



Crop Walkers' Guide

Protected Edibles

*HDC is a division of the Agriculture and
Horticulture Development Board*

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Every year, a significant proportion of the UK protected edibles crop would be lost to insect pests and diseases if growers did not monitor their crops and employ effective crop protection strategies.

This Crop Walkers' Guide is aimed at assisting growers, supervisors and nursery staff in the vital task of monitoring glasshouse tomato, cucumber, pepper and aubergine crops. It is designed for use within the glasshouse to help with the accurate identification of pests, their predators and parasitoids and; diseases within a crop.

Images of key stages in the life cycles of pests, predators, parasitoids and diseases are included along with bullet point comments to help with identification.

It is impossible to show every symptom of every pest or disease therefore growers are advised to familiarise themselves with the range of symptoms that can be expressed and be aware of new problems that occasionally arise.

The guide does not offer any advice on the measures available for controlling pests or diseases as both chemical active ingredients and their approvals frequently change. However, having identified a particular pest or disease in their crop, growers should acquaint themselves with the currently available control measures.

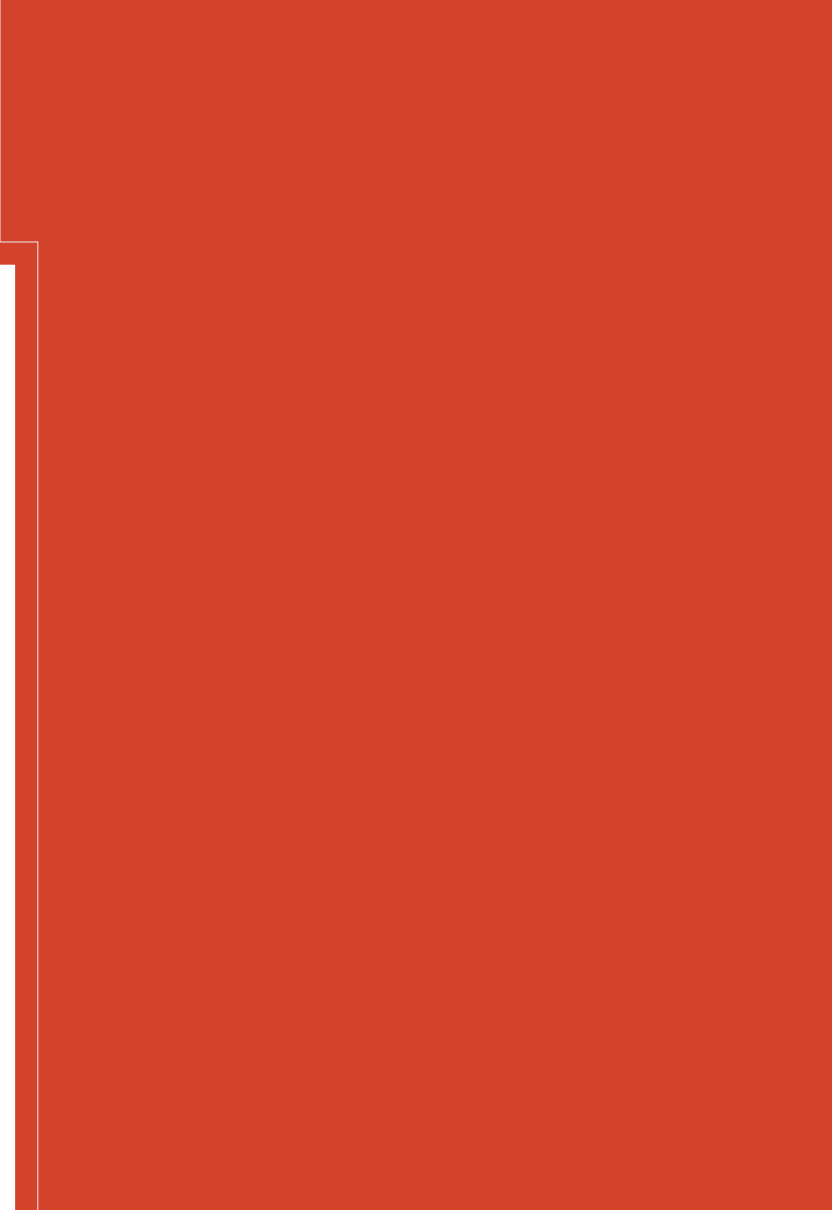
Grace Choto

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Invertebrate Pests

A





- ▶ Damages cucumber, aubergine and pepper foliage and fruit.
- ▶ Adult thrips 1-2 mm long, found on the undersides of leaves and in flowers.
- ▶ If attacked when young, fruit may become seriously distorted e.g. 'pig tail' damage to cucumbers.
- ▶ Breeding is continuous throughout the year.
- ▶ Western flower thrips (*F. occidentalis*) and onion thrips (*T. tabaci*) can only be distinguished by a microscope.

Glasshouse whitefly

(*Trialeurodes vaporariorum*)



- ▶ Adults (1 mm) are found on the underside upper leaves of many crops including tomato, aubergine and cucumber.
- ▶ Oval eggs are white at first but turn black after 2–3 days.
- ▶ Immature stage is a flattened scale (up to 1 mm) attached to the underside of leaves.
- ▶ They produce copious quantities of honeydew which provides a growth medium for sooty moulds.

