds and flowers.
- They feed on pollen, young thrips larvae and will also eat mites, whitefly eggs and young scales.
- The latter two mite species are only licensed for release in fully enclosed structures in the UK.
- Supplied in tubs with a bran or vermiculite carrier for sprinkling onto plants, or in slow-release paper sachets for hanging on plants or hanging baskets.

Aphidius and other parasitoid wasp species

For the control of aphids

- Small brown and black parasitoid wasps used for aphid control.
- Adult wasps emerge from the mummies via a hole cut into the aphid body (bottom left) and fly to find suitable aphids in which to lay eggs.
- The wasp larva develops inside the aphid, turning it into a parasitised mummy, the colour of which varies with the parasitoid species.
- Different species attack different aphid species, so correct identification of the aphid is important. However, mixes of parasitoid species are now available that attack several aphid species, reducing the need for aphid identification.
- Supplied in tubes as parasitised aphid 'mummies'.

Aphidoletes aphidimyza

For the control of aphids

- A predatory midge, the larvae of which eats most aphid species.
- The delicate adult midges emerge from pupae and lay eggs in the middle of aphid colonies.
- The pale orange larvae hatch from the eggs and feed on the aphids, becoming a deeper orange as they develop.
- Supplied as pupae in vermiculite either in tubes, bottles or blister packs.

Dacnusa sibirica and *Diglyphus isaea*

For the control of leaf miners

- Small parasitoid wasps used for leaf miner control. *Dacnusa* is black with long antennae (left) and *Diglyphus* is metallic green with short antennae (right).
- *Dacnusa* adults lay eggs inside leaf miner larvae, whereas as *Diglyphus* adults lay eggs onto the surface of the leaf miner larvae inside the mine.
- The parasitoid larvae feed on the leaf miner larvae and kill them.
- A combination of multi-parasitism and host feeding make *Diglyphus* more suited to controlling higher populations of leaf miner.
- Both are supplied as adults in bottles.

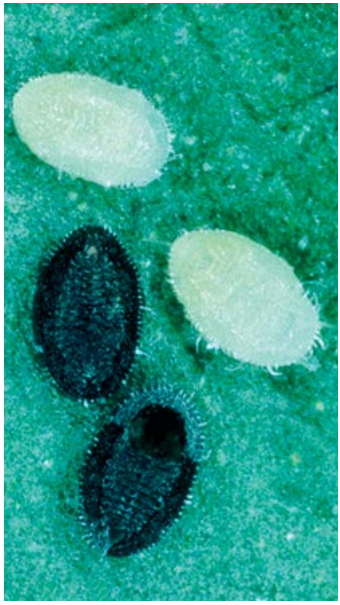
Dalotia (Atheta) coriaria

For the control of sciarid and shore flies

- A ground-dwelling predatory 'rove' beetle used for the control of sciarid and shore fly eggs and larvae.
- The adult beetle is small, dark brown and shiny, often hidden in the growing medium or under containers and trays but can also fly in warm temperatures.
- The larvae are white when young and brownish-yellow when older and are usually hidden in the growing medium. The head is the same colour as the body and the larvae have three pairs of legs at the front end.
- Adults and larvae are supplied in tubes or bags with a carrier to sprinkle over the growing medium or matting.

Encarsia formosa

For the control of glasshouse whitefly



- A small, yellow and black parasitoid wasp used for whitefly control.
- Male wasps are all black, but make up only a very small percentage of the population.
- The adult wasp lays an egg into a whitefly scale and the young parasitoid develops inside the scale, turning it from white to black.
- The new adult wasp cuts a hole in the top of the black scale and emerges.
- Adult wasps feed on honeydew and from wounds made to whitefly scale.
- The parasitoids are supplied as parasitised black scales, often stuck on cards, for hanging on plants.

