CROP WALKERS' GUIDE

Cross Sector

AHDB HORTICULTURE

Cut flowers

Protected and outdoor

Cut flower growers can encounter a range of problems that can quickly render flower crops unmarketable unless they are identified and dealt with promptly. Often, such problems are linked to pests and diseases, but nutritional and physiological 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 cut flower crops. Images of the key stages of each pest or pathogen, along with the typical plant symptoms produced, have been included, together with succinct bullet point comments to assist with identification.

The cut flower industry produces a wide range of crops and it's clearly impossible to show every problem associated with all the crops grown. The guide, therefore, presents the most commonly occurring issues, listed alphabetically within each section, on a range of important crops (excluding *Narcissi*, which is covered in a separate Crop Walker's Guide).

Although covering some of the key biological control agents that may be used in protected cut flower 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.

Wayne Brough
AHDB Horticulture, Knowledge Exchange Manager (Ornamentals)

SECTION 1 Invertebrate pests

Aphid, leaf-curling plum

(*Brachycaudus helichrysi*)

- A small, brownish-green aphid that can be difficult to find when hidden in the growing point or flower buds of plants.
- Mainly troublesome on *Aster* where it tends to attack the growing points of plants and causes a severe leaf distortion and yellow or purple blotching.
- Due to the distortion created, the aphids can be difficult to target with some contact-acting insecticides.

Aphid, melon-cotton

(*Aphis gossypii*)

- A small aphid, pale green to olive, dark or mottled green or black (the most common colour found on *Chrysanthemum*). The siphunculi (the tubes extending from the rear of the body) are short and black.
- A major pest of *Chrysanthemum, Dahlia* and column stocks, the species causes leaf distortion, and the honeydew excreted by the aphids leads to the development of sooty moulds.
- Resistant to many insecticides and can, therefore, be difficult to control.

Aphid, peach-potato

(*Myzus persicae*)

- Pale green, yellowish-green or pink/red in colour. The siphunculi (the tubes extending from the rear of the body) have dusky black tips.
- The species can form large colonies on the underside of leaves and in young shoots, causing distortion.
- Infests a wide range of plant hosts including *Chrysanthemum* and *Dianthus.*
- Most UK strains are resistant to certain insecticides.

Aphid, potato

(*Macrosiphum euphorbiae*)

- Long, pear-shaped aphid, green or pink in colour, often with a longitudinal stripe running down the back.
- The siphunculi (the tubes extending from the rear of the body) are long and slender with no black tips.
- Has a wide host range including *Dahlia, Dianthus* and Sweet William.

Caterpillars (leaf holing)

(*Autographa gamma, Lacanobia oleracea, Pieris brassicaes,* etc)

- Some caterpillar species eat completely through the leaf while others feed only on the leaf underside, leading to 'windowing' (bottom left image). Frass (droppings) may also be visible (bottom right image).
- A wide range of plant species are attacked such as *Chrysanthemum* and column stocks.
- Numerous species of caterpillar (both moth and butterfly) can attack cut flowers including the large white butterfly and silver Y moth.
- Caterpillars can vary in size and colour from yellow, through various shades of green to brown and other colours.

Caterpillars (leaf rolling)

(*Cacoecimorpha pronubana,* etc)

- Numerous species of caterpillar (mainly moth) can cause leaf rolling and irregular leaf holing on cut flowers including the carnation tortrix moth.
- Totrix caterpillars are small, green with a brown head and wriggle backwards when disturbed. Adult moths are small and pale brown with orange-brown markings depending upon the species.
- The caterpillars roll up the growing point and leaves, spinning them together with silk to form a shelter in which they feed.
- The main cut flower species attacked is *Dianthus*, although *Chrysanthemum* can also be infested.

