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Synchytrium endobioticum
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 *Synchytrium endobioticum*, the following documents were used as key references: the EFSA pest categorisation (EFSA PLH Panel, 2018) and the pest survey card (EFSA, 2019b).

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[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

Synchytrium endobioticum, the soil-borne fungal pathogen causing potato wart disease, is a single taxonomic entity, for which about 40 pathotypes have been reported in Europe. Among the identified pathotypes, 2(G1), 6(O1), 8(F1), and 18(T1) are the most aggressive and widely distributed (EFSA, 2019b). Its winter sporangia can remain viable in soil for a long time (in extreme cases up to 40–50 years, e.g. Przetakiewicz, 2015, much shorter in frequently cultivated land), causing, under favourable conditions, disease reoccurrence even from a single sporangium (EFSA PLH Panel, 2018). The most favourable conditions for development of the disease are wet and cool soil during tuber development: cool summers with average temperatures below 18°C (although outbreaks have been reported at higher summer temperatures from South-Eastern Europe, e.g. EPPO 2017 and 2018), winters with temperature below 5°C for approximately 160 days and annual precipitation above 700 mm (EFSA PLH Panel, 2018). Different pathotypes of the pathogen infect different potato varieties and some pathotypes have a wide range of hosts (potato varieties) (EFSA PLH Panel, 2018).

The typical symptoms of the disease are warts produced on tubers, stolons and in severely infected plants on stem bases. Because the symptoms often develop on plant organs below the ground the disease is rarely noticed before harvest (EFSA, 2019b; EFSA PLH Panel, 2018).

2.2. Host plants

2.2.1. List of hosts

In natural conditions, the major host of *Synchytrium endobioticum* is *Solanum tuberosum* (cultivated potato).

Under experimental conditions, *S. endobioticum* can infect the roots of *Solanum lycopersicum* (tomato) and other species of the Family Solanaceae, such as *Capsicastrum nanum, Datura* sp., *Duboisia* sp., *Hyoscyamus* sp., *Lycium* sp., *Nicandria* sp., *Nicotiana* sp., *Schizanthus* sp., *Physalis franchetii*, and *Solanum dulcamara* without inducing wart formation (Hampson, 1976, 1979 and 1986; Hampson and Haard, 1980; CABI, 2018; EPPO, online).

Appendix A provides the full list of hosts.

2.2.2. Selection of hosts for the evaluation

The major host of *Synchytrium endobioticum* is *S. tuberosum* and this is the only host on which disease symptoms are recorded. In Mexico the pest was also reported from wild species of *Solanum* spp. (EFSA PLH Panel, 2018).

2.2.3. Conclusions on the hosts selected for the evaluation

Only potatoes were assessed for impact because this is the only host on which disease symptoms are recorded in the EU.

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. *S. endobioticum*, originally from South America (Andean region), was introduced in Europe in the 1880s and into North America in the 1900s (EFSA, 2019b). EU outbreaks occurred in Austria (eradicated), Bulgaria (restricted distribution), Czech Republic (restricted distribution), Denmark (few occurrences), Estonia (restricted distribution), Finland (few occurrences), France (eradicated), Germany (restricted distribution), Greece (few occurrences), Hungary (eradicated), Ireland (restricted distribution), Italy (restricted distribution), Latvia (eradicated), Lithuania (no longer present), Luxembourg (restricted distribution), the Netherland (few occurrences), Poland (few occurrences), Portugal (eradicated), Romania (restricted distribution), Slovakia (restricted distribution), Slovenia (eradicated), Sweden (restricted distribution), UK (restricted distribution, a part from Northern Ireland, where it was eradicated).

