

# Fusarium and Verticillium Wilts

## Introduction

Verticillium and Fusarium species are soil-borne fungi that can survive for extended periods in the absence of a host plant by producing resilient resting structures. Species commonly causing vascular wilt diseases of plants are *Verticillium dahliae*, *Verticillium albo-atrum* and host-specific strains of *Fusarium oxysporum*.

Wilt diseases are found most commonly in soil-grown crops and in gardens, but severe attacks may also occur in some container-grown crops (e.g. Fusarium wilt of cyclamen). Plants commonly affected by wilt diseases include the following:

- Verticillium wilt: *Acer*, *Cercis*, *Cotinus*, *Helichrysum*, chrysanthemum, potato, rose, strawberry, tomato and linseed.
- Fusarium wilt: asparagus, basil, beans (*Phaseolus* and *Vicia* spp.), Callistephus, cyclamen, *Dianthus* spp., *Gladiolus*, *Lisianthus*, peas, stocks and tomato.

Some other fungal and bacterial pathogens are capable of causing wilt diseases. These include the fungus *Phialophora*, bacterial wilts caused by *Ralstonia* and *Xanthomonas* species, and Dutch elm disease caused by the fungus *Ophiostoma novo-ulmi*.

## Key Facts

- These are soil-borne fungal pathogens that invade through the roots and disrupt water transport through the vascular tissues
- Fusarium wilts are host-specific, whilst Verticillium wilts have wider host ranges
- Symptoms include wilting, dieback and characteristic vascular staining
- Resting structures can contaminate soil or growing areas for long periods
- Spread may occur via movement of infected plants and cuttings
- Good hygiene, including the use of disinfectants, will help to reduce the risk
- Soil sterilisation can be used for high-value field crops
- Fungicides often give poor control



Vascular staining of carnation

## Symptoms

Many of the symptoms of wilt diseases are non-specific and simply indicate difficulties with water uptake and movement. They include yellowing, wilting and shrivelling of leaves, stunting, bark cracking and twig or branch dieback.

These symptoms could also occur in plants affected by root diseases or cultural problems such as waterlogging or drought.

The most diagnostic symptom of a wilt disease is staining of the water conducting vessels (xylem), also known as the vascular tissue. This staining can affect the stems, branches, petioles, crowns (e.g. strawberries), corms (e.g. cyclamen) and even roots.



*Fusarium wilt of stock*



*Chrysanthemum stem with fungal mycelium and microsclerotia of Verticillium*



*Basil wilt - Fusarium oxysporum f. sp. basilici*

The staining can vary in colour; in many woody plants it is olive-green, brown or black, but in plants such as cyclamen, peas and stocks it is usually reddish. In woody plants it may affect part or all of one or more annual rings. Vascular staining can also occur in plants affected by root or stem base diseases (e.g. Phytophthora root rot in many plant species, Fusarium root rot of peas and beans), but in these cases the staining rarely extends more than a few centimetres up the stem.

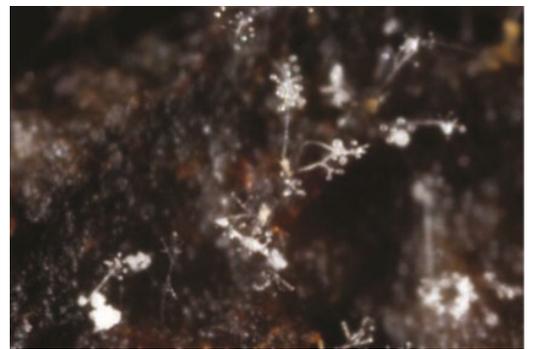
Some plants, however, do not produce obvious vascular staining when attacked by wilt diseases. Examples include chrysanthemums and roses affected by Verticillium wilt.

Additional indicators that a wilt disease may be involved include wilting affecting one side of the plant only, or yellowing, browning or wilting affecting one half of a leaf or leaflet (a common symptom in tomatoes affected by Verticillium wilt, for example). In plants such as China aster (*Callistephus*), basil and stocks affected by Fusarium wilt there may be necrosis or collapse of stem tissue, and white, pink or orange fungal growth may develop on the affected tissue under conditions of high humidity.

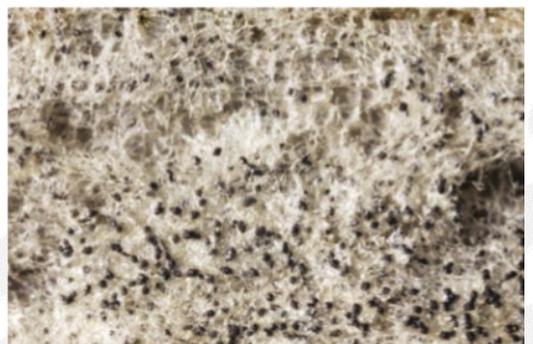
## Biology

The fungi causing Fusarium and Verticillium wilts infect the plant through its root system. Infection can occur through healthy roots, but root damage often aids colonisation - there are some well documented links between increased levels of wilt diseases and root damage from certain nematode species.

Once within the plant, the pathogen colonises the xylem vessels. The effects of the disease on the host are thought to be due to a number of factors. These include physical blockage of the vessels by growth of the fungus, production of toxins by the fungus that are then carried upwards via the transpiration stream, and production of gums and outgrowth by the plant to try and limit the infection by blocking the vessels.



*Verticillium sporulation*



*Verticillium microsclerotia*

All of these wilt pathogens produce microscopic resting spores or structures that can contaminate the soil or growing area of the crop for an extended period (probably up to several years). These are released from the host plant tissue as it decays.

