



Pests of tomato crops

Background

Tomato growers should be aware of the potential risk from viroids, viruses and other pests and diseases that can affect tomato crops. This leaflet details some of the main pests of tomatoes and suggests methods of minimising the risk of transmission.

Over the last two decades, four viroids have been identified in the UK which pose a significant threat to tomato production. *Potato spindle tuber viroid* (PSTVd) has been confirmed in both tomato crops and imported solanaceous ornamentals, *Tomato chlorotic dwarf viroid* (TCDVd) was recorded in imported Petunia plants, *Columnnea latent viroid* (CLVd) was identified in tomato crops and *Tomato apical stunt viroid* (TASVd) has been detected in nursery *Solanum jasminoides* plants. All of these were considered to pose a significant risk to UK tomato production and therefore statutory action was imposed to eradicate them.

Three other viroids which have not been reported in crops growing in the UK can also naturally infect tomatoes, *Citrus exocortis viroid* (CEVd), *Tomato planta macho viroid* (TPMVd) and *Pepper chat fruit viroid* (PCFVd).

Additionally, many viruses are known to naturally infect tomatoes. Seven tomato viruses are detailed in this factsheet. Of these, five have not been recorded in the UK yet: *Tomato infectious chlorosis virus* (TICV), *Tomato yellow leaf curl virus* (TYLCV), *Tomato torrado virus* (ToTV), *Tomato brown rugose fruit virus* (ToBRFV) and *Tomato mottle mosaic virus* (ToMMV). However, outbreaks of *Tomato chlorosis virus* (ToCV) were detected in the UK in 2018 in glasshouse tomato crops, and outbreaks of *Southern tomato virus* (STV) were confirmed in several tomato nurseries in 2019.

Two other significant pests of tomato have also been included on this factsheet, in order to raise awareness of the symptoms; the Columbia root-knot nematode, *Meloidogyne chitwoodi*, a pest of both potato and tomato detected in some European countries, and Tomato bacterial canker disease (*Clavibacter michiganensis* subsp. *michiganensis*), which is widespread throughout Europe with occasional outbreaks being detected in the UK.

Viroids

Viroids are the smallest known pathogen of plants, consisting of a single stranded RNA molecule. Viroids differ from viruses in that they lack a protein shell. Viroids are classified into two families, the *Avsunviroidae* and the *Pospiviroidae*. Within the family *Pospiviroidae* the genera *Pospiviroid* contains the seven species which are listed on this factsheet: PSTVd, TCDVd, CLVd, TASVd, CEVd, TPMVd and PCFVd.

There are no chemical or biological controls available for viroids. Exclusion of infected seed or planting material and destruction of infected plants coupled with hygiene measures to prevent infection of subsequent crops are the only means of control.

Viruses

Although, larger than viroids, plant viruses are some of the smallest parasitic organisms to infect plants. They consist of a protein coat and a nucleic acid. There are many different families and genera of plant viruses.

The means of transmission depends on the virus. Some viruses, such as ToBRFV and ToMMV can be transmitted from one plant to another by mechanical means, such as by infected sap being present on tools, clothing or hands, or by infected plants coming into close contact with non-infected plants. Other viruses are vectored by organisms such as insects and nematodes. The main mode of spread of TICV, ToCV, TYLCV and ToTV is by insect vectors. Some viruses, such as STV, are transmitted via the seed embryo, this is known as vertical transmission. Plant viruses cannot be directly controlled by chemical application, although control measures can be focussed on controlling the vector of a virus where appropriate. However, as with viroids, the most effective prevention is the exclusion of infected seed or planting material and destruction of infected plants coupled with hygiene measures to prevent infection of subsequent crops are the only means of control.

Please note that in the following photos where plants have been artificially inoculated symptoms may be more intense than in natural infections.

Tomato viroids in the UK

Potato spindle tuber viroid (PSTVd)

PSTVd is probably the most well-known of the viroids which infect tomatoes. It has a worldwide distribution. There have been outbreaks of PSTVd in tomato crops in the UK, Belgium, France, Germany and the Netherlands, all of which have been eradicated. However, PSTVd is present in certain ornamentals in the EU and has been identified in *Brugmansia*, *Dahlia*, *Solanum jasminoides* and *S. rantonntii* in the UK.