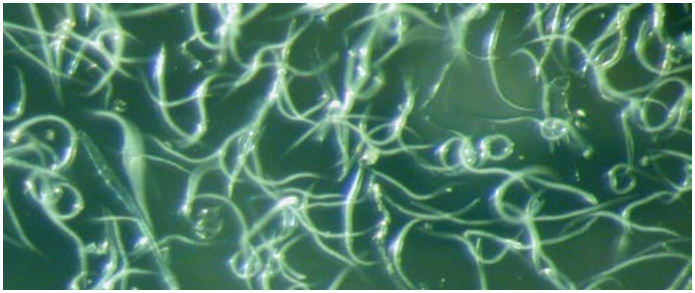
Eretmocerus emericus

For the control of glasshouse and tobacco whitefly

- A small, yellow parasitoid wasp used for the control of whitefly, especially tobacco whitefly.
- The adult wasp lays an egg into the whitefly scale and the young parasitoid develops inside the scale, turning it from white to yellow.
- The new adult wasp cuts a hole in the top of the yellow scale and emerges.
- *Eretmocerus emericus* is supplied as parasitised scales on cards, in blister packs or in a bran carrier.

Heterorhabditis and *Steinernema* species

For the control of sciarid fly, thrips and vine weevil



- Microscopic worm-like nematodes used for the control of a number of pests.
- Applied in water as a growing media drench for the control of sciarid fly (*Steinernema feltiae*) and vine weevil (*Heterorhabditis bacteriophora* and *S. kraussei*) or as foliar sprays for the control of thrips larvae (*S. feltiae*).
- The nematodes enter the insect's body and release bacteria that kill the insect.
- With larger insect hosts the nematodes multiply inside the body and are released into the growing medium (bottom right).
- The nematodes are supplied in a gel-like carrier in plastic trays.

Neoseiulus (Amblyseius) californicus

For the control of two-spotted spider mite

- A small, oval, straw-coloured predatory mite, found most easily on leaf undersides.
- The eggs are oblong, transparent to white, and are attached to hairs along veins on the underside of leaves.
- It can persist in the absence of spider mites on various small prey and pollen.
- The predatory mite is a useful supplement to *Phytoseiulus persimilis* because it has a wider temperature range and is more tolerant of low humidity.
- Only licensed for release in fully enclosed structures in the UK.
- Supplied in bottles of bran or vermiculite to sprinkle over plants.

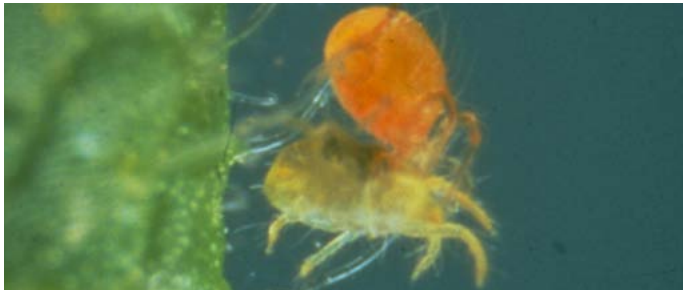
Orius laevigatus and *O. majusculus*

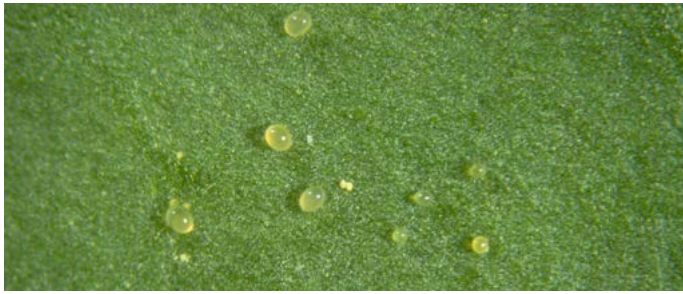
For the control of thrips

- Predatory bugs used for thrips control, feeding on thrips adults and larvae. Often found in flowers.
- Will also predate aphids, mites and moth eggs.
- Adult predators are black with paler markings on the wings, giving them the appearance of having a black diamond shape.
- The nymphs are yellow or pinkish with red eyes, and develop immature wing buds on the sides of the body.
- Supplied in bottles with a buckwheat carrier.

Phytoseiulus persimilis

For the control of two-spotted spider mite





- An orange-red predatory mite that feeds on two-spotted spider mite eggs, nymphs and adults.
- The adult predator has a shiny body and is slightly larger, with longer legs than a two-spotted spider mite.
- The predator eggs are pale pink, oval and about twice the size of the round spider mite eggs (bottom).
- Predators and eggs are found on leaf undersides.
- The predators are supplied in bottles with a bran or vermiculite carrier that is sprinkled over plants.

