

# Integrated pest management in ornamentals information kit

Reprint – information current in 2000



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This publication has been reprinted as a digital book without any changes to the content published in 2000. We advise readers to take particular note of the areas most likely to be out-of-date and so requiring further research:

- Chemical recommendations—check with an agronomist or Infopest [www.infopest.qld.gov.au](http://www.infopest.qld.gov.au)
- Financial information—costs and returns listed in this publication are out of date. Please contact an adviser or industry body to assist with identifying more current figures.
- Varieties—new varieties are likely to be available and some older varieties may no longer be recommended. Check with an agronomist, call the Business Information Centre on 13 25 23, visit our website [www.deedi.qld.gov.au](http://www.deedi.qld.gov.au) or contact the industry body.
- Contacts—many of the contact details may have changed and there could be several new contacts available. The industry organisation may be able to assist you to find the information or services you require.
- Organisation names—most government agencies referred to in this publication have had name changes. Contact the Business Information Centre on 13 25 23 or the industry organisation to find out the current name and contact details for these agencies.
- Additional information—many other sources of information are now available for each crop. Contact an agronomist, Business Information Centre on 13 25 23 or the industry organisation for other suggested reading.

Even with these limitations we believe this information kit provides important and valuable information for intending and existing growers.

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This information has been made available to assist users to identify issues involved in ornamental horticulture. This information is not to be used or relied upon by users for any purpose which may expose the user or any other person to loss or damage. Users should conduct their own inquiries and rely on their own independent professional advice.

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# Know your Diseases

## What can you expect to learn from this section?

*This section deals with the key diseases that you are likely to find in your ornamental crops and the complexities of their identification. A key disease is a pathogen that causes severe and regular damage to plants. It may be nationally important, or only locally important. It may be seasonal or all year round.*

*There is also a brief description of disease types, including information on how they develop and spread. Methods used to identify diseases are listed.*

*Fungi are listed first, then bacteria, viruses and nematodes. Diseases within each of these classifications are listed in alphabetical order. The symptoms, host range, method of dispersal, diagnosis, and methods of monitoring and management of each disease are described.*

*The aim of this section is to make you aware of key diseases in your crops, and to offer guidance in diagnosis and management.*

**Coloured photographs** of each of these diseases can be found in the companion publication *Pests, Diseases, Disorders and Beneficials in Ornamentals: Field Identification Guide*, see Section 10, Further reading page 7.

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## About plant diseases

A plant disease can be thought of as any condition within a plant that interferes with normal functioning or development. The plant responds to this interference by producing characteristic symptoms. Plant diseases are generally caused by infectious micro-organisms known as pathogens.

The occurrence of diseases not only depends on the presence of pathogens but also on environmental conditions and the susceptibility of different plants.

Unfavourable temperature, nutritional imbalance, pesticide toxicity, varietal peculiarities or inappropriate or sudden changes in light intensity can also cause disease symptoms.

## Types of pathogens causing disease symptoms

The four types of pathogens that cause disease symptoms are:

- fungi
- bacteria
- viruses and virus-like organisms
- nematodes.

The specific disease species are shown in the directory.

## Fungi



*Botrytis cinerea* forming spores at the end of fungal threads

There are over 100 000 recognised species of fungi and of these more than 8000 can cause plant disease. Fungi include macro fungi (for example, those that produce easily seen structures such as mushrooms) and micro fungi (for example, grey mould). Most plant pathogens are micro fungi and can only be seen with a microscope or magnifier because they are 5 to 100 micrometres ( $\mu\text{m}$ ) long ( $1 \mu\text{m} = 1/1000$  of a millimetre).

Some fungi grow actively only in the host plant. Others can live for long periods by obtaining nourishment from dead leaves and other plant material, attacking living plants whenever they are available.

## Spread

### Spores—the 'seeds' of fungi

The most common method of fungal spread from plant to plant is through very small or microscopic spores (which are like the seeds of plants).

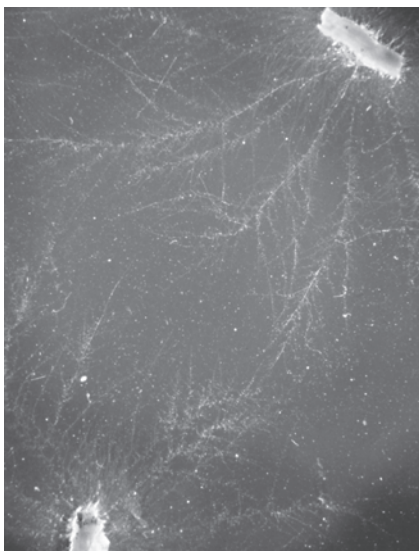
Most spores are blown about in air currents and sometimes reach a plant that they could infect. At any time, the air has many fungal spores floating in it but most never reach a plant that is suitable for their growth. Even if they do, they will not germinate and successfully start the infection unless some moisture is present. The spores of some fungi, such as those responsible for damping-off, need water for efficient spread from place to place.

One fungal spore is far too small to be seen by the unaided eye but larger numbers together are easily seen. The fine blue or green powder on a mouldy orange consists of billions of minute spores, which are easily moved off in air currents to other nearby oranges.

Fungi differ in their germination and growth requirements. Downy mildew spores require a film of rain or dew on the plant surface, whereas powdery mildew spores germinate best on a dry surface in humid conditions.

Temperature also influences germination. Most fungi germinate best at  $15^{\circ}$  to  $30^{\circ}\text{C}$  but each fungus has its own optimum temperature. At germination a fungal spore produces a small tube which begins to elongate and branch. After a few hours or days a network of fine threads has grown in the leaf or other plant part. These fine threads or tubes (called hyphae) produce enzymes which change plant tissue into a food source for the fungus.

The furry growth on a piece of mouldy bread is composed of fine hyphae characteristic of fungi. Most plant-attacking fungi have hyphae thinner than those on mouldy bread.



*Rhizoctonia solani* fungal threads on culture medium growing from infected blocks of plant tissue

### Hyphae—the 'roots' of fungi

The basic function of hyphae is to obtain nourishment (which makes them similar to plant roots), but sometimes they serve other purposes by growing into different structures. These structures help the fungus survive and spread, and differ from one fungus to another.

Some fungi (*Rhizoctonia* and *Sclerotinia*) form sclerotia, which consist of a mass of hyphae bunched together. Sclerotia look a little like the seeds of higher plants but have no other similarity. They are pale at first but gradually darken as the hyphae on the outside dry out. The formation of this hardened 'skin' protects the inside hyphae from drying out, enabling them to start growing again, sometimes years later, when conditions are suitable.

Rhizomorphs are structures formed of many hyphae growing parallel and close to one another. They can be about the thickness of a shoelace and may grow in the soil from one plant to another, thus finding a new food supply for the fungus and producing yet another diseased plant. Armillaria root rot is caused by a fungus that produces rhizomorphs.

### Spore dispersal

Hyphae also produce spores and structures to carry or contain spores. These are usually on or near the outside of the plant or on the soil surface, within reach of air currents or other spreading agents.

One of the largest spore containers is the mushroom. The spores are produced on the sides of the gills underneath the cap and would look like dark brown dust if they fell from a mature mushroom onto the kitchen table. *Armillaria* produces clusters of mushrooms on decaying wood.

The spore-containing structures of those fungi that attack plants are usually much smaller than mushrooms and may appear as pinhead-size black dots on an area of damaged leaf. The fungus *Septoria* has such structures.

The spores of other fungi are not contained in a special structure but are borne on the ends of hyphae, which grow out from the plant surface. These aerial hyphae may be in groups characteristic of a particular fungus or just scattered on the plant surface. They may give the plant surface a furry look, as in the case of grey mould (*Botrytis*).

