

Bacterial wilt and canker of tomato (*Clavibacter michiganensis* subsp. *michiganensis*)

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***Clavibacter michiganensis* subsp. *michiganensis* occurs worldwide and is a notifiable disease when it occurs in propagating material. It has occasionally entered the UK, including four outbreaks since 2003. The disease has potential for epidemic spread and can be difficult to control. This factsheet summarises the latest information available, gives practical advice on recognising the disease and describes contingency measures to be adopted if it is detected.**

Background

Clavibacter michiganensis subsp. *michiganensis* (Cmm) is the bacterium that causes bacterial wilt and canker on tomato. The disease was first reported in the USA in 1910, and by the mid 1950s had spread worldwide in

infected seeds and seedlings. It has occurred occasionally in the UK since the first finding in 1957, most recently in the Isle of Wight in 2008 and Cambridgeshire in 2009. Bacterial canker is an EU-listed quarantine disease and all suspected outbreaks in propagation crops should be reported to the

Fera Plant Health and Seeds Inspectorate (PHSI) in England and Wales, or to the equivalent authorities in Scotland, N. Ireland and the Channel Islands, who will advise on how to contain and eliminate the pathogen.

Economic significance

The main host is tomato, while some susceptible solanaceous weeds (including *Solanum nigrum*) could be potential reservoirs of the pathogen. Transmission from infected seeds usually occurs at a rate of less than 1% but secondary infections can cause serious losses to both glasshouse and field tomato crops, either by killing the plants (Figure 1) or disfiguring the fruit. In North Carolina (USA), up to 70% reduction in yield has been recorded in some years. Experimental data from France has shown direct yield losses of between 20–30%. Lack of chemical or other controls can lead to removal and destruction of entire infected crops as an eradication measure in propagation crops.



1 Plant death due to systemic infection by Cmm

Distribution

Cmm has been reported from a wide range of countries on all continents, although current status is difficult to determine. In Europe it has been previously reported

as - widespread in France, mainland Greece, the Russian Federation and Switzerland - but in most other countries it has been described either as present with restricted distribution or; few occurrences or; as formerly present now

absent or; eradicated. Outbreaks are often attributed to movement in international trade of infected seed lots, or more recently infected rootstocks. There are few countries in Europe that have not reported interceptions or findings.

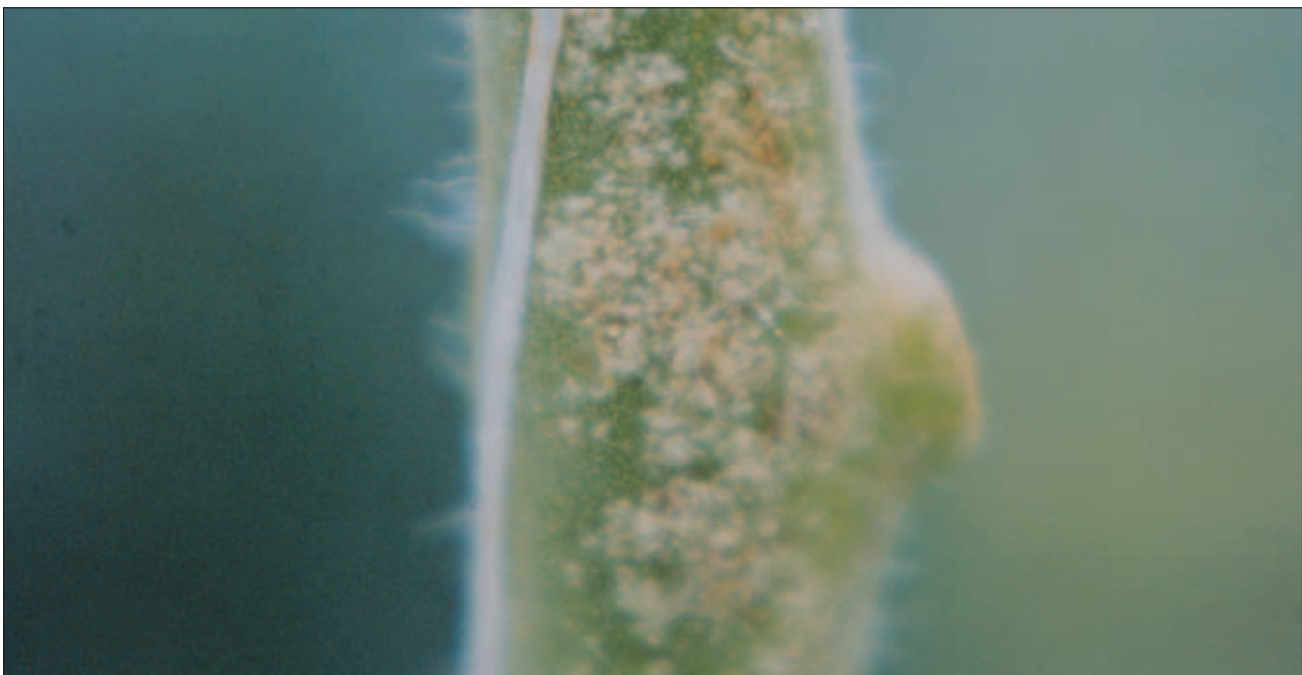
Symptoms

Symptoms can be divided into two types, depending on whether infection is systemic (primary) within

the vascular tissue or superficial (secondary) on plant surfaces. The recent outbreaks in the UK have all been systemic and spread within crops was contained. There is a

greater risk of epidemic spread where superficial symptoms occur.