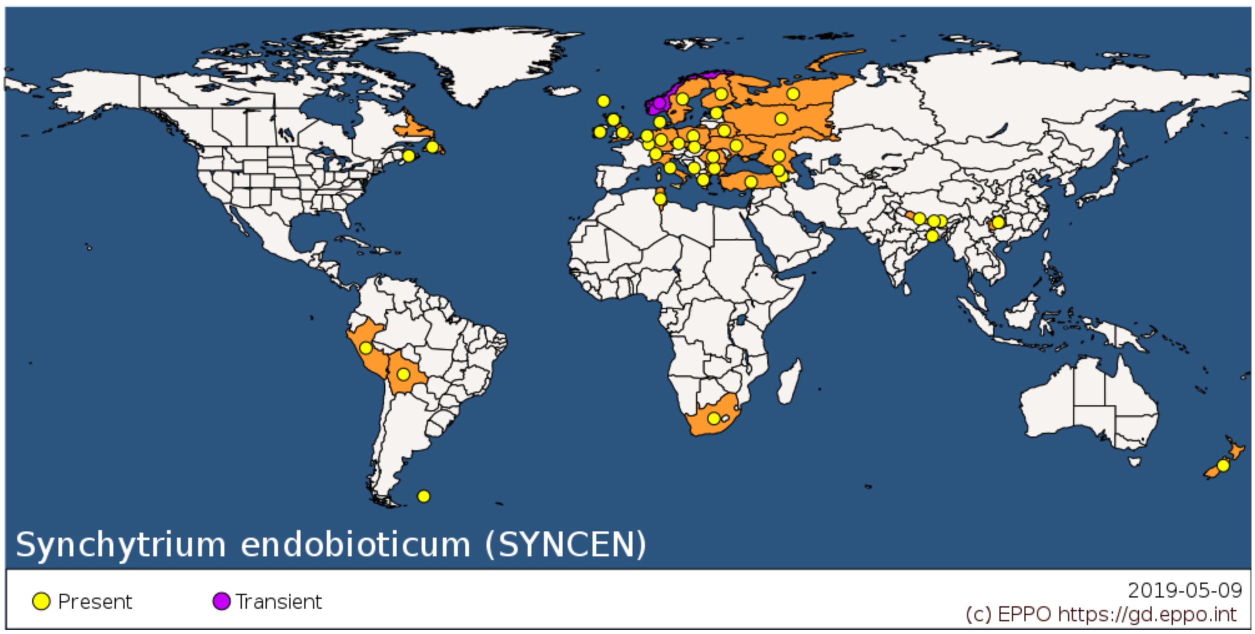

Figure 1 Distribution map of *Synchytrium endobioticum* from the EPPO Global Database accessed 09/05/2019.

2.3.2. Area of potential establishment

Potatoes are widely grown in the EU territory (Figure 2) and *S. endobioticum* may potentially establish wherever potato is grown in the European Union (EFSA, 2019b; EFSA PLH Panel, 2018).