## Bacteria

About 200 different bacteria cause plant disease. Bacteria are single-celled micro-organisms capable of rapid multiplication under favourable conditions. They usually enter the plant through wounds or natural openings. Any part of the plant may be attacked.

There are always some bacteria on plant surfaces. Some never harm the plant, others can infect the plant after it has been damaged by a hailstorm or pruning. Bacteria can also enter plants through natural openings such as leaf stomates and lenticels (both types of pores).

Most bacteria that cause plant diseases can survive in the soil on dead plant material. Some, like those causing bacterial soft rot, can live in the soil indefinitely while others will decrease in numbers unless plants they are able to attack are grown in that area.



*Bacterial cell of Xanthomonas sp. viewed through an electronic microscope*



*Bacteria growing on culture medium*

Bacteria thrive in moist conditions and can build up into larger populations in a short time. Single bacterial cells can't be seen with the unaided eye. Bacteria are much smaller than fungi, less than  $5\ \mu\text{m}$ , and are only seen as small dots using a compound microscope.

Some bacteria destroy the material holding plant cells together. As a result, the plant cells are no longer held in a regular arrangement but collapse into a heap. This damage may show up as sunken areas on the stem or rotting in organs like tubers and bulbs. These bacterial soft rots are often accompanied by unpleasant smells.

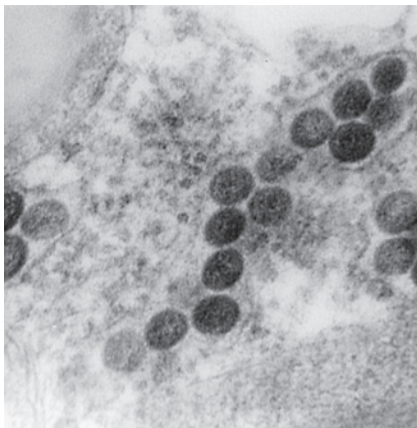
Bacterial cells which get into the water and food conducting tubes of the plant spread quickly and some end up in fruit and seeds. If these seeds are used to produce a new crop, the bacteria will quickly produce disease symptoms in the seedlings and they will probably die. Bacteria also multiply in the water conducting cells and may cause them to block up and disintegrate. This causes wilting of plant parts above the blockage.

Some bacteria stimulate plant cells to multiply and enlarge abnormally, causing lumps to appear on plant parts. Crown gall is one disease characterised by lumps.

### Spread

Bacteria are spread when water splashes bacterial cells from one plant to another or from infected parts to non-infected parts of the same plant by irrigation or rain. Running water in or on the soil can carry bacteria to new areas, as can pruning or other activities within the crop when it is wet. Seed from infected plants may also lead to spread of bacterial infections.

### Viruses and virus-like organisms



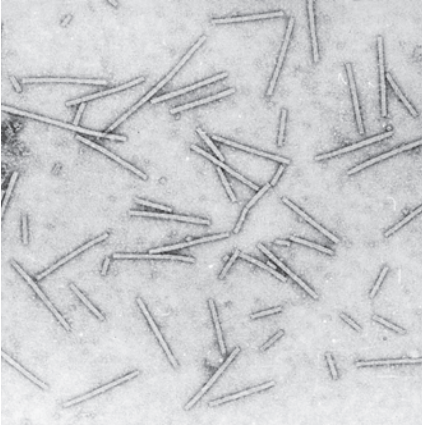
*Tomato spotted wilt virus viewed through an electron microscope*

Virus particles are extremely small, around 1/1000 times smaller again than fungi. Their size is measured in nanometres ( $1\ \text{nm} = 1/1\ 000\ 000\ \text{mm}$ ). Most viruses are less than 1000 nm and many are less than 100 nm. They may be various shapes such as rods, bullets or spherical and can only be seen using an electron microscope.

Unlike fungi or bacteria, viruses can't reproduce by themselves but can only increase in numbers inside a living organism like a plant.

Viruses do not themselves produce enzymes to digest plant cells or toxins that kill plant cells, but instead disrupt normal plant activities by organising plant cells into producing more virus particles. This reorganisation interferes with critical plant processes like photosynthesis and respiration. The plant can't grow properly and growth is generally reduced. The plant may also be stimulated into producing substances harmful to itself.

Virus names usually mention the plant on which the problem was first known to occur and a brief description of the major symptoms. For example, tomato spotted wilt virus (TSWV) was first studied on tomato though it is known to attack more than 500 other plants. On tomatoes it causes small spots on leaves, subsequent wilting and occasionally killing the plant. It can be symptomless (or nearly so) on other plants.



*Tomato mosaic virus viewed through an electron microscope*

### Symptoms and host range

Viral diseases produce a range of symptoms in plants. Some viruses cause disease symptoms only on one plant or a group of closely related plants (for example, orchid fleck). Others can attack a wide range of different plants, including weeds (tomato spotted wilt). Some viruses (cucumber mosaic) tend to produce the same type of symptom in host plants regardless of which species it is. Others (tomato spotted wilt) produce a wide range of symptoms in a wide range of species, and in some infected plants (cucumber) are symptomless.

Typical plant virus symptoms include:

- stunting
- leaf yellowing—whole leaf or in irregular patterns (chlorotic spots, mosaics, mottles, vein clearing)
- ringspots on leaves
- brown or black (necrotic) spots
- rolled leaves
- pits or raised areas in fruit
- stripes on flowers (flower breaking).

### Spread

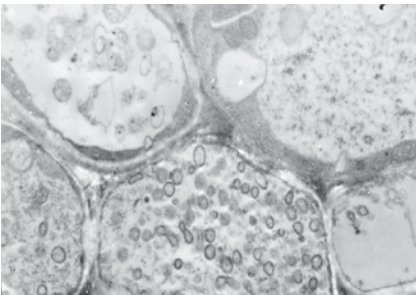
Viruses spread from one plant to another in various ways. Some have only one way of spreading, while others can be spread in several ways. You need to know how a particular virus is spread to put the right control measures in place.

#### Common means of spread

**Insects.** Aphids, thrips and leafhoppers have piercing and sucking mouthparts. If such an insect feeds on a diseased plant and later feeds on a healthy one, virus particles will be transferred to the healthy plant. Once virus particles have been introduced into a plant, they will spread to all plant parts, with the usual exception of the seeds and tissue at the very ends of the shoots—the apical meristems (growing point). Some insects carry virus(es) throughout their life, while others may only transmit viruses within a defined period after feeding on an infected plant.

**Vegetative propagation.** Any infected plant part (bulb, tuber, corm, grafted or rooted cutting, rootstock or scion) used for propagation will produce a new plant also infected with the virus.

**Mechanical.** Secateurs and budding knives can spread particles of some viruses in plant sap unless they are disinfested between plants.



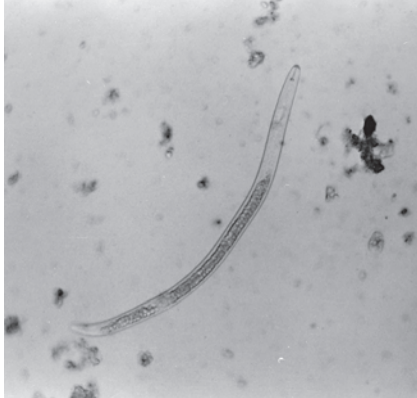
*Phytoplasma: section through phloem cells filled with circular phytoplasma particles; viewed through an electron microscope*

### Phytoplasmas

Phytoplasmas are another group of organisms that cause symptoms similar to viruses, but they are structurally different and more closely related to bacteria. They produce fairly characteristic symptoms (witches broom, aster yellows) and with some experience, a tentative diagnosis can be made based on symptoms only. Some genetic or hormonal disorders can resemble phytoplasma-induced symptoms. Molecular tests or electron microscopy of

thin sections of phloem cells (part of the cell tissue within a plant that carries food) are required for more accurate diagnosis.

