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Tomatoes

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Potato spindle tuber viroid in tomato and new viroid reports

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The first confirmed case of Potato spindle tuber viroid (PSTVd) in a UK tomato crop occurred in 2003. Outbreaks have also occurred in recent years in Germany, the Netherlands and New Zealand. PSTVd is an EU listed quarantine pathogen. This factsheet summarises information on the biology and control of this potentially serious notifiable disease. Information is also provided on four other viroid diseases.

Action points

- Be aware of the symptoms of PSTVd and related viroid diseases in tomato (see the photographs in this factsheet)
- If a viroid disease is suspected, inform the Plant Health and Seeds Inspectorate (PHSI) and rope-off the affected rows to prevent staff entry
- If PSTVd or another viroid disease is suspected or confirmed, implement a strict hygiene protocol. In particular, all staff should wear vinyl or similar gloves when working in the crop and change them frequently
- Perform all plant handling tasks in the same direction along a row
- Disinfection with 0.5% sodium hypochlorite (5,000 ppm) or stronger has been shown to be effective at inactivating PSTVd in dried sap after 5 minutes; 0.125% was not effective
- As a general precaution, control volunteer tomato seedlings and Solanaceous weeds (eg woody nightshade) in and around tomato glasshouses
- Keep ornamentals (eg petunias) out of tomato crops.

1 Typical 'bunchy top' symptom caused by PSTVd

What is a viroid?

Viroids are the smallest agents known to cause serious diseases in plants. They are extremely simple virus-like microorganisms. Like viruses, they multiply only in living plant cells. A characteristic feature of viroids is that their structure is exceptionally stable enabling them to survive in sap and crop debris for some considerable time. PSTVd is one of about 30 viroids that have been described, several of which cause disease in tomato (eg tomato apical stunt viroid). Viroid diseases are especially common in Solanaceous and Compositae hosts and, in most cases, are not host-specific.

Symptoms of PSTVd in tomato

PSTVd symptoms can be quite variable, especially as both mild and severe strains exist. Mild strains generally cause no obvious symptoms on tomato. With severe strains, symptoms depend on the cultivar and environmental conditions. Symptoms can be similar to those caused by nutrient deficiency, root disease or spray drift damage from a hormone weedkiller making the disease difficult to detect in a crop. There is a latent period of around 4 weeks between infection and symptom development. PSTVd can also occur as a symptom-less infection.

Leaf symptoms

In a mature plant, symptoms usually show first in the plant head as severe yellowing of leaves, often with a purplish tinge; the main veins remain bright green (Figs 2 and 3). Leaves are smaller than normal and bunched together and the plant becomes stunted. The alternative name ‘bunchy top’ is an apt description (Fig 1). Leaves are often down-curled and distorted. If the affected plant head is removed and a side shoot allowed to develop, this generally develops the same ‘bunchy top’ symptom (Fig 4). Affected shoots are usually brittle. Later, similar symptoms may show in leaves lower down the plant; severe necrosis may develop along the veins and leaves die.

Fruit symptoms and yield

The disease is often not obvious in a crop until around 2–3 months after planting, after the fifth flowering truss has developed. Flowers often abort.

2 PSTVd first shows as severe yellowing in the head of a plant

Infected fruit may appear small, dark green, hard and ripen irregularly. The severity of symptoms varies with crop (being affected by temperature and light levels), variety and strain of PSTVd. The yield of marketable tomatoes from affected plants can be significantly reduced, varying with plant age and disease severity; losses of 10–60% have been reported.

Infection and severity

Infection in plants is systemic with evidence of downward movement in the phloem. Unlike some virus diseases, it appears extremely unlikely that tomato plants have the ability to recover from PSTVd disease.

Viroid concentration and symptom severity in plants are affected by temperature, with greater viroid concentration and more severe symptoms at high temperatures (25–37°C). Symptoms tend to occur once the 24-hour average temperature is above 20°C. There are also reports that high light intensity increases symptom severity.

3 Yellowed leaves often have a purplish tinge and are curled

4 Side shoots develop symptoms if the affected head is removed; note the distorted leaves and green veins

Host range

The primary hosts of PSTVd are potato and tomato. Cucumber is not a reported host. In recent years outbreaks have occurred in crops of pepino (Netherlands), pepper (New Zealand), potato (Estonia, Canada, France, Poland) and tomato (Netherlands, Germany, New Zealand, UK). Natural infection by PSTVd has been recorded in avocado, aubergine, pepino, pepper, potato and wild Solanum species as well as tomato. Naturally-infected weed hosts in the Solanum family (such as nightshades) have also been recorded. Grasses are not reported to be hosts.