Earwig, common

(*Forficula auricularia*)

- A useful predator of aphids, but earwigs are also a pest of cut flower crops.
- 13–16mm in length, brown in colour with pincers at the rear of the body.
- Causes damage to flower petals in the form of ragged holes, and leaves unsightly frass (droppings).
- Mainly attacks *Chrysanthemum,* especially disbudded blooms, but can also damage *Dahlia, Dianthus, Rosa* and *Zinnia.*

Flea beetles

(*Phyllotreta* and *Psylliodes* species)

- Very small (2–3mm) beetles that quickly leap off plants when disturbed.
- Adults vary in colour depending upon species and may be black, green, metallic blue or black with yellow/brown stripes.
- Feeding results in leaf pitting and 'shot-holing'.
- Mainly attacks members of the *Brassicaceae*, especially column stocks; and can rapidly build up to high numbers.

Leaf miners

(*Chromatomyia syngenesiae, Liriomyza* species etc)

- The most common species is the native *Chrysanthemum* leaf miner (*Chromatomyia syngenesiae* – top left image); *Liriomyza* is a non-indigenous notifiable species.
- Adult leaf miners are small, robust flies, like small house flies, with a grey or black body. *Liriomyza* species have a yellow spot on their backs. Adult feeding gives rise to small bleached spots on leaves.
- Larvae feed within the leaf causing whitish mines especially in *Antirrhinum, Chrysanthemum,* column stocks and *Dahlia.*

Mite, two-spotted spider

(*Tetranychus urticae*)

- Adult mites are very small (up to 0.6mm) and usually found on leaf undersides. The young mites and summer adults are green with two black patches on their backs. In autumn, the females turn brick red prior to overwintering (top left image).
- Feeding damage causes a fine yellow specking on the leaves that can develop into necrotic patches. Extreme infestations can lead to webbing on the leaves and flowers (bottom right image).
- Common hosts include *Aster, Chrysanthemum, Dahlia* and lisianthus.

Nematodes

(*Aphelenchoides, Ditylenchus, Meloidogyne, Pratylenchus* species etc)

- Nematodes (or eelworms as they were known) are microscopic, translucent 'worms' around 0.3–1.3mm in length.
- The leaf and bud nematode (*Aphelenchoides* species – left-hand image) causes blackened areas on the leaves of *Chrysanthemum* usually delineated by the veins; it also attacks *Aster* and *Phlox*.
- The stem nematode causes stunted and distorted foliage in some bulb crops (*Freesia*) and also attacks *Gypsophila* and *Phlox*.
- *Meloidogyne* species (root-knot nematodes) and *Pratylenchus* species (root-lesion nematodes) attack the roots of plants.

Pollen beetles

(*Meligethes* species)

- The adult beetles are shiny greenish-black and are about 2.5mm in length.
- They are found in the flowers and are particularly attracted to plant species with yellow petals, such as sunflower.
- They feed on ripe pollen and nectar but very rarely cause physical damage to the flowers. They are more of a 'cosmetic' nuisance and can usually be removed by shaking infested flowers.

Slugs and snails

(*Arion, Deroceras, Helix, Milax* species etc)

- The field slug (*Deroceras reticulatum*) is the commonest and the most damaging species, it is grey/light brown in colour and around 3–4cm in length.
- Other species include *Arion* species (top image) and *Milax* species.
- Slugs and snails tend to be general feeders on a range of cut flower species, being problematic when environmental conditions are favourable (damp and humid).
- Feeding damage is similar to caterpillar damage, but slime trails are usually visible and frass (droppings) is not present.

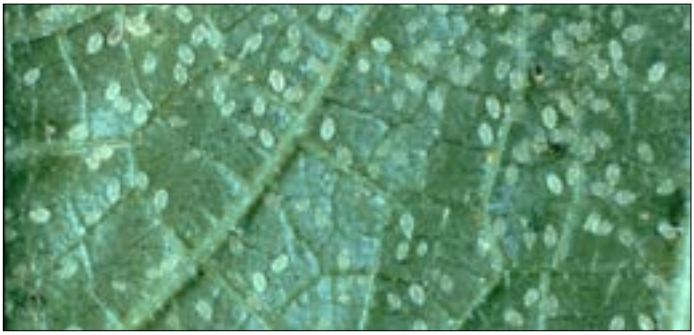
Thrips

(*Frankliniella occidentalis, Taeniothrips simplex, Thrips tabaci,* etc)

- Western flower thrips (*Frankliniella occidentalis*) are the most difficult species to control; the adults are small, narrow and yellow or pale brown in colour. Larvae are smaller and yellow.
- Thrips cause a wide range of damage symptoms, including: leaf crinkling (top right image), leaf and flower petal flecking and flower distortion.
- Thrips have a wide host range but are especially damaging on *Chrysanthemum* and *Gladiolus* (bottom left and right images).
- As well as the physical damage caused, thrips are also vectors of important viruses.

