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Ralstonia solanacearum Pest Report to support ranking of EU candidate priority pests

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1. Introduction to the report

This document is one of the 28 Pest Reports produced by the EFSA Working Group on EU Priority Pests under task 3 of the mandate M-2017-0136. It supports the corresponding Pest Datasheet published together on Zenodo[1] and applies the methodology described in the Methodology Report published on the EFSA Journal (EFSA, 2019a).

This Pest Report has five sections. In addition to this introduction, a conclusion and references, there are two key sections, sections 2 and 3.

Section 2 first summarises the relevant information on the pest related to its biology and taxonomy. The second part of Section 2 provides a review of the host range and the hosts present in the EU in order to select the hosts that will be evaluated in the expert elicitations on yield and quality losses. The third part of Section 2 identifies the area of potential distribution in the EU based on the pest's current distribution and assessments of the area where hosts are present, the climate is suitable for establishment and transient populations may be present. The fourth part of Section 2 assesses the extent to which the presence of the pest in the EU is likely to result in increased treatments of plant protection products. The fifth part of section 2 reviews additional potential effects due to increases in mycotoxin contamination or the transmission of pathogens.

In Section 3, the expert elicitations that assess potential yield losses, quality losses, the spread rate and the time to detection are described in detail. For each elicitation, the general and specific assumptions are outlined, the parameters to be estimated are selected, the question is defined, the evidence is reviewed and uncertainties are identified. The elicited values for the five quantiles are then given and compared to a fitted distribution both in a table and with graphs to show more clearly, for example, the magnitude and distribution of uncertainty. A short conclusion is then provided.

The report has two appendices. Appendix A contains a host list created by amalgamating the host lists in the EPPO Global Database (EPPO, online) and the CABI Crop Protection Compendium (CABI, 2018). Appendix B provides a summary of the evidence used in the expert elicitations.

It should be noted that this report is based on information available up to the last day of the meeting[2] that the Priority Pests WG dedicated to the assessment of this specific pest. Therefore, more recent information has not been taken into account.

For *Ralstonia solanacearum*, the following documents were used as key references: EPPO standards on national regulatory control systems (2011) and diagnostics (2018), the Norwegian pest risk assessments (VKM 2004, 2005 and 2010), the EFSA pest categorization (EFSA PLH Panel, 2019) and survey card (EFSA, 2019b).

[1] Open-access repository developed under the European OpenAIRE program and operated by CERN, https://about.zenodo.org/

[2] The minutes of the Working Group on EU Priority Pests are available at http://www.efsa.europa.eu/sites/default/files/wgs/plant-health/wg-plh-EU_Priority_pests.pdf

2. The biology, ecology and distribution of the pest

2.1. Summary of the biology and taxonomy

Ralstonia solanacearum is a soil-borne, gram-negative, motile bacterium in the family Burkholderiaceae. It causes wilting and related symptoms on a large number of plant species (EFSA PLH Panel, 2019).

The assessment takes into account the reclassification of *R. solanacearum* as a species complex, which includes *Ralstonia solanacearum*, *Ralstonia pseudosolanacearum* and *Ralstonia syzygii* (Table 1 from Safni et al., 2014, 2018; Prior et al., 2016), therefore, for the purposes of this report, *R. solanacearum* refers to the whole species complex.

Table 1: Overview of the Safni et al. (2014) revision of the *R. solanacearum* species complex, including information on the host range of the different phylotypes / species (from Wicker et al., 2012; Safni et al., 2014; EFSA PLH Panel, 2019).

Before 2014	**After the revision of Safni et al. (2014)**	**Main hosts**
R. solanacearum phylotype I	*R. pseudosolanacearum*	*Solanum* spp., mulberry (*Morus* spp.) and many other hosts
R. solanacearum phylotype II	*R. solanacearum*	*Solanum* spp. (including *S. tuberosum* affected by the potato brown rot), *Anthurium*, *Heliconia*, *Musa* spp. and many other hosts
R. solanacearum phylotype III	*R. pseudosolanacearum*	*Solanum* spp., *Nicotiana* spp. and many other hosts
R. solanacearum phylotype IV	*R. syzygii* subsp. *celebensis*	Banana (*Musa* spp.)
	R. syzygii subsp. *Indonesiensis*	*S. tuberosum, S. lycopersicon, C. annuum*, *Syzygium aromaticum*
R. syzygii	*R. syzygii* subsp. *Syzygii*	Clove (*Syzygium* spp.)

R. solanacearum enters into plants by way of injured roots, stem wounds or through stomata. Within the plant, the bacteria move in the vascular bundles, a process which is accelerated by higher temperature. Blocking of the vessels by bacteria is the major cause of wilting (EPPO, 1997). Foliar symptoms include rapid wilting of leaves and stems. Eventually, plants fail to recover and become yellow and then necrotic. On tubers, external symptoms may or may not be visible, depending on the state of development of the disease. Infection eventually results in bacterial ooze emerging from the eyes and stolon end attachment of infected tubers.

2.2. Host plants

2.2.1. List of hosts

Ralstonia solanacearum has an extremely wide host range which is likely not to be fully known (EFSA PLH Panel, 2019), as the list of recognised hosts is regularly enriched by new findings (Prior et al., 2016; Bergsma-Vlami et al., 2018; Lopes and Rossato, 2018; Norman et al., 2018.

It can cause potato brown rot or bacterial wilt on major crops such as eggplant (*Solanum melongena*), pepper (*Capsicum annuum*), potato (*Solanum tuberosum*), tobacco *(Nicotiana tabacum*) and tomato (*Solanum lycopersicum*).

Appendix A provides the full list of hosts.

2.2.2. Selection of hosts for the evaluation

The strains which are currently established in the EU have a limited host range. Potatoes), tomatoes and the weed *Solanum dulcamara* are particularly affected. Among the main cultivated hosts of *R. solanacearum* also peppers and eggplants are widely cultivated in the EU.

2.2.3. Conclusions on the hosts selected for the evaluation

The impact of *R. solanacearum* was assessed for the following crops: i) seed potato, ii) ware potato, and iii) tomato, eggplant and pepper grouped together. This decision was based primarily on the importance of the crop in the EU but also on the evidence available to estimate the impact. Thus *Annona*, *Heliconia*, *Musa* spp. were excluded due to their limited importance in the EU agricultural production and *Nicotiana tabacum* was excluded due to missing information from literature. Tomato, eggplant and pepper were assessed together in the same group because of the similar methods of production, symptoms and susceptibilities to *R. solanacearum*.

2.3. Area of potential distribution

2.3.1. Area of current distribution

Figure 1 provides an overview of the current area of distribution of the pest. EU outbreaks occurred in Austria (eradicated), Belgium (few occurrences), Bulgaria (no longer present), Czech Republic (under eradication), France (few occurrences), Germany (few occurrences), Greece (few occurrences), Hungary (few occurrences), Italy (eradicated), the Netherlands (restricted distribution), Poland (few occurrences), Portugal (few occurrences), Romania (few occurrences), Slovakia (few occurrences), Slovenia (eradicated), Spain (few occurrences), Sweden (eradicated) and UK (under eradication).

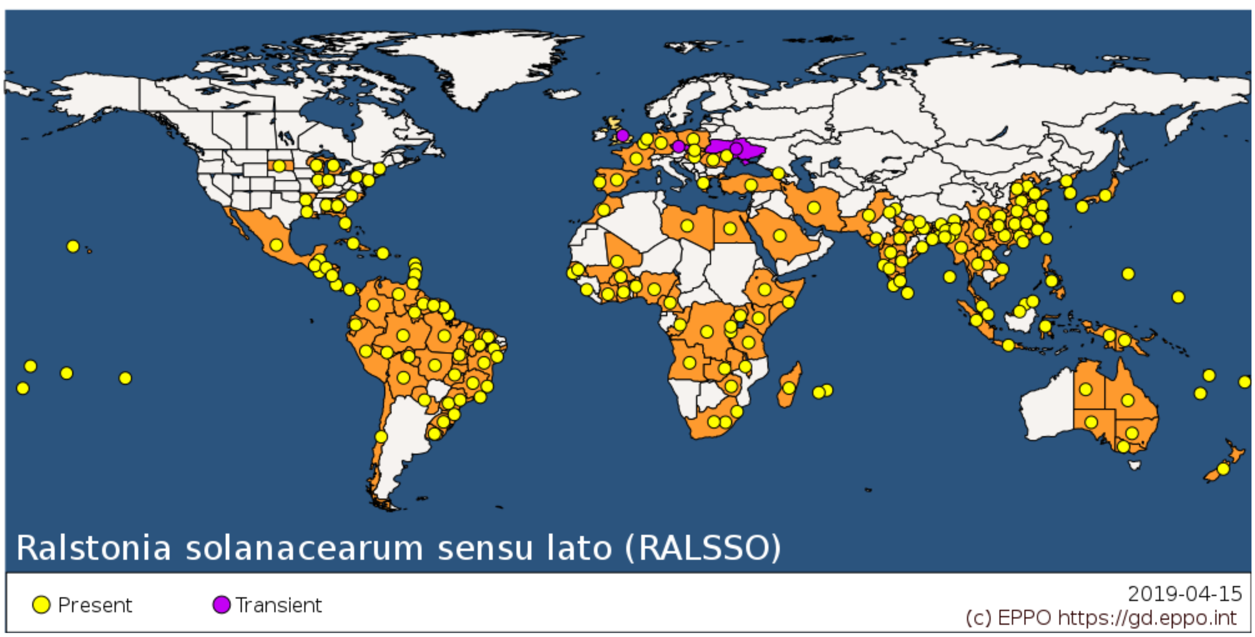

Figure 1 Distribution map of *Ralstonia solanacearum sensu lato* from the EPPO Global Database accessed 15/04/2019.