Disease spread

Mechanical

PSTVd is easily spread in tomato sap by handling plants, by natural plant to plant leaf contact and on glasshouse equipment (eg knives, trolleys and crates). Spread on clothes is also thought to occur, though not proven. Leaf hairs carry a high concentration of the viroid. Transfer following fruit handling is unlikely unless the fruit has been squashed. Transfer between plants in the same slab by root contact is considered unlikely. Monitoring of plants at the UK outbreak site in 2003 revealed local spread down rows, generally in the direction of working and with clusters of several affected plants together (Fig 5). There was also unexplained long-distance spread, with isolated infected plants appearing many rows away from the original focus. Overall, the rate of spread in the monitored crop was slower than is usually seen with Pepino mosaic virus (PepMV) infections.

By pests

There is also a small risk that aphids may spread PSTVd. In potato crops, aphids have been shown to spread the disease – but only if the aphid is already carrying Potato leaf roll virus (PLRV). In practice, the risk of aphid spread of PSTVd in a commercial tomato crop is probably low. There is also some evidence that nematode larvae may transmit PSTVd infections after feeding on infected hosts which may have implications for organic or soil grown crops.

In seed

PSTVd is also spread in seed and pollen. It is not known if the pollen carried by bees in crop pollination can spread infection. Outbreaks in tomato in New Zealand are believed to have arisen from the use of infected seed. Seed infection is internal and levels of 10% infection, or greater, have been recorded in tomato seed. In the recent UK outbreak, seed collected from PSTVd-infected fruit was shown to be infected. However, when this seed was sown, none of the resultant 330 plants tested positive for the viroid after 9 weeks, indicating a seed transmission rate of less than 0.3%: lower than found previously.

5 The virus is spread along a row by crop handling and leaf contact between adjacent plants

Survival of PSTVd in sap and debris

PSTVd survives in dried tomato sap for over 8 weeks (much longer than PepMV), and in both dried and moist infected leaf debris it survives for over 6 months. Survival in water is unlikely for any significant time, the viroid RNA undergoing natural decay. The viroid is also killed by thorough composting.

In recent tests seeking to identify sources of the viroid after a natural outbreak, some plant debris samples found after removal of the affected crop tested positive for PSTVd. In contrast, no viroid was detected on swab samples from glass, concrete pathways, drip pegs or a range of glasshouse equipment.

Control measures

Legislative control

PSTVd is an EU listed quarantine pathogen. This means that a suspected outbreak should be reported to the PHSI. Contact your local office (see under Defra, Department for Environment, Food and Rural Affairs) or contact PHSI Headquarters at York, Tel: 01904 455174, Fax: 01904 455197. An inspector will examine the crop and the Central Science Laboratory (CSL) will test samples free of charge. The viroid particle is usually detected using a highly-specific and sensitive molecular technique known as Polymerase Chain Reaction (PCR). Additionally, sap is inoculated onto an indicator plant, usually tomato cv. Rutgers, to determine if the particle is infectious or not. PHSI will provide detailed guidance on containment and elimination if the disease is confirmed. The outbreak in 2003 was successfully contained and eradicated.

Reducing the risk of seed-borne infection

A non-destructive seed test for PSTVd (and PepMV) is currently being developed by CSL (HDC Project PC 229). Infection can be deep-seated within the seed and there is no recognised treatment to eliminate it. Heat treatment is not effective, the viroid being capable of surviving exposure to 150°C for 2 minutes.

Controlling other possible sources of PSTVd

- Control volunteer tomato seedlings and any Solanaceous weeds in and around tomato crops.
- Do not grow any Solanaceous ornamentals (eg petunia) or other ornamentals susceptible to viroid diseases (eg chrysanthemum) in the same glasshouse as tomatoes.
- Carefully manage the movement of any foreign tomato fruit brought onto a UK tomato production nursery so that the risk of sap transfer (eg by handling, on equipment, or through the movement of birds or other animals) to the growing crop is minimised. For example, use separate staff to deal with imported fruit and crop packing in an area isolated from UK production and staff; make containers of fruit waste bird and rodent-proof; ensure staff wash their hands thoroughly after all breaks.