## Nematodes



A nematode, *Pratylenchus* sp. (round worms or eel worms)

Nematodes are microscopic worm-like animals. They live in the soil where they feed on bacteria, fungi and other nematodes. Some parasitise plant roots and foliage and can be destructive. Typical symptoms include root galling, root lesions, injured root tips, foliage blight and distorted new tips.

Nematodes spread with contaminated planting material, running water and soil. They may live in the soil and survive without host plants for long periods.

In ornamental crops, leaf nematodes are common but often overlooked. Their diagnosis is usually simple as they can be seen with a dissecting microscope. Identification to species requires a specialist nematologist.

## Identification methods

Several methods can be used to diagnose diseases.

The background information, that only you can supply, will assist plant pathologists in arriving at a correct diagnosis. While some pathogens produce characteristic symptoms in susceptible plants, others will require specialist diagnostic services to identify the disease organism before a correct treatment can be recommended.

**Review of field and environmental data.** Keep notes of disease severity and distribution, and potential predisposing factors. Many environmental conditions influence the development of disease. Nutritional imbalances, high or low temperature, humidity and over/under-watering or pesticide applications can predispose plants to disease or mimic disease symptoms.

Make a note of any aspect of crop hygiene that you suspect may be contributing to disease. This could include: source of propagation material, growing media or containers, condition of propagation and growing areas, weed control, source of water, disposal of waste plants and media, and staff hygiene.

**Visually examine plants for symptoms.** Look at plants that are in the early stages of the problem. Do not look at dead plants because secondary fungi, bacteria and insects, all of which invade dead tissue, can mask the cause of death. Whole plants are best to observe, and more than one gives you a feel for the symptoms. Use a hand lens, magnifying glass or dissecting microscope and record the symptoms on the whole plant, including the foliage, flowers, stems and roots. Tip out potted plants. Gently shake off the soil, rinse the roots and examine, again with a hand lens or microscope.

Where a fungal or bacterial problem is suspected, you can encourage symptom development by putting the plant sample in a plastic bag in a warm position for a few days to increase the humidity. Use a pocketknife and cut open the roots, stem tissue, galls, fruits or flowers to observe the internal conditions. Record the symptoms observed in the visual examination.

**Microscopic examinations**—magnified view of insect pests and fungal, bacterial and nematode pathogens. Low power (less than 40x magnified with



a dissecting microscope for surface view) and high power (40 to 1000x magnified with a compound microscope for viewing thin sections of affected tissue or scrapings from the surface) microscopes are used.

**Electron microscopy**—useful for screening several (but not all) viruses in plant sap. Used for more complex examination of pathogens from thin sections of infected plant material.

**Laboratory extraction, moist incubation or culturing**—techniques for isolating and identifying pathogens by their distinctive appearance.

**Inoculating test plants**—bioassays for pathogenicity (disease-causing capability) of suspect organisms. This involves inoculating a plant with sap or graft from an affected plant to reproduce disease symptoms.

**Baiting soil, potting media and water for pathogens**—bioassays or *in vitro* assay for certain pathogens such as *Phytophthora*, *Pythium* and *Rhizoctonia*. This involves floating plant material (baits) on the surface of a representative sample of soil, media or water and observing the baits for signs of rotting. This technique indicates whether plant pathogens are present.

The full baiting technique is detailed in the Nursery Industry Accreditation Scheme, Australia (NIASA) Best Practice Guidelines, see *Section 10, Further reading* page 4.

**Grow-on tests**—useful to confirm certain abiotic (non-living), non-pathogen-related disorders, where plants recover after initial exposure, whereas pathogen-related problems persist into new growth.

**Specialised techniques**—serology, Enzyme Linked Immuno-Sorbent Assay (ELISA) and various nucleic acid and cellular fatty acid profile analyses for a range of plant pathogens.

Taken together, the first three methods—review of field and environmental data, and visual and microscopic examination—constitute a thorough clinical examination from which a tentative (or in some cases a confirmed) diagnosis can be made.

## Identifying a pathogen

Identifying a pathogen (fungi, bacteria, virus and virus-like organisms, and nematodes) can be a complex task. Here are some general methods used by plant pathologists to give you an understanding of some of the procedures and complexities.

### Fungi

Identification methods for fungi rely on identifying a fungus associated with the observed symptoms. This can usually be achieved by examining the affected tissue under a low power (dissecting) or high power (compound) microscope.

The features of the fungus can then be compared with published descriptions found in a range of general reference texts such as the American Phytopathological Society compendium series or more specialised texts.

Association of a fungus with symptoms does not prove that it is the primary cause of the symptoms, it may be a secondary invader of tissue damaged by a true pathogen or other agent.

In addition to direct examination of symptoms and detection of a fungus, diagnosis of a fungal disease often requires placing symptomatic tissue onto agar media and identifying the organisms that are cultured. Identification often involves the assistance of a fungal taxonomist.

Biochemical tests have been developed as a means of identifying fungal disease without the need for microscopes or plating techniques. These tests need further development and are not suitable for general use. The test kits are likely to be expensive but could be used by consultants for accreditation schemes and quality assurance.

### **Bacteria**

Bacteria are diagnosed using a high powered compound microscope to observe the presence of bacterial ooze in association with the symptoms. For practical purposes this is probably all that is required. For accurate identification pure cultures are taken and referred to an appropriate expert.

Biochemical tests and molecular techniques are precise and the species and subspecies can be identified. Test kits (for example, Biolog™) have been developed for bacterial pathogens, but are not generally used.

### **Viruses and virus-like organisms**

Virus diseases are harder to positively identify than other diseases because the particles can only be seen under an electron microscope. Sometimes identification is as simple as preparing a sap sample and checking it for the presence of virus particles. At other times plants more sensitive to the suspected virus(es) (called indicator plants) must first be infected. A study of the symptoms produced on these plants enables identification of the virus. Sometimes indirect detection methods are used. These include serology, which uses antibodies from the blood of animals that have been infected with purified virus, and ELISA tests.

It is not practical to refer every suspected virus sample to a specialist laboratory and field identification often relies on recognition of characteristic symptoms only. This can be unreliable because some viruses can cause symptoms that resemble a fungal wilt. Virus symptoms can also be confused with unfavourable growing conditions, toxicities, nutritional imbalance and insect injury.

ELISA test kits are available for a range of virus diseases but their use is generally restricted to laboratories.

Viruses may also be identified by inoculation of symptomatic tissue to indicator plants. If a virus is present, characteristic symptoms that can aid identification develop on the indicators.

## **Disease management**

The best disease management is achieved by selecting as many control methods as possible. Here are general approaches that you can take to manage diseases.

NIASA Best Practice Guidelines give useful information on disease management issues.




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Indicator plants  
Section 4 page 14




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NIAA web site  
Further reading  
Section 10 page 4



*The Nursery Papers*  
1999#003, 1997#008,  
1996#005, #013  
Section 10 page 8

### Avoid and exclude pathogens

- Use disease-free planting material.
- Sanitise soil or substrates, water and seed.
- Rotate crops and avoid having successions of a single crop.
- Practise good hygiene. Do not handle diseased material before handling seed or moving through the crop. Avoid movement of machinery and workers from infected to disease-free crops, particularly when wet. Do not wet foliage unnecessarily and avoid over-head watering. Clean trash from machinery and disinfest implements after working in diseased crops before working in a disease-free crop.
- Monitor and adjust environmental conditions around crops to reduce disease pressure (for example, lower humidity in glasshouses, optimise soil pH and moisture level for plant growth not for pathogen).
- Prevent crowding of plants; well spaced, open plantings reduce disease levels by allowing good air circulation around plants.
- Ensure good drainage.
- Monitor for early detection of diseases. An early alert and immediate removal of diseased plants (roguing) or strategic spraying can halt the spread of disease.
- Monitor and control weeds and insects in and around crops. Weeds can be alternative hosts for some pathogens and biting and sucking insects can spread many diseases.