Aphids – 1

(General information)



- ▶ Several species attack pepper, cucumber, aubergine and tomato.
- ▶ Winged adults fly into glasshouses (spring - autumn) and give birth to wingless offspring. The first sign may be white cast skins on the upper surface of lower leaves.
- ▶ Feed mainly on the undersides of leaves, producing copious quantities of honeydew – a growing medium for sooty moulds.
- ▶ All species have distinct tubular processes (siphunculi) at the rear which are useful for identification.

Aphids – 2

(Four common species)



- ▶ ***Myzus persicae*** (1): 2 mm long, common on peppers. Usually green but can vary from yellow to red.
- ▶ ***Aphis gossypii*** (2): 1-2 mm, forms dense colonies on cucumber leaves. Yellow to dark green, siphunculi black.
- ▶ ***Aulacorthum solani*** (3): 2-3 mm, yellow-green with distinctive dark patches around siphunculi.
- ▶ ***Macrosiphum euphorbiae*** (4): Largest of these species. Pink to yellow-green with darker stripe down their backs.

Capsid bugs

(*Lygus rugulipennis* / *Liocoris tripustulatus*)



- ▶ *Lygus* adult (top left) usually has two generations per year, invading cucumber crops in April and mid-summer. *Liocoris* adult and nymph (top right and bottom left) may be found in aubergines and peppers from March onwards.
- ▶ Attack apical parts of plants causing leaf distortion and loss of growing points.
- ▶ Feeding / egg laying in young fruit can lead to distortion.
- ▶ Nymphs are fast runners and are most easily caught by tapping foliage over a white tray.

Southern green shieldbug

(*Nezara viridula*)



- ▶ A recent introduction to the south east of England - a particular pest of aubergine and pepper. Very similar to the native shieldbug - (*Palomena prasina*).
- ▶ Damage is seen as stunting and wilting of heads and swellings on stems.
- ▶ The larvae change colour at each moult - starting out black and then going through various spotty stages until they mature as green "shieldbugs". The adults are easy to identify - they are up to 15 mm long.
- ▶ Refer to HDC Factsheet 36/12.

Tomato leafminers

(*Liriomyza bryoniae*)



- ▶ Important on tomato, less so on cucumber, aubergine and pepper.
- ▶ Adult *Liriomyza* spp. (2–2.5 mm), feed on the upper leaf surface causing numerous small bleached spots.
- ▶ Larvae are translucent to pale yellow with no distinct head or legs. Fully grown larva are 5-6 mm long. They produce meandering mines within the leaf and eventually form red-brown pupae on lower leaf surface.
- ▶ Increasingly large populations develop in cycles at 4-5 week intervals from the start of the season. Breeding is continuous and later generations overlap.

South American tomato moth

(*Tuta absoluta*)



- ▶ Adults (6 mm) are nocturnal but may be seen during the day when numerous.
- ▶ Eggs (1 mm) are laid on the surface of leaves and stems.
- ▶ Larvae produce 'blotch' mines with an accumulation of dark coloured frass in one part of the mine.
- ▶ Larvae may also tunnel in fruit leaving a very obvious exit hole.
- ▶ Refer to HDC Factsheet 03/10.

Caterpillars

(*Laconobia oleracea* / *Autographa gamma*)



- ▶ These are the most common species but many other moths enter glasshouses and may attack tomatoes, cucumbers, aubergines and peppers.
- ▶ Tomato moth (*L. oleracea*) larvae feed on leaves and fruit before pupating under debris or in the glasshouse structure. Usually two distinct generations per year.
- ▶ Silver Y moths (*A. gamma*) arrive in the UK from April onwards. Distinguished from tomato moth by three pro-legs (instead of five) and move with a looping action.

Spider mites

(*Tetranychus urticae* / *Tetranychus cinnabarinus*)



- ▶ Feed under leaves, speckling shows on upper surfaces of cucumber / tomato leaves, less so on peppers. Sometimes damage is more severe (hyper-necrotic) to tomatoes.
- ▶ Dense webbing is produced as populations increase.
- ▶ Two-spotted spider mite (*T. urticae*) is most common. Adults (0.5 mm) turn red in autumn and hibernate off the plant.
- ▶ Carmine spider mite (*T. cinnabarinus*) is similar size but dark red and remains on the plant all year.

Broad mites

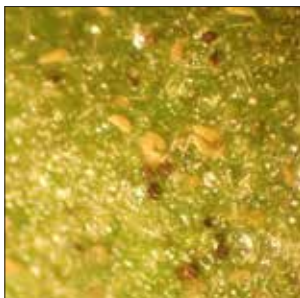
(*Polyphagotarsonemus latus*)



- ▶ Microscopic mites (0.2 mm) the presence of which is indicated by the damage caused to peppers and cucumbers.
- ▶ Growing points of peppers become distorted and sometimes blind.
- ▶ Foliage of cucumbers is stunted and thickened, similar to hormone herbicide damage.
- ▶ Fruits are distorted and may acquire a waxy bloom.