Systemic infections cause blockage of the xylem vessels resulting in wilting, often on only



2 Mealy spots on a stem caused by superficial infection



3 Leaf margin yellowing following infection of water excreting glands

one side of a leaf, which is initially reversible, with the leaves recovering in the cooler part of the day. Leaves may become stressed rather than wilted in more mature plants, and may develop windows of white and then brown interveinal necrotic tissue. Young petioles or leaves may

show curved or distorted growth. Severe vascular infections result in removal of the epidermis and outer cortical tissue from the inner stem, if stems are squeezed between thumb and finger. The exposed tissues often have a soapy feel due to the copious production of

slime by the pathogen. Fruits may fail to develop normally and fall or ripen unevenly, appearing marbled. Severely wilted plants often die.

Superficial infections occur when bacteria multiply on the plant surface or within surface wounds and stomata. Leaves, stems



4 'Bird's-eye' spotting on fruit, a relatively rare symptom



5 Windows of necrotic tissue were a common symptom in recent outbreaks

and calyces may show a mealy appearance, as if dusted by coarse flour. Close examination reveals raised or sunken blisters which are usually white to pale orange. Mealy spots on stems (Figure 2) are usually more discrete than those on leaves. A common leaf symptom is a dark brown spot surrounded by a

yellow-orange area as seen in Figure 3, usually at the edge of the leaf. This results from infection of a water excreting gland. On fruits, superficial infections cause 'bird's-eye' spotting: raised, pale green or whitish pustules which develop a light brown centre and a chlorotic halo as the young fruit expands (Fig 4).

Canker-like symptoms are actually rare; the disease's most common name, bacterial canker, is in reality a misnomer.

Other symptoms of the disease are illustrated in figures 5, 6, and 7.



6 Severe wilting can result from systemic infections



7 Leaf necrotic windows and distortion

Infection and spread

Sources of inoculum

Infected seed is the main source of inoculum and can give rise to either systemic or superficial infections. The bacteria can be present on the surface of the seed as well as within the innermost layer of the seed coat. The pathogen can also be present as a latent infection in rootstocks and seedlings for transplanting. It can be introduced from infected plants, crop debris, weed hosts or volunteer tomatoes and contaminated equipment. In glasshouses, infected plant debris (especially calyces), contaminated tools and glasshouse structures are sources of carryover of the disease from season to season.

Bacterial survival

The bacterium can remain viable for at least 8 months in seeds. It can survive from season to season in plant debris and on equipment and glasshouse structures. Survival times in soil are not documented.

Bacterial spread

Cmm is dispersed by wind-driven rain, overhead irrigation, or on contaminated tools, hands or clothing. Transfer by machinery or workers is particularly important in greenhouse conditions where plant density is high and growth conditions for the bacterium are optimal. Systemic infections usually appear in 3–6 weeks and are often spread during leaf trimming and shoot removal.

Secondary infections spread through splashing water.

Infection pathway

Bacteria enter the plant through natural openings and wounds, including root wounds. Pruning or clipping operations can introduce the bacteria directly into the vascular system, resulting in the more serious systemic infections.

Conditions favouring infection

Spread of the disease in the field or in glasshouses is favoured by water (rainsplash, irrigation) and cultural practices that cause plant damage (trimming, chemical sprays).

Control

It is not possible to eliminate bacteria from an infected crop. Preventing the pathogen from entering and becoming established is the most appropriate and cost-effective course of action. Screening seeds or seedlings to make sure they are free of the pathogen is expensive, so a preventative program should be employed early in the crop's development.

Preventative measures

Do not accept planting material without a valid plant passport. Seed traded into and within the EU is required to be acid extracted and should be free of the pathogen. Obtain seeds and young plants from reputable sources and ask for assurances that it is disease free, such as results of seed testing.

Where grafted plants are ordered, check that seeds of the rootstock, as well as the scion

variety, are treated with a suitable disinfectant (sodium hypochlorite is approved as a Commodity Substance for treatment of tomato seed).

Inspect all seedlings/transplants for symptoms of the disease. Train staff to recognise disease symptoms and inspect the crop regularly. Ensure high standards of sanitation. Do not enter into a propagation crop after visiting a fruiting crop unless very strict hygiene measures have been undertaken. Wash hands (eg use alcohol gel hand wash) and remove any soil and debris from footwear when moving between crops. Use disinfectant pads at glasshouse doorways and wear disposable gloves, especially when dealing with propagation crops.

Control measures

In propagation

The disease is notifiable if it occurs during plant propagation. If suspected, immediately notify your local Plant Health Inspector.

Further laboratory testing will be required to verify the cause of symptoms. If the disease is confirmed, inspectors will provide advice on how to contain the pathogen and the necessary eradication procedures.