2.3.2. Area of potential establishment

R. solanacearum presence has been observed in a wide variety of climatic conditions (Cruz et al., 2012). It was initially considered to be a pathogen that requires warm climatic conditions, but it was then observed establishing in cooler countries such as the Netherlands and Sweden (Janse, 1996; Persson, 1998) due to strains adapted to the climates in these counties. The pest has been reported in some MSs, but the current distribution cannot be considered as the area of potential distribution due to the presence of favourable climatic conditions in MSs where the pest has not yet been reported.

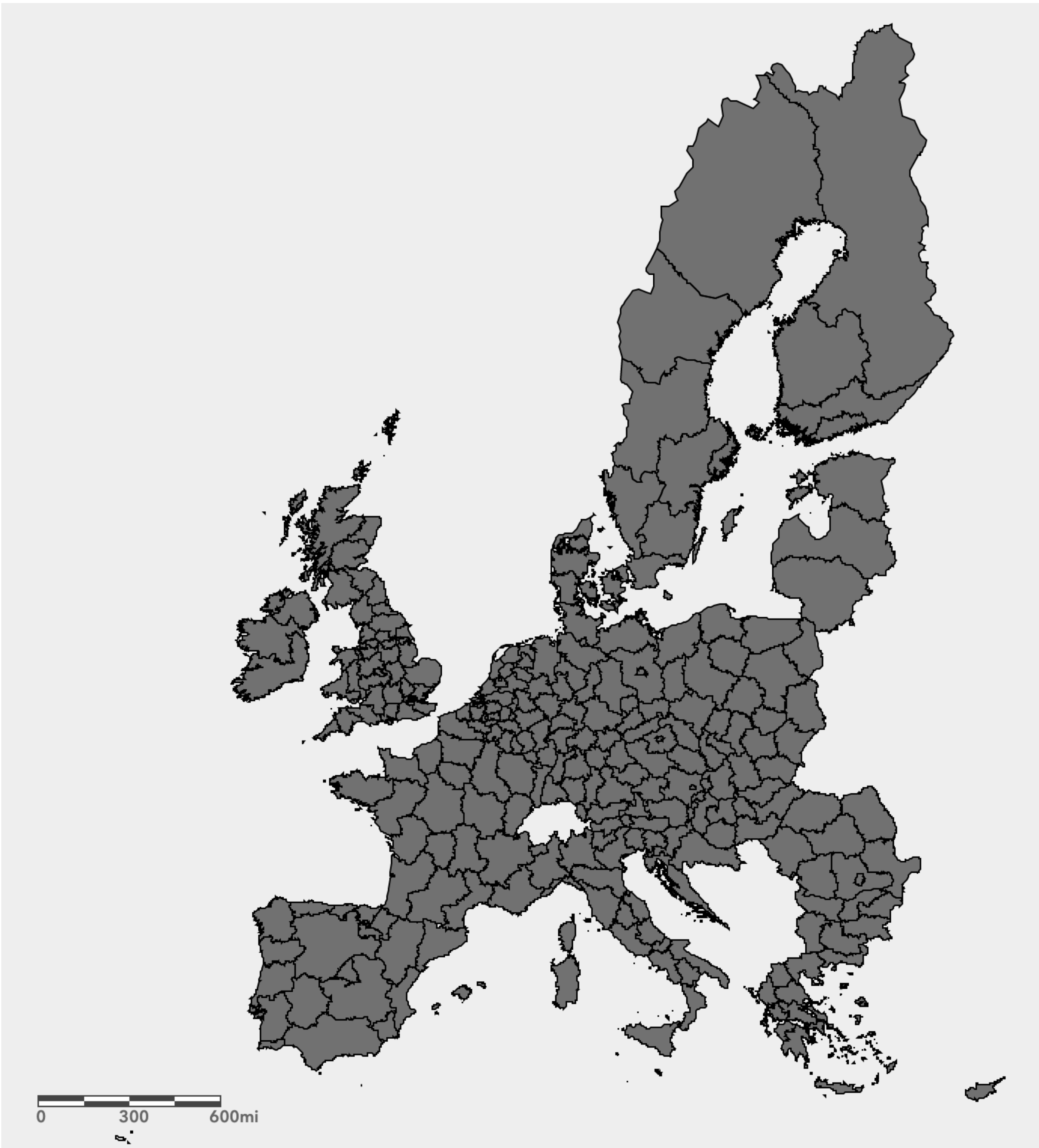

Figure 2 The potential distribution of the pest in the EU NUTS2 regions based on the scenarios established for assessing the impacts of the pest by the EFSA Working Group on EU Priority Pests (EFSA, 2019a). This link provides an online interactive version of the map that can be used to explore the data further: https://arcg.is/1HmXyW

2.3.3. Transient populations

Ralstonia solanacearum is not expected to form transient populations in the EU (for "transient" see the definition in EFSA, 2019a).

2.3.4. Conclusions on the area of potential distribution

The area of potential distribution of *R. solanacearum* is equivalent to the area where the main hosts occur in the EU (Figure 2). The mean abundance of the pest, the main driver of pest impact, is considered to be the same throughout the area of potential distribution.

2.4. Expected change in the use of plant protection products

The control of *R. solanacearum* consists primarily of phytosanitary and cultural practices (e.g. crop rotation). Commercial chemicals and antibiotics generally are ineffective in controlling *R. solanacearum*. One exception may be fumigation (e.g. Santos et al. 2006,). However, fumigation might not be as effective as rotation or the use of tolerant cultivars, and many of the fumigants that might be effective are not approved in the EU.

Due to the fact that no effective treatments with plant protection products (PPPs) are currently available, the most suitable PPP indicator is Case "A" and the category is "0" based on Table 2.

Table 2: Expected changes in the use of Plant Protection Products (PPPs) following *Ralstonia solanacearum* establishment in the EU in relation to four cases (A-D) and three level score (0-2) for the expected change in the use of PPPs

Expected change in the use of PPPs	Case	PPPs indicator
PPPs effective against the pest are not available/feasible in the EU	**A**	**0**
PPPs applied against other pests in the risk assessment area are also effective against the pest, without increasing the amount/number of treatments	B	0
PPPs applied against other pests in the risk assessment area are also effective against the pest but only if the amount/number of treatments is increased	C	1
A significant increase in the use of PPPs is not sufficient to control the pest: only new integrated strategies combining different tactics are likely to be effective	D	2

2.5. Additional potential effects

2.5.1. Mycotoxins

The species is not known to be related to problems caused by mycotoxins.

2.5.2. Capacity to transmit pathogens

The species is not known to vector any plant pathogens.

3. Expert Knowledge Elicitation report

3.1. Yield and quality losses

3.1.1. Structured expert judgement

3.1.1.1. Generic scenario assumptions

All the generic scenario assumptions common to the assessments of all the priority pests are listed in the section 2.4.1.1 of the Methodology Report (EFSA, 2019a).

3.1.1.2. Specific scenario assumptions

- Potato
  - Cropping practices for potato production include current crop rotation schemes and avoidance of surface water irrigation.
  - Infection level of seed potatoes is expected to be negligible because of current measures taken in seed production (Council Directive 2002/56/EC[3] on the marketing of seed potatoes).
- Tomato, eggplant, pepper
  - On tomato the scenario is a scattered distribution, low prevalence, well controlled by current management measures, but not eradicated.
  - The artificial warmer conditions of greenhouses can favour the survival of tropical strains even in Northern European countries.
  - Irrigation is an important component for the local spread of the disease.
  - The possibility to decontaminate the water is not taken into account.
  - Impact is assessed considering together the two growing conditions of open field and protected cultivation.
  - The effect of Commission Directive 2006/63/EC of 14 July 2006[4] is not taken into account.

3.1.1.3. Selection of the parameter(s) estimated

According Council Directive 98/57/EC[5] the member states are required to carry out surveys for *Ralstonia solanacearum*. In the fact sheet the infection data for domestic production of seed and ware potatoes

[3] Council Directive 2002/56/EC of 13 June 2002 (lastly amended 16 June 2014) on the marketing of seed potatoes. OJ L 193, 20.7.2002, p. 60–73.

[4] Commission Directive 2006/63/CE of 14 July 2006 amending Annexes II to VII to Council Directive 98/57/EC on the control of *Ralstonia solanacearum* (Smith) Yabuuchi et al. OJ L 206, 27.7.2006, p. 36–106.

[5] Council Directive 98/57/EC of 20 July 1998 on the control of *Ralstonia solanacearum* (Smith) Yabuuchi et al. OJ L 235, 21.8.1998, p. 1–39.

for the years of 1995 to 2015 were used (DG Health and Food Safety, 2017). To calculate the total European infection rate, the reported national rates were weighted by the relative production in the EU of 2015 (EUROSTAT). Assuming that the pest is already widespread and reached its maximum extension.

For seed and ware potatoes, yield loss is defined as the percentage of infested lots; it includes lots rejected for quarantine reasons. Yield loss is estimated from the rate of infested lots retrieved from the annual European survey. A smooth distribution is fitted to interpolate missing percentiles. Yield loss includes the decline of plant and not harvested tubers. Quality loss is defined, in seed potatoes production, as the percentage of lots downgraded to animal feed; in ware potatoes production, as the percentage of lots downgraded to starch or animal feed; in starch potatoes production, as the percentage of lots downgraded to animal feed.

The annual variation within the survey period is used as approximation to estimate the uncertainty of the annual impact. Having these survey data, the need to perform an additional Expert Knowledge Elicitation was not given. For quality losses on potato the values are derived from an Expert Knowledge Elicitation procedure.