Whitefly, glasshouse

(*Trialeurodes vaporariorum*)



- The adults (top image) are small, white and moth-like and tend to hold their wings flat across their back when at rest. The scales (bottom image) are white, flat and immobile.
- All stages are found on the underside of leaves and, as with aphids, the honeydew excreted by the pest can lead to the growth of sooty moulds.
- Whitefly attack a wide range of subjects, but are especially common on *Alstroemeria* and *Chrysanthemum*.

SECTION 2 Biological control agents

Aphidius and other parasitoid species

(For the control of aphids)

- Small brown and black parasitic wasps used for aphid control.
- Different species attack different aphid species, so the correct identification of the aphid is important. However, mixes of parasitoid species are now available that attack a number of aphid species.
- Larvae of the parasitoid develop inside the host, and the parasitised aphid swells and hardens into a leathery, beige, golden-brown or black mummy depending upon the parasitoid species.
- Parasitic wasps are supplied in bottles or tubes as parasitised aphid mummies.

Aphidoletes aphidimyza

(For the control of aphids)

- *Aphidoletes/aphidimyz* is a predatory midge whose larvae prey on most aphid species.
- Adult females lay eggs close to aphid colonies. Larvae are pale orange and 0.3mm in length when newly hatched, growing to 2.5mm and becoming a deeper orange.
- Supplied as pupae mixed with vermiculite or shredded paper in tubs or blister packs. The adults emerge from the pupae and fly to aphid-infested plants.

Dacnusa and *Diglyphus* species

(For the control of leaf miners)

- Small parasitic wasps used for control of leaf miners. *Dacnusa* (top image) is dark brown to black with long antennae, whereas *Diglyphus* (bottom image) is metallic green to black with short antennae.
- *Dacnusa* is an internal parasitoid, with the adults laying eggs inside the leaf miner larvae. *Diglyphus* is an external parasitoid, with the eggs being laid onto the surface of the leaf miner larvae in the mines. The parasitioid larvae feed on the leaf miner larvae and kill them.
- The wasps are supplied as adults in bottles for release into the crop.

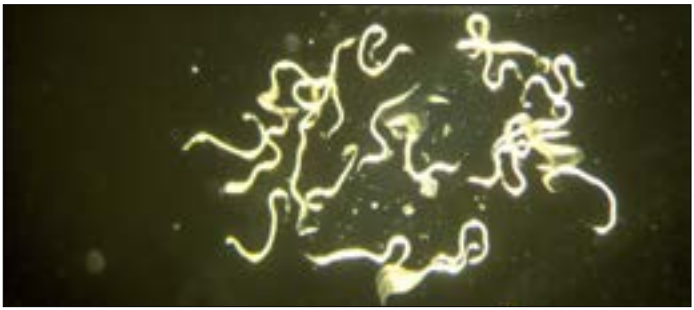
Encarsia formosa

(For the control of whitefly)

- *Encarsia formosa* is a parasitic wasp about 0.6mm long; the female has a dark brown to black head and thorax, and a yellow abdomen. Males are black in colour and represent only 1–2% of the population.
- The adult wasp lays an egg into a whitefly scale, the parasitoid larva then develops inside the scale, eventually turning it from white to black. When the parasitoid larva becomes an adult, it emerges via a round hole cut in the top of the black scale (left-hand scale, bottom image).
- The wasps are supplied as parasitised black scales attached to cards for hanging onto plants.