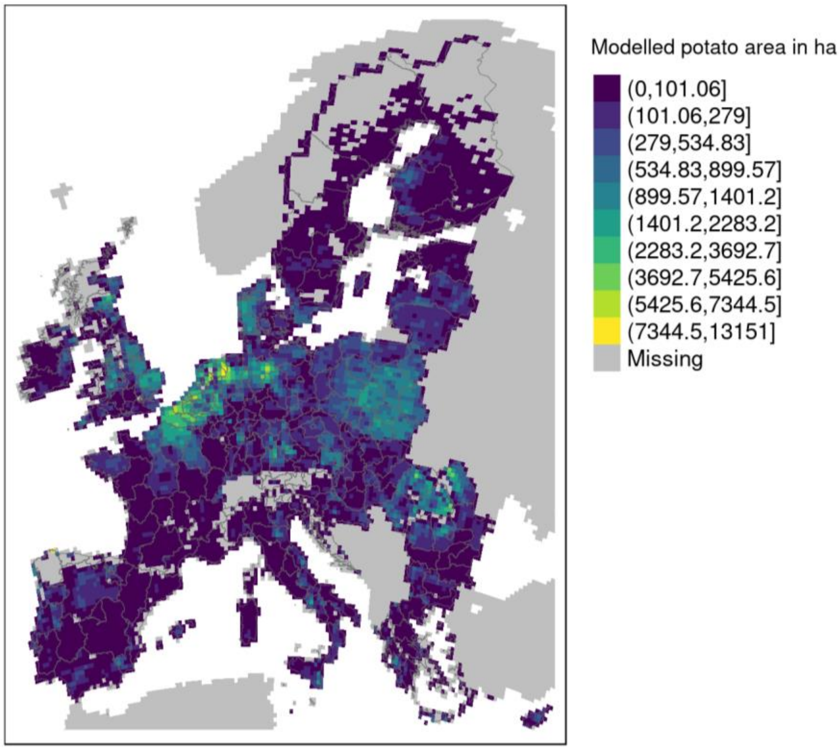

Figure 2 Map on estimated area of potato production in the EU (based on JRC "Yearly modeled crop area in EU-28 at grid level" with categories following "jenks" algorithm http://agri4cast.jrc.ec.europa.eu/DataPortal/Index.aspx)

2.3.3. Transient populations

Synchytrium endobioticum 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

All the current area of production of potato in the EU is considered to be suitable for *S. endobioticum* and was therefore used as the area of potential distribution in this assessment (Fig. 3). The mean abundance of the pest, the main driver of the pest impact, is considered to be the same throughout the whole area of potential distribution.