For tomato, eggplant and pepper yield loss is estimated as the percentage of wilted plants (disease prevalence). The values of yield loss are derived from an Expert Knowledge Elicitation procedure. Quality losses are not evaluated as the pest will not affect the fruit but will kill the plant, and losses due to plant not reaching maturity are not evaluated.

3.1.1.4. Defined question(s)

What is the percentage yield loss in seed potato production under the scenario assumptions in the area of the EU under assessment for *Ralstonia solanacearum*, as defined in the Pest Report?

What is the percentage yield loss in ware potato production under the scenario assumptions in the area of the EU under assessment for *Ralstonia solanacearum*, as defined in the Pest Report?

What is the percentage of the harvested potato damaged by *Ralstonia solanacearum* that would lead to downgrading the final product because of quality issues under the scenario assumptions in the area of the EU under assessment as defined in the Pest Report?

What is the percentage yield loss in tomato/eggplant/pepper production under the scenario assumptions in the area of the EU under assessment for *Ralstonia solanacearum*, as defined in the Pest Report?

3.1.1.5. Evidence selected

The experts reviewed the evidence obtained from the literature (see Table B.1 in Appendix B) selecting the data and references used as the key evidence for the Expert Knowledge Elicitation (EKE) on impact. The annual European survey data were judged as sufficient to calculate the requested indicators for yield and quality loss. For this reason, the table in appendix has been provided for the use of the reader although not directly applied to this parameter.

For tomato/eggplant/pepper a general point was made: IPM on Solanaceae rotation requires to rotate to non-solanaceous crops, and if possible non-cucurbit crops, for two years before trying to grow tomatoes again in the same field.

3.1.1.6. Uncertainties identified

- Potato
    - The uncertainty of the future yield loss is estimated by the year variability in a time series of production and infection data.
- Tomato, eggplant, pepper
    - Spatial distribution of the pest at a fine scale (e.g. fields in a production area).
    - Survival of the pest after period of crop rotation.
    - The scenario considering the distribution of *R. solanacearum sensu lato* without regards to how its genetic variation could affect the spatial distribution, host preference and severity of the impact.
    - Variation of impact between open field and protected cultivation.

3.1.2. Values calculated for yield losses on seed potato

What is the percentage yield loss in seed potato production under the scenario assumptions in the area of the EU under assessment for *R. solanacearum*, as defined in the Pest Report?

The five values on yield loss on seed potato calculated from the annual European survey data are reported in the table below.

Table 3: The 5 elicited values on yield loss (%) on seed potato

Percentile	**10%**	**25%**	**50%**	**75%**	**90%**
Expert elicitation	0.000%	0.001%	0.005%	0.011%	0.014%

3.1.2.1. *Estimation of the uncertainty distribution for yield loss on seed potato*

The comparison between the fitted values of the uncertainty distribution and the values agreed by the group of experts is reported in the table below.

Table 4: Fitted values of the uncertainty distribution on the yield loss (%) on seed potato

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation				0.000 %	0.000 %	0.001 %	0.002 %	0.005 %	0.008 %	0.011 %	0.014 %	0.014 %			
Fitted distribution	0.000 %	0.000 %	0.000 %	0.000 %	0.000 %	0.001 %	0.001 %	0.003 %	0.007 %	0.010 %	0.014 %	0.020 %	0.029 %	0.037 %	0.050 %

Fitted distribution: Gamma (0.47934,0.00015255), @RISK7.5

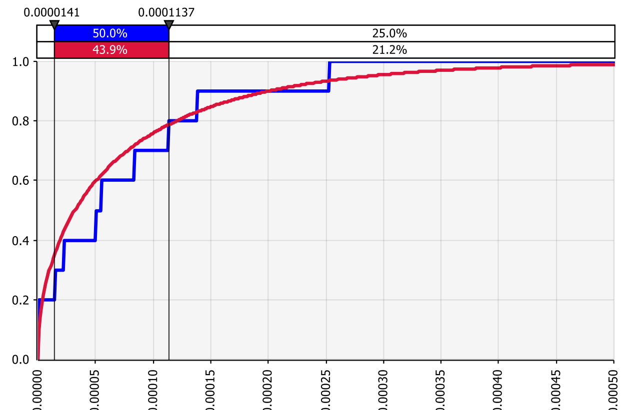

Figure 3 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on seed potato.

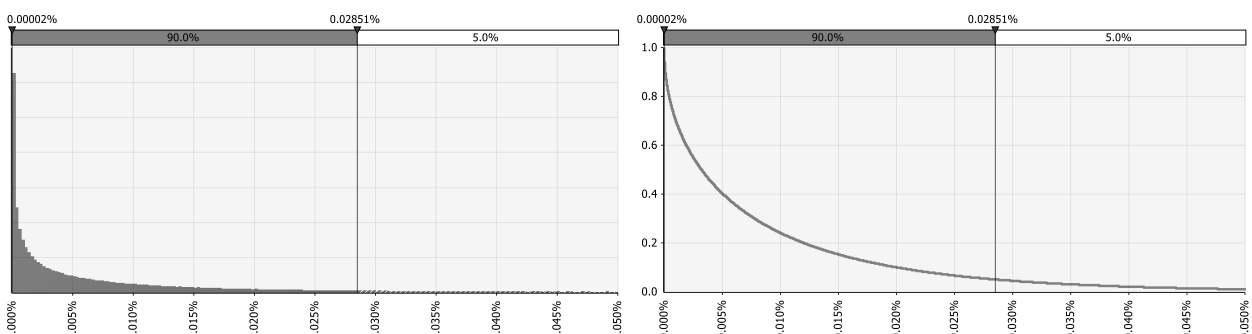

Figure 4 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on seed potato.

3.1.3. Values calculated for yield losses on ware potato

What is the percentage yield loss in ware potato production under the scenario assumptions in the area of the EU under assessment for *R. solanacearum*, as defined in the Pest Report?

The five values on yield loss on ware potato calculated from the annual European survey data are reported in the table below.

Table 5: The 5 elicited values on yield loss (%) on ware potato

Percentile	**10%**	**25%**	**50%**	**75%**	**90%**
Expert elicitation	0.076%	0.114%	0.154%	0.243%	0.271%

3.1.3.1. *Estimation of the uncertainty distribution for yield loss on ware potato*

The comparison between the fitted values of the uncertainty distribution and the values agreed by the group of experts is reported in the table below.

Table 6: Fitted values of the uncertainty distribution on the yield loss (%) on ware potato

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation				0.076 %	0.097 %	0.114 %	0.128 %	0.154 %	0.213 %	0.243 %	0.271 %	0.271 %			
Fitted distribution	0.051 %	0.062 %	0.072 %	0.087 %	0.103 %	0.119 %	0.135 %	0.169 %	0.210 %	0.239 %	0.277 %	0.326 %	0.393 %	0.462 %	0.558 %

Fitted distribution: Lognorm (0.0019249,0.0010588), @RISK7.5

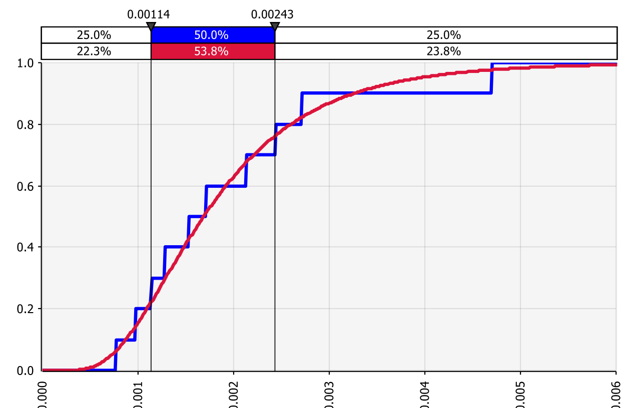

Figure 5 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on ware potato.

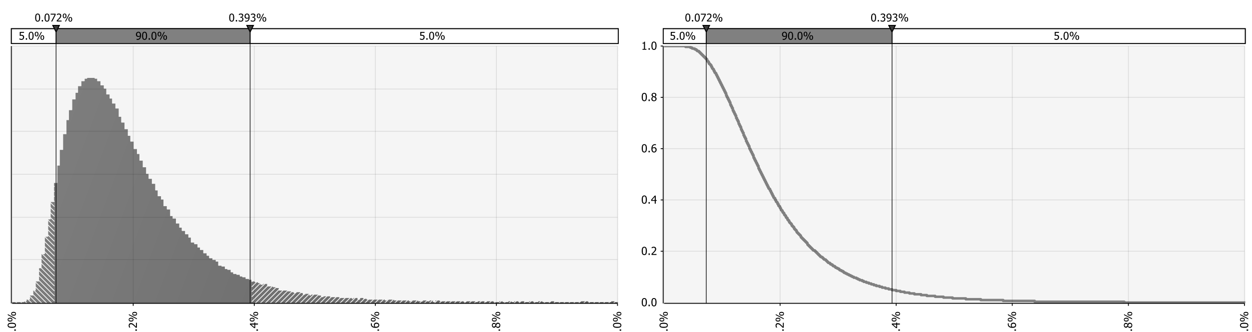

Figure 6 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on ware potato.

3.1.4. Elicited values for quality losses on potato

What is the percentage of the harvested potato damaged by *R. solanacearum* that would lead to downgrading the final product because of quality issues under the scenario assumptions in the area of the EU under assessment as defined in the Pest Report?

The five values on quality loss on potato on which the group agreed are reported in the table below.

Table 7: Summary of the 5 elicited values on quality loss on potato

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	5%	10%	25%	40%	50%

3.1.4.1. Justification for the elicited values for quality loss on potato

Reasoning for a scenario which would lead to high quality loss (99th percentile / upper limit)

The upper value of quality loss is based on a scenario where the situation in the Netherlands in the 90's is extended to the whole EU. It is considered that 70% of seeds are from farm-saved seed potatoes and once the farm is infested, it is difficult to get rid of *R. solanacearum* without any additional measures.