Heterorhabditis and *Steinernema* species

(For the control of thrips and soil-dwelling pests)



- Entomopathogenic nematodes can infect thrips larvae on foliage when applied as a spray, or soil dwelling pests when applied via the irrigation system or as a drench.
- The nematodes enter the insect's body and release bacteria that kill it.
- Affected insects die by septicaemia and disintegrate.
- The microscopic nematodes are supplied in an inert carrier (*Steinernema feltiae* will control sciarid fly and thrips).

Hypoaspis and *Macrocheles* species

(For the control of sciarid fly larvae and thrips pupae)

- Very active ground-dwelling predatory mites that prey on eggs and larvae of sciarid flies and on thrips larvae that drop to the ground to pupate (image shows *Macrocheles robustulus* with thrips pre-pupa).
- The adult mites are off-white with a brown shield covering most of the upper surface of the body, nymphs are paler.
- The predators are supplied in tubs containing a peat and vermiculite carrier for sprinkling onto the soil surface around the base of the crop.

Neoseiulus (Amblyseius) californicus

(For the control of two-spotted spider mite)

- *Neoseiulus californicus* is a small (0.4mm), oval, straw-coloured predatory mite used to control two-spotted spider mites.
- The eggs are oblong, transparent to white, and are attached to hairs along veins on the underside of leaves.
- Only licensed for release in fully enclosed structures in the UK.
- The adult predators are supplied in bottles for sprinkling onto the crop or in slow release sachets for hanging onto plants.

Neoseiulus species (also *Amblydromalus*, *Amblyseius,* etc)

(For the control of thrips larvae and whitefly eggs and scales)

- *Neoseiulus cucumeris* (top image) is a predatory mite used to control thrips larvae. *Amblydromalus limonicus* (bottom image), *Amblyseius swirskii* and *Typhlodromips montdorensis* are used for the control of thrips larvae and whitefly eggs and scales.
- The predatory mites are less than 0.4mm in length, straw-coloured and oval-shaped. They are found on the undersides of leaves.
- *A. limonicus, A. swirskii* and *T. montdorensis* are only licensed for release in fully enclosed structures in the UK.
- They are supplied in bottles with a bran, vermiculite or sawdust carrier or in slow release sachets for hanging onto plants.

Phytoseiulus persimilis

(For the control of two-spotted spider mite)

- *Phytoseiulus persimilis* is a specialised predatory mite of the two-spotted spider mite and its eggs.
- Adult predators are orange-red and up to 0.6mm long. The predator eggs are oval and pinkish (left and middle, bottom image) and bigger than the round, uncoloured eggs of two-spotted spider mites (right, bottom image).
- The nymphs are smaller in size and paler in colour than the adults. The predator and its eggs are usually found on the leaf undersides.
- The predators are supplied as adults mixed with a vermiculite or wood chip carrier for sprinkling onto plants.

Alternaria leaf spots

(*Alternaria* species)

- Disease symptoms vary with plant species. In the case of *Eryngium* (image), symptoms include angular, necrotic spots that can kill the whole leaf.
- In the case of *Zinnia*, reddish brown spots develop on the leaf with dark brown 'canker-like' areas on the stem.
- The disease is quite rare on cut flowers, but can occur on *Dianthus, Eryngium* and *Zinnia*.
- The disease can be seed-borne on some subjects such as *Zinnia*.

Bacterial leaf spots

(*Pseudomonas* and *Xanthomonas* species)

- Symptoms vary depending upon the bacterial pathogen present and the plant species.
- In the case of *Delphinium* (*Pseudomonas* – top image), leaf spots are large, black and irregular with a slight yellow halo.
- With *Zinnia* (*Xanthomonas* – bottom image) the leaf spot is brown and 'dry' in appearance.
- As well as leaves, disease symptoms can also be found on stems and flower buds.

Downy mildews

(*Bremia*, *Peronospora* species, etc)

- A foliar disease causing a yellow mottling on the upper leaf surface.
- Sporulation on the lower leaf surface gives rise to a felty mass of creamy white, brown, purple or grey spores.
- Susceptible species include *Antirrhinum*, column stocks and lisianthus.
- The disease is favoured by high humidity and free water on the leaf surface.
- Each downy mildew pathogen is usually host-specific.