Stratiolaelaps scimitus (*Hypoaspis miles*)

For the control of sciarid fly

- Ground-dwelling predatory mites, primarily used for sciarid fly larvae control but will also feed on other prey including thrips larvae and pupae.
- The predators are off-white with a pale brown shield covering most of the upper surface of the body, nymphs are paler in colour.
- The predators are very active and can be found running over the growing medium, the bench or floor covering under pots and trays.
- Supplied in tubs with a peat and vermiculite carrier for sprinkling on the floor or benches.

Diseases

BACTERIAL
FUNGAL
OOMYCETE
VIRAL

Bacterial leaf spots, blights and wilts

Pseudomonas syringae, Xanthomonas hortorum, etc

- Symptoms usually appear as small, necrotic spots with a dark-coloured margin.
- They can be circular, angular (limited by leaf veins) or irregular in shape.
- If spots are numerous, they can coalesce, leading to leaf neorosis.
- *Xanthomonas hortorum* can also produce blight symptoms, following lesion coalescence, and plant wilt.
- Species affected include *Alyssum*, *Antirrhinum*, *Impatiens*, *Lobelia*, *Pelargonium*, *Primula*, *Tagetes*, *Verbena*, *Viola* and *Zinnia*.

Bacterial soft rot

Pectobacterium carotovorum

- Usually causes a soft rot of corms or the crowns of plants, leading to plant wilt and collapse.
- In the case of *Cyclamen*, the top of the plant can be pulled away easily, leaving a slimy, foul smelling corm rot.
- The pathogen can also cause a soft rot in cuttings.
- There is some evidence that damage caused by feeding sciarid fly larvae can predispose plants to bacterial soft rot.
- Species affected include calla lily, *Cyclamen*, *Primula obconica* and *Schlumbergera.*

Alternaria leaf spots

Alternaria alternata, A. cinerariae, etc

- On *Lobelia* seedlings, the fungus causes orange-brown leaf spots and a similarly coloured stem constriction, resulting in damping-off.
- On *Cineraria*, the fungus causes dark brown to black, irregular leaf spots.
- On *Pelargonium*, infection often shows as pale brown, V-shaped leaf sections.
- The pathogen also causes losses in *Cheiranthus*, *Tagetes* and *Zinnia*.

Black root rot

Thielaviopsis basicola

- The pathogen causes stunted growth, leaf chlorosis and purpling, and blackened and decayed roots. Plants often rot off at their stem bases.
- Initial disease symptoms can be confused with nutrient deficiency symptoms.
- Infection is favoured by high moisture levels in the growing medium, warm temperatures (17–23ºC), high pH (6.5+) and stress.
- The fungus has a wide plant host range including *Cyclamen*, *Petunia* and poinsettia, but is most often found on summer-sown pansy and viola crops.

Grey mould or *Botrytis*

Botrytis cinerea

- The fungus can infect many bedding plant species and most plant parts causing a soft decay.
- Produces fluffy, grey-brown fungal strands bearing masses of spores and causes plant collapse and death.
- Infection is most common in cool (around 15°C), humid conditions, especially on senescent or damaged tissue and fallen flowers.
- If humidity is low, infections may be contained within discrete spots.
- Leaves in contact with moist growing medium are often the initial site of infection in *Primula*.
- *Botrytis* is also found in, and sporulates on, plant debris.

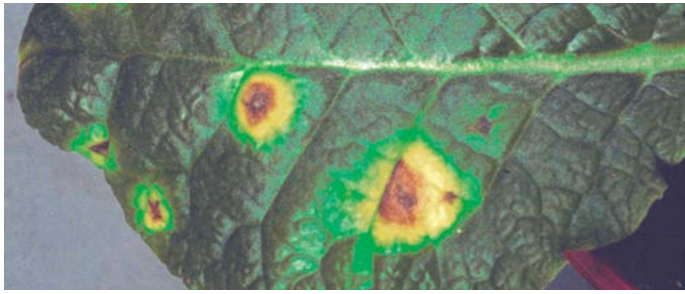
Powdery mildews

Erysiphe cichoracearum, Podosphaera violae, etc

- The pathogen primarily affects leaves, especially young leaves, usually on the upper surface. Growth may be visible as distinct white spots or as sparse white, or off-white, fungal strands.
- Fungal growth becomes more powdery in appearance as spores develop, in severe cases growing points and flowers can become infected.
- Several fungi cause powdery mildew diseases and they are usually host-specific.
- Species commonly affected include *Cineraria*, *Dahlia*, *Nicotiana*, pansy, *Petunia*, *Phlox* and *Verbena*.
- Poinsettia are susceptible to four powdery mildew pathogens, two of which, American and African powdery mildew, are quarantine pathogens.