### Protect plants

- Apply chemical and biological sprays, mulches or drenches. Chemicals are not always the most cost-effective method of controlling a disease. They can only slow disease progress, not return a crop to its previous healthy and unblemished condition. Strategic sprays in combination with other methods of disease control can often be more effective than heavy chemical use.

### Use disease-resistant or tolerant cultivars

- Check with seed or plant suppliers for specific information.
- Some plant pathogens (for example, *Phytophthora*) can attack known resistant or tolerant plant cultivars under favourable environmental conditions, and when plants are stressed or damaged.

# Anthracnose

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**Card reference 148 in**

*Pests, Diseases, Disorders  
and Beneficials in  
Ornamentals: Field  
Identification Guide, see  
Section 10 page 7*

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**Cause:** The fungi *Colletotrichum* and *Glomerella* spp.

**Symptoms:** Dark lesions on leaves, stems or flowers. Pink or orange spore-masses form on the surface of lesions during moist conditions. Severe infections can cause leaf dieback, stem cankers and blights, and crown or bulb rots. *Colletotrichum* can also cause leaf curl symptoms on anemone and ranunculus.

**Host range:** Wide.

**Spread:** The fungi survive as microsclerotia (small, compact masses of fungal hyphae, usually with a dark rind) in the soil and can multiply rapidly under wet and warm conditions (around 26°C and relative humidity above 93%). Microsclerotia spread with seed and infected plant debris. Spores formed in the pink mould are spread in water splash. Free moisture is required for infection.

**Diagnostic features:** Dark lesions with pink spore masses.

**Aid to diagnosis:** Incubate symptomatic tissue in moist chamber for two to four days to encourage development of pink spore masses.

**Confirmation of diagnosis:** Microscope preparation. Confirm spores and related structures agree with published descriptions.

**Possibility of confusion:** Often confused with other fungal and bacterial leaf spots, which are readily distinguished by microscopic examination. *Colletotrichum* can be a secondary cause of rotting where other plant pathogens or physical damage have initiated the problem.

**Monitoring procedure:**

- Careful observation of leaves for spotting or dieback symptoms. Check wetter and more shaded areas of greenhouses.

**Control:**

- Manipulate environment to lower humidity, space plants to provide good ventilation, and minimise overhead watering. Subirrigation or similar methods that avoid wetting the leaves will greatly assist in preventing outbreaks.
- Avoid physical damage to plants and optimise nutrition.
- Apply protectant fungicides. Check label registrations.

## Black root rot

### Card reference 152 in

*Pests, Diseases, Disorders  
and Beneficials in  
Ornamentals: Field  
Identification Guide, see  
Section 10 page 7*

**Cause:** The fungus *Thielaviopsis basicola* (*Chalara elegans*)

**Symptoms:** Slow growth, stunting, yellowing or purpling, generally of older leaves first. Dark and rotted appearance of most of the roots.

**Host range:** Pansies are very susceptible. It is likely that many other hosts are affected. Overseas, cyclamen, begonia, poinsettia, fuchsia, gerbera, pelargonium, cineraria and verbena are reported as hosts. In Australia, petunia, vinca, snapdragon, brachycome, salvia, lettuce (nursery and field) and cotton are known to be susceptible.

**Spread:** Soil-borne spores, which are persistent and may survive for several years.

**Diagnostic feature:** Distinct black flecking in roots and general black appearance of the root system.

**Aid to diagnosis:** Examination of root tissue with a compound microscope usually gives a clear diagnosis. A carrot baiting method has been used to detect the fungus in unused peat or potting mix when plant root material is not available.

**Confirmation of diagnosis:** Microscope examination confirms presence of characteristic spores in affected root tissue.

**Possibility of confusion:** Other root infecting fungi such as *Pythium* and *Phytophthora* and possibly *Rhizoctonia*. The presence of the characteristic spores of *Thielaviopsis* confirms this fungus as the cause.

Mixed infections are possible, especially if hygiene is lax.

### Monitoring procedure:

- Watch for evidence of slow growth, discolouration (purpling or yellowing) of lower leaves, and stunting.
- Carefully remove medium from around roots and examine entire root system in water against a white background. Look for dark flecking in roots. Compare with root system of healthy plants.

### Control:

- Maintain high levels of hygiene at all times to prevent introduction in potting medium or on cuttings, tools, personnel. Minimise dust where possible.
- Control insects such as fungus gnats, which can spread the spores.
- Some peat supplies may contain the pathogen and may need treatment (for example, pasteurising) before use.
- There are no specific fungicide label registrations for control of black root rot.



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# Downy mildew

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**Card reference 154 in**

*Pests, Diseases, Disorders  
and Beneficials in  
Ornamentals: Field  
Identification Guide, see  
Section 10 page 7*

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**Cause:** Fungi belonging to *Peronospora*, *Plasmopara*, *Bremia* and related genera. A different pathogen generally infects each plant family.

**Symptoms:** Varied. Leaves usually show various discoloured areas depending on the host/pathogen combination. On roses purple areas are evident that later turn pale brown. Downy mildews in stock, pansies, lisianthus and several other hosts cause prominent yellow areas, the margins of which may be irregular or have an angular shape where they are limited by veins.

Typical white or grey downy fungal masses may form on the underside of infected tissue and be visible with the unaided eye. Sometimes there are insufficient fungal masses and these cannot be seen, even with a magnifier. Rose downy mildew is especially virulent and causes severe leaf drop even when other symptoms are not obvious. Certain downy mildews can become systemic (be translocated through the vascular system), causing stunting and yellowing of growing tissues.

**Host range:** Species are usually restricted to a single host genus or family. When a species infects more than one host, host specific strains develop. Downy mildews affect a wide range of host species. Some important flower and nursery crops include rose, lisianthus, sweet alyssum and stock.

**Spread:** Short-lived, air-borne spores that only germinate in water or by seed and cuttings.

**Diagnostic features:** Development of downy growth, usually on underside of leaves. Systemic infections are characterised by discolouration and stunting of growing points.

**Aid to diagnosis:** Incubate symptomatic tissue in moist chamber for about 48 hours to encourage development of downy growth on underside of leaves.

**Confirmation of diagnosis:** Microscope preparation. Confirm spores and related structures agree with published description. Structures giving rise to spores have a characteristic (tree-like or antler) branching pattern.

**Possibility of confusion:** Often confused with powdery mildew, which is readily distinguished by microscopic examination.

**Monitoring procedure:**

- Careful observation of leaves for spotting or discoloured zones. Check underside by using magnifiers.

**Control:**

- As for grey mould (this section page 16), that is manipulate environment to lower humidity and maintain even temperature.
- A restricted number of fungicides is registered for use on ornamentals.
- Protectants should be applied regularly, with specially formulated systemic fungicides restricted to use when disease pressure is high. Overuse of systemic fungicides has led to fungicide resistance in some crops.




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## Fungal leaf spots and blights

### Card reference 156 in

*Pests, Diseases, Disorders  
and Beneficials in  
Ornamentals: Field  
Identification Guide, see  
Section 10 page 7*

**Cause:** Various fungi including *Alternaria*, *Bipolaris*, *Botrytis*, *Colletotrichum*, *Cylindrocladium*, *Diplocarpon*, *Fusarium*, *Gliocladium*, *Phyllosticta* and *Septoria*.

**Symptoms:** Vary in size, shape and colour depending on the host and on the fungus involved in the infection. Often fungal structures develop on the spots. These structures can be small dark fruiting bodies which house spores or silk-like threads on which spores are produced. Leaf spots often have concentric rings with red or yellow borders.

Blight infections may develop from wounds. Blighted tissue can release gummy secretions and spore masses are often evident.

**Host range:** Wide, almost all ornamental plants are susceptible to one or more fungal leaf spot or blighting diseases.

**Spread:** The fungi can be spread on diseased material such as new stock or plant debris. Spores may be wind blown, water splashed, carried on the bodies of insects or on the hands and tools of staff from infected material. Most of the pathogens prefer warm and humid conditions such as in crowded greenhouses where air circulation is restricted and wounding can favour infection. Free water on leaf surfaces (especially at night) is essential for spore germination.

**Diagnostic features:** Lesions with small dark fruiting bodies which produce spores.

**Aid to diagnosis:** Incubate symptomatic tissue in moist chamber for two to four days to encourage development of spores.

**Confirmation of diagnosis:** Microscope preparation. Confirm spores and related structures agree with published descriptions.

**Possibility of confusion:** Often confused with bacterial leaf spots and blights, both of which are readily distinguished by examination under a microscope. Some fungi can be a secondary cause of rotting where other plant pathogens or physical damage have initiated the problem.

### Monitoring procedure:

- Careful observation of leaves for spotting symptoms. Check wetter and more shaded areas of greenhouses.

### Control:

- Manipulate environment to lower humidity, space plants to provide good ventilation and minimise overhead watering. Subirrigation or similar methods which avoid wetting the leaves will greatly assist in preventing outbreaks.
- Avoid physical damage to plants and optimise nutrition.

# Fungal vascular wilt

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**Card reference 158 in**

*Pests, Diseases, Disorders  
and Beneficials in  
Ornamentals: Field  
Identification Guide, see  
Section 10 page 7*

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**Causes:** *Fusarium* spp., *Verticillium* spp.

**Symptoms:** Stunting, yellowing, wilting and eventual death of plants. Internally, the vascular system of affected plants shows dark discolouration.

**Host range:** Wide range of hosts affected. *Fusarium* species are usually host specific. For example, verticillium wilt in roses and liatris, fusarium wilt in carnations, heliconia, asters and gladioli.

**Spread:** Soil-borne spores and mycelium. Spores are freely produced and also spread from water splash and surface drainage. Resistant spores can survive in plant debris and soil for several years.

**Diagnostic feature:** Presence of internal discolouration of the vascular system. Discolouration moves upwards in stems of affected plants.

**Aid to diagnosis:** None.

**Confirmation of diagnosis:** Isolation from affected tissue, then microscopic examination of consistently isolated fungus. Additional tests may be needed as some *Fusarium* spp. associated with affected plants are secondary invaders.

**Possibility of confusion:** Root rots caused by other fungi such as *Phytophthora*, *Pythium*, *Thielaviopsis* (or *Chalara*) and *Cylindrocladium* can cause similar above-ground wilting. Certain bacteria and viruses can also cause wilt symptoms. Differential laboratory tests are needed to identify the cause where the disease is not a well-known problem. On carnations, for example, *Fusarium* is the common cause of wilt but on other hosts detailed investigation may be needed to identify the causal organism.

**Monitoring procedure:**

- Look for evidence of stunting, yellowing and wilting.
- Examine internal vascular system for evidence of discolouration.
- Confirm provisional diagnosis with a professional diagnostic laboratory.

**Control:**

- Maintain high levels of hygiene at all times to prevent introduction of inoculum in potting media or on propagation material, tools and personnel.
- Affected plants should be removed promptly and destroyed.
- Clean stock schemes are in place for some hosts, for example carnations.



## Grey mould

### Card reference 160 in

*Pests, Diseases, Disorders  
and Beneficials in  
Ornamentals: Field  
Identification Guide, see  
Section 10 page 7*

**Cause:** Usually *Botrytis cinerea*. Other species such as *Botrytis elliptica* on lilies have been reported but are not common.

**Symptoms:** Blighting of softer tissue such as petals. Stem or shoot blights. Rotting of cuttings and seed, and dieback (for example roses). Damping-off of seedlings and cuttings in crowded situation. Postharvest breakdown of flowers.

**Host range:** Very wide. Some species, for example lisianthus, cyclamen, are extremely susceptible.

**Spread:** Air-borne spores that are short-lived and need moisture for germination and infection, or by seed or cuttings.

**Diagnostic feature:** Consistent visual development of grey mould (furry grey fungal growth) on affected tissue.

**Aid to diagnosis:** Incubate symptomatic tissue in moist chamber for about 48 hours. Grey mould will develop if *Botrytis* is present.

**Confirmation of diagnosis:** Microscope preparation. Confirm spore-bearing fungal structures, spore shape and size agrees with published description.

**Possibility of confusion:** *Cladosporium* sp. is another fungus that is often present on dead tissue. A microscope preparation is required to distinguish *Cladosporium* from *Botrytis*. *Botrytis* may also be secondary to other damage.

### Monitoring procedure:

- Concentrate on young tissue and petals. Look for characteristic spotting. Incubate in moist chamber for observation if necessary.

### Control:

- Improve air movement, increase space between pots, avoid overhead watering or water when leaves will dry quickly. Manipulate temperature/humidity if possible to prevent condensation overnight.
- Chemicals can be used but resistance to dicarboximides (for example iprodione) is common and to benzimidazoles (for example benomyl, carbendazim) is universal. Protectants need to be applied regularly. Some new products are promising but not yet registered.
- Avoid highly susceptible species if growing conditions cannot be controlled.
- Control insects such as fungus gnats, which can carry the spores.



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# Phytophthora root and collar rot, Phytophthora leaf blight

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**Card reference 164 in**

*Pests, Diseases, Disorders  
and Beneficials in  
Ornamentals: Field  
Identification Guide, see  
Section 10 page 7*

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**Cause:** *Phytophthora* spp.

**Symptoms:** General or localised rotting of roots. May extend into collar region, causing stem rot. Some species, for example *P. nicotianae*, can attack the collar region preferentially without causing root rot.

Above-ground plant parts will show symptoms to varying degrees, depending on the extent of root damage. In young seedlings damping-off may develop while in older plants stunting, discolouration and wilting are common. Collar rot usually results in rapid death.

Leaf infection results in blighting of a portion or death of the entire leaf.

**Host range:** Extensive.

**Spread:** *Phytophthora* belongs to the water mould group and motile (moving) spores spread readily in surface water and in recycled irrigation water. Resistant sexual spores (oospores) also form in infected tissue and remain infective in soil or potting medium for some years.

In wet environments, motile spores (zoospores) are formed in specialised structures called sporangia. Sporangia, which are formed on infected leaves, are spread in water splash and in drainage water.

Cuttings may be a source of infection if taken too close to ground level.

**Diagnostic feature:** *Phytophthora* root and collar rots cannot be distinguished on symptoms alone. Laboratory culture is necessary.

**Aid to diagnosis:** Suspect potting mix, soil or water can be baited with lupins. The subsequent rotting of the lupin roots is a guide but not conclusive evidence that *Phytophthora* is the culprit. Lupin roots should be examined under a compound microscope and cultured to confirm the presence of *Phytophthora*. A negative result is useful in indicating freedom from *Phytophthora* and other root rotting organisms. This is not a technique growers should undertake.

**Confirmation of diagnosis:** Detection of distinguishing spore structures in the infected tissue, on agar culture or baits. Experience is needed. Taxonomic keys are required to identify the species. A specialist may be needed for unfamiliar species.