Reasoning for a scenario which would lead to low quality loss (1st percentile / lower limit)

The lower value of quality loss is based on the consideration that the pest is widely spread in the EU and there are no practices favorable to dispersal (i.e. human-assisted), and that seed potatoes are not cut.

Reasoning for a central scenario equally likely to over- or underestimate the quality loss (50th percentile / median)

The median value of quality loss is based on the consideration that the epidemiology of the disease and the production systems are favorable to disease development, while common growing practices limit the number of incidents.

Reasoning for the precision of the judgement describing the remaining uncertainties (1st and 3rd quartile / interquartile range)

The precision reflects the fact that there is high uncertain around the median value while experts are more confident about the upper limit. It is expected to have higher quality losses than yield losses, considering the epidemiology of the disease and the biology of the pest as reported in the evidence (high chance the pest is maintain by companies use farm-saved seed potatoes).

3.1.4.2. Estimation of the uncertainty distribution for quality loss on potato

The comparison between the fitted values of the uncertainty distribution and the values agreed by the group of experts is reported in the table below.

Table 8: Fitted values of the uncertainty distribution on quality loss on potato

Percentile	1%	2.5 %	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	5%					10%		25%		40%					50%
Fitted distribution	4.5 %	4.7 %	5.0 %	6.0 %	8.0 %	11.3 %	15.2 %	24.5 %	34.6 %	39.6 %	44.2 %	47.4 %	49.3 %	50.0 %	50.4 %

Fitted distribution: BetaGeneral (0.60357,0.70933,0.045,0.505), @RISK7.5

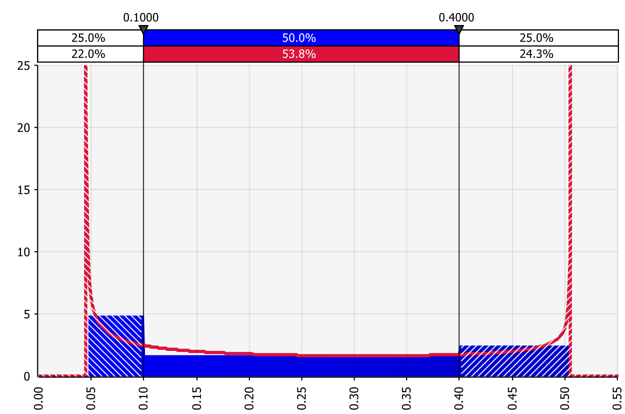

Figure 7 Comparison of judged values (histogram in blue) and fitted distribution (red line) for quality loss on potato.

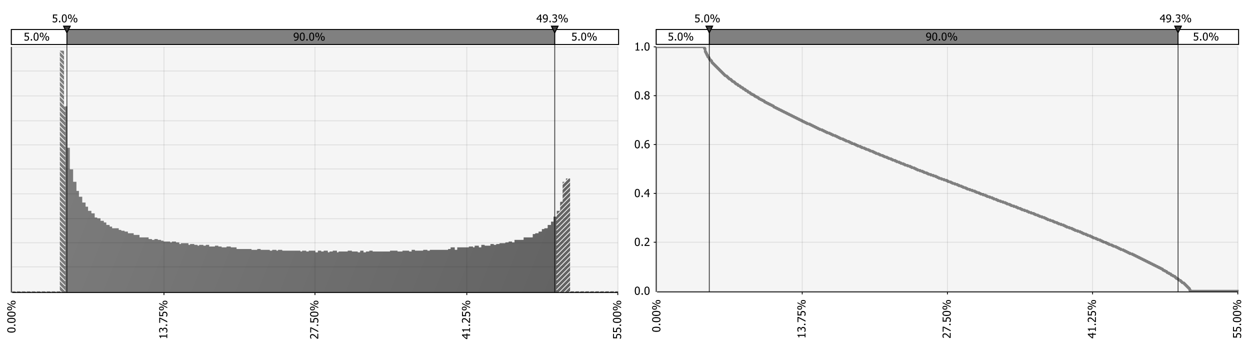

Figure 8 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for quality loss on potato.

3.1.5. Elicited values for yield losses in tomato, eggplant and pepper

What is the percentage yield loss in tomato/eggplant/pepper production under the scenario assumptions in the area of the EU under assessment for *R. solanacearum*, as defined in the Pest Report?

The five values on yield loss in tomato, eggplant and pepper on which the group agreed are reported in the table below.

Table 9: Summary of the 5 elicited values on yield loss (%) on tomato, eggplant and pepper

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	1%	5%	8%	15%	30%

3.1.5.1. *Justification for the elicited values for yield loss on tomato, eggplant and pepper*

Reasoning for a scenario which would lead to high yield loss (99th percentile / upper limit)

The upper value of yield loss is based on the consideration that all these crops can be grown in favourable conditions for the disease, both in open field and in protected conditions, and on a worst-case scenario with early infection and total losses occurring in infected production units. High level of inoculum in infected fields would facilitate the dispersal of the bacterium to neighboring fields. The maximum potential impact (100%) is expected to be reduced by a factor 3 by the widely applied IPM on Solanaceae rotation.

Reasoning for a scenario which would lead to low yield loss (1st percentile / lower limit)

The lower value of yield loss is based on a scenario with the pest present at very low inoculum levels. The lowest value of loss provided in the evidence (1%) for infected production units takes into account the different cropping practices and level of sanitation, the EU climate that could act as a limiting factor particularly in the Northern EU countries, and the expected scattered distribution of the pest. In addition, this best-case scenario considers infections happening late in the year. Finally, Solanaceae rotation has the effect of reducing the inoculum of the pest.

Reasoning for a central scenario equally likely to over- or underestimate the yield loss (50th percentile / median)

The median value of yield loss is based on a scenario where half of the production units are infected by *R. solanacearum*. The yield in each production unit is reduced to 50% due to all the factors related to climate and the period in which infection takes place. The current IPM would further reduce loss by a factor 3.

Reasoning for the precision of the judgement describing the remaining uncertainties (1st and 3rd quartile / interquartile range)

Uncertainty is mainly located in the upper part of the curve.

3.1.5.2. Estimation of the uncertainty distribution for yield loss on tomato, eggplant and pepper

The comparison between the fitted values of the uncertainty distribution and the values agreed by the group of experts is reported in the table below.

Table 10: Fitted values of the uncertainty distribution on the yield loss (%) on tomato, eggplant and pepper

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	**1%**					**5%**		**8%**		**15%**					**30%**
Fitted distribution	0.6%	1.1%	1.6%	2.5%	3.5%	4.7%	5.9%	8.6%	11.9%	14.2%	17.2%	20.9%	25.7%	30.4%	36.4%

Fitted distribution: Gamma (1.7933,0.058291), @RISK7.5

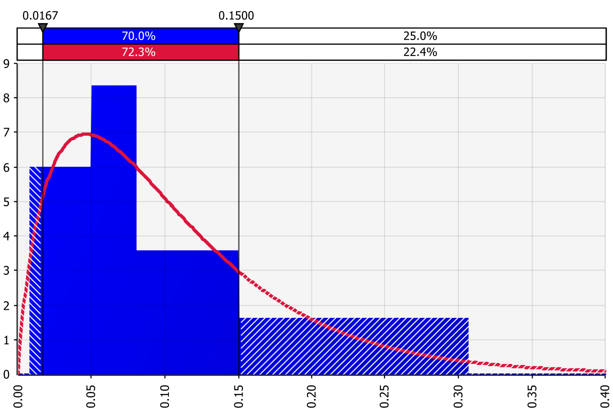

Figure 9 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on tomato, eggplant and pepper.

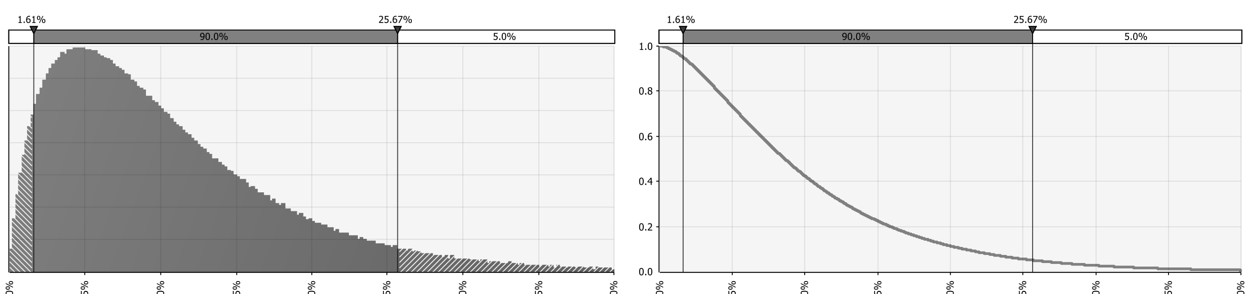

Figure 10 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on tomato, eggplant and pepper.

3.1.6. Conclusions on yield and quality losses

Based on the general and specific scenarios considered in this assessment:

- For seed potatoes, the proportion (in %) of yield losses (here with the meaning of proportion infested lots) is estimated to be 0.003% (with a 95% uncertainty range of 0.000 - 0.037%).
- For ware potatoes, the proportion (in %) of yield losses (here with the meaning of proportion infested lots) is estimated to be 0.17% (with a 95% uncertainty range of 0.06 - 0.46%).
- For ware and seed potatoes, the proportion (in %) of quality losses (here with the meaning of proportion of downgraded lots) is estimated to be 24.5% (with a 95% uncertainty range of 4.7 - 50.0%).
- For tomato, eggplant and pepper, the proportion (in %) of yield losses (here with the meaning of disease prevalence) is estimated to be 8.6% (with a 95% uncertainty range of 1.1 - 30.4%).