Ramularia leaf spots

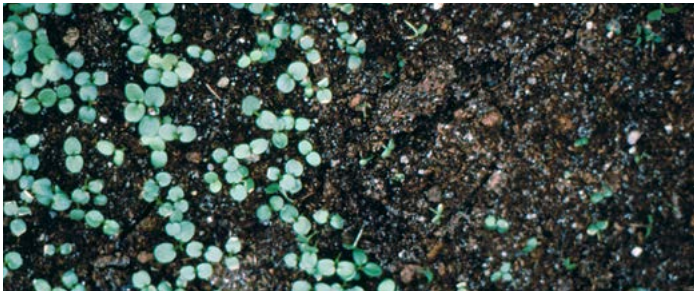
Ramularia agrestis, *R. interstitialis*, *R. lactea*, *R. primulae*, etc



- The leaf spot pathogen most commonly affects pansy, primrose and polyanthus crops.
- Symptoms on pansy range from small black flecks to white or pale brown spots with narrow brown borders.
- *R. agrestis* gives rise to a pale tan leaf spot, while *R. lactea* produces a darker, greasy spot.
- Symptoms on primrose and polyanthus are usually round or irregular pale brown leaf spots with a bright yellow border; sometimes the centres drop out leaving shot-holes.

Rhizoctonia root and stem rot

Rhizoctonia solani



- Symptoms usually start at the growing media surface and take the form of damping-off in seedlings and a stem base rot and root rot in older plants.
- Fungal strands can sometimes be seen around affected stem bases and on the surface of growing media.
- The pathogen is favoured by high levels of moisture and warm temperatures.
- Wire stem, so called due to a withering of the stem base which is dry and pale brown in colour, is another symptom of the pathogen.
- *Rhizoctonia* affects a wide range of species, especially members of the crucifer family, *Alyssum*, *Aubretia*, *Cheiranthus*, *Matthiola*; also *Impatiens* and *Salvia*.

Rust diseases

Puccinia antirrhini, *P. distincta*, *P. horiana*, etc

- Visible on the upper leaf surface as pale yellow spots and/or yellowing growth; leaves may be distorted.
- Brightly-coloured pustules of spores are produced, usually on the leaf underside.
- Rust colours vary from white (*Chrysanthemum*) to yellow (*Bellis*) to orange (*Fuchsia*) to dark-brown (*Pelargonium*).
- Most rust pathogens are host-specific; some produce more than one spore type (often of different colours), although some rust species need more than one plant species to complete their life cycle.

Sclerotinia disease

Sclerotinia sclerotiorum

- Early symptoms are a brown soft rot and dense masses of white, cotton wool-like, fungal strands.
- Large, hard, black resting bodies may eventually develop, among the fungal strands or within the stems of plants.
- Infection occurs from spores in the air or from fungal strands that develop from the resting spores.
- Not host-specific and attacks a range of plant species including *Chrysanthemum*, *Lobelia*, *Pelargonium* and *Matthiola*.

Septoria leaf spots

Septoria dianthi, *S. drummondii*, etc

- Causes a pale-brown irregular leaf spot or tip necrosis, usually with a narrow, black or purple border.
- Shiny, grey-black spore cases develop within affected tissue and are just visible with the naked eye.
- Infection and spread are favoured by high humidity and water splash.
- Relatively uncommon; the most susceptible hosts are *Antirrhinum*, *Dianthus* and *Phlox*.

Downy mildews

Plasmopara obducens, Peronospora violae, etc

- Primarily a foliar fungus-like pathogen, typically causing a yellowing on the upper leaf surface.
- Sporulation is usually visible as a felty growth on the lower leaf surface, ranging from white to purplish or grey.
- In some hosts, infection results in leaf and shoot distortion if the pathogen becomes systemic.
- The pathogens are generally host-specific.
- Species commonly affected include *Alyssum*, *Aubretia*, *Chieranthus*, *Cineraria*, *Impatiens*, *Matthiola*, *Nicotiana* and pansy.

Phytophthora root rots

Phytophthora cryptogea, *P. primulae*, etc

- A fungus-like pathogen closely related to *Pythium*, but is less common on bedding plants.
- Root decay by *Phytophthora* is generally more severe than that caused by *Pythium*, and may extend to cause a stem base rot.
- As well as decay of the fine and main roots, other symptoms include leaf yellowing, wilting and shoot dieback.
- Brown core of primrose is caused by the host-specific species *Phytophthora primulae*.
- Other susceptible hosts include *Cineraria*, pansy, *Petunia* and poinsettia.

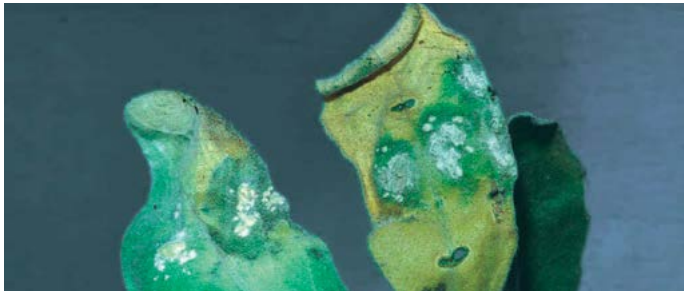
Pythium root rots

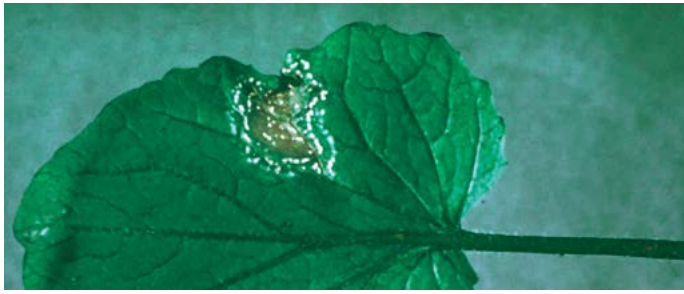
Pythium aphanidermatum, P. ultimum, etc

- *Pythium* causes damping-off in seedlings, cuttings and young plants, poor growth, root decay, and occasionally a stem base rot.
- The fungus-like pathogen is favoured by high moisture levels in the growing medium.
- The pathogen produces long-lived resting spores that can contaminate matting and growing media.
- The most susceptible plant species are *Alyssum*, *Antirrhinum*, *Lobelia*, *Nemesia* and *Pelargonium*.

White blister

Albugo candida and *Pustula obtusata*





- The fungus-like pathogen can give rise to raised, chlorotic spots on the leaf upper surface.
- Creamy white pustules (blisters) develop on the leaf underside, usually in irregular groups or concentric circles. Surrounding tissue eventually becomes chlorotic and necrotic.
- Similar in appearance to, and can be confused with rust infections.
- Infection is favoured by wet leaves.
- *Alyssum*, *Aubretia* and *Cineraria* are the bedding plant species most commonly affected.

Cucumber mosaic virus

CMV

- Symptoms include flower streaks (colour 'break') and leaf mosaic, chlorosis and distortion.
- Usually transmitted by aphids and occasionally in seeds.
- In recent years the virus has been uncommon in ornamentals.
- Susceptible hosts include *Cyclamen*, *Dahlia*, pansy, *Primula* and *Viola*.

Impatiens necrotic spot virus

INSV

- Virus symptoms include dark purple ring spots, mottling, mosaics and necrotic spots/areas on foliage and dark streaks on stems.
- In the UK, the virus is transmitted by western flower thrips and via propagation from infected plants.
- The virus has become more common than tomato spotted wilt virus in recent years.
- Susceptible plant species include *Chrysanthemeum*, *Coleus*, *Fuchsia*, *Impatiens*, *Lobelia* and *Nemesia*.