Tomato russet mites

(*Aculops lycopersici*)



- ▶ Microscopic (0.2 mm) eriophyoid mites (top right) cause bronzing and roughening of stems and 'graze off' trichomes (hairs). Top left image compares a healthy and an infested stem.
- ▶ Early damage is most evident on lower stems but can affect foliage and trusses.
- ▶ Infested leaves have localised necrotic lesions. Foliage damage is often confused with potato blight.
- ▶ Advanced infestations lead to brown, rough and deeply cracked fruit.
- ▶ Refer to HDC Factsheet 21/10.

Leafhoppers

(Various)



- ▶ Adults (3 mm), feed on undersides of leaves damaging cucumber, tomato and pepper. Symptoms sometimes mistaken for thrips. Pepper fruit can also be damaged.
- ▶ As feeding continues areas coalesce and leaves may become totally bleached.
- ▶ Both adults and nymphs jump when disturbed.
- ▶ As nymphs grow, they cast skins which can be confused with aphids.

Glasshouse mealybug

(*Pseudococcus viburni*)



- ▶ On tomatoes, infestations develop on lower stems and later thrive among the horizontal stem bundles.
- ▶ On peppers, females hide under the calyx of fruit leading to rejection by customers.
- ▶ Females (3–4 mm) are covered in white waxy filaments for protection. They lay eggs in batches of 100–500 in waxy sacs.
- ▶ Immature mealybugs are similar in appearance to females but smaller.

Woodlice

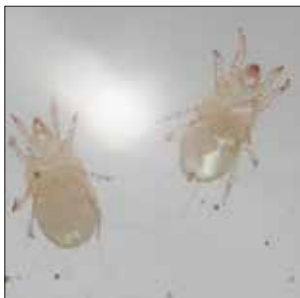
(*Porcellio scaber* / *Armadillidium nasatum*)



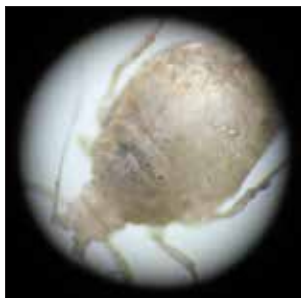
- ▶ Live in the surface layers of soil / compost and are very common in organic cropping systems.
- ▶ They climb plants after dark to graze on leaves and stems. This can seriously deplete the foliage of young plants.
- ▶ In the early season, stems may be girdled, particularly around grafting scars.
- ▶ Later, stems may be penetrated at weak points such as deleafing scars, allowing entry of secondary disease.

“French Fly”

(*Tyrophagus* spp.)



- ▶ This pest was widespread when straw bales were in cucumber production - it is less common these days but still occurs from time to time.
- ▶ The small mites feed in the head of the plant and produce small holes in the leaves. As the leaves expand the holes become obvious.
- ▶ *Tyrophagus* and similar prey mites are used in *Amblyseius* packs. The damage is usually associated with sub-optimal formulations in the packs which allows the mites to breed out of control and emerge to cause damage. Damage can be quite extensive if the pest is not controlled.



- ▶ Ten species of hyperparasitoids have been found attacking primary parasitoids of aphids in pepper crops.
- ▶ The female hyperparasitoid probes the parasitised aphid to feed and / or lay eggs. Typical holes are shown top right.
- ▶ The immature hyperparasitoid develops inside the mummified aphid killing the primary parasitoid.
- ▶ The first indication of hyperparasitoid activity is often the characteristic irregular-shaped emergence hole in the mummy. By comparison, *Aphidius* emergence holes have neater edges and often retain a distinct lid (Image bottom left). Refer to HDC Factsheet 27/12.