3.2. Spread rate

3.2.1. Structured expert judgement

3.2.1.1. Generic scenario assumptions

All the generic scenario assumptions common to the assessments of all the priority pests are listed in the section 2.4.2.1 of the Methodology Report (EFSA, 2019a).

3.2.1.2. Specific scenario assumptions

- Movement machinery between fields is considered.

3.2.1.3. Selection of the parameter(s) estimated

The spread rate has been assessed as the number of metres per year.

3.2.1.4. Defined question(s)

What is the spread rate in 1 year for an isolated focus within this scenario based on average European conditions? (units: m/year)

3.2.1.5. Evidence selected

The experts reviewed the evidence obtained from the literature (see Table B.2 in Appendix B) selecting the data and references used as the key evidence for the EKE on spread rate. Some more points were made:

- Natural spread is limited and slow
- Root-to-root spread of the bacterium observed (Kelman and Sequeira, 1965), but there is little evidence of long-distance spread from field to field
- Not all EU outbreaks were due to contaminated irrigation water
- *R. solanacearum* can be carried over very long distances in symptomless, infected vegetative propagating material (e.g. by Olsson 1976; Hayward 1991; Turco et al., 1998)

- *S. dulcamara*, growing with roots in watercourses contaminated with the bacterium, become infected and can remain so for several years, leaching the pathogen from the infected roots to further contaminate the river water and thus to transmit *R. solanacearum* to new *S. dulcamara* plants downstream or to potato and tomato crops if the water is used for irrigation

3.2.1.6. Uncertainties identified

- The main cause of dispersal to long distance is farm saved seed potatoes.
- Methods of cultivation in different regions of the EU can affect the spread rate
- Potato processing affect the spread by surface water (waste water from plant processing plants infect the surface water)
- Usage of surface water for irrigation is not common in the EU and the main means of spread will be machinery
- The pest can be transmitted by river water although the distance is difficult to determine
- The spread by surface water follows the terrain
- *R. solanacearum* is also spread by soil: the waste material at the farm could be an important inoculum source

3.2.2. Elicited values for the spread rate

What is the spread rate in 1 year for an isolated focus within this scenario based on average European conditions? (units: m/year)

The five values on the spread rate on which the group agreed are reported in the table below.

Table 11: Summary of the 5 elicited values on spread rate (m/y)

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	0	200	400	600	1000

3.2.2.1. Justification for the elicited values of the spread rate

Reasoning for a scenario which would lead to wide spread (99th percentile / upper limit)

The upper value takes into account that spread by surface water can reach a value of 1000 m/y (even higher than this) as supported by several observations from Germany. However, as the use of surface water for irrigation is not common in the EU, it is estimated that spread will usually be within field or between neighboring fields with spread via contaminated surface water occurring in 10% of the outbreaks.

Reasoning for a scenario, which would lead to limited spread (1st percentile / lower limit)

The lower value is based on the following considerations: there are many situations reported in the literature where the bacterium does not spread between fields; surface water has a limited role in spreading the pest in the EU; the natural spread of the bacterium is extremely limited; machinery will play a role only in local spread within a single field.

Reasoning for a central scenario, equally likely to over- or underestimate the spread (50th percentile / median)

The median value takes into account the average distance between fields (estimated as 600 m), the low usage of surface water for irrigation and the contribution of infected machinery moving between fields, and considers that there will be very low local spread in 90% of the outbreaks.

Reasoning for the precision of the judgement describing the remaining uncertainties (1st and 3rd quartile / interquartile range)

The precision is given by the uncertainty connected to different methods of cropping of potatoes (difference in the use of surface water for irrigation) and movement machinery between the fields.

3.2.2.2. Estimation of the uncertainty distribution for the spread rate

The comparison between the fitted values of the uncertainty distribution and the values agreed by the group of experts is reported in the table below.

Table 12: Fitted values of the uncertainty distribution on the spread rate (m/y)

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	0					200		400		600					1,000
Fitted distribution	15	31	53	94	145	205	266	390	529	608	701	792	882	946	1,002

Fitted distribution: BetaGeneral (1.2604,2.0485,0,1100), @RISK7.5

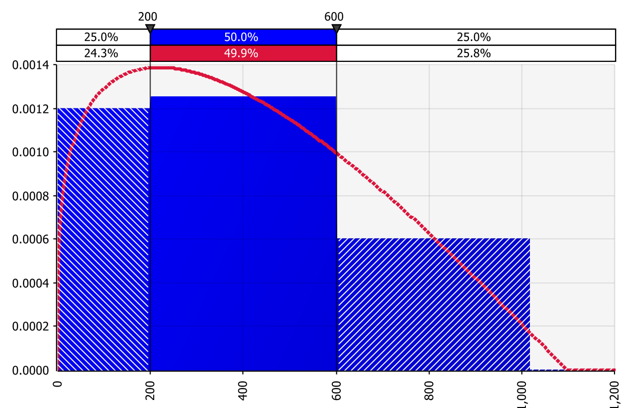

Figure 11 Comparison of judged values (histogram in blue) and fitted distribution (red line) for spread rate.

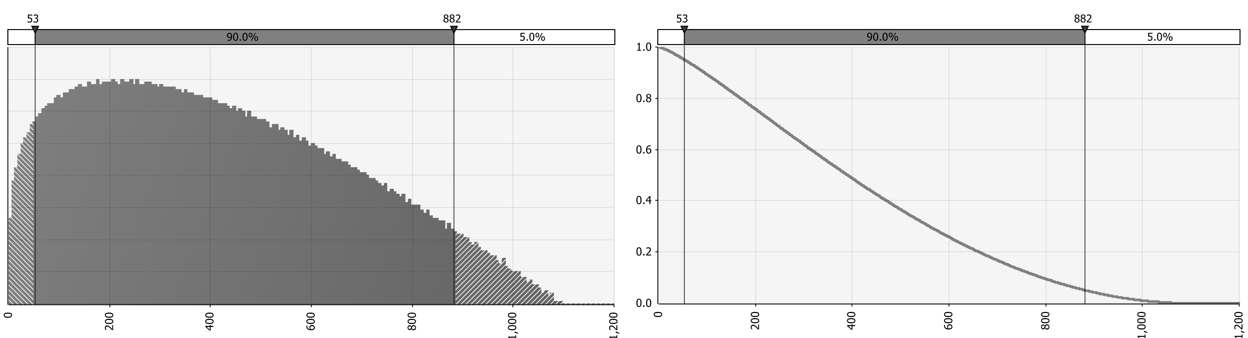

Figure 12 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for spread rate.

3.2.3. Conclusions on the spread rate

Based on the general and specific scenarios considered in this assessment, the maximum distance expected to be covered in one year by *R. solanacearum* is 390 m (with a 95% uncertainty range of 31 - 946 m).

3.3. Time to detection

3.3.1. Structured expert judgement

3.3.1.1. Generic scenario assumptions

All the generic scenario assumptions common to the assessments of all the priority pests are listed in the section 2.4.2.1 of the Methodology Report (EFSA, 2019a).

3.3.1.2. Specific scenario assumptions

No specific assumptions are introduced for the assessment of the time to detection.

3.3.1.3. Selection of the parameter(s) estimated

The time for detection has been assessed as the number of months between the first event of pest transfer to a suitable host and its detection.

3.3.1.4. Defined question(s)

What is the time between the event of pest transfer to a suitable host and its first detection within this scenario based on average European conditions? (unit: months)

3.3.1.5. Evidence selected

The experts reviewed the evidence obtained from the literature (see Table B.2 in Appendix B) selecting the data and references used as the key evidence for the EKE on time to detection.

3.3.1.6. Uncertainties identified

- The storage conditions that are in place in the EU (<10 °C) will not allow the development of symptoms so the pest can be not detected
- The pest is detected under certification scheme
- The ratio of seed potatoes production to ware/starch potatoes (1:17) will affect the time of detection as for seed potatoes the time is shorter given the higher level of control

3.3.2. Elicited values for the time to detection

What is the time between the event of pest transfer to a suitable host and its first detection within this scenario based on average European conditions? (unit: months)

The five values on the time to detection on which the group agreed are reported in the table below.

Table 13: Summary of the 5 elicited values on time to detection (months)

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	16	28	40	70	120

3.3.2.1. Justification for the elicited values of the time to detection

Reasoning for a scenario which would lead to a long time for detection (99th percentile / upper limit)

The upper value with longer period is based on a scenario with low pest prevalence. The main contribution to the high value is due to farm saved potatoes. The selection of tubers done at the farm could favour the condition of the pest not being detected. It is considered that disease expression can be low, also due to climate and storage conditions not favourable to symptoms expression, driving to misidentification. Moreover, if the outbreak occurs in a country that has never experienced the pest before, the time to identify *R. solanacearum* could be longer than for countries where the pest is regularly found due to the lower effort and efficacy in survey. Finally, it is considered that the pathogen could remain undetected for many years on wild weeds.

Reasoning for a scenario which would lead to a short time for detection (1st percentile / lower limit)

The lower value is the average of the time needed to identify the pest on materials of different origin (shorter time for certified potato seeds, 1/3 of the total; longer time for farm saved potatoes, 2/3 of the total), for different type of productions (longer time for ware potatoes) and for different potato varieties (with different levels of symptoms expression). The estimation is based on the following considerations. The percentage of tested potatoes is limited and therefore finding the infected potatoes could still require years. The minimum optimal time is at least 4 months (the production cycle plus the testing phase). However, even in a system with quite intensive sampling (e.g. The Netherlands), it is not so easy to find the pest in the first season: hence, 1-2 years is considered already an optimistic scenario.