Tomato spotted wilt virus

TSWV

- Symptoms are extremely variable, ranging from leaf spots, line patterns and rings to leaf vein blackening and leaf and stem necrosis.
- The virus is most commonly transmitted by western flower thrips, sometimes in cuttings, rarely in seed.
- Many bedding plant species are susceptible including *Chrysanthemum*, *Cineraria*, *Cyclamen*, *Dahlia*, *Fuchsia*, *Impatiens* and *Primula*.

Nutrient disorders

The importance of early diagnosis of crop nutrient disorders

Suspected nutrient disorders based on the appearance of symptoms should be confirmed by growing media and leaf analysis.

General guidance on collecting both growing media and leaves for analysis can be found in the AHDB factsheet 10/16 ‘Sampling methodologies and analysis interpretation for growers of hardy nursery stock’.

Ammonium

NH_4

- Ammonium deficiency is not really an issue (see nitrogen deficiency).
- Ammonium toxicity causes chlorosis of the growing point (image), reduced growth, leaf curling, stem lesions and wilting.
- Toxicity can occur in conjunction with high growing media pH.

Boron

B

- Boron deficiency (left) produces leaf thickening and a downward leaf curl. Leaves may become chlorotic with necrotic spots.
- Growing points may abort, flower buds may drop and stems may become brittle.
- Symptoms are restricted to the younger tissue.
- Boron toxicity (right) causes marginal leaf necrosis on older leaves, which spreads up the plant.
- Flower set is poor and abortion often occurs.

- Calcium deficiency can lead to immature leaf tips becoming chlorotic and necrotic. Young leaves can become distorted (top), with an upward leaf curling in some plant species. Flower bracts can also show an edge necrosis (bottom).
- Shoots and roots can stop growing and growing points abort. Root tips may appear ‘clubbed’. Symptoms are restricted to younger growth.
- Toxicity symptoms are seldom seen.

Chlorine

Cl

- Chloride deficiency is not really an issue.
- Chloride toxicity causes a paleness of the new growth (image), leaf edge necrosis and leaf cupping.
- Very poor shoot and root development is another characteristic symptom.

Copper

Cu

- Deficiency symptoms (left) include stunted growth and growing point distortion. In some cases, leaf chlorosis can occur on younger leaves and in severe cases, leaf size is reduced and leaf 'burn' occurs.
- In terms of copper toxicity (right), plants initially grow normally, but then develop leaf rolling and tip burning, starting with the older leaves.

Iron

Fe

- Iron deficiency (image) produces an interveinal chlorosis in the younger leaves. Leaves may become totally yellow and later necrotic.
- Symptoms are restricted to younger leaves.
- Iron toxicity often leads to associated manganese accumulation.

Magnesium

Mg

- Magnesium deficiency (image) symptoms include an interveinal chlorosis on the older leaves. Necrotic spots may also form.
- Eventually, leaves may become completely chlorotic and fall off.
- Symptoms progress from older to younger growth.
- Magnesium toxicity may induce calcium deficiency and older leaves may show ‘russeting’.

Manganese

Mn

- Manganese deficiency (top) causes a star-like mottling on young leaves. On heavily chlorotic leaves, light tan sunken spots can develop between the leaf veins.
- Symptoms are restricted to younger leaves.
- Manganese toxicity symptoms include brown/gold spotting on older leaves (bottom), eventually merging to form necrotic areas.
- Overall plant growth (including root growth) is restricted.

- In the case of deficiency, leaves may become pale and scorched and, in certain plant species, become disfigured so that they are ‘strap’ or ‘whip-like’ (image). Symptoms become progressively worse on developing leaves.
- Molybdenum deficiency is usually associated with low pH in the growing medium.
- Molybdenum toxicity symptoms are seldom seen.

Nitrogen

N

- Nitrogen deficiency (top and bottom) results in stunted plants that are pale green to yellow.
- A red colouration can develop on older leaves, later, necrotic symptoms can occur, particularly along the margins.
- Plants with coloured leaves may exhibit less intense colours. All symptoms progress from older to younger growth.
- Nitrogen toxicity symptoms include the production of blue-green, soft, fleshy leaves that are disease susceptible.
- High levels of nitrogen can lead to leaf wilting under mild stress.

- Phosphorus deficiency (top and bottom) gives rise to stunted plant growth. Foliage is dark green in colour. Older leaves become purple; in some species bronzed.
- All lower leaves eventually become chlorotic and then necrotic. All symptoms progress from older to younger growth. Root systems become highly branched and fibrous.
- Phosphorus toxicity symptoms are similar to those caused by high pH-induced iron deficiency: stunted, very pale to white young growth.