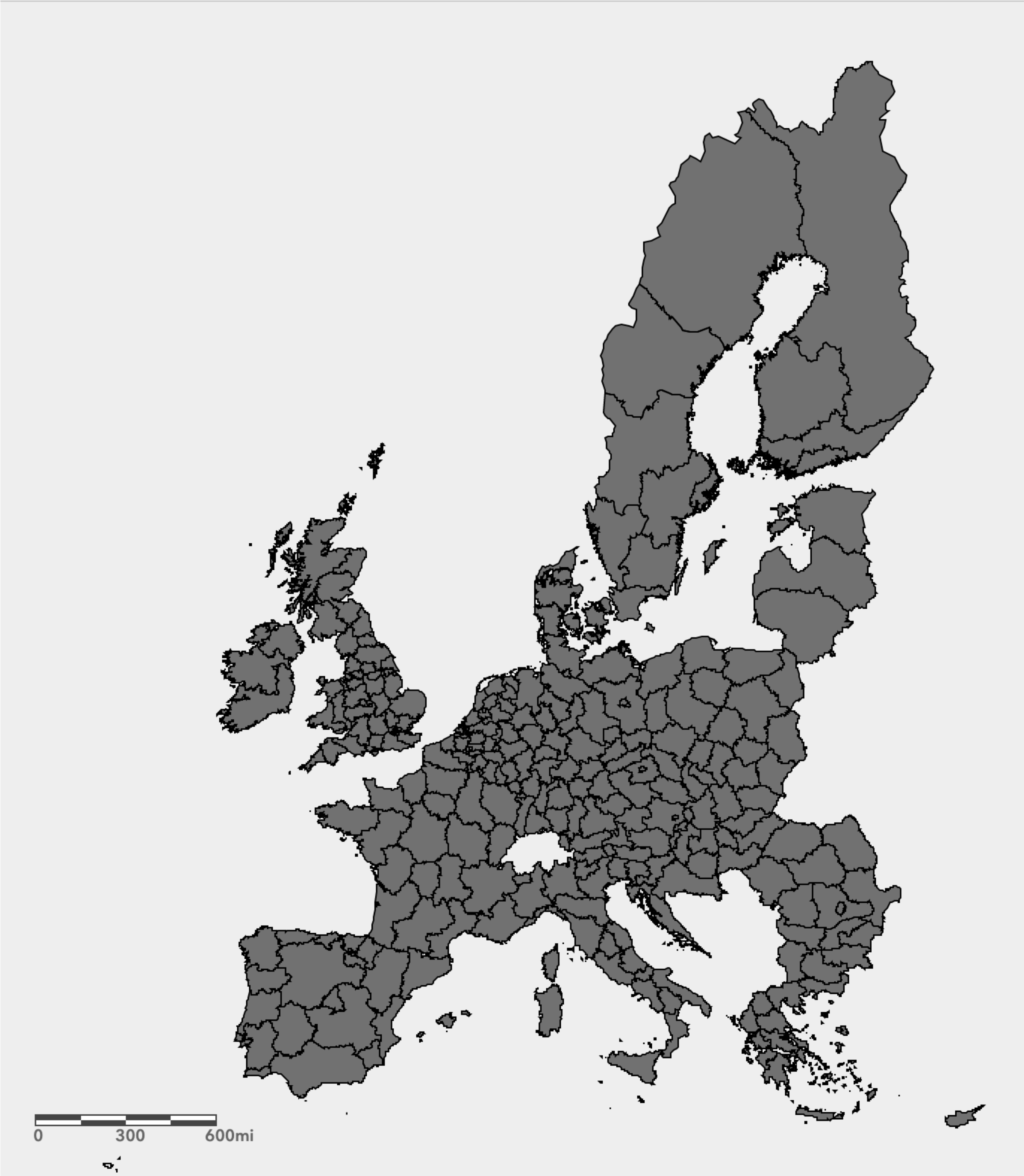

Figure 3 The potential distribution of the pest in the EU NUTS2 regions based on the scenarios established for assessing the impacts of the pest by the EFSA Working Group on EU Priority Pests (EFSA, 2019a). This link provides an online interactive version of the map that can be used to explore the data further: https://arcg.is/0viiyr

2.4. Expected change in the use of plant protection products

It is impossible to eliminate the pest in the soil by chemical or physical means (Obidiegwu et al., 2014), infested fields cannot be used for potato production for more than 20 years after the detection of the pest (Ballvora et al., 2011).

Due to the seriousness of the pest, for more than 75 years, quarantine and domestic legislations have been in force throughout the world to prevent the pest from spreading.

In the EU, there are long term control measures against potato wart disease (Council Directive 69/464/EEC[3]) because potato production occupies an important place in the EU agriculture and *S. endobioticum* is considered one of the most harmful organisms to potatoes. Long term control measures exist also for certain other potato diseases (potato ring and brown rot, potato cyst nematode) that occur in some parts of the EU and pose a permanent risk to potato cultivation throughout the EU territory.
The Council Directive 69/464/EEC, which sets the long term measures for the control of potato wart disease, mainly concerns:

- the demarcation of the contaminated plots and a safety zone around it large enough to ensure the protection of surrounding areas, the prohibition of growing or storing in the contaminated plots potato plants or other plants intended for transplanting
- the cultivation of the safety zone only with potato varieties resistant to the *S. endobioticum* pathotype(s) present in the contaminated plot
- the obligation for Member States (MS) to communicate to the Commission before 1 January each year a list of all the potato varieties accepted by them for marketing and which they have found, by official investigation, to be resistant to *S. endobioticum* and they will state the pathotypes to which the varieties are resistant, and
- the possibility for MS-s to revoke the measures taken to control potato wart or to prevent its spreading only if *S. endobioticum* is no longer found to be present.

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 1: Expected changes in the use of Plant Protection Products (PPPs) following *S. endobioticum* establishment in the EU in relation to four cases (A-D) and three indicators (0-2)

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

[3] Council Directive 69/464/EEC of 8 December 1969 on control of Potato Wart Disease. OJ L 323, 24.12.1969, p. 1–2

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

- Different pathotypes distribution in EU area of production and prevalence at potato field level are not considered in the assessment.
- The effectiveness of the currently applied long term EU control measures is considered to lower the impact of an order of magnitude at least in comparison to conditions where measures are not applied.
- Lots with low symptoms expression could still be accepted therefore not included in the assessment
- Lots with heavy symptoms expression are considered as a full loss
- Quality loss is considered negligible and is therefore not included in the assessment

3.1.1.3. Selection of the parameter(s) estimated

The impact of *S. endobioticum* is assessed considering the long term average proportion (in %) of yield loss in potato production. The current cropping practices for potato production including the currently applied long term EU control measures.