Macrolophus bugs

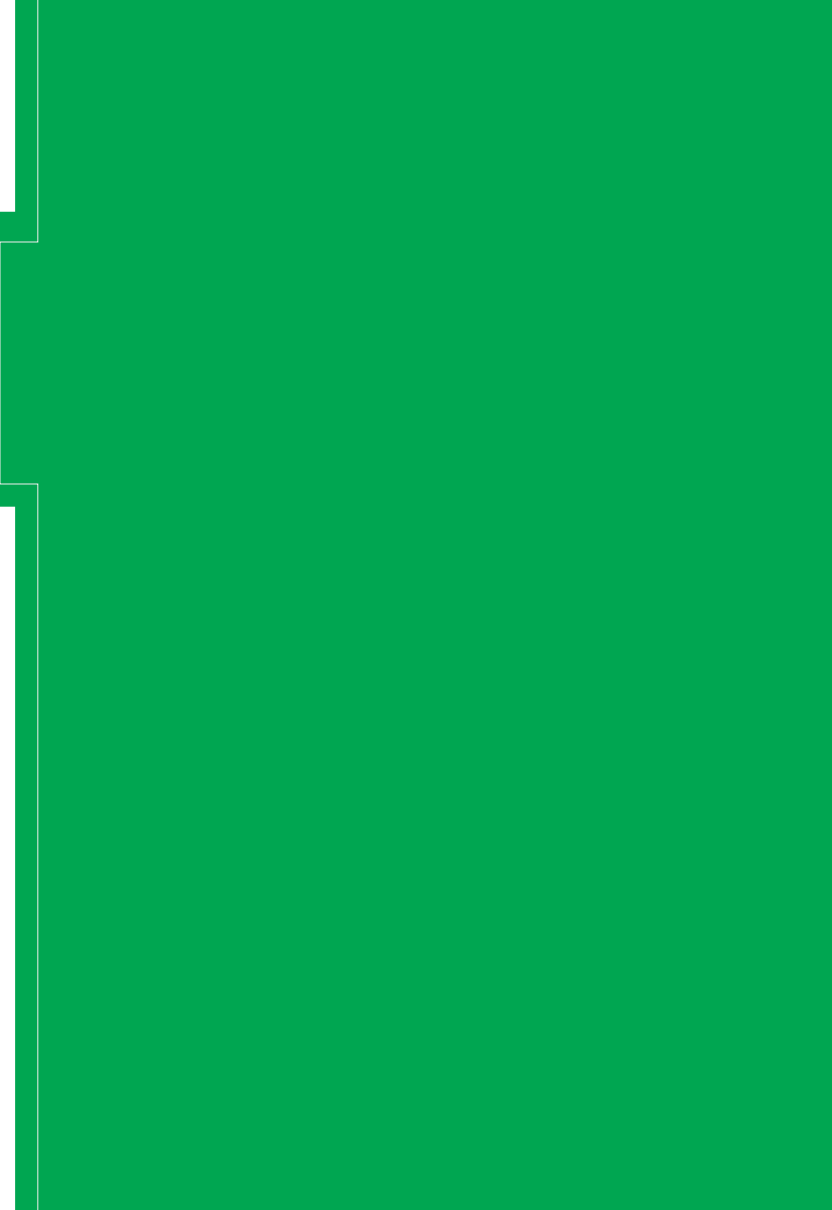
(*Macrolophus caliginosus*)



- ▶ A predatory insect which also feeds on plants.
- ▶ Feed on veins of tomato leaves causing characteristic down turning and also on trusses causing premature flower and fruit drop.
- ▶ Adults are 6 mm and bright green with large membranous wings. Nymphs are of similar shape but smaller and wingless.
- ▶ Large populations build up quickly when there is adequate insect prey. Plant damage usually occurs after other pests have been killed.

Beneficials: Predators & Parasitoids

B



Macrolophus

(*Macrolophus caliginosus*)



- ▶ Adults (6 mm) are bright green with large membranous wings.
- ▶ Nymphs are of similar shape but smaller and wingless.
- ▶ Both are voracious predators feeding on a wide range of insects / mites.
- ▶ Can become a pest when insect / mite prey is limiting.
- ▶ When numerous, *Macrolophus* can be collected and redistributed to areas of need – refer to HDC Factsheet 02/10.

Amblyseius species

(Generalist predators and scavengers)



- ▶ Various species released against thrips, broad mites, whiteflies and spider mites.
- ▶ Small (~0.5 mm) mites, just visible to the naked eye. Usually found on the underside of leaves, often close to veins, or in flowers.
- ▶ Most species vary from semi-translucent to pale straw-coloured but *A. degenerans* are shiny black.
- ▶ *A. cucumeris*, *A. swirski* and *A. andersoni* are available in culture packs, in which the predators continue to breed.

Encarsia formosa

(Parasitoid of whitefly)



- ▶ This small (0.6 mm) parasitic wasp is specific to whiteflies.
- ▶ Eggs are laid in whitefly scales on the underside of leaves. The immature wasp develops inside.
- ▶ After a few days the scale turns black and eventually one adult emerges leaving a characteristic round emergence hole.
- ▶ Supplied as black scales, either loose or attached to cards.

Parasitoids of aphids

(Several species)



- ▶ Most parasitoids are specific to one type of aphid but act in the same way; an egg is laid within the aphid, the immature wasp develops internally and the aphid becomes 'mummified'.
- ▶ Each parasitoid produces a characteristic mummy; eg *Aphidius* spp. (1) in *Myzus* or *Macrosiphum*, *Aphelinus* spp. (2) in *Aulacorthum* or *Macrosiphum*, and *Praon* spp. (3) in *Myzus*.
- ▶ These parasitoids occur in the UK but may be released to supplement natural populations.

Predators of aphids

(Several species)



- ▶ The predatory midge, *Aphidoletes aphidimyza* (1), is a specific predator of aphids and is available commercially.
- ▶ Many other species may be found in crops that are free from chemical pesticides. Some, such as syrphids (2), are specific to aphids.
- ▶ Anthocorid bugs (3) and lacewings (4) are generalist predators and may attack a wide range of pests.

Diglyphus isaea

(Parasitoid of leafminers)



- ▶ Adults (1-2 mm) are black wasps with short antennae.
- ▶ Females sting (1) and immobilise leafminer larvae (2).
- ▶ One or more eggs may be laid in the mine.
- ▶ The immature wasp latches onto the miner (3) and completes its development in that position (4).
- ▶ When fully grown, the immature wasp builds several 'pit-props' and then forms a turquoise pupa.