*Verticillium dahliae* produces microsclerotia, *Verticillium albo-atrum* resting mycelium and *Fusarium oxysporum* chlamydospores.



*Sporulation of Fusarium on Begonia*

As the pathogens may be found in the vascular tissues in many parts of the plant so, too, may their resting structures be produced in these various areas. For example, large numbers of microsclerotia of *Verticillium dahliae* may be produced in roots, stems or even leaves.

The *Verticillium* species have fairly wide host ranges, and whilst some host specialisation may occur within the individual species this is poorly understood. The pathogenic strains of *Fusarium oxysporum* (known technically as *formae speciales* or form species, and abbreviated to f. sp.) are highly host specific and will not cause damage to other hosts. For example, Fusarium wilt of cyclamen is caused by *F. oxysporum* f. sp. *cyclaminis*, and that of China aster by *F. oxysporum* f. sp. *callistephi*.

In addition to the pathogenic strains of *F. oxysporum*, there are also many nonpathogenic or saprophytic strains. Many of these other strains are capable of colonising the roots of a plant (particularly if these are damaged or decaying due to other factors), but only the host-specific strain will be able to penetrate into the vascular tissue and cause wilt.

Both *Fusarium* and *Verticillium* wilts can be present as latent (symptomless) infection in plants and cuttings moving within the nursery trade. In work carried out by Fera on *Verticillium* wilt of chrysanthemums (funded by the HDC) exceptionally low levels of *Verticillium* were found in apparently healthy young cuttings by laboratory testing. This would be enough to introduce the pathogen into a crop, where it could multiply and cause significant damage to future crops. Another area of concern for disease introduction is contaminated seed. This is a particular problem with *Fusarium oxysporum*, for example Fera demonstrated the importance of seed infection in preventing outbreaks of basil wilt caused by *Fusarium oxysporum* f.sp. *basilici*. Fera offers a comprehensive seed health screening service.



*Fusarium oxysporum chlamydospores*



*Fusarium oxysporum conidia*

## Diagnosis

Whilst staining of the host plant's vascular tissues can be a good indication that a wilt disease is involved, laboratory testing may be required to confirm the diagnosis. A standard test involves exposing the vascular tissue of stems, crowns or leaf petioles and then incubating the material at high humidity, to encourage the production of characteristic spore-bearing structures of the pathogen. The vascular tissues are also commonly placed onto nutrient agar in Petri dishes to isolate the fungus in pure culture. This combination of techniques is usually sufficient to confirm most cases of fungal wilt diseases, but molecular tests can also be utilised if required.

It is not possible using these techniques to differentiate between pathogenic and saprophytic strains of *Fusarium oxysporum*. Therefore, if a potential new host plant is involved, or conclusive evidence is required of the involvement of this pathogen, host inoculation testing may be necessary.

Fera is able to offer a soil test to determine the level of *Verticillium dahliae* by calculating the number of microsclerotia per gram of soil. Accurate interpretation of the result is available for strawberry crops, so that recommendations can be given for the most suitable course of action depending on the degree of infestation.

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## Chemical control

Various chemical (e.g. chloropicrin, dazomet, formaldehyde, metamsodium) or non-chemical (e.g. steaming, solarization, biofumigation) methods can be used on infested soil. None are 100% effective and they will only penetrate to a limited depth. Plants can still become infected if the wilt pathogen is re-introduced into the treated area by drainage / run-off water or capillary action, or by the roots growing down beyond the treated soil.

A large number of disinfectants are available to treat standing areas, capillary matting, pots etc. These are likely to vary in their efficacy against the resting structures of *Fusarium oxysporum* and the *Verticillium* species.

Fungicide treatment against wilt diseases gives variable and often poor results. For this reason there are few specific recommendations or approvals, but in a few cases (e.g. *Fusarium* wilt of cyclamen) fungicides are used quite widely as protectants.

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## Preventative measures

- If growing susceptible container-grown plants use new pots, trays, etc. or at least treat any re-used items with a disinfectant
- Consider soil testing to determine levels of *Verticillium dahliae* in field soils, particularly for strawberries. This test can also be used for other susceptible crops, such as field-grown nursery stock, but at present detailed interpretation of results to determine risk is available for strawberries only
- Knowledge of field crop rotations can pinpoint potential problems. It is known that growing linseed, for example, can greatly increase the numbers of microsclerotia of *Verticillium dahliae* if this pathogen is present in a field
- Avoid using sites for susceptible crops where *Verticillium* wilt has been a problem. As *Fusarium* wilts are host-specific then only the crop on which the disease occurred may need to be avoided

- Inspect bought-in plants. If possible, have a quarantine area where bought-in stock can be held and monitored for disease development for a few weeks
- Consider the use of resistant varieties, particularly where a wilt disease has occurred previously. Crops in which specifically bred resistant varieties are available include tomatoes (*Fusarium* and *Verticillium* wilt), and peas (*Fusarium* wilt). In some other crops such as strawberry there are widespread differences in susceptibility (in this case to *Verticillium dahliae*) between varieties
- Dispose of wilt-affected plants immediately and carry out rigorous hygiene measures to prevent further spread
- Composts containing amendments such as composted pine bark have been shown to reduce levels of *Fusarium* wilt in cyclamen. Preparations containing organisms such as *Trichoderma* are sold as growth stimulants for use on a range of crops and are also claimed to reduce levels of diseases including *Fusarium* wilt, but there has been little detailed experimental evaluation of these products