Potassium

K

- Potassium deficiency (image) leads to slow growth with older leaf margins becoming chlorotic, eventually necrotic. The necrosis can extend from the margins to cover the whole leaf.
- With some plant species a downward leaf curling may result. Premature leaf drop sometimes results.
- Potassium toxicity can lead to induced calcium and magnesium deficiencies.
- High levels of potassium can lead to root damage and wilting.

Sulphur

S

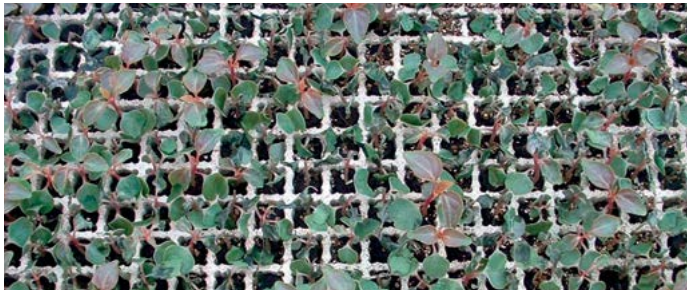
- Sulphur deficiency causes a general plant chlorosis (image), with more intense symptoms towards the top of the plant.
- Leaf symptoms resemble nitrogen deficiency, but unlike nitrogen deficiency symptoms don't begin on the lowest leaves.
- Sulphur toxicity is seldom seen.

Zinc

Zn

- Zinc deficiency (image) leads to chlorosis of the younger leaves and shortening of the internodes, which creates a rosette-like growth habit.
- Leaf size is reduced and growing point abortion may occur. Symptoms generally occur in the younger tissue.
- Zinc toxicity leads to stunted yellow growth on plants.

Cultural disorders



- When temperatures are only a few degrees below optimum, growing point/leaf chlorosis can occur (top left).
- More excessive leaf chlorosis, purpling or reddening and leaf drop can occur on crops transferred from high to low temperatures to harden-off (top right).
- Where plants have been chilled/ frosted, leaves and stems become glassy and water-soaked and plants collapse and die (bottom).

Drought stress

- First symptoms may be a slight change in leaf colour from green to grey/green. Leaves wilt and eventually, with continued stress, may become chlorotic, purple or red, depending upon the plant species (top).
- Extreme drought will cause the whole plant to collapse.
- Depending upon the plant species and the severity/longevity of the lack of water, leaf scorch and flower bud abortion may occur and plants may become more stunted in growth.
- If the level of watering is uneven then crop uniformity can be affected (bottom).

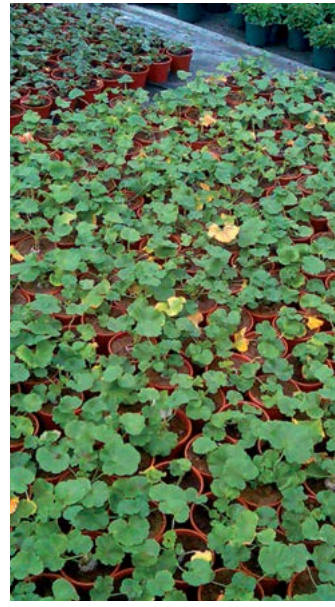
Environmental stress (bedding plants)

- Symptoms of distortion have been noted on several plant species, most often on pansy (often referred to as pansy mottle syndrome – top) and petunia (bottom).
- The exact cause of the problem has yet to be confirmed but appears to be triggered by environmental stress.
- It may be found in a few isolated plants or it may be associated with specific varieties or flower colours.
- Symptoms include distortion of the growing point, leaf curling, twisting and bleaching.

Environmental stress (pot plants)

- A symptom seen in poinsettia, where new leaves can be puckered, distorted and malformed and may have yellow or silver markings on the upper surface.
- The cause of the symptom is not completely understood. Plant stress resulting from high temperatures and rapid changes in humidity have been suggested.
- Thrips feeding damage, early in the season, has also been suggested as a potential cause.