Dacnusa sibirica

(Parasitoid of leafminers)



- ▶ Adult *Dacnusa* are larger (2-3 mm) than *Diglyphus* and have long antennae.
- ▶ Eggs are laid through the leaf and into the leafminer larvae where the immature wasp completes its development.
- ▶ Unlike *Diglyphus*, the leafminer is allowed to continue to feed and eventually emerges from the leaf to pupate.
- ▶ Parasitism can be confirmed by dissecting the leafminer larvae or waiting for the wasp to emerge from pupae.

Bacillus thuringiensis

(Control of caterpillars)



- ▶ *Bacillus thuringiensis* (Bt) is the most widely used pathogen for the control of caterpillars.
- ▶ The products, which contain a toxin produced by the Bt bacteria during fermentation, are sprayed onto the leaf and kill the caterpillar following ingestion.
- ▶ Before use, the caterpillars should be correctly identified as this may influence the choice of product. If in doubt, consult your supplier.

Predators of spider mite

(*Phytoseiulus persimilis* and *Feltiella acarisuga*)



- ▶ *P. persimilis* (1) is slightly larger than an adult spider mite and distinctly pear shaped. Eggs (2) are pale pink, oval and twice as big as spider mite eggs.
- ▶ The larva of the predatory midge, *F. acarisuga* (3), has no legs or discernible head.
- ▶ When fully grown, *F. acarisuga* larvae pupate in a cocoon (4) that remains attached to the underside of the leaf.

Orius bugs

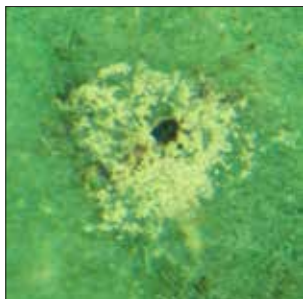
(Various species)



- ▶ Several species reared primarily for thrips control but attack other pests e.g. aphids and caterpillars. All are of similar appearance.
- ▶ Adults are 2-3 mm and are strong fliers. Nymphs are similar in appearance to adults but without true wings.
- ▶ Found wherever their prey are living on the plant.
- ▶ Breed particularly well on peppers where they use pollen to supplement their insect diet.

Entomopathogenic fungi

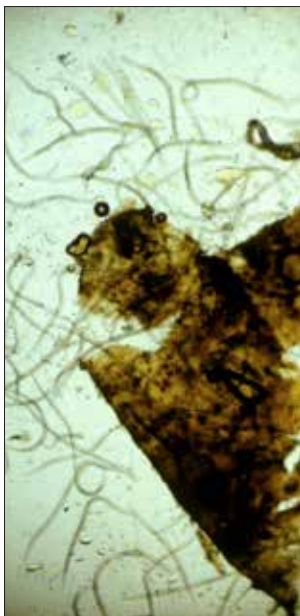
(Various species)



- ▶ Large colonies of aphids or whiteflies may become infected with fungal pathogens causing populations to suddenly crash.
- ▶ For most species, a mass of white fungal mycelium grows on the dead body.
- ▶ Several Entomophthorales (bottom left) are specialist parasites of particular species of aphids. They cause discolouration without white mycelium.
- ▶ Commercial formulations of *Verticillium lecanii* and *Beauveria bassiana* are available against various insects / mites.

Entomopathogenic nematodes

(Various species)

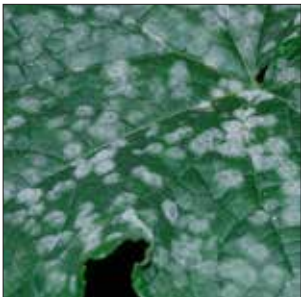


- ▶ Microscopic worm-like animals which penetrate the insect's body and release lethal bacteria.
- ▶ Traditionally used as a drench against larvae of soil-borne pests.
- ▶ Under favourable conditions, foliar sprays of *Steinernema feltiae* have given up to 60% mortality of *Tuta absoluta* larvae (Image left) and 50% mortality of *Liriomyza* leafminer larvae (Image right) within mines.
- ▶ Refer to HDC Factsheet 08/00.

C

Cucumber powdery mildew

(*Sphaerotheca fuliginea* & *Erysiphe orontii*)



- ▶ Powdery mildew can develop at any time of year.
- ▶ Initial infection is usually on the upper leaf surface but it can develop on the underside of the leaf, the stem and even the fruit.
- ▶ First signs are very small patches on the upper surface of the leaf.
- ▶ Initial infection is usually slower on mildew tolerant varieties but once infection has occurred spread can be quite rapid.
- ▶ Where inoculum levels are high the underside of the leaf is quickly colonised.

Powdery mildew (*Oidium lycopersici*)

Oidium neolycopersici - Tomato) (*Leveillula taurica* - Pepper)



- ▶ In peppers the first signs of infection are the appearance of pale patches on the upper leaf surface with spore development on the underside of the leaf. Infected leaves curl and prematurely fall from the plant.
- ▶ In tomato initial infection is usually on the upper surface but it can develop on the underside of the leaf, truss and stem.
- ▶ Initial infection is usually slower on mildew tolerant varieties but once infection has occurred spread can be quite rapid.