Reasoning for a central scenario, equally likely to over- or underestimate the time for detection (50th percentile / median)

The median value is based on the consideration that 70% of farms do not use certified potato seeds in the EU; and in some MSs almost the whole potato production does not come from certified seeds. However, the main part of potato production is done in countries with higher awareness on the pest (DG Health and Food Safety, 2017), which would lead to a shorter time to detection. It is also considered that the pest is less distributed than *Clavibacter*, but it is easy to detect via water samples and natural hosts. On the other hand, the availability of natural hosts can help spreading the epidemics.

Reasoning for the precision of the judgement describing the remaining uncertainties (1st and 3rd quartile / interquartile range)

The precision reflects the fact that higher values are considered more unlikely; uncertainty is large for lower values.

3.3.2.2. Estimation of the uncertainty distribution for the time to detection

The comparison between the fitted values of the uncertainty distribution and the values agreed by the group of experts is reported in the table below.

Table 14: Fitted values of the uncertainty distribution on the time to detection (months)

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	16					28		40		70					120
Fitted distribution	15	16	17	19	22	27	32	43	58	67	78	90	101	110	118

Fitted distribution, BetaGeneral (0.86225,2.0857,15,132)@RISK7.5

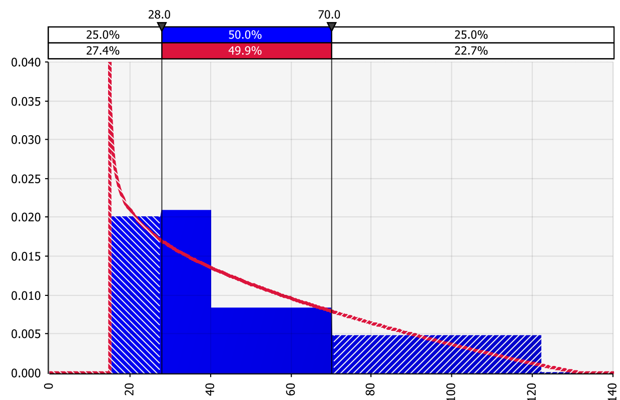

Figure 13 Comparison of judged values (histogram in blue) and fitted distribution (red line) for time to detection.

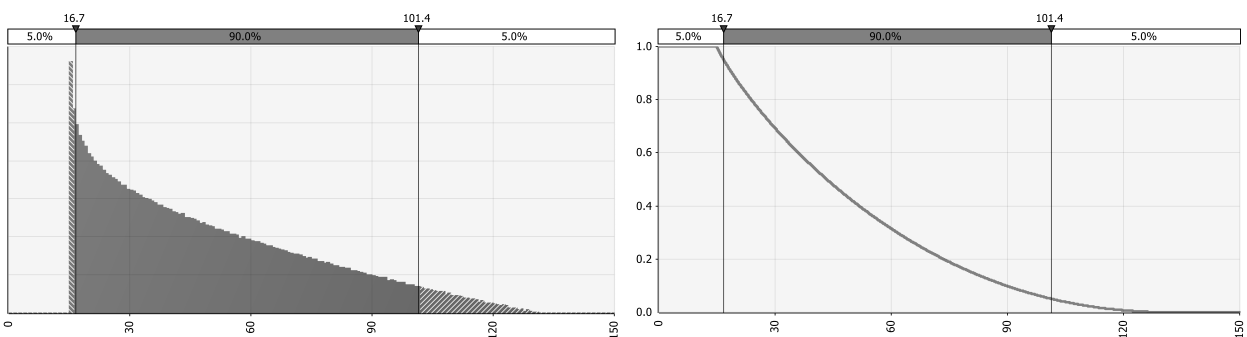

Figure 14 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for time to detection.

3.3.3. Conclusions on the time to detection

Based on the general and specific scenarios considered in this assessment, the time between the event of pest transfer to a suitable host and its detection is estimated to be 43 months (with a 95% uncertainty range of 16 - 110 months).

4. Conclusions

Hosts selection

The impact of *R. solanacearum* was assessed for the following crops: i) seed potato, ii) ware potato, and iii) tomato, eggplant and pepper grouped together. This decision was based primarily on the importance of the crop in the EU but also on the evidence available to estimate the impact. Thus *Annona*, *Heliconia*, *Musa* spp. were excluded due to their limited importance in the EU agricultural production and *Nicotiana tabacum* was excluded due to missing information from literature. Tomato, eggplant and pepper were assessed together in the same group because of the similar methods of production, symptoms and susceptibilities to *R. solanacearum*.

Area of potential distribution

The area of potential distribution of *R. solanacearum* is equivalent to the area where the main hosts occur in the EU. The mean abundance of the pest, the main driver of pest impact, is considered to be the same throughout the area of potential distribution.

Increased number of treatments

Due to the fact that no effective treatments with plant protection products (PPPs) are currently available, the most suitable PPP indicator is Case “A” and the category is “0”.

Yield and quality losses

Based on the general and specific scenarios considered in this assessment:

- For seed potatoes, the proportion (in %) of yield losses (here with the meaning of proportion of infested lots) is estimated to be 0.003% (with a 95% uncertainty range of 0.000 - 0.037%).
- For ware potatoes, the proportion (in %) of yield losses (here with the meaning of proportion of infested lots) is estimated to be 0.17% (with a 95% uncertainty range of 0.06 - 0.46%).
- For ware and seed potatoes, the proportion (in %) of quality losses (here with the meaning of proportion of downgraded lots) is estimated to be 24.5% (with a 95% uncertainty range of 4.7 - 50.0%).
- For tomato, eggplant and pepper, the proportion (in %) of yield losses (here with the meaning of disease prevalence) is estimated to be 8.6% (with a 95% uncertainty range of 1.1 - 30.4%).

Spread rate

Based on the general and specific scenarios considered in this assessment, the maximum distance expected to be covered in one year by *R. solanacearum* is 390 m (with a 95% uncertainty range of 31 - 946 m).

Time for detection after entry

Based on the general and specific scenarios considered in this assessment, the time between the event of pest transfer to a suitable host and its detection is estimated to be 43 months (with a 95% uncertainty range of 16 - 110 months).

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Appendix A – CABI/EPPO host list

The following list, defined in the Methodology Report (EFSA, 2019a) as the full list of host plants, is compiled merging the information from the most recent PRAs, the CABI Crop Protection Compendium and the EPPO Global Database. Hosts from the CABI list classified as 'Unknown', as well as hosts from the EPPO list classified as 'Alternate', 'Artificial', or 'Incidental' have been excluded from the list.

Genus	Species epithet
Ageratum	*conyzoides*
Amomum	*subulatum*
Annona	*cherimola*
Anthurium	
Arachis	*hypogaea*
Artemisia	
Beta	*vulgaris*
Bougainvillea	*glabra*
Capsicum	*annuum*
Casuarina	*cunninghamiana*
Casuarina	*equisetifolia*
Casuarina	*glauca*
Cereus	*peruvianus*
Cestrum	*nocturnum*
Chenopodium	
Citrullus	*lanatus*
Coleus	
Coleus	*forskohlii*
Colocasia	*esculenta*
Corchorus	*olitorius*
Cosmos	*bipinnatus*
Cucumis	*melo*
Cucumis	*sativus*
Cucurbita	*moschata*
Cucurbita	*pepo*
Curcuma	*longa*
Cynara	*cardunculus*
Cyphomandra	*betacea*
Datura	*stramonium*
Emilia	*sonchifolia*
Eucalyptus	
Eupatorium	*cannabinum*
Galinsoga	*parviflora*
Galinsoga	*quadriradiata*
Gossypium	
Heliconia	
Heliconia	*caribaea*
Hevea	*brasiliensis*

Ipomoea	*batatas*
Justicia	*adhatoda*
Lagenaria	*siceraria*
Maranta	*arundinacea*
Momordica	*charantia*
Musa	
Musa	*paradisiaca*
Nicotiana	*rustica*
Nicotiana	*tabacum*
Olea	*europaea*
Pelargonium	
Pelargonium	*hortorum*
Pelargonium	*zonale*
Physalis	
Physalis	*angulata*
Plants	
Platostoma	*chinensis*
Plectranthus	*barbatus*
Pogostemon	*cablin*
Polygonum	*capitatum*
Portulaca	*oleracea*
Ricinus	*communis*
Rosa	
Salpiglossis	*sinuata*
Salvia	*reflexa*
Siraitia	*grosvenorii*
Solanum	*capsicastrum*
Solanum	*carolinense*
Solanum	*cinereum*
Solanum	*dulcamara*
Solanum	*luteum*
Solanum	*lycopersicum*
Solanum	*melongena*
Solanum	*nigrum*
Solanum	*phureja*
Solanum	*sisymbriifolium*
Solanum	*tuberosum*
Soliva	*anthemifolia*
Tagetes	
Tagetes	*erecta*
Talinum	*fruticosum*
Tectona	*grandis*
Urtica	*dioica*
Verbena	*brasiliensis*
Washingtonia	*filifera*
Zingiber	*officinale*

Appendix B – Evidence tables

B.1 Summary on the evidence supporting the elicitation of yield and quality losses