***Fusarium* wilt and stub rot**

(*Fusarium culmorum, F. oxysporum* and other species)

- Symptoms vary, but *Fusarium oxysporum* usually results in severe wilt and eventual death of the plant.
- Early symptoms in stocks can be a kinking of the stem and a yellow veinal mottling of the leaves (top left image). Staining of the vascular tissue can also occur.
- *Fusarium* stub rot results in a rotting of the stem usually at ground level leading to discoloration of the foliage (bottom image).
- Fusarium is particularly troublesome on *Aster*, column stocks, certain *Dianthus* (especially pinks and carnations), *Gladiolus* and lisianthus.

Grey mould or *Botrytis*

(*Botrytis cinerea* and other species)

- *Botrytis* colonises a wide range of cut flower species (*Aster*, *Chrysanthemum*, lily, sunflower, tulip, etc) throughout production, and will attack most parts of the plant leading to symptoms such as leaf rot, stem rot, bulb rot and petal spotting.
- Characterised by a pale brown tissue decay followed by fluffy fungal strands bearing grey-brown spore clusters.
- Infection is most common in cool (around 15˚C), humid conditions; the pathogen often attacks senescent or damaged tissue.

Phytophthora root and stem rots

(*Phytophthora* species)

- The pathogen causes a general root decay that may extend to cause a stem base rot.
- Has a wide host range but is a particular problem on China asters where it causes a black girdling of the stem at soil level leading to wilt and eventual death (top image).
- The pathogen is closely related to *Pythium* and may need a plant clinic examination to confirm which pathogen is present.

Powdery mildews

(*Erysiphe*, *Golovinomyces* and Podosphaera species)

- Primarily a foliar disease but, in cases of severe infection, will also attack the stems, flower buds and petals.
- The fungus is usually seen on the upper leaf surface as distinct white spots or a mass of off-white fungal strands.
- Susceptible species include *Aster*, *Dahlia*, lupin, *Phlox*, *Zinnia,* etc.
- Several host-specific pathogens cause powdery mildew infection.

Pythium root rots

(*Pythium* species)

- Causes damping-off, root and stem decay, general poor or uneven growth and wilting, especially in warm weather (top right image).
- Can attack a wide range of cut flower species (*Chrysanthemum*, column stocks, lisianthus, tulip, etc) especially at the seedling or young plant stage.
- The disease is favoured by stress conditions, especially waterlogging of the soil.
- *Pythium* species can produce long-lived resting spores.

Ring spot

(*Mycosphaerella dianthi*)

- The fungus causes round grey-brown spots with concentric rings of dark pustules. The spots are usually surrounded by a purple halo.
- Symptoms can occur on both leaves and calyces (especially on carnations).
- Attacks *Dianthus* species, especially carnation, pinks and Sweet William.
- Primarily occurs during periods of high humidity.

Rusts

(*Phragmidium*, *Puccinia* and *Uromyces* species)

- Symptoms can be visible on the upper leaf surface as pale yellow, often sunken spots. In severe cases, the leaf may be distorted.
- The spore pustules are visible on the lower leaf surface and, depending upon the rust species and stage of growth, may be brown-red, creamy white or orange in colour.
- Susceptible species include *Antirrhinum*, *Chrysanthemum*, *Dianthus* and *Rosa*, but the pathogens are usually host-specific.

Sclerotinia

(*Sclerotinia sclerotiorum*)

- The pathogen attacks the vascular tissue usually leading to a stem necrosis at soil level or higher.
- At a more advanced stage, large black resting bodies (sclerotia – bottom image) develop and these are often surrounded by white fluffy fungal strands.
- It is not host-specific and susceptible plant species include *Chrysanthemum*, column stocks and sunflower.
- Infection occurs from spores in the air or fungal strands that develop from resting spores (that can remain viable in contaminated soil for many years).

Septoria leaf spots

(*Septoria helianthi* and other species)

- A very common disease of sunflowers producing water-soaked spots on the leaves that turn brown or grey, usually surrounded by a yellow halo. The spots eventually coalesce to produce irregular necrotic areas on the leaf.
- The disease usually attacks the lower leaves first (typically, after flowering) but does not tend to cause serious damage. There are known to be wide varietal differences in plant susceptibility.
- Other susceptible plant species include *Antirrhinum* and *Phlox*.