Downy mildew

(*Pseudoperonospora cubensis*)



- ▶ A disease of the summer and early autumn on Cucurbits only. Small pale patches develop on the foliage that become clearly defined by the leaf veins.
- ▶ Following the initial infection there are few spores produced but quite rapidly patches of dark brown spores develop within the pale patches on the underside of the leaf.
- ▶ Spread within the crop is very rapid, especially if foliage is wet for any reason.
- ▶ Spores can only come from infected Cucurbits but can move many miles. Effective crop disposal is important in preventing spread.

Grey mould

(*Botrytis cinerea*)



- ▶ Infects a wide range of crops causing plant collapse. Grey or grey-brown spores usually seen quite rapidly.
- ▶ On tomato, check inside damaged stems and trusses for fungal growth if not seen externally.
- ▶ Usually infects via wounds e.g. leaf scorch wounds or those due to poor crop work or dying leaves or trusses.
- ▶ Surface wetness, warm temperatures and high humidity favour the disease.

Root and stem rot

(*Pythium* spp.)



- ▶ Affects cucumber, tomato and peppers. Infected plants can rapidly wilt and orange / brown root rot can be seen.
- ▶ There may be visible fungal like growth or stem lesions of *P. aphanidermatum* on the stem base at delivery.
- ▶ Frequently introduced on new plants or from a localised infection in the old crop when interplanting or re-planting.
- ▶ Rapidly spread from plant to plant in hydroponic growing systems especially at temperatures above 24°C.

Mycosphaerella

(*Didymella bryoniae*)



- ▶ Affects Cucurbits only.
- ▶ Initial infection produces a purple lesion that quickly dries to a papery/straw colour with black dots – spore bearing bodies that spread infection through the crop.
- ▶ Lesions often develop on the stem base where condensation occurs in the early morning or evening.
- ▶ Can also enter via dying flowers and surface damage causing internal browning and rapid decay.

Verticillium wilt

(*Verticillium* spp.)



- ▶ Occurs on cucumber, tomato and peppers.
- ▶ First sign is usually a darkening of the plant head but this is common to a range of diseases.
- ▶ Affected plants wilt, often only on one side, and may recover overnight before wilting again the next day. Cutting into the stem shows brown vascular tissue.
- ▶ Roots are unaffected by this disease. If plant wilts and has poor roots, *Pythium*, *Phytophthora* or some other physiological condition may be the cause.

Fusarium wilt

(*Fusarium* spp.)



- ▶ Affects cucumber, tomato and pepper probably via seed.
- ▶ On cucumber and tomato, initial infection seen at stem base as a pink / orange fungal mat. Further infection sites can be anywhere on surrounding plants.
- ▶ Basal lesions on tomato are usually associated with adventitious root growth from the stem.
- ▶ On pepper can develop inside the fruit and is difficult to detect until opened. Dark brown lesions occur on stems.

White rot

(*Sclerotinia sclerotiorum*)



- ▶ Able to attack any part of most plants usually during warm conditions. Premature plant death is often the first sign of damage. Infection in tomato and pepper can show no external fungal growth. Black resting bodies (*Sclerotia*) are found when the stem is opened.
- ▶ White fungal growth rapidly develops on cucumber and aubergine. *Sclerotia* develop within the white fungal growth. These survive to re-infect subsequent crops.
- ▶ Initial infection comes from field crops such as OSR.

Potato blight

(*Phytophthora infestans*)



- ▶ Not common, occasionally infects tomatoes in unheated / poorly ventilated summer crops where infected potatoes are grown nearby.
- ▶ Leaves, petioles and stems have dark necrotic patches and a pale downy fungal growth which spreads rapidly in humid conditions.
- ▶ Brown leathery lesions develop on the upper surface of green fruit. Fungal growth also forms on fruit and calyx.

Root rots

(*Phytophthora cryptogea*)



- ▶ Occur on tomatoes, cucumbers and peppers. Affected plants have a purple or red foliage tinge, wilt quickly in bright conditions and grow slowly.
- ▶ Can occur shortly after planting – check roots at the base of the rockwool cube at planting. In NFT systems browning of the roots rapidly spreads down the channel.
- ▶ Can be introduced on infected plants or picked up from infected soil.

Black root rot

(*Phomopsis sclerotioides*)



- ▶ Only occurs on cucumber – *Phomopsis* infection is normally first seen as a small lesion at the base of the stem but is not normally noticed until plants start to wilt.
- ▶ The wilting plant problem is often blamed on *Pythium* – but close examination of the roots shows the characteristic small black spots.
- ▶ Larger black lesions develop on the roots – these can cover large areas of root tissue.
- ▶ Infection comes from resting spores in the soil especially at row ends where soil is easily exposed.