Susceptibility	Infection	Symptoms	Impact	Additional information	Reference	Limitation/uncertainties
	Incidence	***Severity***	***Losses***			
Solanum tuberosum	% infected tubers (with visual symptoms) cv. Liseta: all (100%) cv. Primura: 'a relatively low number' (between 0 and 50%)	Cv. Liseta: numerous tubers showed brownish slightly sunken lesions around the eyes and soft rot (no description for cv. Primura tubers)	% tubers destroyed (same as infected, see incidence)	Outbreak in the Veneto region, Italy, 1995. Primary infection: potato seeds from the Netherlands. 25 fields contaminated; two cultivars involved (Liseta and Primura) Note: non-infected tubers were not destroyed but were sent for industrial processing	Turco et al., 1998	Relevant for tuber downgrading variation between cultivars There were eradication measures
S. tuberosum	30% tubers were infected at harvest (infected: positive at the test)	No data on symptom expression		Field experiment in the Netherlands. Testing efficacy of biological control methods for *R. solanacearum*	Messiha, 2007	Experimental field No data on symptom expression (were the positive tubers also symptomatic?)
S. tuberosum	% wilted plants (wilting index) 27% to 96% depending on the cultural practice			Field experiment in South Africa. Survival of *R. solanacearum* monitored in an artificially infested field over a five-year period. Four different cultural practices were applied prior to final potato planting	Stander et al., 2003	Experimental field Results about survival in soil in contradiction with other papers. Several European studies report much shorter survival times. Possibly because of presence of several weeds. Unclear why it survived so long
S. tuberosum	36%-70% farm plots infested			Bolivia, Chuquisaca region	Castillo and Plata, 2016	Country: Bolivia average altitude 2300 m above sea level (a.s.l.) average temperature: 11°C Only a reference
S. tuberosum	6.66 % positive tubers	No data on symptom		Bolivia, highland areas, 2013 1085 tubers sampled from 47	Castillo and Plata, 2016	Country: Bolivia average altitude: 3470 m a.s.l.

	Pathogen present in 75% of the municipalities (12 out of 16)	expression		randomly chosen locations (fields), representing 16 municipalities (all those above 3000 m)		average temperature: 8.3°C (<0°C during morning hours in winter). No data on symptom expression (were the positive tubers also symptomatic?) Missing data on farming practices
S. tuberosum	22% to 37% positive tubers (in 1992 and 1996 resp.)	No data on symptom expression		Venezuela, 1992-1996 Tubers of symptomatic and asymptomatic plants taken in a zig zag way going on diagonally	García et al., 1999	Country: Venezuela Altitude: 1167-3000 m a.s.l. Yield losses caused by three biovars, biovar 2 was 82% of the biovars
S. tuberosum	See Figure 34. Number of farms with brown rot infection in the Netherlands from season 1994/1995				NVWA, 2010	
Solanum lycopersicum	% wilted plants at the time of observation: 10-45% (probably lowest/highest parish)			Louisiana, 2015. During spring and fall, bacterial wilt was observed on commercially produced tomato plants in three parishes in southern Louisiana (LA), both in fields and greenhouses	Jimenez Madrid et al., 2016	No more details
S. lycopersicum, Solanum melongena, Capsicum			'up to 100% plant loss' (not clear)	Georgia outbreak (2010). Greenhouse and fields. June of 2010: wilt disease affecting tomato seedlings reported by farmers in Chkhorotsku region, Western Georgia, causing up to 100% plant loss (greenhouses and fields) Anecdotal reports suggested that eggplant and sweet pepper plants on farms in the same region were also infected	Mepharishvili et al., 2012	Anecdotal reports
S. melongena	Wilt incidence		The severely infected	Open fields. Survey conducted	Selastin	No details

	was sporadic		fields had 80 to 100% yield loss	during 2012–13 for the occurrence of bacterial wilt in eggplant (brinjal) in TamilNadu in southern India. Random survey at 3 locations in each district of TamilNadu, 5 farm fields from each location	Antony et al., 2015	
S. lycopersicum	The percentage of wilted plants ranged from 10 to 70%			Sardinia (Italy), 2007 outbreak Five greenhouses, 3 different tomato cultivars.	Loreti et al., 2008	No details
S. lycopersicum	% of wilted plants: 10%-50%			Sardinia (Italy), 2008 outbreak Four greenhouses, 1 tomato cultivar	Fiori et al., 2009	No details
S. lycopersicum, *S. melongena*, *Capsicum*			Total losses observed on susceptible varieties of tomato when planted in areas previously occupied by other *R. solanacearum* hosts. In new areas, losses reached 40%. Losses ≤ 10% on pepper varieties with good level of resistance and grown as protected cultivations. Losses >40% on eggplants	Amazonas state in Brazil	Coelho Netto et al., 2004	
S. lycopersicum	10-100% and 10.83-90.62% wilting at different stages of inoculation		Maximum loss 81.70%/91.06%, minimum 31.47%/36.88% (number and weight of fruits) recorded during summer/winter	Bangalore, India during summer (March-June, 1982), monsoon (July-October, 1982) and winter (November-February, 1982-83) seasons using a susceptible tomato variety	Kishun, 1987	

			seasons			
S. melongena	Incidence: 12-23% (resistant cultivars), 25-75% (susceptible), 75-90% (highly susceptible)			Fifteen different eggplant cultivars subjected to screening against bacterial wilt disease for 45 days under greenhouse conditions	Avinash et al., 2017	
S. melongena			0% loss (most tolerant genotype), 10.1%-19.3% loss (susceptible), 99% (most susceptible)		Oliveira et al., 2014	
Capsicum	Progeny: 38% - 67% wilted (year 1-2). Parental line: 10%-20% wilted			Susceptibility tested in two parental lines and a double haploid progeny. Naturally infested research field in Gouadaloupe, 2-year experiment	Lafortune and Béramis, 2005	
S. lycopersicum	Higher disease incidence (% wilted plants) in the untreated control (UTC). See Table 1 and Table 2 in the paper		Lower marketable yield in the untreated control (UTC). See Table 1 and Table 2 in the paper (estimate of disease incidence/ yield loss: compare the values for the untreated control with the highest value among the other treatments)	Two field experiments, 2006 and 2008. (Field infested 10 day prior to transplantation). Aim: to evaluate the effectiveness of thymol and acibenzolar- S-methyl to control bacterial wilt. Marketable/unmarketable yield determinted according to USDA standards	Hong et al., 2011	
S. lycopersicum	Higher disease incidence (% wilted plants) in the untreated control (see Table 1 in the paper for numbers)		Marketable yield (Table 1 and Table 3 in the paper); marketable fruit and fruit size (paper, Table 3) (Estimate of disease incidence/yield loss: compare "untreated" values with highest	Two field experiments, 2002 and 2003. Experimental naturally infested fields Aim: to evaluate the effectiveness of essential oils to control bacterial wilt	Ji et al., 2005	

			treated value)			
S. lycopersicum, Capsicum	Higher disease incidence for 'control (Rs)' See Table 7 in the paper (compare control (Rs) with the other treatments)			Pot experiment Aim: characterise the effectiveness of microbial antagonists isolated from soils. Tomato and capsicum seedlings planted into pots. Selected antagonists applied individually to pots	Nguyen et al., 2010	
S. lycopersicum	% wilting (see paper, Table 6)			Greenhouse experiment Aggressiveness of 19 randomly selected isolates on 6 tomato varieties	Ramsubhag et al., 2012	

Infected lots (in %) and total production area (in ha) for the years 2006 to 2015 for seed potatoes

	Infection rate of lots from annual survey											
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	abs (ha)	rel
Malta											0.00	0.00%
Portugal	0.000%	0.000%	0.000%	0.000%					0.000%	0.000%	9.10	0.01%
Slovenia	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	30.29	0.03%
Croatia							0.000%	0.000%	0.000%	0.000%	52.81	0.05%
Cyprus	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	75.11	0.07%
Lithuania	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	124.54	0.11%
Hungary	0.000%	1.402%	4.390%	0.000%	0.508%	0.000%	0.000%	0.524%	0.000%	0.000%	198.00	0.18%
Estonia	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	203.86	0.18%
Ireland	0.000%	0.140%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	238.00	0.21%
Bulgaria	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	254.15	0.23%
Italy	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	306.00	0.28%
Luxembourg		0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	338.41	0.30%
Greece	3.896%	0.840%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	339.13	0.31%
Latvia	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	354.11	0.32%
Slovakia	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	488.63	0.44%
Romania	0.000%	0.000%	0.000%	0.000%	0.215%	0.291%	0.219%	0.000%	0.000%	0.000%	713.18	0.64%

Sweden	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	945.60	0.85%
Finland	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	1014.70	0.91%
Austria	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	1508.95	1.36%
Spain	0.091%	0.000%	0.000%	0.000%	0.000%	0.114%	0.000%	0.000%	0.000%	0.000%	2257.15	2.03%
Belgium	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	2284.85	2.06%
Czech Republic	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	2854.90	2.57%
Denmark	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	4785.00	4.31%
Poland	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	5657.00	5.09%
United Kingdom	0.000%	0.000%	0.000%	0.160%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	14397.50	12.95%
Germany	0.000%	0.000%	0.000%	0.009%	0.000%	0.009%	0.000%	0.029%	0.000%	0.000%	15814.00	14.23%
France	0.000%	0.000%	0.012%	0.011%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	19314.00	17.38%
Netherlands	0.000%	0.009%	0.005%	0.004%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	36581.00	32.91%
EU AVERAGE	**0.014%**	**0.008%**	**0.011%**	**0.025%**	**0.002%**	**0.005%**	**0.001%**	**0.005%**	**0.000%**	**0.000%**		100.00%

Infected lots (in %) and total production area (in ha) for the years 2006 to 2015 for ware potatoes