Tubers affected by potato wart disease are not marketable, therefore quality loss is not considered in the assessment.

3.1.1.4. Defined question(s)

What is the percentage yield loss in potato production under the scenario assumptions in the area of the EU under assessment for *Synchytrium endobioticum*, 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 EKE on impact. The following general points were made:

- Data from EUROPHYT indicate an average of 4 outbreaks/year in the EU.
- Current quarantine measures reduce the risk of the pest.
- Baayen et al. (2005) observed an annual reduction of inoculum levels of 97–99% during cultivation of non-host species and for black fallow.
- However, the pest is difficult to detect and may remain undetected in the fields for many years.
- Pathotypes other than 1(D1) are present in the EU and many potato varieties are not resistant to these.
- The new pathotypes have proved to be more difficult to control and eradicate than 1(D1) (Baayen et al., 2006).

- Therefore, the currently negligible impact could increase in the future.

3.1.1.6. *Uncertainties identified*

- Resistant varieties are available especially against pathotype 1(D1). Resistance against other patotypes (if available) is less common (e.g. resistance against pathotypes 2(G1), 6(O1), 8(F1), and 18(T1)).
- The prevalence of the different pathotypes in the EU.
- Differences in agricultural practices in the area of production.
- Effect of climate of the pest prevalence and incidence in the area of production
- Survival period in the field in absence of host (5-50 years)
- Evidence about heavy losses (up to 100%) is obtained from observations in artificial condition therefore not reflecting the real conditions of potato fields.

3.1.2. Elicited values for yield losses

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

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

Table 2: The 5 elicited values on yield loss (%) on potato

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	0.3%	0.5%	1.0%	1.5%	2.5%

3.1.2.1. *Justification for the elicited values for yield loss on* ***potato***

Reasoning for a scenario which would lead to high yield loss (99th percentile / upper limit)
The upper value refers to a scenario in which:

- Host: potato varieties are only resistant to few pathotypes.
- Environment: weather can cause variation on the level of impact.
- Pest survival: when the pest reaches the field, it can survive for many years in absence of a host.
- Pest prevalence: extreme circumstances that would produce 100% losses are considered extreme and unlikely to happen at large scale.
- Pest incidence: The highest incidence observed in experimental conditions is unlikely to reach the 100% loss.
- Pest severity: A high level of field infestation does not necessarily imply high yield losses.

Reasoning for a scenario which would lead to low yield loss (1st percentile / lower limit)
The lower value refers to a scenario in which:

- Host: majority of growers use (partially) resistant varieties against the most commonly occurring pathotypes in the EU.
- Environment: adverse weather conditions can limit the level of impact.

- Hosts availability influences the spatial epidemic: not all the fields are affected, not all plants are affected in a field and resistant varieties are available.

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

The central (media) value refers to a scenario in which

- Host: most of the commercially grown potato varieties are susceptible to some pathotypes.
- Environment: the climatic conditions are not equally suitable in the different EU areas (e.g. Northern vs Mediterranean countries) and the final impact could therefore be highly variable.
- Pest survival: although the pest can survive for many years in soil, inoculum levels are expected to decrease between 2 potato crops.
- Some potato varieties are effectively resistant to the pest.

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

The level of uncertainty is equal in relation to lower and upper limit. No precise knowledge about the median value.

3.1.2.2. Estimation of the uncertainty distribution for yield 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 3: Fitted values of the uncertainty distribution on the yield loss (%) on potato

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	0.3%					0.5%		1.0%		1.5%					2.5%
Fitted distribution	0.1%	0.1%	0.2%	0.3%	0.5%	0.6%	0.7%	1.0%	1.3%	1.5%	1.7%	2.0%	2.3%	2.6%	2.9%