Smut, *Dahlia*

(*Entyloma dahliae*)

- Initial symptoms are circular brown spots that appear on the lower leaves, these then spread up the plant.
- Where the spots coalesce, they form necrotic patches that may kill large parts or the whole of the leaf. In some instances, the leaves may show 'shot-hole' type symptoms where the central dead area of the spot drops out.
- The pathogen is specific to *Dahlia*.

Verticillium wilt

(*Verticillium dahliae*)

- Symptoms include a one-sided wilt and a yellowish-brown discoloration of the lower leaves that progresses up the stem. Plants can be stunted or woody in severe cases.
- The pathogen has a wide host range but, among cut flower species, it mainly attacks *Chrysanthemum.*
- Crop infection occurs either from contaminated soil or via infected cuttings.

Viroid, *chrysanthemum* stunt

(CSVd)

- The main symptom is a substantial stunting of the plant. Flowering occurs earlier, with the blooms not always being typical of the variety affected (fewer petals and more 'spiky' in appearance).
- The main host for the viroid is *Chrysanthemum* but, experimentally, it has been shown to infect a wider host range.
- The main source of the viroid is infected cuttings, mechanical sap transmission can occur via actions such as disbudding.

Virus, *impatiens* necrotic spot

(INSV)

- Symptoms can be very variable including leaf spotting, vein blackening and necrotic patches on both the stems and leaves.
- *Chrysanthemum* is the most susceptible species where it tends to form more localised symptoms rather than becoming systemic (but not in all cases).
- The main source of the virus is infected cuttings, with transmission via western flower thrips.

Virus, *plantago asiatica* mosaic virus and others

(PlAMV, TBV, LMV, TRV, etc)

- A number of viruses can infect lilies.
- The most damaging virus is *Plantago asiatica* mosaic virus (PlAMV), the symptoms of which are rust-coloured necrotic streaks, usually along the leaf veins (left image) making the stems unmarketable in most cases.
- Other lily viruses include tulip breaking virus (TBV), lily mosaic virus (LMV) and tobacco rattle virus (TRV).
- Some of these other viruses can produce a general mottling of the leaves (right image), but may require a plant clinic examination to confirm the exact virus present.

Virus, tomato spotted wilt

(TSWV)

- Very similar to INSV and a plant clinic examination may be required to confirm which virus is present.
- Symptoms vary but can include leaf mottling, leaf necrosis and stunting.
- *Chrysanthemum* is a very susceptible species but it also causes problems on *Alstroemeria*, China asters, column stocks and lisianthus.
- The virus is most commonly transmitted by western flower thrips, the main source being infected cuttings.

Wire stem

(*Rhizoctonia solani*)

- The pathogen can cause damping-off in recently emerged seedlings and also a 'foot rot' or 'wire stem' in older plants. It rarely attacks established plants.
- It usually infects the stem tissue at soil level producing a characteristic reddish-brown stem lesion ('wire stem') leading to seedling collapse.
- Column stocks are the most susceptible species; but it can also occur on *Chrysanthemum*, *Delphinium* and *Dianthus*.

Calcium

(Ca)

- Ca deficiency is not commonly seen in cut flowers, except in the case of lilies, where it results in a characteristic leaf scorch.
- Some varieties are more prone to it than others and symptom expression is also influenced by factors such as humidity, temperature and bulb size.
- Ca is not a mobile nutrient within the plant so, as a general rule, fresh symptoms are often seen in the growing point and towards the top of the plant.

High conductivity

(EC)

- Symptoms can include leaf discoloration and necrosis, root damage, severe stunting and sometimes plant death.
- Results from an excessive level of nutrients in the soil, especially (but not exclusively) nitrogen (N).
- Other elements, such as chlorides, can also build up and give rise to high conductivity levels, especially after the incorporation of some green compost soil improvers.