The principle hosts of PSTVd are potatoes, tomatoes and solanaceous ornamentals. However, it is generally symptomless in ornamentals. In tomato, symptoms include yellowing and leaf curling, stunting of the whole plant and bunching of stems at the crown. The viroid is known to be seed transmitted and can be spread within a crop by mechanical transmission e.g., when working on the crop or during grafting. Two outbreaks of PSTVd have been identified in commercial tomato crops in the UK. Spread of PSTVd within the crops was relatively slow and action was taken to eradicate the outbreak. There was no evidence of spread to other tomato crops or surrounding potato crops. PSTVd did not recur in the following season and both outbreaks were officially declared eradicated.



Figure 1: Symptoms of PSTVd in a glasshouse outbreak in the UK (2003). Photo courtesy of Fera Science Ltd.



Figure 2: PSTVd symptoms from a glasshouse outbreak include thinning of plant heads, stunted and distorted, yellowing leaves (2003). Photo courtesy of Fera Science Ltd.

Tomato chlorotic dwarf viroid (TCDVd)

TCDVd is known to be capable of infecting tomatoes but it has not been reported in tomato crops in the UK. It causes similar symptoms to PSTVd in tomato crops and has a similar host range including potatoes and solanaceous ornamentals. Transmission of TCDVd is by mechanical means; seed transmission has not been demonstrated experimentally in tomato. However, the 2011 EFSA opinion on solanaceous pospiviroids concluded that all can be seed transmitted to some extent in all host viroid combinations. Infection of a tomato crop with TCDVd results in the crop producing very small fruit which would be unmarketable.

TCDVd has been recorded in tomato crops in France, the Netherlands and Norway. TCDVd came to the attention of the Plant Health authorities in the UK following its interception on Petunias. Like PSTVd, TCDVd causes few symptoms in ornamental hosts. Some puckering and distortion of the leaves and yellowing of the veins was observed in infected plants, but these symptoms seemed to be temporary.



Figure 3: TCDVd symptoms in a glasshouse outbreak in Norway (2012). Photograph courtesy of Dag-Ragnar Blystad, Norwegian Institute of Bioeconomy Research (NIBIO).



Figure 4: TCDVd symptoms in head of plant. From a glasshouse outbreak in Norway (2012). Photograph courtesy of Dag-Ragnar Blystad, Norwegian Institute of Bioeconomy Research (NIBIO).

Columnea latent viroid (CLVd)

Initially CLVd was thought to only infect the ornamental species *Brunfelsia erythrophae* (Jamaican raintree), *Columnea undulate* and *Nematanthus wettsteini* (goldfish plant). However retrospective analysis of samples from viroid outbreaks in the Netherlands and Belgium have shown that infection can occur in tomatoes. The outbreaks in the Netherlands and Belgium were all subsequently eradicated. However in 2007, CLVd was detected in four

tomato crops in the UK and a number of tomato crops in France. There was also one further UK outbreak in 2009.

Like PSTVd and TCDVd, CLVd causes few symptoms in ornamental hosts. However CLVd causes serious problems in tomato. Symptoms can be similar to those caused by PSTVd, with stunting, leaf distortion and chlorosis. In the UK outbreaks leaf reddening ('bronzing') and necrosis were also prominent symptoms, fruit quality was unaffected but yield was reduced. Unlike PSTVd, spread within the crop was rapid. Seed transmission of CLVd has not been demonstrated. However, there is circumstantial evidence that the 2007 outbreaks were caused by infected seed, as the seed was the common factor linking the outbreaks. All UK outbreaks have been successfully eradicated.



Figure 5: Close-up of symptoms on tomato leaves artificially inoculated with CLVd. Photograph courtesy of Fera Science Ltd.



Figure 6: CLVd outbreak symptoms in glasshouse tomato plants with leaf symptoms in foreground (2007). Photograph courtesy of Marcus Lazenby, APHA.

Tomato apical stunt viroid (TASVd)

TASVd was reported in 1999 and 2000 as a new and serious disease of tomatoes in Israel. It was first reported in the Ivory Coast, and then in Indonesia and Senegal. The virus has also been detected in several European countries, including France, the Netherlands, Germany and Belgium. There has been one outbreak of TASVd in the UK, with the virus being detected in *Solanum jasminoides* plants in a nurseery in Surrey in 2015.

In Israel, tomato plants showed severe symptoms including stunting, leaf deformation, yellowing and brittleness. The fruit was considerably reduced in size with a pale red discolouration. The disease spread rapidly along the rows, resulting in close to 100% infection in most cases and heavy yield losses. Mechanical and seed transmission of TASVd has been demonstrated. It has also been confirmed that bumblebees can transmit the viroid from infected plants to healthy plants during pollination and that aphids are able to ingest and carry the viroid, potentially increasing the risk of transmission in a crop. In 2017, it was

reported from the Netherlands that TASVd had been detected in 24-year-old seed lots of *Capsicum annuum* originating from Taiwan.



Figure 7: Symptoms of TASVd artificially inoculated onto tomato leaves, showing leaf yellowing, purpling distortion and leaf stunting. Photo courtesy of Fera Science Ltd.

Other viroid threats to tomato production

Citrus exocortis viroid (CEVd)

CEVd has a worldwide distribution but mainly in *Citrus*. In recent years, it has spread throughout Europe and has been detected in *Citrus* in France, Spain, Italy and Portugal. There are few reports of natural infection of tomatoes but in 1991 it was established that tomato bunchy top disease in India was caused by a distinct strain of CEVd and outbreaks have also been confirmed in tomatoes in the Netherlands. CEVd is known to be mechanically transmitted but it is not clear whether it can be transmitted by tomato seeds. Symptoms of CEVd in tomato include downward curling leaves, rough and wrinkled leaves and stunting of the plants.



Figure 8: Leaf symptoms of CEVd artificially inoculated on tomato plants. Photograph courtesy of Fera Science Ltd.



Figure 9: Symptoms of CEVd on fruit and leaves of tomato (artificial inoculation). Photograph courtesy of Fera Science Ltd.

Tomato planta macho viroid (TPMVd)

TPMVd is only present in Mexico, Mexican papita viroid used to be a separate species to TPMVd but has now been re-classified and is now a synonym of TPMVd and has previously been known as the *Mexican papita viroid*. It causes severe losses in commercial tomato crops. Infected plants produce unmarketable marble-sized fruit. TPMVd is mechanically and aphid transmitted, but seed transmission has not been conclusively demonstrated in tomato.

Pepper chat fruit viroid (PCFVd)

To date, PCFVd has been reported in Canada and Thailand, and has been intercepted in Australia. There was an outbreak in the Netherlands in 2006 in a glasshouse crop of *Capsicum annuum*. This outbreak has been eradicated, but there was one further interception in the Netherlands of the viroid in a seed lot of *Solanum sisymbriifolium* (Sticky nightshade or red buffalo-bur) imported from Asia, which has since been destroyed. *Solanum sisymbriifolium* is sometimes used as a trap crop for potato cyst nematode in potato production.

This viroid naturally infects *C. annuum* and tomatoes. Symptoms of infected pepper plants include reduction in fruit size of up to 50%, with overall reduced plant growth, in tomatoes infection has been reported to lead to stunting and leaf symptoms including necrosis, distortion and discoloration. Mechanical and seed transmission of the viroid has been demonstrated in *C. annuum*.



Figure 10: Image showing growth reduction of PCFVd infected plants (front) and healthy plants (back). Photograph courtesy of the National Plant Protection Organization, the Netherlands.



Figure 11: Image from research on PCFVd, showing normal, non-infected fruits (top) and small, infected fruits (bottom). Photograph courtesy of the National Plant Protection Organization, the Netherlands.

A factsheet produced by SASA and the Scottish Government on viroid threats to potato mini-tuber and tomato production can be found [here](#):

Virus threats to tomato production

Southern tomato virus (STV)

STV has been recorded in Bangladesh, China and South Korea, as well as in Mexico and the USA. In Europe, STV has been detected in France, Italy and Spain (both from the mainland and the Canary Islands). In 2019 outbreaks of STV were detected in several UK tomato nurseries, and it has been retrospectively confirmed that the virus was present in at least one of these nurseries during the previous growing season. A newly developed diagnostic test for STV may reveal that the virus has a wider distribution than previously thought. The only known host of STV is tomato, and to date, two cultivars of tomato have been found to be infected with STV in the UK.

Symptoms of STV are difficult to define, as most findings of the virus have occurred in mixed infections with other viruses of tomato. There is some uncertainty over whether STV causes disease symptoms during single infections. However, distinct symptoms have been observed in UK outbreaks of STV, such as mottled, yellowed or necrotic leaves, stunting, reduced fruit size and spots on the fruit surface. Reports from these outbreaks suggest that environmental conditions may affect the severity of STV symptoms, with most symptoms being reported in plants situated in cooler locations in the nursery, such as underneath air vents. Reports also suggest that infected plants are able to grow out of the symptoms. Some tomato cultivars have been reported to be asymptomatic when infected with STV.

Transmission of STV occurs from plant to seed, with the virus being present in the seed embryo rather than in the seed coat. Currently, there is no evidence that the virus is spread mechanically.



Figures 12 & 13: Images showing necrotic veining symptoms in STV-infected tomato leaves from an outbreak in a UK nursery. Photographs courtesy of Fera Science Ltd.



Figures 14 & 15: Images showing a STV-infected green fruit (left image) and a STV-infected ripe fruit (right image) tomato fruit from an outbreak in a UK nursery. Please note that *Pepino mosaic virus* (PepMV) was also present on this site, therefore symptoms may be a reaction to both STV and PepMV. Photographs courtesy of Fera Science Ltd.

Tomato chlorosis virus (ToCV)

ToCV has a global distribution and is present in many European countries, with outbreaks recorded in France, Italy, Netherlands, and Spain. In May 2018, it was first detected from tomato leaves in a glasshouse in Kent, UK. This outbreak is currently undergoing eradication measures. ToCV is transmitted by *Bemisia tabaci* and the glasshouse whitefly, there is no evidence that it is seed borne. Symptoms of ToCV include bronzing and reddening of leaves, reduced plant vigour and the production of smaller and fewer fruits.

A detailed factsheet on both *Tomato infectious chlorosis virus* and *Tomato chlorosis virus* produced by the ADHB can be found [here](#):



Figure 16: Leaf chlorosis and rolling in a ToCV-infected tomato plant. Photograph courtesy of William M. Wintermantel, USDA-ARS.



Figure 17: Close up of ToCV-infected tomato plant. Photograph courtesy of William M. Wintermantel, USDA-ARS.

Tomato infectious chlorosis virus (TICV)

TICV is present in Greece, Italy and Spain and there have also been outbreaks in France. TICV is transmitted by the glasshouse whitefly and is unlikely to be seed borne. TICV has been detected in various weeds which may serve as a reservoir of inoculum. The symptoms of TICV are similar to those caused by ToCV (see above).



Figure 18: Close up of tomato leaves infected with TICV. Photograph courtesy of William M. Wintermantel, USDA-ARS.

Tomato yellow leaf curl virus (TYLCV)

TYLCV has a global distribution following a pandemic of the disease in the 1980s. It is present throughout the Caribbean, some southern states in the USA and northern African and Middle Eastern countries. It is present throughout the Mediterranean and there were outbreaks in France in 1999 and the Netherlands in 2007, but reports indicate that these outbreaks have been successfully eradicated. TYLCV is transmitted by the whitefly *Bemisia tabaci*, which is absent from the UK, although there have been findings of *B. tabaci* in plants other than tomatoes. There is some evidence that the virus is seed transmitted. Symptoms of TYLCV include severe stunting of leaves and shoots, leading to bushy growth. Leaves also roll upward and inward, with interveinal yellowing of leaflets occurring.



Figure 19: Close up of tomato leaves infected with TYLCV. Photograph courtesy of Fera Science Ltd.
Figure 20: Symptoms of TYLCV on tomato leaves. Photograph courtesy of Fera Science Ltd.

Tomato torrado virus (ToTV)

ToTV has a limited global distribution and has been detected in Australia, Colombia, Morocco, Panama and South Africa. Although there have been outbreaks in Belgium, the Canary Islands, France, Hungary, Italy, Poland and Spain since 2001, the virus has not been detected in the UK. ToTV is transmitted by *Bemisia tabaci* and the indigenous glasshouse whitefly (*Trialeurodes vaporariorum*) but it is not known if it can be transmitted by seed.

Symptoms include necrotic lesions at the base of leaflets which can develop into shot holes, giving infected plants a burnt appearance. In some cases necrosis of the stem and fruits can also occur, leading to an unmarketable crop. However, the economic impact of this virus has yet to be determined.

A short EPPO factsheet on *Tomato torrado virus* can be found [here](#):

Tomato brown rugose fruit virus (ToBRFV)

ToBRFV is present in Israel and Jordan, and is present but under eradication in Germany, Italy and Mexico. Tomato is a major host of ToBRFV, but inoculation trials have demonstrated that *Nicotiana* species, *Capsicum annuum*, *Solanum nigrum*, *Chenopodium quinoa*, *Petunia hybrida* and *Chenopodium murale* can act as minor hosts showing slight symptoms. There are no known vectors of ToBRFV and transmission is thought to be via mechanical means.

Symptoms include mild to severe mosaic discolouring on the leaves, with some leaves becoming narrower. Tomato fruits can be discoloured, turning yellow or brown with crinkling of the skin, leading to an unmarketable crop. The virus can readily spread to all plants in a crop. Due to the symptoms, the fruit of infested plants lose market value or are unmarketable. In Israel, the virus spread in tomato greenhouses almost nationwide within the period of one year.

More information from the ADHB on Tomato brown rugose fruit virus can be found [here](#).



Figure 21: Close up of tomato leaves infected with TBRFV. By kind permission of Dr Wulf Menzel, DSMZ, Germany, as used in Menzel *et al.*, 2019. New Disease Reports 39, 1.



Figure 22: Close up of tomato fruits infected with TBRFV. By kind permission of Dr Wulf Menzel, DSMZ, Germany, as used in Menzel *et al.*, 2019. New Disease Reports 39, 1.

Tomato mottle mosaic virus (ToMMV)

First described from plants in Mexico, ToMMV has since been detected in parts of Brazil, China, Iran, Israel and two states in the USA. In Europe, ToMMV has only been detected in Spain in a research glasshouse in 2015 and, as far as is known, has not been found since. The virus is known to naturally infect tomatoes and peppers, but it has been shown to

experimentally infect *Petunia*, *Solanum nigrum* and some *Brassica* species. Under experimental conditions, ToMMV has been shown to overcome resistance genes to the closely related Tomato mosaic virus (ToMV).

Symptoms on tomato include mosaic blistering, deformation, crinkling and occasional necrosis of leaves, with some leaves growing downwards. Anecdotal reports suggest that this virus can reduce fruit yield, but no other symptoms on fruit have been reported. ToMMV is a tobamovirus and like other tobamoviruses it is likely to be carried on the seed-coat and spread by mechanical methods, such as on clothes and tools. The virus can also persist in the soil and on plant debris for many months and possibly years.

Other pests and pathogens of tomato

Columbia root-knot nematode

Meloidogyne chitwoodi, more commonly known as the Columbia root-knot nematode is a pest of both potato and tomato. It is distributed throughout the Pacific Northwest states of the US where it is considered to be a major pest of potato. It has a limited distribution in Europe, with outbreaks in Belgium, Germany, Netherlands and Sweden, but active surveying is currently taking place to establish whether the nematode has a wider distribution throughout Europe.