**Possibility of confusion:** Other root rot causing fungi such as *Pythium*, *Fusarium*, *Cylindrocladium*, *Rhizoctonia* and *Thielaviopsis* (*Chalara*) are difficult to distinguish from *Phytophthora* as the cause of root rot on initial examination.

Non-pathogenic causes, such as anaerobic conditions in the root zone caused by excessive watering or poor quality potting mix, can cause similar breakdown of roots.

**Monitoring procedure:**

- Look at plants closely for evidence of wilting. Tip out potted plants to assess root health. Closely examine the collar region and cut into the internal tissue with a knife to detect evidence of infection. Wash roots from potting medium and examine under a dissecting microscope against a white background.
- Use baiting (leaf disks or lupin seedlings) to check potting mix or medium from growing plants and irrigation water.

**Control:**

- Maintain high levels of hygiene at all times to prevent introduction in potting medium or water, or on cuttings, tools and personnel.
- Maintain cleanliness in propagation and grow out areas. Prevent containers from contacting the soil.
- Some fungicides are registered for use but only suppress and do not eradicate *Phytophthora*. They are not a substitute for good hygiene and cultural practice.
- Highly soluble salts can kill rootlets and provide a site for infection with *Phytophthora* and other root rot organisms.
- Use free draining potting mixes and avoid overwatering. Subirrigation may result in spread of motile (moving) spores from infected to healthy plants.

# Powdery mildew

**Card reference 166 in**  
*Pests, Diseases, Disorders*  
*and Beneficials in*  
*Ornamentals: Field*  
*Identification Guide, see*  
 Section 10 page 7

**Cause:** Fungi belonging to *Oidium* sp., *Oidiopsis* sp., *Uncinula* sp., *Uncinuliella* sp., *Erysiphe* sp., *Microsphaera* sp., *Leveillula* sp., and *Sphaerotheca* sp. More specific identification can only be confirmed if the complete life cycle including sexual reproductive stages can be observed.

**Symptoms:** Easily recognised by white powdery appearance on infected host tissue. Usually on upper leaf surface but also on stems and undersides of leaves. Tissue discolouration beneath the area of infection is common.

**Host range:** Each powdery mildew is usually restricted to a single host or family. The appearance of powdery mildew simultaneously on a range of hosts is usually an indication of environmental conditions being favourable for infection rather than the same powdery mildew attacking multiple hosts.

**Spread:** Short-lived, air-borne spores that can germinate and infect without free moisture on the leaves.

**Diagnostic feature:** White powdery growth usually appears on upper leaf surfaces and juvenile stem tissue.

**Aid to diagnosis:** Not necessary. Usually sporulating (releasing spores) freely if mildew is present.

**Confirmation of diagnosis:** Microscope preparation to confirm characteristic spore stage and formation, which is in chains.

**Possibility of confusion:** Often confused with downy mildew. Can be readily distinguished by examination using low power microscope or magnifiers.

**Monitoring procedure:**

- Concentrate on leaf surfaces and young growth, and watch for small areas of white powdery growth. Use magnifiers as initial infection sites can be easily missed and prompt treatment is essential.
- Plants receiving lower light levels should be closely monitored as they generally become infected and show typical symptoms sooner.

**Control:**

- Manage environment to reduce humidity and maintain even temperatures.
- Several fungicides are registered for use against powdery mildew diseases but only a few have registration for ornamentals.
- Fungicides active against powdery mildew do not often control many other diseases and careful selection is necessary.

## Pythium root rot

### Card reference 164 in

*Pests, Diseases, Disorders and Beneficials in Ornamentals: Field Identification Guide*, see Section 10 page 7

**Cause:** *Pythium* spp.

**Symptoms:** Rotting of roots, especially the finer, feeder roots. Infection may extend into the lower stem of seedlings, causing damping-off. Extensive infection of the root system of older plants may cause slow growth, stunting and yellowing of foliage. The extent of root infection determines the appearance of symptoms above ground.

**Host range:** Wide. Most plants are susceptible to infection in the seedling stage. Rootlets of older plants are often infected. Pythium root rot is one of the most common diseases present in ornamental crops. It is often undetected, except as a cause of damping-off.

**Spread:** A water mould fungus, which produces motile (moving) water-borne spores. Often present in drainage water and readily spread throughout a crop where untreated water is recycled.

Staff may also introduce spores on shoes, clothes and hands.

Cuttings, if not carefully taken, may also be contaminated.

**Diagnostic feature:** Pythium root rot is difficult to distinguish from other fungi which cause root rot and damping-off. Death of the fine roots from the tip is an indicator but not conclusive evidence that *Pythium* is present.

**Aid to diagnosis:** The lupin baiting method can indicate if some *Pythium* species, but not all, are present, but will not differentiate between *Pythium* and *Phytophthora* without microscopic examination. Culturing from roots onto selective media determines if *Pythium* is present.

Potting mix can be sown with susceptible species and germinating seedlings examined for evidence of infection. Quick germinating lettuce seed is useful for this purpose.

**Confirmation of diagnosis:** Detection of the characteristic spore structures in association with the infected tissue, or baits or by culturing on agar. Use taxonomic keys and specialist assistance, if needed, to identify to species.

**Possibility of confusion:** Pythium root rot is difficult to distinguish from other root rots caused by *Phytophthora*, etc. Anaerobic conditions in the root zone caused by poor quality potting mix or overwatering can cause a similar breakdown of roots. Excess soluble salts can also cause burn to roots.

### Monitoring procedure:

- Look for evidence of damping-off in seedlings. Carefully remove affected plants from medium and examine the collar region under a dissecting microscope. Shrunken lower stem tissue is an indicator of infection with *Pythium*.
- In older plants look for evidence of poor growth, yellowing and stunting. Carefully wash roots from medium and observe against a white background using a dissecting microscope. Compare with root system of healthy plant.

**Control:**

- *Pythium* spp. are easily introduced on soil, dirty tools, water and cuttings and strict hygiene at all production stages is essential to prevent infection. Recycled water or water pumped from dams or creeks must be treated to eliminate *Pythium*.
- Fungicides are available that are active against *Pythium* when applied as soil drenches but they only suppress and do not eradicate the fungus. Some fungicides can be applied as a foliar spray and will move into the root system to suppress *Pythium*.

# Rhizoctonia root and collar rot, soreshin, leaf blight

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## Card reference 168 in

*Pests, Diseases, Disorders  
and Beneficials in  
Ornamentals: Field  
Identification Guide, see  
Section 10 page 7*

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**Cause:** The fungus *Rhizoctonia* sp., usually *Rhizoctonia solani* type, but the taxonomy of *Rhizoctonias* infecting ornamentals has not been studied in detail.

**Symptoms:** On seedlings a collar rot and sudden collapse is the usual symptom. Under humid conditions the fungus can grow on leaves and cause blight. This is common with hosts such as ferns, which are usually grown under moist conditions. On older plants lower stem and taproot infection is also common, causing symptoms ranging from stunting and discolouration to wilting.

**Host range:** Very wide.

**Spread:** In soil, potting medium, cuttings, dust, seed and by personnel. Air-borne spores are known but not considered to be a common source of infection.

**Diagnostic feature:** The presence of characteristic fungal mycelium associated with the symptoms.

**Aid to diagnosis:** Sometimes *Rhizoctonia* will grow from infected tissue when it is incubated on blotting pads in a moist chamber. This is not always reliable and plating to agar media is usually necessary to confirm the diagnosis.

**Confirmation of diagnosis:** Microscope preparation. Confirm presence of characteristic fungal mycelium. Plating of tissue usually necessary.