During fruit production

Cordon off the affected rows and one row on either side (Figure 8). Restrict staff who can enter these areas. Carefully remove infected plants and adjacent plants from the greenhouse, placing them in plastic bags before you take them through the crop. Dispose of these plants and debris carefully, either burn or send to landfill. When handling affected plants, use a disposable oversuit and gloves and dispose of them on leaving the house. Wash hands well. If a disposable oversuit and gloves are not used, change clothing after infected plants are removed. Wash clothing before wearing it again. Comply with the Fera code of practice regarding the disposal of agricultural and horticultural plant waste (see Further Information).



8 Cordon off affected rows immediately, if the disease is suspected

Disinfect pruning tools promptly. Suitable disinfectants include quaternary ammonium products (such as alkyldimethylbenzylammonium chloride), peroxide/peroxygen based products, or household bleach (sodium hypochlorite). Where practicable, assign trolleys, picking boxes and other equipment for use in the affected areas (i.e. the visibly healthy plants in a roped-off area in the immediate vicinity from where affected plants were removed). Work with plants in these areas last. Consider removing the heads of these plants, abandoning de-leafing, and just pick the fruit. In affected houses, remove all leaves and fallen fruit after each de-leafing. Affected calyces can be an important source of carryover on crops. Monitor the crop carefully for disease. Pay close attention to plants in the proximity of the initial outbreak.

Seek to manage the crop to avoid soft, succulent growth. Control the glasshouse environment so as to minimise high temperatures (above 25°C) as far as practicable. Keep the crop foliage as dry as possible; avoid

high humidity and sudden temperature changes that can result in condensation conditions. Do not apply high volume pesticide or foliar nutrient sprays unless it is critical to do so.

Products that contain copper have previously been reported as moderately effective at controlling spread of secondary superficial infections in the USA. In the UK, copper oxychloride (Cuprolyt, Cuprolyt FL and Headland Inorganic Copper) and cupric ammonium carbonate (Croptex Fungex) are permitted for use on protected tomato. The value of fungicide spray treatments is questionable if the disease is present as a systemic infection without superficial symptoms. There is also a risk that water splash from spray application may spread the bacterium.

Additional controls in areas where the disease has occurred

- Remove dead plants and plant parts before tissues become brittle.

- Thoroughly clean the greenhouse after harvest and remove all plant debris.
- Clean all greenhouse surfaces, including crop wires, and disinfect irrigation lines.
- For further details on nursery hygiene and use of chemical disinfectants, see HDC Factsheet 15/05.
- Control weeds in and around the glasshouse, especially solanaceous weeds.
- Be extra vigilant to ensure following crops remain free from symptoms.

A checklist of tasks to keep the UK free of tomato bacterial canker is given in Table 1.

Laboratory testing

For disease diagnosis, choose representative plants showing early symptoms. Submit as much of the plant as possible, or several plants showing a range of symptoms. Pack roots and foliage in absorbent paper within separate plastic bags inside a strong box. Deliver to the diagnostic

laboratory at the beginning of the week to arrive as soon as possible. Commercial testing services, based on isolation of the pathogen on bacteriological media and rapid molecular screening tests such as immunofluorescence and PCR, are available at plant health laboratories such as Fera and SASA.

Screening seeds or seedlings for latent infections is expensive

because large numbers have to be destructively tested (one infected seed in 10,000 can cause an outbreak under optimum disease conditions). Nevertheless it is worth checking with your supplier to determine what testing they have done to verify that the disease is absent from their propagation areas.

Table 1 Checklist of tasks to keep the UK free of tomato bacterial canker

Stages	Tasks
Pre-planting	Buy in disease-free seed or plants. Accept only plant material that comes with a valid plant passport and ensure that the nursery of origin is disease free. Carefully inspect all material on arrival for symptoms of wilting and bacterial canker.
Propagation	Restrict the movement of visitors and workers. Make sure that fruiting crops have not been visited before going into propagation crops. Tighten hygiene procedures.
Fruiting crops	Train staff to recognise the symptoms. Check crops for signs of the disease. Disinfect pruning knives regularly.
Post harvest	Remove all infected and associated plants and debris and burn or dispose to landfill. Clean and disinfect surfaces and irrigation lines.

Further information

In England and Wales your local Plant Health and Seeds Inspectorate (PHSI) office should be notified if an outbreak of the disease is suspected in propagation material. The PHSI can also be contacted for details of the plant passport scheme and for further advice on avoiding or eradicating the disease.

The PHSI headquarters are in York.
Tel. 01904 465625
Fax. 01904 465628
planthealth.info@fera.gsi.gov.uk

More information is also available from these EPPO and Fera web pages:

- www.eppo.org/QUARANTINE/bacteria/Clavibacter_michiganensis/CORBMI_ds.pdf
- www.fera.defra.gov.uk/plants/publications/plantHealth/informationCards.cfm
- www.fera.defra.gov.uk/plants/publications/plantHealth/documents/copManagementWaste.pdf
- www.fera.defra.gov.uk/plants/publications/plantHealth/documents/pass.pdf

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Additional information: