Department for Environment Food & Rural Affairs

Rapid Pest Risk Analysis (PRA) for:

Tomato ringspot virus (ToRSV)

April 2018

Summary and conclusions of the rapid PRA

This rapid PRA shows that *Tomato ringspot virus* is a quarantine virus that has become established in parts of the EU, and is very likely to be present in the UK. Though the virus is spread by nematode vectors not present in the UK, it can still establish via seed, pollen and clonal propagation of infected ornamental plants, though impacts in these hosts are small.

Risk of entry

Due to a lack of phytosanitary measures on plants entering from the EU, where the virus has been found in a variety of hosts, entry on plants for planting is considered very likely with high confidence. The virus can also be transmitted by seed in some host species; entry on this pathway is moderately likely with medium confidence and entry with import of pollen unlikely with low confidence. As nepoviruses can persist in their nematode vectors for some time, isolated populations of the vectors imported with growing medium or non-host plants may also introduce the virus, this pathway is considered unlikely with low confidence.

Risk of establishment

Though the vectors are not present in the UK, ToRSV is capable of establishing via seed transmission and clonal propagation of infected mother plants. Establishment both

outdoors and under protection in ornamental species is considered very likely with high confidence, establishment in systems such as fruiting crops is unlikely as symptoms are severe enough that propagation from infected stock is unlikely, and the virus is not seed transmitted in woody hosts.

Economic, environmental and social impact

Tomato ringspot virus causes medium impacts with medium confidence in its current range. Impacts largely occur in fruiting crops such as apple, blueberries and various *Prunus* species. Impacts in ornamental species are generally small, and occur due to unspecific foliar symptoms and a lack of vigour.

Since impacts would largely be limited to ornamentals in the UK, potential economic impacts are small with high confidence. No environmental or social impacts are reported and so these are rated as very small with high confidence.

Endangered area

The virus is likely to survive in plants across the UK. Largest impacts would likely occur in ornamental systems that rely heavily on clonal propagation.

Risk management options

The current status of *Tomato ringspot virus* as an Annex I quarantine pest is not appropriate, due to the fact it is established in a number of EU member states. Current phytosanitary measures are not strong enough to prevent the entry and spread of the virus. Consideration should be given to deregulating the pest in ornamental species, with the possibility of industry led certification schemes to obtain clean propagating material, and listing as an RNQP on hosts such as various fruiting species in which economic impacts are incurred.

Key uncertainties and topics that would benefit from further investigation

- The status of the pest in the United Kingdom, in particular in *Pelargonium* and other ornamental production systems.
- If the virus may be more widespread in the EU than currently reported.
- The complete host list for the virus for which seed and pollen transmission occur.
- If small populations of the vector, *Xiphinema americanum s. l.,* may be present in the UK undetected.

Images of *Tomato ringspot virus*

	
Foliage of a tomato (*Solanum lycopersicum*) infected with *Tomato ringspot virus.* Image courtesy of Gerald Holmes, California Polytechnic State University at San Luis Obispo, Bugwood.org.	Symptoms of apple union necrosis and decline (AUND) infection, caused by Tomato Ringspot Virus. Image courtesy of H.J. Larsen, Bugwood.org.

Is there a need for a detailed PRA or for a more detailed analysis of particular sections of the PRA? If yes, select the PRA area (UK or EU) and the PRA scheme (UK or EPPO) to be used.

No	X				
Yes		PRA area: UK or EU		PRA scheme: UK or EPPO	

Given the information assembled within the time scale required, is statutory action considered appropriate / justified?

Since *Tomato ringspot virus* continues to be listed in Annex IAI of the EU plant health regulation, statutory action will be taken against any findings.

However, it is the recommendation of this PRA that the regulation should be reviewed, due to the presence of this pest in a number of EU Member States. If, as suggested in the PRA, the pest were to be given the status of an RNQP pest then the recommendation would be that action would only be taken on plants for planting or seed where there was a risk of the nematode vector being present, or a risk of further spread from the planting material i.e. mother plants or propagation material.

Yes Statutory action	✓	No Statutory action	

Stage 1: Initiation

1. What is the name of the pest?

Tomato ringspot virus

Synonyms include: *Peach yellow bud mosaic virus, Prunus stem pitting virus, Tomato ringspot nepovirus,* ToRSV.

This virus will be referred to as ToRSV throughout the PRA.

ToRSV is a nepovirus, and spread by the nematode *Xiphinema americanum* Cobb *sensu lato* as discussed in section 9. These nematode vectors are absent from the UK, though present in the EU, and risk from these vectors has previously been assessed (Tomlinson, 2014).

2. What initiated this rapid PRA?

Whilst reviewing the Risk Register entry for *Tobacco ringspot virus* (TRSV) in order to take into account the fact the virus is transmitted by pollen, UK files on the pest from the 1970s to the current year were reviewed. Due to the long association of TRSV and ToRSV with ornamental plants in the UK, and the presence of both viruses in the EU despite their quarantine status, two PRAs were initiated to review the quarantine status of both of these viruses.

3. What is the PRA area?

The PRA area is the United Kingdom of Great Britain and Northern Ireland.

Stage 2: Risk Assessment

4. What is the pest's status in the EC Plant Health Directive (Council Directive 2000/29/EC[1]) and in the lists of EPPO[2]?

ToRSV is listed in Annex IAI of Council Directive 2000/29/EC – which means it is classified as a harmful organism not known to occur in the community, and whose introduction and spread is banned on all commodities. Additionally there are specific Annex IV

[1] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2000L0029:20100113:EN:PDF

[2] https://www.eppo.int/QUARANTINE/quarantine.htm

requirements that *Malus*, *Pelargonium*, *Prunus* and *Rubus* should be certified as free from ToRSV – see section 8 for more details.

In addition, the nematode *Xiphenema californicum* and non-European populations of the nematodes *Xiphinema americanum* Cobb *sensu lato,* which are known vectors of this virus, are also listed in Annex IAI.

5. What is the pest's current geographical distribution?

Distribution of this virus is summarised in Table 1. ToRSV is widespread, being found on every continent except Antarctica. Further details on distribution are found below the tables, concentrating in particular on the presence of the virus in EU countries.

Older records (pre-1970) which may have only been based on indicator plants should be treated as unconfirmed and so have not been included in the distributions.

Table 1: Distribution of *Tomato ringspot virus* taken from (EPPO, 2018)	
North America:	Canada (British Columbia, Manitoba, New Brunswick, Ontario, Quebec), Mexico, United States (Alabama, Arkansas, California, Colorado, Connecticut, Delaware, Florida, Georgia, Illinois, Indiana, Kansas, Kentucky, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Montana, New Hampshire, New Jersey, New Mexico, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, South Carolina, Tennessee, Texas, Utah, Virginia, Washington, West Virginia, Wisconsin, Wyoming)
Central America:	Puerto Rico
South America:	Brazil, Chile, Columbia, Peru, Venezuela
Europe:	Belarus, Croatia, France, Lithuania, Poland, Russia, Serbia, Slovakia, Slovenia, Turkey
Africa:	Egypt, Togo, Tunisia
Asia:	China, India, Iran, Japan, Jordan, South Korea, Oman, Pakistan, Taiwan
Oceania:	Australia, Fiji, New Zealand

Tomato ringspot virus – Further Details on Distribution

- Bulgaria: absent, pest no longer present, found in 1978 on grapevine with no records since (EPPO, 2018).
- Croatia, listed by EPPO as present with records from a vineyard in 1973 (EPPO, 2018), there appear to be no more recent records.
- Czech Republic, listed by EPPO as 'absent, pest no longer present' based on information provided by the NPPO in 1994 (EPPO, 2018), it is not known in which hosts there have previously been findings of ToRSV in.
- Denmark, absent pest eradicated. ToRSV has previously been found in Denmark, including in *Pentas lanceolata* (Koenig, 1984) as well as findings in *Pelargonium* in the 1970s and 1980s (EPPO, 2018). No publications concerning recent outbreaks in Denmark could be found.
- France: though EPPO list the pest as present the NPPO state it to be absent and that records are unreliable (EPPO, 2018). A survey conducted by INRA in 1994 of viruses effecting tobacco in France stated that ToRSV was found only sporadically (Blancard *et al.*, 1994). The status of ToRSV in France is uncertain.
- Germany: transient, under eradication. Outbreak on asymptomatic *Hosta* plants in 2006 where eradication action was taken (EPPO, 2018). The current status of the virus is uncertain.
- Italy: transient, under eradication. Outbreak in 2015 on *Punica granatum* trees that had been imported from the USA, under eradication. An earlier record in 1981 on raspberry was judged by the NPPO to have probably been imported from abroad, and since there were no records between 1981 and 2015 it was judged the virus did not establish (EPPO, 2018).
- Lithuania: present, it was found in a wide range of ornamentals during a survey in 2000 (Samuitienė & Navalinskienė, 2001) and on additional species on work completed since (EPPO, 2018).
- Netherlands: Absent, pest eradicated. Like the UK, there are records on *Pelargonium* dating back to the 1970s as well as records in various bulb crops. Recent surveys (2011, 2012, 2013) did not detect the pest and the NPPO no longer consider it present (EPPO, 2018).
- Poland: EPPO list the pest as present, citing a published finding in 2006 on rhubarb (*Rheum*). The original publication could not be found and no other Polish records were found (EPPO, 2018).
- Slovenia: Listed as present with a restricted distribution by EPPO based on information provided by the NPPO (EPPO, 2018). No publications concerning the virus in Slovenia could be found.
- Slovakia: Present, restricted distribution. In 1995 the virus was isolated from raspberry and grapevine on plants presumably of Slovakian origin (ŠUBÍKOVÁ *et al.*, 1995) and the NPPO informed EPPO that the pest is present with a restricted distribution (EPPO, 2018). It was also identified during a survey for nepoviruses in small fruits and fruit trees in Slovakia (Šubíková *et al.*, 2002).
- Sweden: absent, pest no longer present. There is a history of records in *Pelargonium* (Rydén, 1972).

6. Is the pest established or transient, or suspected to be established/transient in the UK/PRA Area?

A full summary of the status of ToRSV in the UK is provided in Appendix I of this PRA. There is a long history of ToRSV and TRSV causing symptomless findings of infection on *Pelagonium* (geranium) stocks in the UK, with unpublished records beginning in 1979 and the most recent survey being from 2003 (Defra, unpublished data). The results of the most recent survey did indicate that levels of viral contamination had dropped, but there is no evidence ToRSV has ever been fully eradicated from *Pelagonium* – especially since the virus can be transmitted via seed and pollen (Scarborough & Smith, 1977).

7. What are the pest's natural and experimental host plants; of these, which are of economic and/or environmental importance in the UK/PRA area?

The host lists given in this section are correct, but not comprehensive. ToRSV is polyphagous with a wide host range encompassing both cultivated and uncultivated plants, herbaceous and woody species and many experimental hosts in addition to those found to be naturally infected.

CABI (2017) list the following as the main hosts of ToRSV: *Cydonia oblonga* (quince), *Fragaria chiloensis* (Chilean strawberry), *Malus domestica* (apple), *Nicotiana tabacum* (tobacco), *Pelargonium, Prunus* (stone fruits), *Ribes* (currants), *Rubus idaeus* (raspberry) and *Vitis vinifera* (grapevine).

Uncultivated hosts can also act as a reservoir of ToRSV, *Taraxacum officinale* (dandelion) is thought to play a role in the epidemiology of the disease, as in this host seed transmission occurs (Mountain *et al.*, 1983). A survey of orchard weeds also identified *Rumex acetosella* (sheep sorrel) and *Stellaria* spp. (chickweed) as commonly infected hosts, with 21 species identified in total by this study (Powell *et al.*, 1984).

In Lithuania, ToRSV was identified from 39 different ornamental plant species that showed generalised symptoms such as stunting, malformation of leaves and flowers, ringspots and chlorosis – though in 22 out of the 29 species other viruses were present. Hosts identified included (but are not limited to): *Aquilegia vulgaris* (columbine), *Delphinium sp., Helleborus foetidus* (stinking hellebore)*, Hosta* spp., *Iris* sp. and *Viola cornuta* (horned pansy) (Samuitienė & Navalinskienė, 2001).

8. What pathways provide opportunities for the pest to enter and transfer to a suitable host and what is the likelihood of entering the UK/PRA area?

Plants for Planting (excluding seeds and pollen)

There are some additional requirements in Annex IVAI related to ToRSV summarised in Table 2. It is important to note these requirements only apply to plants being imported from outside of the EU, and not to plants moving within the community, as ToRSV is listed in Annex IAI as a quarantine pest, which implies the pest is absent from the EU. However, as shown in section 5, this is not the case.

The measures in Table 2 are considered to reduce the likelihood of ToRSV entering on the specified hosts from outside of the EU, however given the very wide host range of ToRSV these measures are not fully effective.

Table 2.

Host	Requirements
Plants of *Malus,* intended for planting, other than seeds, originating in countries where ToRSV are known to occur on *Malus*	a) either officially certified under a certification scheme requiring them to be derived in direct line from material which has been maintained under appropriate conditions and subjected to official testing for at least the relevant harmful organisms using appropriate indicators or equivalent methods and has been found free, in these tests, from those harmful organisms OR derived in direct line from material which is maintained under appropriate conditions and subjected, within the last three complete cycles of vegetation, at least once, to official testing for at least the relevant harmful organisms using appropriate indicators or equivalent methods and has been found free, in these tests, from those harmful organisms. AND (b) no symptoms of diseases caused by the relevant harmful organisms have been observed on plants at the place of production, or on susceptible plants in its immediate vicinity, since the beginning of the last complete cycle of vegetation
Plants of *Prunus*, intended for planting, where ToRSV is known to occur on *Prunus*	(a) either officially certified under a certification scheme requiring them to be derived in direct line from material which has been maintained under appropriate conditions and subjected to official testing for at least the relevant harmful organisms using appropriate indicators or equivalent methods and has been found free, in these tests, from those harmful organisms OR derived in direct line from material which is maintained under appropriate conditions and has been subjected, within the last three complete cycles of

	vegetation, at least once, to official testing for at least the relevant harmful organisms using appropriate indicators or equivalent methods and has been found free, in these tests, from those harmful organisms AND (b) no symptoms of diseases caused by the relevant harmful organisms have been observed on plants at the place of production or on susceptible plants in its immediate vicinity, since the beginning of the last three complete cycles of vegetation.
Plants of *Rubus,* intended for planting, originating in countries where ToRSV is known to occur on *Rubus*	a) the plants shall be free from aphids, including their eggs AND (b) official statement that: (aa) the plants have been: either officially certified under a certification scheme requiring them to be derived in direct line from material which has been maintained under appropriate conditions and subjected to official testing for at least the relevant harmful organisms using appropriate indicators or equivalent methods and has been found free, in these tests, from those harmful organism OR derived in direct line from material which is maintained under appropriate conditions and has been subjected, within the last three complete cycles of vegetation, at least once, to official testing for at least relevant harmful organisms using appropriate indicators for equivalent methods and has been found free, in these tests, from those harmful organism AND (bb) no symptoms of diseases caused by the relevant harmful organisms have been observed on plants at the place of production, or on susceptible plants in its immediate vicinity, since the beginning of the last complete cycles of vegetation.
Plants of *Pelargonium*, intended for planting, other than seeds, originating in countries where ToRSV and its vectors are **not known** to occur	official statement that the plants: (a) are directly derived from places of production known to be free from *Tomato ringspot virus*; OR (b) are of no more than fourth generation stock, derived from mother plants found to be free from *Tomato ringspot virus* under an official approved system of virological testing.
Plants of *Pelargonium*, intended for planting, other than seeds, originating in countries where ToRSV and its vectors **are known** to occur	official statement that the plants: (a) are directly derived from places of production known to be free from *Tomato ringspot virus* in the soil or plants OR b) are of no more than second generation stock, derived from mother plants found to be free from *Tomato ringspot virus* under an officially approved system of virological testing.

As summarised in Appendix I, there have been a number of findings related to plants traded in the UK, demonstrating this is a pathway for this virus.

Due to the presence of the virus in both ornamental and edible crops within the European Union from which large numbers of plants are imported, the wide host range of the virus, and the lack of measures on plants in relation to the virus being imported from both the EU and third countries, **entry on plants for planting is rated as very likely with high confidence.** It is also possible that host plants may be associated with the nematode vectors, especially if transported with soil or growing medium attached.

Seeds

ToRSV has been shown to be seed transmitted in some hosts.

ToRSV can be transmitted by the seeds of *T. officinale*, the dandelion (Mountain *et al.*, 1983). This is a widespread and native species in the UK, and sometimes considered a weed, but dandelion seeds are sold commercially for sowing such as within tortoise food mix. It is not known if seeds are imported from countries where ToRSV is known to infect *T. officinale*.

ToRSV is also seed transmitted in *Rubus* species (Auger & Converse, 1982, Braun & Keplinger, 1973). There are phytosanitary requirements on the seed of *Rubus* imported from outside of the EU related to ToRSV, as described in Table 2. This should mitigate against the entry of the virus on this pathway from outside of the EU and there is no evidence that ToRSV is present in *Rubus* production in the EU.

EPPO state that ToRSV has been transmitted “occasionally through seeds of tomatoes, tobacco and grape, and frequently through seed of *Gomphrena globosa* (globe amaranth), strawberries, *Pelargonium* and soyabean cv. Lincoln” (EPPO, 1990), primary references could not be found for all of these hosts, but seed transmission of both ToRSV and TRSV is known in *Pelargonium* (Scarborough & Smith, 1977).

Thus seed transmission of ToRSV has only been demonstrated in a few hosts, including *Rubus* whose seeds are regulated. *Pelargonium* seeds may represent the most likely host seed to introduce both ToRSV and TRSV since contamination of *Pelargonium* stocks with these viruses appears to be a common issue and these seeds are imported and sold commercially in the UK. **Entry on seeds is rated as moderately likely with medium confidence**, as there is little information on the efficiency of seed transmission in *Pelargonium.*

Pollen

There is evidence that ToRSV can be transmitted by pollen in some species. In a review of pollen transmitted viruses, ToRSV was stated to be pollen transmitted in *Pelargonium* spp., *Rubus* spp., *Prunus* spp. and *Vaccinium* spp. (Card *et al.*, 2007), However, it should be noted that pollen transmission has been relatively poorly studied, and it is unclear how efficient it is as a pathway of transmission. Significantly less pollen was viable in ToRSV infected *Pelargonium* (Scarborough & Smith, 1977) which reduces the likelihood of transmission on this pathway.

Though Card *et al.* (2007) list ToRSV as pollen transmitted in *Prunus*, the 2013 EFSA opinion on risks posed by *Prunus* pollen listed both ToRSV and TRSV as “agent known to be vertically transmitted by pollen in hosts other than *Prunus*” and that these viruses are “not reported to be pollen transmitted in its woody hosts” (The EFSA Panel of Plant Health, 2013) – though both viruses were rated as unlikely to moderately likely, with high uncertainty, to enter on *Prunus* pollen.

It is very uncertain how much pollen of these hosts is imported into the UK, as no specific commodity code records import of pollen. It is also unclear if pollen of other host species may also be capable of transmitting the viruses, as capacity to be transmitted via pollen in one host does not mean all hosts will show pollen transmission (The EFSA Panel of Plant Health, 2013).

Entry of this virus on pollen has been rated as **unlikely with low confidence**, as there is a paucity of data on the efficiency of pollen transmission, how many hosts may have pollen transmission and how much pollen of host species is imported into the UK.

Nematode Vectors

A review of nepoviruses lists ToRSV as transmitted by *Xiphinema americanum sensu lato, X. americanum sensu stricto* and *X. rivesi,* and the virus can persist once associated with the nematode vectors. In plant free laboratory conditions nepoviruses persisted in *Xiphinema* spp. for 8 to 12 months (Brown *et al.*, 1995). This means that *Xiphinema* spp., which are ectoparasites feeding on the outside of roots and found free in soil and growing medium, could introduce the virus if associated with imports of non-host plants of the viruses or other soil and growing medium.

A rapid UK PRA on European populations of *X. americanum sensu lato* rated them as likely to enter in association with plants for planting, unlikely with soil associated with commodities and moderately likely with bulk soil imports (Tomlinson, 2014). However, the PRA also identified *X. rivesi* as the only known virus vector species within the European population of *X. americanim s.l.*, and this nematode is described as locally distributed, with presence in 7 Member States: Bulgaria, France, Germany, Italy, Portugal, Slovenia and Spain, of which only France and Slovenia are known to have ToRSV present. The risk of importing non-European strains of *X. americanum sensu lato* is much less likely, as these are listed in Annex IAI and there are phytosanitary measures associated with the import of plants and soil/growing medium to reduce the likelihood of nematodes remaining associated with either commodity.

This pathway is made difficult to judge due to the fact that ToRSV is likely to be more widespread in Europe then currently reported. **The likelihood of infectious vectors being associated with commodities other than host plants for planting is unlikely with low confidence.** Confidence is low because the majority of plants, soil associated with other commodities, and bulk soil imports imported from the EU will not be tested for nematodes, and so there is insufficient data on how often *X. americanum sensu lato* is associated with commodities other than virus host plants.

Plants for planting (excl. seeds and pollen)	Very unlikely	☐	Unlikely	☐	Moderately likely	☐	Likely	☐	Very likely ☑
Confidence	High Confidence	☑	Medium Confidence	☐	Low Confidence	☐			
Seeds	Very unlikely	☐	Unlikely	☐	Moderately likely	☑	Likely	☐	Very likely ☐
Confidence	High Confidence	☐	Medium Confidence	☑	Low Confidence	☐			
Pollen	Very unlikely	☐	Unlikely	☑	Moderately likely	☐	Likely	☐	Very likely ☐
Confidence	High Confidence	☐	Medium Confidence	☐	Low Confidence	☑			
Nematode vectors	Very unlikely	☐	Unlikely	☑	Moderately likely	☐	Likely	☐	Very likely ☐
Confidence	High Confidence	☐	Medium Confidence	☐	Low Confidence	☑			

9. If the pest needs a vector, is it present in the UK/PRA area?

ToRSV is transmitted by *Xiphinema americanum sensu lato, X. americanum sensu stricto* and *X. rivesi.*

The vectors of ToRSV are not known to occur in the UK, though the rapid PRA for these nematodes acknowledged that some populations may have been inadvertently imported in large containerised plants. If nematode vectors were to enter they are very likely to be able to establish both outdoors and in protected conditions (Tomlinson, 2014).

10. How likely is the pest to establish outdoors or under protection in the UK/PRA area?

Though nematode vector populations are not established in the UK, the history of virus findings in *Pelargonium* indicates that ToRSV is capable of establishing in the UK in the absence of vectors. This is due to the ability of the virus to spread in seed, clonally

propagated material and via pollen, with infection often asymptomatic. In *Pelargonium* and similar ornamentals, establishment of ToRSV is rated as **very likely with high confidence both outdoors and under protection.**

However, establishment in some other crop systems such as soft fruits and fruit trees is unlikely unless nematode vectors are introduced, as the viruses are not spread by seed/pollen in these hosts and symptoms are severe enough that continued propagation from infected mother material is unlikely.

Outdoors	Very unlikely	☐	Unlikely	☐	Moderately likely	☐	Likely	☐	Very likely	☑
Confidence	High Confidence	☑	Medium Confidence	☐	Low Confidence	☐				
Under Protection	Very unlikely	☐	Unlikely	☐	Moderately likely	☐	Likely	☐	Very likely	☑
Confidence	High Confidence	☑	Medium Confidence	☐	Low Confidence	☐				

11. How quickly could the pest spread in the UK/PRA area?

ToRSV would be expected to spread **very slowly by natural means with high confidence**, even if the nematode vectors were introduced. Without vectors, natural spread could only occur in a limited number of hosts for which pollen and seed transmission occurs. Studies on the spread of ToRSV in a raspberry field by nematode vectors demonstrated the very slow rate of spread with mean rate of annual spread by 70 cm per year (Pinkerton *et al.*, 2008). As the vectors are not endemic to the UK, and have very low mobility, it would take many decades before they would become widespread enough to have any significant impact on the ability to spread the viruses.

The fact that this virus has a long history of contaminating *Pelargonium* stocks in the UK and elsewhere demonstrates the ability of this pest to be readily moved in trade, especially in terms of mother plant material used for propagation. **Spread with trade is rated as quickly with high confidence.**

Natural Spread	Very slowly	☑	Slowly	☐	Moderate pace	☐	Quickly	☐	Very quickly	☐
Confidence	High Confidence	☑	Medium Confidence	☐	Low Confidence	☐				
With trade	Very slowly	☐	Slowly	☐	Moderate pace	☐	Quickly	☑	Very quickly	☐
Confidence	High Confidence	☑	Medium Confidence	☐	Low Confidence	☐				

12. What is the pest's economic, environmental and social impact within its existing distribution?

Impacts in crops

ToRSV is the causal agent of "brownline disease" or "prune brownline" or "*Prunus* stem pitting" in *Prunus* trees. This disease is so called due to narrow dark-brown strip of dead vascular tissue that forms at the bud union (where the scion meets the rootstock), and eventually the tree will decline and then die (Hoy *et al.*, 1984). High instances of the disease were noted in the 1970s and 1980s in certain orchards in California leading to losses (Hoy & Mircetich, 1984, Mircetich & Hoy, 1981), and orchards in Chile were also affected (Auger, 1988).

ToRSV also causes apple union necrosis in *Malus*, similar to brownline disease, an incompatibility will occur at the graft union approximately 4 – 6 years after planting. Trees will suffer from decline and the graft union may become so weak that under stressful conditions the scion separates from the rootstock (Michigan State University, 2014). Severity of the condition is influenced by the cultivar-rootstock combination, and the disease can cause economic impacts in commercial apple production in the USA (Peter, 2017). Infection of *Malus domestica* in Iran with ToRSV has also been reported, but symptoms did not include apple union necrosis. Disease symptoms were largely foliar, with yellowing of leaves and development of necrotic lesions (Moini, 2010).

ToRSV is widespread in red raspberry production in the north-west and Pacific states of the USA (Martin *et al.*, 2013), though economic impacts in this crop are relatively minor with canes being slightly less vigorous and sometimes producing "crumbly berries" where fruit fails to fully develop (OARDC, 2017). However some cultivars can be severely affected, such as Meeker and Willamette, and will show significant decline of vigour and may be killed by the infection (Pinkerton *et al.*, 2008). ToRSV also causes American current mosaic in red currant, and was introduced on this host to New Zealand where it can cause mild mosaicking symptoms (Fry & Wood, 1978). It does not appear to be a disease of economic importance.

ToRSV causes more serious disease problems in *Vaccinium corymbosum* (highbush blueberry). Symptoms include stunted growth and top dieback as well as necrosis of lead and flower buds and reduced yield, and many plants were also infected with TRSV (Fuchs, 2010).

An outbreak of ToRSV occurred on chilli pepper (*C. fructescens*) in Iran in 2012, with mosaicking on leaves and fruits showing chlorosis and stunting (Sokhansanj *et al.*, 2012).

Impacts in Ornamentals

ToRSV will infect numerous ornamental species – in some cases disease is asymptomatic but ringspot disease is recorded in some hosts.

TRSV and ToRSV both cause a ringspot disease of *Pelargonium* (Hollings *et al.*, 1972, Kemp, 1967, 1969, Rydén, 1972). Symptoms of ringspot increase in severity on older leaves until mid-July, when they begin to fade, and new leaves produced from the summer onwards are generally symptomless. Infection may occasionally affect flowers and reduce vigour, leading to economic impacts (University of Illinois, 1989). Severity of the disease is dependent upon the cultivar of *Pelargonium* infected, but reports of significant losses in the literature could not be found.

In Lithuania, both viruses were found infecting a range of ornamentals during surveys, the fact that these viruses had not previously been reported in the literature may indicate their impacts were relatively small.

Impact Conclusions

Impacts of ToRSV vary depending on host and region. In general, impacts in Europe have been small, and the majority of cases associated with infection of ornamentals.

However ToRSV can cause economically important diseases of fruit crops and peppers, especially in fields where the nematode vectors are found. **Overall impacts are rated as medium with medium confidence,** as many reports are several decades old which may indicate the viruses are of decreasing importance.

Impacts	Very small	☐	Small	☐	Medium	☑	Large	☐	Very large ☐
Confidence	High Confidence	☐	Medium Confidence	☑	Low Confidence	☐			

13. What is the pest's potential to cause economic, environmental and social impacts in the UK/PRA area?

The potential impacts in the UK are limited due to the absence of the nematode vectors, and it is expected that the majority of impacts will occur in ornamental species as has been recorded in the past. Economic impacts will be incurred when ringspot diseases of *Pelargonium* or other ornamentals occur and reduce the marketability of the plants and their ability to be used for further propagation.

Should the vectors be introduced and disseminated through trade, their long lifecycles and very low natural dispersal capacity would also limit impacts, it would take many decades without any control measures for the vectors to become widespread enough in fruit production for significant impacts to occur.

Potential economic impacts in the UK are rated as small with high confidence, and are expected to be largely limited to ornamentals and similar to impacts seen in the past in the UK and in other EU countries.

There are no known environmental impacts caused by ToRSV though significant numbers of uncultivated plants are host species. **Potential environmental impacts have been rated as very small with high confidence.**

Though ToRSV will cause disease in commonly grown ornamentals, symptoms are not significantly worse than other widespread viral diseases in the UK. **Social impacts are rated as very small with high confidence.**

Economic Impacts	Very small	☐	Small	☑	Medium	☐	Large	☐	Very large	☐
Confidence	High Confidence	☑	Medium Confidence	☐	Low Confidence	☐				
Environ - mental Impacts	Very small	☑	Small	☐	Medium	☐	Large	☐	Very large	☐
Confidence	High Confidence	☑	Medium Confidence	☐	Low Confidence	☐				
Social Impacts	Very small	☑	Small	☐	Medium	☐	Large	☐	Very large	☐
Confidence	High Confidence	☑	Medium Confidence	☐	Low Confidence	☐				

14. What is the pest's potential as a vector of plant pathogens?

ToRSV is not capable of acting as a vector of plant pathogens.

15. What is the area endangered by the pest?

ToRSV is likely to be already established in ornamental production within the UK, with the largest impacts likely to occur in those industries which rely heavily on clonal propagation. Fruit crops could incur greater impacts, but unless the vectors are introduced any effects are likely to be limited by controlling planting material.

Stage 3: Pest Risk Management

16. What are the risk management options for the UK/PRA area?

Exclusion

Current phytosanitary measures are not adequate to exclude ToRSV from the UK: there are specific requirements for some hosts (*Malus*, *Pelargonium*, *Prunus and Rubus*). However, there are no measures on host plants entering the UK from the EU. Many of the host species are unregulated from 3rd countries, however, all plants for planting from third countries need to be accompanied by a phytosanitary certificate and the listing of the pathogen in Annex IAI means that all material should be free from TRSV regardless of whether there are specific requirements associated with that host. As discussed in section 6, it is likely that the virus is already present in some ornamental production systems and the prospect of continued exclusion is very poor.

Due to the confirmed presence in several EU member states, ToRSV no longer meets the criteria of an Annex I quarantine pest, and its regulatory status should be reviewed. Since this virus primarily causes economic impacts on fruiting crops, status as an RNQP in crops in which economic impacts occur could be considered, as well as deregulation in other hosts species. However, this pest was not put forward for consideration in the recent EPPO RNQP project.

Containment and Eradication

Statutory action to contain and eradicate outbreaks of the viruses that occur in non-ornamental crops may be justified, in particular in cases where the nematode vectors are also detected. Eradication or containment measures would be dependent on the crop, but at a minimum would include the destruction of infected plants and prohibition on the movement of soil if vectors are known to be present.

Non-Statutory Controls

There are few treatment options for viruses and their nematode vectors. Crop rotation can be used to reduce the populations of nematode vectors, and thus disease incidence (Evans *et al.*, 2007, Pinkerton & Martin, 2005). Use of clean propagating material or certified seed can also be effective at reducing impacts.

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Appendix I – History of TRSV and ToRSV in the UK

There is a long history of TRSV and ToRSV causing symptomless infection of *Pelargonium* (geranium) in the UK. Unpublished Defra records begin in 1979. Within the literature, there are earlier references. A publication refers to TRSV being occasionally reported from *Gladiolus* in Scotland in in the 1960s (Bellardi & Pisi, 1985) but the original reference cannot be found. Cases of Anemone necrosis, which was reported from Somerset in 1957, were attributed to TRSV after investigation (Hollings, 1965). In June 1979 a stakeholder wrote to what was then MAFF to inform them of a finding of TRSV in *Pelargonium.* MAFF replied that TRSV had been found on a variety of hosts in the UK and was regarded as *"having been established for a long time"* and it was concluded statutory action was not appropriate, though the grower was advised to destroy the plants (Defra, unpublished data).

A survey of *Pelargonium* was then proposed that would also encompass ToRSV and was carried out during 1979-1980. The conclusion was that "ToRSV is distributed throughout the UK pelargonium industry but only a small foci of infected cultivars are present on individual holdings" (Defra, unpublished data).

Further work in 1983 stated that all ToRSV findings were related to imports from North America, and that TRSV was quite rare, and so it was advised that both viruses be treated as non-indigenous and action taken against them. Advice from others in MAFF appears to have led to the conclusion that eradication was not possible, but that action could be taken to limit introduction and spread of the pest (e.g. destruction of plants when recently imported).

New files were opened on TRSV and ToRSV ten years later in 1994, and it is not known if any other discussions on the pest occurred in the gap of a decade. A survey was commissioned after TRSV and ToRSV were found in pelargoniums being traded in the UK, as these viruses, "do not usually occur in Europe" and were ECIAI listed. The survey took place between November 1996 and April 1997 and involved testing mother plants. ToRSV was found in seven nurseries across seventeen varieties, and one case of mixed infection of TRSV and ToRSV was found (Defra, unpublished data).

Another survey took place in 1997/98 and instructions on eradication and containment supplied to the PHSI. The survey concluded that the viruses were "not uncommon" in *Pelargonium* cultivars and were being spread in the horticultural industry by cuttings (Defra, unpublished data).

The matter was to be discussed at an EU level at Plant Health Standing Committee in 1998, and the UK informed the EU the viruses were absent except in *Pelargonium* and asked for clarification on if they should continue to be considered quarantine. The UK position was that RNQP status was not suitable for these viruses though certification schemes may offer a useful element to a package of management measures. It was

decided the issue would be considered by the comparative trial of *Pelargonium*, however the trial did not address the issue as no testing for latent infection was carried out.

Surveys in 2001-2002 found 8 positive findings and in 2002-2003 only 2 findings were made (Defra, unpublished data). A paper was also published in 2001 concerning an isolate of TRSV from cherry of UK origin (Zadeh & Foster, 2000). This isolate was apparently obtained from the University of Birmingham as an infected tobacco leaf but no other information is given, so it is unclear if this is truly of "UK" origin.

In 2011, there was a UK finding of TRSV on lettuce seeds at pre-export testing. The seeds originated in France and were destined for Thailand, and action was taken against this finding (Defra, unpublished data). In 2011 advice was given that both viruses should be listed as "not occurring in the UK" as they were only found occasionally whilst screening *Pelargonium* stocks.

However, it is the conclusion of this PRA that there is no evidence that ToRSV has ever been eradicated from *Pelargonium* stocks, especially since no surveys have been carried out since 2003. Though very few nurseries in the UK now keep their own propagation material, both ToRSV and TRSV can be transmitted via *Pelargonium* seed and ToRSV via pollen – even if mother plants were clean, the virus may have continued to persist in garden plants through these two pathways. Given infections are usually latent, and the findings in other ornamentals in Europe, it is very likely that TRSV and ToRSV are present in the UK.

This publication is available via the UK Plant Health Information portal https://planthealthportal.defra.gov.uk/

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