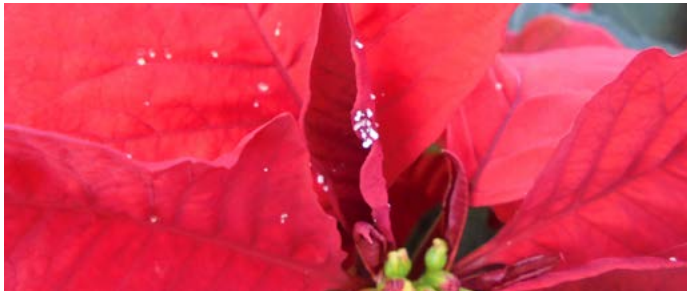
Ethylene damage



- Ethylene is a gaseous substance released in minute amounts by plants under stress which triggers a response.
- Symptoms take the form of leaf chlorosis and premature leaf and flower drop.
- Its effects can be seen (usually at warmer temperatures) if the gas cannot readily escape into the surrounding environment, as with bought-in cuttings in sealed bags.
- Plants generally grow away from the symptoms.

Genetic instability

- Symptoms including flower colour instability, leaf bleaching and whole plant bleaching, through to reversion to parental type have all been associated with genetic instability or mutation.
- In many cases, the exact trigger and nature of the problem has never been fully identified.
- Symptom expression may be limited to the odd plant in a crop (left) but may also be more common across the crop (right).



- High environmental humidity can limit the rate of water loss from leaves, leading to physical injury and the development of a range of symptoms.
- In the case of poinsettia, high humidities can lead to internal cell injury and sap exudation, which dries on the surface of the leaf, bract or growing point (top).
- With ivy-leaf geranium, high humidity can lead to the physiological disorder known as oedema, typified by the production of 'corky' marks on the lower surface of older foliage (bottom).
- Other plant species may show symptoms of leaf 'glassiness' or water soaking.

Insufficient light level

- Symptoms are noted if plants are kept in the dark or semi-darkness for too long (for example during delivery).
- Plant stems stretch, leaves become smaller and sparser in number and shoots become chlorotic (etiolation).
- Plant quality is reduced and plants can become more disease susceptible.
- Once back in the light, plants grow away from the symptoms.

- Transplanting damage may take many forms. Often, holes of various shapes (image) can be seen in the foliage. These are caused by the fingers of the transplanting machine, which can pierce the leaves/cotyledons of larger plugs.
- Other damage may include torn leaves and broken leaf petioles and stems.

Overwatering

- Overwatering results in waterlogged growing medium within the pack or container with corresponding root loss.
- Foliage may become yellow and wilt. Plants can become stunted and collapse as a result of excessive root loss and/or the establishment of pests or pathogens, such as sciarid fly larvae or *Pythium*.
- If the level of watering is uneven then crop uniformity can be affected (image).

Pesticide damage – Chemical growth regulators

- Generally, plant growth is restricted if the product rates or water volumes applied are too high.
- Other symptoms include reduced flower size, reduced flower stem length (if products are applied too close to flowering), reduced internode length, reduced leaf size, delayed flowering and darker leaf colour.
- Chlormequat gives rise to leaf chlorosis (left) if used at higher rates, and paclobutrazol can cause severe stunting (right) if applied at too high a rate or water volume.

Pesticide damage – Fungicides and insecticides

- The most common symptom is a physical leaf scorch. Leaves become bronzed and then necrotic and may drop off.
- Other symptoms include leaf chlorosis and growing point distortion.
- Plants usually grow away from the symptoms unless they are very severe.

- Contact herbicides can give rise to necrotic spotting where droplets have drifted onto plants (top and bottom). Accidental direct application may kill the plant.
- Systemic herbicides can cause a yellowing/interveinal yellowing of the growing points, growth distortion and eventual plant death.
- Residual herbicides can produce leaf chlorosis (marginal, interveinal, veinal) necrosis, intense growth distortion and stunting over time.

Sun scorch

- Leaf scorch can occur where levels of shading are inadequate on young/sensitive crops or when crops are transferred from low to high light conditions.
- Symptoms occur on the 'soft' foliage produced as a result of the low light conditions.
- The scorch often takes the form of bleached areas on the foliage, sometimes followed by necrosis.
- Plants usually grow away from the symptoms.

References

Acknowledgements

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