Fitted distribution: Weibull(1.7482,0.012194), @RISK7.5

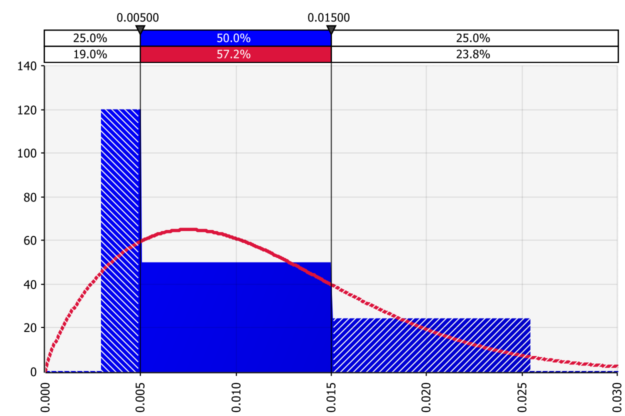

Figure 4 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on potato.

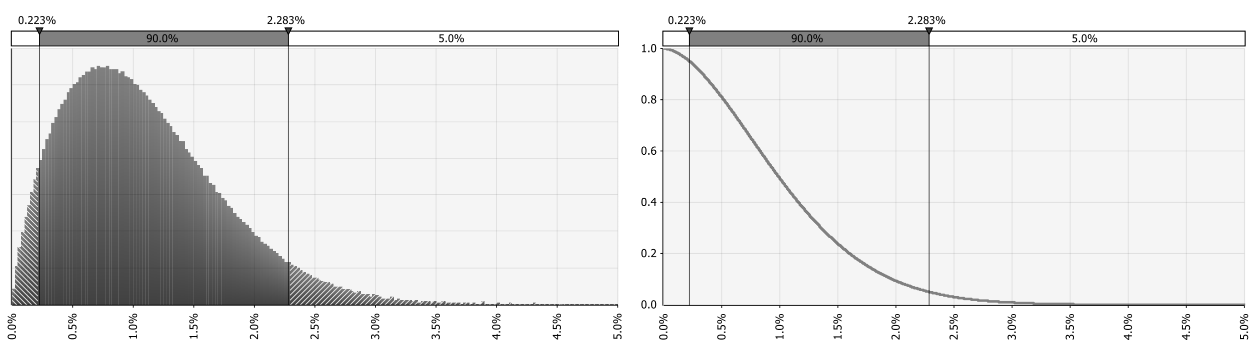

Figure 5 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on potato.

3.1.3. Conclusions on yield and quality losses

Based on the general and specific scenarios considered in this assessment, the proportion (in %) of yield losses is estimated to be 1.0% (with a 0.1% uncertainty range of 2.6%).

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

No specific assumptions are introduced for the assessment of the spread.

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.

3.2.1.6. Uncertainties identified

- The main mean of spread between fields is by human assistance (trade is excluded). The pest can be spread through movement of soil attached to non-host plants, shoes, and machineries.
- The machinery used for harvesting of potatoes by a group of producers can spread the pest for bigger distance.

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

Table 4: The 5 elicited values on spread rate (m/y)

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	50	200	400	1,000	2,000

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 scenario for the upper value refers to long distance spread due to the movement of machinery used by many producers, therefore spreading the pest between fields. The agreed value considers an estimation of the average distance between fields. Dilution effect of moving between the fields was also considered.

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

The scenario for the lower value considers that the major contribution to the spread is due to the spread within the field using machinery (spores will drop down from machinery during movement before the machinery reaches next field).

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

The scenario for the median considers the average of situation of spread within and between the fields, therefore it reflects the average situation for the distance of machinery movement including the dilution effect (spores will drop down from machinery during movement before the machinery reaches next field).

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

The precision reflects the uncertainty about the maximum distance of machinery movement which is the main means of spread.