Penicillium stem rot

(*Penicillium oxalicum*)



- ▶ Not common on cucumber but kills the plant quickly when it occurs. Does not occur on tomato or pepper.
- ▶ Dense blue / grey fungal growth seen, usually low down on the stem at a node.
- ▶ Can spread rapidly in humid conditions.
- ▶ Dead tissue often rapidly colonised by *Botrytis* thus masking the initial infection and making diagnosis harder.

Root mat disorder (Crazy root)

(*Rhizobium rhizogenes*)



- ▶ Affects cucumber and tomato. Is caused by *Rhizobium* sp.
- ▶ Initial infection spreads quite slowly in infected water and is seen as roots growing vertically out of the propagation cube.
- ▶ Root growth increases and masses of unbranched roots are produced which may restrict water flow into the growing media.
- ▶ Foliage growth may also increase.

Thick root disorder

(*Rhizobium* sp.)



- ▶ Occurs in cucumber only.
- ▶ Most usual symptom is thickened roots at the cube base, at or shortly after planting. These have an 'S' shape and may discolour.
- ▶ Close examination shows older roots to be swollen and younger roots to be 'fatter' than normal, possibly flattened.
- ▶ It is assumed that the disease is caused by *Rhizobium* sp. and introduced into the crop by planting infected plants.

Crown gall

(*Rhizobium radiobacter*)



- ▶ Uncommon but can occur on cucumber, tomato and pepper.
- ▶ Can be seen on cucumber plants with or without root mat disorder – but producing a typical gall on the roots.
- ▶ On tomato and pepper can cause stem galls and also seen on tomato trusses.
- ▶ Infected cucumber plants usually show severe magnesium deficiency (inter-veinal yellowing).

Bacterial canker (*Clavibacter michiganensis* ssp. *michiganensis*) (syn *Corynebacterium*)



- ▶ Bacterial canker can produce a range of symptoms depending on type of infection. Systemic symptoms are more common these days.
- ▶ **Systemic symptoms** - a general wilting of the plant; leaves produce necrotic "windows" as the disease develops. The interior of the fruit can also develop brown staining.
- ▶ **External symptoms** - spotting similar to ghost spot - but raised above the fruit surface and rough to the touch. Similar spots may appear on the leaves and stems.

Cladosporium leaf mould (syn Fulvia Leaf Mould) (*Cladosporium fulvum*)



- ▶ Many modern varieties are resistant to this disease.
- ▶ An increasing problem that was very common on older varieties. Present again because of the use of “Heritage” varieties that have no resistance but also because some new varieties do not have any resistance at all to the strains of *Cladosporium* present in the crop.
- ▶ First seen as slightly paler or discoloured spots on the lower leaves – when you turn the leaf over you can clearly see the “mildew-like” spore growth.
- ▶ If left untreated the foliage will become necrotic.

Bacterial stem rots

(*Pectobacterium* spp.)



- ▶ Uncommon but can occur on cucumber.
- ▶ This bacterial problem is expected to increase in the UK with climate change.
- ▶ Only normally seen in mid-summer (when it is warm) but rapidly goes from first infection to plant destruction.
- ▶ Bottom right shows the complete disintegration of the stem tissue only a few days after the disease was first seen.

Cucumber green mottle mosaic virus

(Tobamovirus group)



- ▶ Affects cucumber only. Plants infected in the first few days after planting often wilt.
- ▶ Produces dark green blisters on the youngest leaves, older leaves are usually symptomless. There are no fruit symptoms.
- ▶ Spread rapidly by hand and sap transfer between plants and through roots affecting all plants in a growing module.
- ▶ Initial infection via infected seed or from existing infection.
- ▶ Refer to HDC Factsheet 18/11.

Melon necrotic spot virus

(Necrovirus group)



- ▶ Affects cucumbers only producing small necrotic patches anywhere on the leaf. There are no fruit symptoms.
- ▶ Necrotic patches can increase in size and number and affect large areas of individual leaves.
- ▶ Plants may succumb to other diseases such as *Pythium*.
- ▶ Infected water is the most common source of entry. Spread by *Olpidium* – a soil fungus that can infect inert growing media as well as soil.

Beet pseudo yellows virus

(Crinivirus group)



- ▶ Occurs on cucumbers causing leaf yellowing very similar to magnesium deficiency. There are no fruit symptoms.
- ▶ Infection often occurs quite low on the plant where infected whiteflies feed shortly after planting and transfer the virus to the crop.
- ▶ Can devastate affected areas when infection is severe.
- ▶ Introduced into the crop via infected glasshouse whitefly.

Tobacco necrosis virus

(Necrovirus group)



- ▶ Affects cucumber only producing small necrotic patches along the veins. There are no fruit symptoms.
- ▶ Necrotic patches increase in size and can affect large areas of individual leaves when large leaf veins are damaged. Stems, petioles and even tendrils are affected.
- ▶ Infected water is the most common source of entry. Spread by *Olpidium* – a soil fungus that can infect inert growing media as well as soil.