Iron

(Fe)

- Deficiency symptoms are most pronounced in the younger, rapidly expanding leaves, which show a very marked interveinal chlorosis (yellowing).
- In more severe cases, the leaves may become completely yellow and symptoms may also be present on the older leaves.
- Fe deficiency is usually associated with soil pH, a high pH gives rise to an insoluble form of iron, making it unavailable to the plant, often referred to as 'lime induced chlorosis'.
- Poor root development and waterlogging may also lead to Fe deficiency.

Manganese

(Mn)

- Deficiency symptoms are very similar to Fe deficiency – a marked interveinal leaf chlorosis.
- Brown spots may appear on the leaf surfaces and severely affected leaves turn brown and wither.
- As with Fe deficiency, symptoms are usually associated with a high soil pH restricting nutrient uptake.
- A leaf analysis may be required to determine if the deficiency is Fe or Mn related.

Nitrogen

(N)

- Deficiency usually results in stunted, poorly developed plants with pale green to yellow leaves.
- In extreme cases of deficiency, a red coloration can occur on the older leaves (bottom image).
- Symptoms are most commonly seen in cut flower crops growing in waterlogged areas (under leaking gutters, for example), where the nutrient has been leached out of the top soil.

Phosphorus

(P)

- Deficiency usually results in dark green foliage with the older leaves becoming purple or possibly bronze-coloured in some species.
- Deficiency can occur at extremes of soil pH as the phosphate ions become insoluble making them unavailable to the plant.
- Growth can be spindly and in extreme cases the plants can be stunted. In some species such as *Chrysanthemum*, flowering can be delayed and the flower size can be reduced.

- Deficiency is observed in the lower leaves first; the nutrient is mobile within the plant and is moved to the younger, developing leaves.
- Deficiency symptoms include dark green leaves that are smaller in size.
- In more extreme cases, leaves exhibit a marginal browning/necrosis that spreads up the plant as the lower leaves die prematurely.
- Flowering may be delayed, flower size reduced and vase life impeded.

Ethylene damage

(Cultural)

- Ethylene is a gaseous substance that is released in small amounts by plants when under stress. It is also released in larger quantities by fruit as it ages and decays.
- It causes flowers to undergo premature senescence leading to a reduction in vase life.
- Symptoms depend upon the sensitivity of the plant subject but include leaf yellowing, bud abortion, petal drop and necrosis of the flowers.
- *Delphinium, Dianthus* (pinks and carnations) and sweet peas are particularly sensitive.

Hail damage

(Physical)

- Hail impact causes physical damage to the plant including leaf holing, shredding and flower damage.
- On some crops, such as peony, hail impact can bruise the flower buds leading to subsequent disease problems such as grey mould (*Botrytis*).
- The damage is usually transitory and plants generally grow away from the symptoms, depending upon their stage of development.

- Symptoms can range from leaf discoloration and necrosis to distorted and stunted growth, and plant death.
- The symptoms are often very specific to the type of herbicide applied, application time and plant species involved.
- In the case of later herbicide applications, the symptoms may not show up until the following year, but plants often grow away from them.

Herbicide damage

(Residual)

- A wide range of symptoms can result, including poor initial germination (in the case of direct-sown crops), leaf yellowing, leaf scorch, stunted growth and plant death.
- The problem may result from herbicides applied to the crop in question or from herbicides applied to a previous crop grown in the same area.
- Overlapping spray applications can result in symptoms that occur in patches or straight lines within crops, a result of overdosing of the herbicide.

Leaf scorch

(Plant protection products)

- Symptoms can include chlorotic or necrotic patches on leaves and marginal leaf yellowing.
- Symptom expression can be very variety-specific.
- Often limited to a certain stage in the development of the plant and new growth will be unaffected. This is indicative of the stage of growth that the causal agent (such as a plant protection product) was applied.

Lily bud abortion and abscission

(Cultural)

- Flower bud abscission (top image) commonly occurs in some varieties grown under protection under low light conditions (during winter).
- Buds are lost a few weeks before flowering, when about 1–2cm in length (note bud scars on top image).
- Flower buds may abort (or blast) at early or late stages in development (when 2–50mm in length – bottom image).
- The bud becomes flaccid, pale or brown, and dies but does not abscise.

- Heating oil spillages can lead to a wide range of symptoms including leaf yellowing, distorted or stunted growth and plant death.
- Symptoms usually occur in patches within a crop rather than over the whole production area.
- Spillages of other materials such as plant protection products, concentrated fertiliser, etc can also give rise to plant phytotoxicity symptoms.

Tulip blindness and bud blast

(Cultural)

- Blindness occurs where the bulb fails to initiate a flower and the stem ends in a narrow leaf-like structure (top image).
- Earliest symptoms of bud blast include a dried–up bud within the bulb.
- Intermediate symptoms can include bud and stem death or the flower anthers may develop poorly (bottom left image).
- Later symptoms include petal tipping, where the tips become white and shrivelled (bottom right image).

Waterlogging

(Cultural)

- Over long time periods, waterlogging can result in the leaching of nutrients from the soil and in root death as a result of oxygen starvation.
- Plants at the very least will appear stunted and deficient and at worse will die off completely.
- Long periods of waterlogging can lead to a deterioration of the soil structure.

Acknowledgements

The production of this guide has been a real team effort and has only been possible by the input of a wide group of people. Particularly Lyndon Mason, LRM Horticultural Services Ltd, for scripting the guide and project managing its creation, Gordon Hanks, Independent Consultant, David Davidson, Koppert Biological Systems Ltd. and Jude Bennison and Dr Tim O'Neill, both of ADAS, for technical input into the various sections.

Thanks go to everyone who contributed images and are acknowledged within the photographic credits section, and to the many growers who allowed images to be taken in order to create an extensive library of crop-specific images for use in this guide.

Photographic credits

Section 1 – Invertebrate pests
All images courtesy and copyright of Lyndon Mason (through LRM Horticultural Services Ltd) except adult leaf curling plum aphid (1.1) courtesy and copyright of Andy Jensen; adult melon-cotton aphid (1.2), adult thrips (1.14) and whitefly adult and scales (1.15) courtesy and copyright of Koppert Biological Systems Ltd; adult potato aphid (1.4), leaf rolling caterpillar and damage (1.6), earwig damage (1.7), adult leaf miner (1.9) and nematode images (1.11) courtesy and copyright of ADAS; adult earwig (1.7) courtesy and copyright of Roger Umpleby and thrips damage on gladioli (1.14) which is Crown Copyright.

Section 2 – Biological control agents
All images courtesy and copyright of Koppert Biological Systems Ltd.

Section 3 – Diseases
All images courtesy and copyright of Lyndon Mason (through LRM Horticultural Services Ltd) except bacterial leaf spot on *Delphinium* (3.2) courtesy and copyright of Steve Roberts, Plant Health Solutions Ltd; tulip fire (3.5) courtesy and copyright of University of Warwick and predecessors; *Pythium* on bulbs (3.8) courtesy and copyright of PPO Lisse and wire stem images (3.18) courtesy and copyright of Dr Tim O'Neill.

Section 4 – Nutrient disorders
All images courtesy and copyright of Lyndon Mason (through LRM Horticultural Services Ltd) except manganese (4.4), nitrogen (bottom image 4.5) and phosphorus (4.6) courtesy and copyright of May Barn Consultancy Ltd and potassium (4.7) courtesy and copyright of Brian Whipker, North Carolina State University.

Section 5 – Other disorders
All images courtesy and copyright of Lyndon Mason (through LRM Horticultural Services Ltd) except ethylene damage (5.1) courtesy and copyright of Chrysal UK, lily bud abortion and abscission images (5.6) courtesy and copyright of PPO Lisse and tulip blindness and bud blast images (5.8) courtesy and copyright of University of Warwick and predecessors.

Disclaimer and copyright

horticulture.ahdb.org.uk

AHDB Horticulture, Stoneleigh Park,
Kenilworth, Warwickshire, CV8 2TL

T: 024 7669 2051

E: hort.info@ahdb.org.uk

@AHDB_Hort

AHDB
HORTICULTURE

AHDB Horticulture is a division of the Agriculture and Horticulture Development Board (AHDB).

£50
Where sold

HT60040715