Symptoms of nematode infestation vary according to host, population density of the nematode and environmental conditions. Plants can be stunted, lacking in vigour, and wilt readily when exposed to moisture stress. Some cultivars of tomatoes develop root galls in response to *M. chitwoodi* infestation. The main pathways for spread are infested plant material and nematode eggs in soil and growing medium, either in containers or on footwear and vehicles. However, the risks posed by these pathways are mitigated as most tomato plants in production are grown in rockwool.



Figures 23 & 24: *Meloidogyne chitwoodi* infesting roots of *Solanum lycopersicum* var. 'Moneymaker'. Photographs courtesy of Fera Science Ltd.

Tomato bacterial canker

Tomato bacterial canker (*Clavibacter michiganensis* ssp. *michiganensis*) has a global distribution, and there have been many outbreaks within Europe. Bacterial canker is not notifiable on fruiting crops, but outbreaks at propagators are notifiable.

Infected plants can be symptomless until they approach maturity. Under glasshouse conditions, leaf wilt occurs before white and then brown necrotic spots develop at interveinal areas. This leads to desiccation of the plant. Plants out in the field slowly desiccate, and white pustules can appear on leaf veins and petioles. Brown stripes on stems and petioles eventually split to expose yellowish to reddish-brown cavities, giving rise to the canker symptom. Fruits can fail to develop and ripen, and some can develop extreme discolouration or characteristic "bird's eye" spots, but canker-like symptoms occur rarely or only very late in the progression of the disease. Seed is thought to be the main pathway for spread of this pathogen. Transmission can also occur locally via contaminated equipment.

A short EPPO factsheet on Tomato bacterial canker can be found [here](#).



Figure 25: Superficial infections of tomato bacterial canker on stems, leaves, and calyces may induce a mealy appearance with raised or sunken blisters that are usually white to pale orange. Photograph courtesy of Fera Science Ltd.



Figure 26: Superficial infection of tomato bacterial canker on leaf of tomato seedling. Photograph courtesy of Fera Science Ltd.



Figure 27: Leaves may develop windows of necrotic tissue; young petioles or leaves may show curved or distorted growth during infection by tomato bacterial canker. Photograph courtesy of Fera Science Ltd.



Figure 28: Superficial infections of tomato bacterial canker can cause 'bird's-eye' spotting on fruits; raised, pale green or whitish pustules that develop a light brown centre and a 'chlorotic' halo. Photograph courtesy of Fera Science Ltd.



Figure 29: Systemic infections of tomato bacterial canker of the xylem vessels result in wilting, initially on only one side of a leaf and or plant. Photograph courtesy of Fera Science Ltd.

Advisory Information

The main advice to growers is to be vigilant for any unusual symptoms in the crop and implement good hygiene measures as a matter of course.

Suspected outbreaks of a viroid or virus in a tomato crop or any other non-native plant pest should be reported to the relevant authority:

For **England and Wales**, contact your local **APHA Plant Health and Seeds Inspector** or the **PHSI Headquarters**, Sand Hutton, York. Tel: 01904 405138

Email: planthealth.info@apha.gov.uk

For **Scotland**, contact the **Scottish Government's Horticulture and Marketing Unit**:

Email: hort.marketing@gov.scot

For **Northern Ireland**, contact the **DAERA Plant Health Inspection Branch**:

Tel: 0300 200 7847 Email: planthealth@daera-ni.gov.uk

For additional information on UK Plant Health please see:

<https://secure.fera.defra.gov.uk/phiw/riskRegister/>

<https://planthealthportal.defra.gov.uk/>

<https://www.gov.uk/plant-health-controls>

<http://www.gov.scot/Topics/farmingrural/Agriculture/plant/PlantHealth/PlantDiseases>

<https://www.daera-ni.gov.uk>

Authors

Sharon Matthews-Berry and Laura Stevens (Defra)

Adrian Fox, Val Harju and Anna Skelton (Fera Science Ltd.)

Date: June 2019

© Crown copyright 2019