	Infection rate of lots from annual survey											
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	abs (ha)	rel
Luxembourg		0.000%		0.000%						0.000%	185.13	0.01%
Malta		0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	701.00	0.05%
Slovenia	0.000%	0.000%	0.000%	0.000%	1.389%	3.279%	0.000%	0.000%	0.000%	0.000%	3280.00	0.23%
Cyprus	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	5000.00	0.35%
Slovakia	1.990%	2.703%	1.201%	1.880%	1.299%	0.000%	0.000%	0.000%	0.000%	0.000%	5506.35	0.38%
Estonia	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	5800.00	0.41%
Croatia							0.000%	0.000%	0.000%	0.000%	7500.00	0.52%
Ireland	0.000%	0.379%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	8567.00	0.60%
Bulgaria	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.441%	0.000%	11993.85	0.84%
Lithuania	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	15578.00	1.09%
Hungary	0.631%	3.768%	0.872%	1.667%	2.525%	2.500%	0.617%	5.202%	1.293%	1.395%	18000.00	1.26%
Austria	0.000%	0.000%	1.149%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	18859.00	1.32%
Czech Republic	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.128%	0.000%	0.000%	1.346%	19857.00	1.39%
Finland	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	21000.00	1.47%
Greece	0.826%	0.000%	0.000%	0.550%	0.233%	0.211%	0.000%	0.192%	0.322%	0.000%	21462.40	1.50%
Sweden	0.000%	0.000%	0.000%	1.227%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	23109.00	1.62%
Latvia	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	26445.84	1.85%
Portugal	7.519%	6.863%	0.758%	0.000%	5.674%	16.814%	0.000%	1.053%	1.653%	1.531%	27334.00	1.91%
Denmark	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	37174.00	2.60%

Italy	0.000%	0.000%	0.000%	0.000%	0.000%	0.493%	0.000%	0.000%	0.000%	0.000%	41026.00	2.87%
Romania	0.000%	0.000%	0.000%	0.000%	0.000%	0.127%	0.141%	0.000%	0.000%	0.000%	44388.11	3.10%
Spain	1.667%	1.042%	0.674%	2.267%	1.107%	1.280%	1.392%	0.312%	0.721%	1.818%	63816.26	4.46%
Belgium	0.000%	0.000%	0.073%	0.000%	0.000%	0.000%	0.000%	0.000%	0.078%	0.078%	78620.44	5.50%
United Kingdom	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	115202.00	8.05%
Netherlands	0.177%	0.000%	0.000%	0.037%	0.066%	0.237%	0.000%	0.000%	0.000%	0.000%	115657.00	8.09%
France	0.104%	0.000%	0.000%	0.101%	0.000%	0.111%	0.000%	0.112%	0.160%	0.000%	149500.00	10.45%
Germany	0.000%	0.035%	0.112%	0.000%	0.041%	0.000%	0.000%	0.000%	0.074%	0.000%	222444.00	15.55%
Poland	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.030%	0.012%	322305.00	22.53%
EU AVERAGE	**0.27%**	**0.24%**	**0.10%**	**0.17%**	**0.21%**	**0.47%**	**0.08%**	**0.11%**	**0.13%**	**0.15%**		100.00%

B.2 Summary on the evidence supporting the elicitation of the spread rate

Spread	**Additional information**	**Reference**
Natural spread (slow and short-range)	The natural spread of *R. solanacearum* is usually limited and slow. Root-to-root spread of the bacterium has been recorded (Kelman and Sequeira 1965), but there is little evidence of long-distance spread from field to field.	VKM, 2010
Machinery	The pathogen can survive for a few days up to several months on materials such as iron and rubber (Janse et al., 1998).	Janse et al., 1998
Machinery	On some farms where infected lots of this local variety had been introduced a few other varieties were found infected, usually in a latent form, indicating machinery contact.	Janse et al., 1998
Spread via machinery, seed and irrigation water	The 1995 outbreak in The Netherlands was confined to a large extent to a heavy infection in some clonal lines of the local cv. Bildtstar, that spread via these clonal lines (seed lots) and contact (agricultural machinery, etc.). Since a number of infections could not be traced back to contact or seed, the involvement of surface water was suspected and proven true by the end of 1995 in surface water and bittersweet in different parts of the country. (Netherlands outbreak, 1995)	Janse et al., 1998
Irrigation with contaminated water	A detailed mapping was done of the distribution of the pathogen in UK waterways. In the UK, a total of 5 outbreaks have occurred since 1992. All five outbreaks of the disease were associated with the use of contaminated river water for irrigation. (UK outbreak)	Elphinstone, 2001
Irrigation with contaminated river water	Outbreaks associated to river water and *S. dulcamara* previously implicated as sources of the pathogen. Authors highlight the role of reservoir of *S. dulcamara*.	Parkinson et al., 2013
Relative weight of infection source: 86% irrigation, 9% direct contact	For each of the infected lots, the most likely infection source was identified. For year 1995, irrigation with contaminated water was the presumed source of infection of 86% of the infected lots; contact with another infected lot was the source of infection for 9% of the lots. (Netherlands outbreak, 1995)	Schans and Steeghs, 1998

Long-range spread in surface waters	Surface water is likely to have been contaminated by *R. solanacearum* before 1992. Primary infection: one seed-potato lot was presumably infected by irrigation and gave rise to many infected offspring by 1995. The infestation probably spread geographically during those years, as indicated by the increase in the number of infected lots originating from this region over the period 1993/1995. In two other distinct areas, one seed-potato lot was presumably infected in 1993. In the other three areas, the presumed infection by surface water dates back to 1995. (Netherlands outbreak, 1995)	Schans and Steeghs, 1998
Pathogen in water and in *Solanum dulcamara*	Extensive survey in 1996: 5% of the water samples were found to be positive for the pathogen. Bacterium also was found in *S. dulcamara* growing with its roots in surface water. The findings suggest that most probably all infections in the Netherlands originated from irrigation with contaminated surface water. (Netherlands post-outbreak, 1996)	Janse et al., 1998
Primary infection	Infection of potato production by use of contaminated surface water is, despite the ban, an important factor explaining the few infections still occurring in the Dutch production chain.	VKM, 2010
Negative result: no spread within 3-km radius	Netherlands, 1992. Brown rot found in an isolated ware potato field in the SE. A survey on 23 potato fields in a 3-km radius of the contaminated farm did not yield any further findings of brown rot.	Janse et al.,1998
Geographical maps of spread in contaminated water	Figure 6 in the paper. Distribution of *Ralstonia solanacearum* in surface water, as determined over the years by intensive monitoring. The maps clearly demonstrate how the bacterium has spread to a large area (from 1997 to 2005). (Netherlands post- outbreak, 1997-2005)	Janse, 2012
Tomato. Spatial scale of secondary infection in the field: between 0.7-1.8 m, approximately	Eastern Shore of Virginia, 2006–2008. Four research trials over three growing seasons (naturally infested commercial fields). Aim: to determine the temporal and spatial distribution of bacterial wilt. Plants assessed for wilt incidence at 1-week intervals. Significant clustering observed within rows but not between rows: plant spacing was 2 ft within rows and whereas 6 ft across the rows	Wimer et al., 2011

B.3 Summary on the evidence supporting the elicitation of the time to detection

Reference	**Case**	**Aspect**	**Results / evidence**
Detection methods			
EU Council control directive 98/57/EC Commission Directive 2006/63/EC		Mandatory surveys	Member States are obliged to conduct targeted official surveys for *R. solanacearum* on potatoes, wild solanaceous host plants and surface water used for irrigation or spraying
EPPO, 2011		Effects on detectability	Visual inspection alone is inadequate for disease detection
EPPO, 2018		Effects on detectability	Official standards for detection in asymptomatic material are available
EPPO, 2018		Effects on	Visual detection of disease “by cutting”: rapid presumptive diagnostic tests to identify *R. solanacearum*

		detectability	
Host conditions during the period of potential detection			
EPPO, 2018		Effects on detectability	Foliar symptoms at the beginning include rapid wilting of leaves and stems, usually first visible in single stems at the warmest time of day
EPPO, 2018		Effects on detectability	Foliar symptoms as the disease develops: a streaky brown discoloration of the stem may be observed on stems above the soil line, and the leaves may have a bronze tint
EPPO, 2018		Effects on detectability	External symptoms on tubers may or may not be visible, depending on the state of development of the disease. Infection eventually results in bacterial ooze emerging
EPPO, 2018		Effects on detectability	External symptoms may be confused with those of ring rot due to *Clavibacter michiganensis* subsp. *sepedonicus*
Janse et al., 1998	Cultivar	Effects on detectability	Presence of visual symptoms (latent infection) depends on the cultivar. (Netherlands outbreak, 1995)
Schans and Steeghs, 1998		Effects on detectability/incidence	The bacterium spread for 3 years before detection (Netherlands outbreak, 1995)
Schans and Steeghs, 1998		Effects on detectability	Only 9% of newly infected lots had visual symptoms; after 3 production cycles, 100% visual symptoms. (Netherlands outbreak, 1995)
Turco et al., 1998	Cultivar	Effects on incidence	Symptoms 1-2 months before harvest: large disease patches (susceptible cultivar) or just a few symptomatic plants (less susceptible cultivar). (Veneto outbreak, 1995)
Turco et al., 1998		Effects on detectability	Planting: end of January-end of March. Symptomatic plants detected by the end of May. (Veneto outbreak, 1995)
Biology of the pest			
van Elsas et al., 2000	Population dynamics	Effects on detectability	Pathogen in soil in latent form for 1 year
Shamsuddin et al., 1979	Population dynamics	Effects on detectability	Survival in bare- or weed-fallowed soil: up to 2 years under temperate conditions
Graham et al., 1979	Population dynamics	Effects on detectability	Survival in soil: up to 4 years
Graham et al., 1979	Population dynamics	Effects on detectability	Survival in debris: up to 32 weeks
Hayward, 1991		Effects on incidence	Synergistic interaction between *Meloidogyne* spp. and *R. solanacearum* on a variety of hosts