Pepino mosaic virus

(Potexvirus)



- ▶ Can infect tomato and aubergine, however, only tomato exhibits symptoms.
- ▶ Symptoms are very variable and range from symptomless in some varieties through small yellow spots to true yellow mosaic. Infected plants may have a “nettle head” appearance.
- ▶ Fruit marbling is quite common but some types, especially cherry types, show little or no fruit symptoms. Yield losses result through reduced vigour and poor fruit quality.
- ▶ Introduced in infected seed or by handling infected fruit. Spread is rapid by root contact or handling.

Potato spindle tuber viroid

(Pospiviroid)



- ▶ Occurs on tomato and pepper. Mild strains may produce no obvious symptoms, severe strains produce variable symptoms depending on variety and environment.
- ▶ Leaves at the head of the plant turn yellow, curl and often have a purplish tinge. Main veins remain green. Leaves are smaller than normal and the plant becomes thin and stunted producing 'bunchy tops'.
- ▶ Symptoms appear to be more severe at temperatures above 25°C and when the 24 hr average is above 20°C.
- ▶ Refer to HDC Factsheet 09/06.

Columnnea latent viroid

(Pospiviroid)



- ▶ Occurs on tomato only, probably from seed infection. First sign is a reduction in growth, some leaf distortion and the heads turn pale. Leaf bronzing and reddening is also frequently seen.
- ▶ Leaf mosaic appears as they mature with some necrotic patches. Plants rapidly run out of vigour. Affected plants may exhibit a thinning of stems.
- ▶ Symptom severity can vary within an affected crop as disease expression is affected by light intensity and temperature.

Alfalfa mosaic virus

(Alfamovirus)



- ▶ Occurs on tomato. Not very common - is spread by aphids.
- ▶ Necrotic patches seen in plant head spread through the plant and the whole head dies.
- ▶ Fruit develops blisters giving them a 'boiled' appearance which can be a different colour to the rest of the fruit.

Tomato yellow leaf curl virus

(Begomovirus)



- ▶ Tomato and pepper can be affected.
- ▶ Infected tomato plants are severely stunted producing very small, yellow leaves and small fruit.
- ▶ Leaves often bend downwards, are stiff and have a leathery texture. There is an upward cupping and chlorosis of leaf margins on less severely affected plants.
- ▶ Introduced and spread by tobacco whitefly.

Cucumber mosaic virus

(Cucumovirus)



- ▶ Can occur on many species including cucumber, tomato and pepper and also weeds such as chickweed and groundsel.
- ▶ Different strains produce various symptoms including distinct spots on leaves and fruits, ring-spots, mosaic pattern and a netting pattern along the leaf veins.
- ▶ Introduced and spread from plant to plant by aphids.

Tomato spotted wilt virus

(Tospovirus)



- ▶ Pepper fruit becomes distorted with uneven ripening, ring spots, line patterns and necrotic patches. Leaf symptoms include mosaic, chlorotic or necrotic flecks and ring spots. Necrotic streaks appear on stems extending to terminal shoots.
- ▶ Tomato leaves may have a yellow mottle, black rings, line patterns and necrotic spots. Young leaves curl slightly downwards and inwards and may be distorted. Brown spotting or bronzing of young leaves occurs mainly on the upper surface.
- ▶ Affects tomato, pepper and aubergine. Spread by Western flower thrips. Refer to HDC Factsheet 23/10.

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Photographic credits

Section A – Invertebrate Pests

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- A1 Thrips adult (top left)
- A1 Thrips nymph (top right)
- A2 Adult whitefly (top left and bottom left)
- A2 Sooty mould (bottom right)
- A3 Winged aphid (top left)
- A3 Wingless aphid (top right)
- A4 All images
- A7 Leafminer (top left)
- A7 Leafminer punctures (top right)
- A7 Leafminer pupae (bottom left)
- A9 Silver-Y moth larva (bottom left)
- A10 Spider mite damage to tomato plant (bottom left)
- A11 Broad mite damage to pepper plant (bottom right)
- A13 Adult leafhopper (top left)
- A13 Leafhopper nymph (top right)
- A13 Leafhopper damage to tomato leaf (bottom left)

- A6 (all images) supplied by Derek Hargreaves.
- A8 Tuta adult (top left) supplied by Dupont.
- A12 (bottom left) supplied by Derek Hargreaves
- A16 (all images) supplied by Derek Hargreaves
- A18 Adult *Macrolophus* (top left) supplied by Syngenta Bioline
- A18 *Macrolophus* nymph (top right) supplied by Syngenta Bioline

Section B – Biological Control Agents

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- B2 Adult *Amblyseius* (top left)
- B3 *Encarsia formosa* adult (top left)
- B3 *Encarsia formosa* scales (top right)
- B4 *Aphidius* adult (top left)
- B4 *Aphidius* mummy (top right)
- B4 *Praon* mummy (bottom right)
- B5 Syrphid larvae (top right)
- B5 Lacewing larva (bottom right)
- B6 *Diglyphus isaea* larva in leaf (bottom left)
- B7 Adult *Dacnusa sibirica* (top)
- B9 All images
- B10 All images
- B11 *Verticillium* on Thrips (top left)
- B11 *Verticillium* on aphids (bottom right)

Section C – Diseases

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C28 Tomato yellow leaf curl virus (left) supplied by Central Science Laboratory

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