**Possibility of confusion:** Other fungi such as *Phytophthora*, *Pythium*, *Thielaviopsis* (*Chalara*), *Cylindrocladium* and *Fusarium* can cause similar symptoms. A professional diagnosis is required to distinguish between these likely causes.

### Monitoring procedure:

- In young plants watch for collapse and death of whole plants. Infection usually starts in the collar region but can rapidly spread to foliage under high humidity. Use a magnifier and with practice you may be able to recognise the typical mycelium. Look carefully, as many other fungi appear similar at this level of magnification. Try incubating some typical specimens in a moist chamber and watch for the appearance of typical brown mycelium. This may take up to two to three weeks.
- On older plants look at the lower stem where often a characteristic reddish-brown lesion can be seen. The typical mycelium can be observed under magnification. In sandy soils, sand particles clinging to the lower stem can indicate a *Rhizoctonia* infection. It is best to examine plants without washing as this can remove the tell-tale mycelium.

### Control:

- Maintain high levels of hygiene at all times to ensure disease-free potting mix, containers and propagating material. Educate staff to prevent inadvertent introduction on clothing, footwear and tools. Control dust in and around the property as this can spread *Rhizoctonia*.
- Some fungicides are registered under several product names and are effective, but check the labels carefully as not all species are covered and some may show phytotoxicity.

# Rust

**Card reference 172 in**  
*Pests, Diseases, Disorders*  
*and Beneficials in*  
*Ornamentals: Field*  
*Identification Guide, see*  
 Section 10 page 7

**Cause:** Fungi belonging to genera such as *Uromyces*, *Puccinia*, *Phragmidium*, *Coleosporium*, *Aecidium*, *Melampsora*, *Uromykladium*. (These are true rusts, sometimes loosely referred to as red rusts.)

**Symptoms:** Coloured spots from white through yellow to orange and black appear on leaves. Spores are usually formed on the lower leaf surface but some rusts produce spores on both surfaces. Rusts produce different spore types and this can result in different coloured lesions depending on the development stage of the rust. Rust on roses, for example, may appear initially as yellow/orange spots when one spore type (uredospores) is forming but later the lesions appear black due to the formation of dark sexual spores called teliospores. Often a yellow halo forms around the zone of infection. In severe outbreaks leaves may drop. Rusts also infect stems and flowers.

**Host range:** Rust species usually only infect a single host or a narrow range of hosts, but there are many species of rust and most plants are subject to infection by at least one species. Some rusts have alternate hosts for some phase of their life cycle. Fuchsia rust, for example, forms uredospores on fuchsia but another type of sexual spore called basidiospores on *Abies*. Basidiospores are the type of spore that forms on the gills of mushrooms and toadstools. Life cycles for some rusts can be complex, others complete their entire life cycle on a single host.

**Spread:** Air-borne spores and water splash. Leaf surface moisture is necessary for the spores to germinate and infect a plant. Plants may be infected within 4 to 5 hours but may not produce symptoms for some time. They appear healthy when dispatched but can subsequently develop rust.

**Diagnostic feature:** Presence of rusty coloured, dry spore masses.

**Aid to diagnosis:** Once spores are present, run the thumbnail across mature lesions to determine the presence of the characteristic rusty spores. Many diseases are loosely referred to as 'rust' but this is misleading. This term should only be used for diseases caused by the true rust fungi.

**Confirmation of diagnosis:** Microscopic examination of spores and comparison with published description. Observation of the intricate structure of the spores is often needed for accurate identification. Specialist taxonomic assistance is often required.

**Possibility of confusion:** True rust can be distinguished from other leaf spotting diseases by the presence of rusty, dry, powdery spores. If these are not detected in older lesions, the disease is unlikely to be a rust.

**Monitoring procedure:**

- Use magnifiers and look carefully at both leaf surfaces, especially the undersurface where spores are usually first developed. In the early stages only a pinpoint spot may be present. Experience is needed to detect the early stages of infection because plants must be treated early to provide good control.



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**Control:**

- Rusts require periods of leaf wetness to initiate infection. Manage the growing environment to enhance air movement, reduce humidity and maintain an even temperature to reduce infection.
- Subirrigation or similar methods that avoid wetting the leaves will help prevent rust outbreaks.
- Several fungicides with specific activity against rusts are available but they need to be applied as soon as infection is detected. Some have eradicant properties. Proper coverage of all plant surfaces is essential for good control.
- Remove and destroy severely diseased and fallen leaves to eradicate the source of infection. This will help to prevent infection of future crops from plant debris.

# White blister

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**Card reference 178 in**

*Pests, Diseases, Disorders  
and Beneficials in  
Ornamentals: Field  
Identification Guide, see  
Section 10 page 7*

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**Cause:** Fungi belonging to the genus *Albugo*, which are closely related to the downy mildews. Sometimes incorrectly termed white rust (*Puccinia horiana*), which only infects chrysanthemum species. These fungi are different to the true rusts (this section page 23), which are sometimes loosely referred to as red rusts.

**Symptoms:** Light spots appear on the lower surfaces of the leaves. Blisters form later and burst, revealing white crusty masses of spores. On some hosts (for example gerbera) pustules also develop on the upper leaf surface, stems and flowers.

**Host range:** *Albugo trapogonis* has a wide host range but it is likely that host specific strains exist. Gerberas, sunflowers and asters are often infected. Lisianthus is affected by another species of white blister. Riceflower is also affected by white blister in coastal climates.

**Spread:** Air-borne spores are released from the pustules. Leaf surface moisture is essential for germination and infection. Resistant, thick-walled sexual spores (oospores) are formed in infected tissue and provide long-term survival in trash, which can be a source of infection for new crops.

**Diagnostic feature:** Presence of white blister-like lesions and white/cream spores.

**Aid to diagnosis:** Run thumbnail across mature lesion. Spores will accumulate on the thumbnail. If spores are not present, it is unlikely to be white blister.

**Confirmation of diagnosis:** Examination of spores under a compound microscope and comparison with published description.

**Possibility of confusion:** Fairly distinct from other leaf diseases. Not easily confused if mature lesions are present.

**Monitoring procedure:**

- Use magnifiers to carefully examine leaf surfaces, concentrating on the undersurface where spores usually are first developed. It is important to detect infection early so that appropriate treatment can be given.
- Infection may also appear on stems and flowers.

**Control:**

- Manipulate growing environment to minimise leaf wetness.
- Remove infected material to prevent early infection of new crops.
- There are no specific fungicide label registrations for control of white blister.
- Choose resistant cultivars where available.

## Bacterial leaf spots and blights

### Card reference 150 in

*Pests, Diseases, Disorders  
and Beneficials in  
Ornamentals: Field  
Identification Guide, see  
Section 10 page 7*

**Cause:** Various pathovars (strains) of *Erwinia*, *Pseudomonas* spp. and *Xanthomonas campestris*.

**Symptoms:** Vary, depending on the host. Leaf spots usually start as small lesions (1 mm diameter) on the leaf undersurface. Lesions enlarge to 2 to 8 mm in diameter, are roughly circular with irregular borders and translucent or yellow halos. Blight infections may develop at the leaf margin or from wounds. Bacteria enter the veins and move into stems. Blockages in the vascular system cause young foliage to blight while older leaves turn yellow and die. Wet rotting tissue appears to be slimy and water-soaked but becomes brown and papery as it dries out.

**Host range:** *Erwinia* and *Pseudomonas* spp. and *Xanthomonas campestris*. Some of these bacteria infect a wide range of hosts whereas other specific strains are restricted to narrow host ranges.

**Spread:** In water splash, recycled and untreated irrigation water, surface water, cuttings, personnel and tools. Any damage to tissue can provide a site for infection.