Hygiene protocol

Where PSTVd has been confirmed, implement a strict hygiene protocol to minimise the risk of spread. This should include:

- Use of disposable vinyl or similar gloves throughout the nursery; ensure that gloves are changed frequently (at every work break). As well as keeping hands clean, there is some evidence that the viroid adheres to plastic and is less readily transmitted from it than from bare hands, thereby reducing the risk of spread along rows
- Staff must wash hands at all breaks
- If practicable, assign staff specifically for work in the affected area and not in other crops on the nursery; in affected areas consider the use of disposable protective clothing and overshoes as well as disposable gloves, and change them frequently (eg daily)
- Staff should perform all plant handling tasks (eg twisting, leaf removal, fruit picking) in the same direction along a row
- Place any leaves or trimmings from the affected area in containers and dispose of them as instructed by PHSI
- Allocate knives, trolleys and other equipment specifically for the affected area(s) and nowhere else; clean and disinfect them regularly with sodium hypochlorite (1% or greater)
- Control and supervise the movement of staff and visitors into the crop; all visitors entering the affected crop should wear new disposable suits, gloves and overshoes
- Visitors should be kept to pathways and not allowed to handle the crop except for good reason
- Do not allow animals into the crop at any time

PHSI may instruct additional requirements, including procedures for removal of the affected plants and neighbouring plants, and removal of the crop from the house, and how to dispose of them. Wear full disposable protective clothing at crop removal, and leave it in the greenhouse during breaks.

Disinfection

PHSI will specify the required disinfection procedure after an outbreak of PSTVd. Sodium hypochlorite is currently the most effective disinfectant to use against PSTVd. Its efficacy has been demonstrated in several studies. In a recent comparison of

nine products (citric acid, Hortisept, Horticide, Jet 5, Menno Florades, Panacide M, sodium hypochlorite, trisodium orthophosphate (TSOP) and Virkon S), only sodium hypochlorite at 0.5% (5,000 ppm active chlorine) eliminated PSTVd from both glass and concrete after 5 minutes. Horticide, Jet 5, TSOP and Virkon S each tested at their recommended rate were all reasonably effective on glass, while Horticide and Menno Florades were most effective on concrete.

A 1% solution of sodium hypochlorite (10,000 ppm active chlorine) was found to be effective on PSTVd contaminated knives with a 5 second dip. Although effective, quick-acting and relatively inexpensive, hypochlorite is an irritant to humans and corrodes metal. Spraying of sodium hypochlorite solution should be avoided if possible as it creates aerosols that may be inhaled.

Resistant varieties

Over 70 tomato varieties have been tested and none was found to be resistant to PSTVd. Some varieties show tolerance of the disease. Tomato varieties affected in recent years include Aranca, Campari, Nectar, Rosa and Trust. Grower observations indicate truss varieties may be more badly affected than round tomato varieties.

Other viroid diseases of tomato

While PSTVd is the most well-known, there are four other viroids that have been isolated from naturally infected tomato plants in European or North African crops. These are:

- Citrus exocortis viroid (CEVd)
- Columnea latent viroid (CLVd)
- Tomato apical stunt viroid (TASVd)
- Tomato chlorotic dwarf viroid (TCDVd).

Like PSTVd, these recent findings strongly suggest that these viroids are also spreading. Infection rates have varied from only a few plants up to almost 100% of a crop. Disease spread usually occurred along the rows, indicating that crop handling was the main way of transmission. In general, the symptoms seen with these other viroids are very similar to PSTVd and recommendations for control are the same (Figs 6–8).

The possible origin of these other viroids in tomato crops is unclear. It is likely that hosts other than tomato, and perhaps wild plants, may play an important role as sources of infection, especially if infections are latent ie they fail to show disease symptoms. Natural infections of CEVd have been found in several vegetable crops (ie aubergine, carrot, turnip) and natural infections of CLVd have been found in several ornamental species (ie *Brunfelsia undulata*, (Jamaican raintree), *Columnea erythrophae* (lipstick vine), *Nematanthus wettsteinii* (goldfish plant).

6 Leaf yellowing in the plant head caused by Columnea latent viroid (CLVd)

7 Leaf distortion affecting new growth of a plant infected with CLVd

8 Spread of CLVd along a row (foreground)

Further information

HDC Report PC 212. Protected tomato: sources, survival, spread and disinfection of potato spindle tuber viroid (PSTVd)

Potato spindle tuber viroid. www.defra.gov.uk/planth/pestnote/pstv.htm

Potato spindle tuber viroid. VegFed Broadsheet Number 139. www.crop.cri.nz/home/products-services/publications/broadsheets/139.pdf

Additional information:

Further information: A full copy of the final report for HDC project PC 212 is available from the HDC office (01732 848383).

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