**Diagnostic feature:** Leaf spots are generally angular with a yellow halo. Fungal structures are absent.

**Aid to diagnosis:** Remove area of leaf with lesion. Place on a microscope slide in water and cut through the centre of the lesion with a razor blade. Observe under a compound microscope for evidence of bacterial ooze. Some experience is required to be confident with this technique. Infection can sometimes be observed if suspect stems are cut transversely with a razor blade and kept in a moist chamber. White/cream bacterial slime can be seen oozing from the vascular system. A dissecting microscope may be necessary.

**Confirmation of diagnosis:** Isolation of pure cultures of bacteria and identification by a specialist.

**Possibility of confusion:** Other pathogens may cause superficially similar symptoms. Some non-pathogenic causes, such as environmental extremes and chemical toxicities, can cause similar symptoms. Secondary bacterial infections are often found associated with such conditions. Considerable expertise can be required for an accurate diagnosis.

### Monitoring procedure:

- Observe leaves carefully and check suspect spots by looking for evidence of bacterial ooze.
- Early detection is essential for control and to prevent spread, which can be rapid under favourable conditions.

### Control:

- Bacteria are easily introduced on propagating material and careful selection of stock is essential. Inadvertent introduction of one diseased cutting can result in rapid spread when conditions are favourable. Seed may also carry infection. Infected plants should be removed and destroyed as soon as they are detected.

- Moisture is essential for bacterial spread and infection. Control growing environment to reduce leaf wetness.
- Staff must be trained in hygienic practices such as washing hands after handling diseased plants or soil, sterilisation of tools, and wearing of clean uniforms.
- Benches used for preparing cuttings must be sterilised between batches to avoid the chance of contamination.
- Copper-based fungicides can suppress bacteria on surfaces but will not eradicate established infections nor prevent reinfection if conditions are favourable.
- All debris must be removed between crops to eliminate the risk of contamination.
- Clean stock scheme material may be needed to avoid repeated infection with bacterial diseases where other control measures are not satisfactory.

## Spotted wilt

### Card reference 174 in

*Pests, Diseases, Disorders  
and Beneficials in  
Ornamentals: Field  
Identification Guide, see  
Section 10 page 7*

**Cause:** Tomato spotted wilt virus (TSWV).

**Symptoms:** Symptoms can include stunting, necrotic spotting, chlorotic spotting, areas of black or brown stem necrosis (dead tissue), ringspots, mosaics, line patterns and vein necrosis. Sometimes growing plants can collapse or die. Some hosts may exhibit several of the symptoms and show variation from variety to variety and from plant to plant.

Latent (symptomless) infections can also develop and temperature can affect the severity of symptoms.

**Host range:** Very wide, including many ornamentals, vegetables and weeds. More than 500 species in 50 plant families are known hosts.

**Spread:** Certain species of thrips including western flower thrips (*Frankliniella occidentalis*). The virus is acquired by larval thrips in 15 to 30 minutes and transmitted by adults in as little as 5 minutes.

**Diagnostic feature:** Appearance of typical symptoms are an indication of virus infection.

**Aid to diagnosis:** Diagnosis based solely on symptoms can be unreliable without considerable experience and knowledge of the typical reaction of a host to TSWV.

The pattern of distribution of affected plants can help you decide if a virus is the cause. Virus infections usually begin in a few scattered plants and gradually spread as the thrips transmit the infection to healthy neighbouring plants. The sudden appearance of symptoms on all plants is usually an indication of reaction to a pesticide or unfavourable environment rather than a virus outbreak.

**Confirmation of diagnosis:** Refer to a specialist diagnostic laboratory, which may use several techniques to identify the virus.

**Possibility of confusion:** Considerable experience is needed for confident field diagnosis. Insect and/or mite injury, phytotoxicities and environmental factors can cause similar symptoms. Fungal wilts can sometimes be confused with TSWV infection.

### Monitoring procedure:

- Regular and careful observation for signs of abnormal leaves and growing points.
- Check thrips populations by using sticky traps to indicate the potential risk of TSWV infection.
- Indicator plants such as petunias flagged with thrips-attractive blue or yellow non-sticky cards can be useful as trap plants for the virus.

### Control:

- Effective control depends on the elimination of infected plants and control of the thrips vector. Plants showing symptoms should be immediately removed and destroyed. Thrips should be excluded from growing areas by using properly designed and covered houses.



Thrips control  
Section 5 page 14

- Select propagating material from clean sources to ensure freedom from thrips and TSWV.
- Use sticky traps to measure thrips activity and apply insecticides when populations are above the recognised action threshold.
- Quarantine new or returning stock in an insect-proof facility to determine their thrips and TSWV status.

## Nematodes (root-knot and leaf)

**Card reference 170  
and 162 in**

Pests, Diseases, Disorders  
and Beneficials in  
Ornamentals: Field  
Identification Guide, see  
Section 10 page 7

**Cause:** Root-knot nematodes, for example *Meloidogyne* spp. Leaf nematodes, for example *Aphelenchoides* spp.

**Symptoms:** *Root-knot nematodes* cause galls ranging from little more than an insignificant swelling to large club-like structures 1 cm or more in diameter on roots. Symptoms vary, depending on the host/nematode combination and the severity of infestation. Above-ground symptoms may include stunting, yellowing and slow growth.

Root-knot nematodes should not be a problem where routine hygiene and soil-less media are used. It can be a common problem in crops grown in the ground.

*Leaf nematodes* cause a variety of symptoms. Nematodes feeding inside the plant commonly cause chlorotic or brown to purple or black water-soaked, angular lesions. Infested leaves eventually shrivel and die but usually remain attached to the plant.

On some hosts leaf nematodes feed mainly on the exterior surfaces, especially on immature leaves and flower buds. Young leaves become cupped and distorted, and the plant may be stunted.

**Host range:** Both root-knot and leaf nematodes have wide host ranges.

**Spread:** In soil/potting media, on cuttings or purchased plants, in surface water on leaves, or on tools.

**Diagnostic feature:** *Root-knot nematode:* Presence of galls on roots.

*Leaf nematode:* Characteristic water-soaked areas on leaves, often restricted by veins. Distortion of young leaves. Death of older leaves.

**Aid to diagnosis:** *Root-knot nematode* infestation of soil can be detected by growing a susceptible host (for example certain tomato varieties) for several weeks and then washing the soil from the roots and examining them for evidence of galling.

Cut up root galls in water and the worm-like nematodes should be easily seen with a dissecting microscope. Mature forms of root-knot nematode are shaped like a sac.

For *leaf nematodes*, cut affected leaves into segments and soak them in water. Nematodes can often be seen swimming out from the lesions. A dissecting microscope is required.

**Confirmation of diagnosis:** Confirm presence of nematodes in root galls and in leaf lesions. Identification to genus and species requires professional expertise.

**Possibility of confusion:** *Root-knot nematodes* are distinctive but galls can sometimes be caused by parasites, for example crown gall, and other non-parasitic agents.

*Leaf nematodes* can be confused with bacterial diseases, fungal leaf spots and other agents (such as mites, pesticide toxicity, nutrient disorders) that distort young tissue.

**Monitoring procedure:**

- Soak segments of leaves showing water-soaked lesions in dishes of sterile water. Observe for evidence of nematodes. Distorted growth can be treated similarly.
- Where growth is generally unthrifty, wash potting medium from roots and examine under a dissecting microscope for evidence of galls.

**Control:**

- Maintain high levels of hygiene at all times to prevent introduction on cuttings, personnel, potting medium, water and roots.
- Control growing environment to reduce leaf wetness.
- Nematodes can be a severe problem if they become established in capillary beds or mats and in other systems where pots are exposed to common subirrigation water.
- Systemic insecticides and nematicides can help to reduce the population in leaves.
- Seriously affected leaves should be removed and destroyed. All leaf debris should be removed between crops.