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 5: 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	50					200		400		1,000					2,000
Fitted distribution	48	53	64	90	130	190	259	436	698	888	1,161	1,508	1,986	2,467	3,109

Fitted distribution: Gamma(0.84115,724.16,RiskShift(45)), @RISK7.5

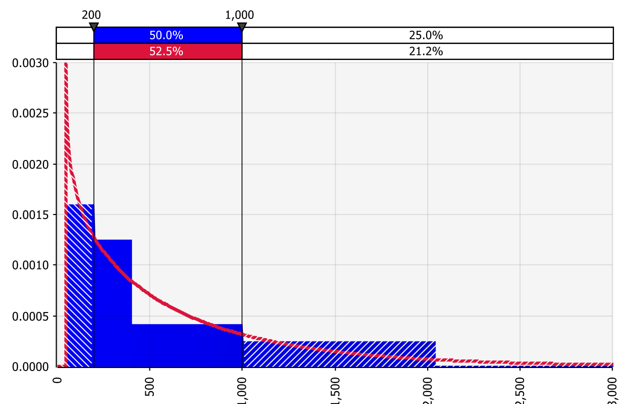

Figure 6 Comparison of judged values (histogram in blue) and fitted distribution (red line) for spread rate.

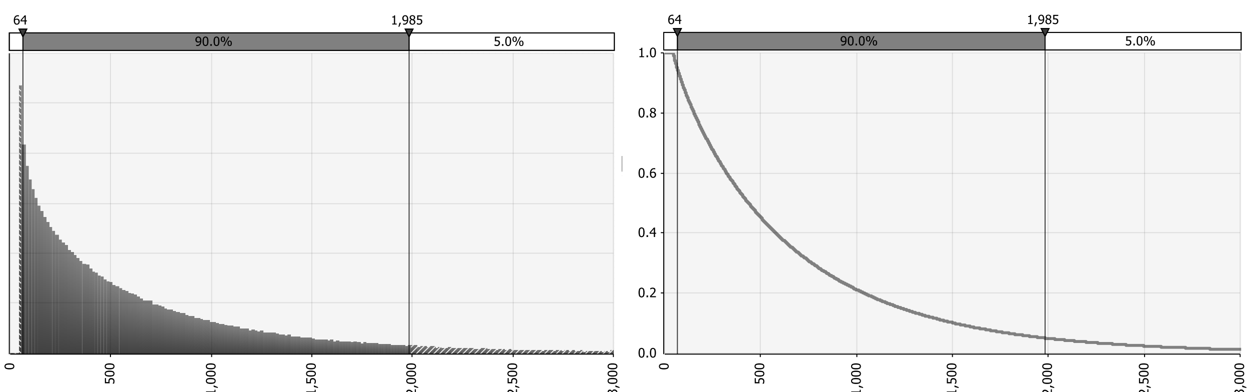

Figure 7 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for spread rate.

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 *S. endobioticum* is 400 m (with a 95% uncertainty range of 53 – 2,467 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 years 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

- Symptoms hardly noticeable on the above ground portion of the plant: risk of overlooking the pest by visual inspection (EFSA, 2019b)

3.3.1.6. Uncertainties identified

- Symptoms (warts on tubers) are visible but similar to other diseases and requiring a final lab confirmation (EFSA, 2019b).

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

Table 6: The 5 elicited values on time to detection (months)

Percentile	1%	25%	50%	75%	99%
Expert elicitation	12	40	70	90	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 of 120 months is based on a scenario in which the inoculum levels will be low and conditions in large parts of the EU may be unfavourable or development (including resistant varieties) of the pathogen so the level of infestation is expected to be low. The decline of inoculum level during first year of infestation is observed. On resistant varieties the time for detection increases also due to the risk of not reporting by the growers. There is a risk of misidentification of visual symptoms. Compared to other pathogens such as *Clavibacter sepedonicus* and *Ralstonia solanacearum*, *S. endobioticum* is also easily spread by soil: the waste material at the farm could be an important inoculum source.

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

The scenario for the lower value of 12 months reflects the time needed for one growing season and the best case of having visible symptoms, which will be seen on tubers that are tested after harvest.

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

The median value is due to the fact that symptoms can be easily overlooked at low impact level and can be misidentified. The detection could require many productive cycles.

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

The pest could be introduced with the soil and survive undetected in the soil until the suitable crop is planted in the field, therefore the expected scenario is closer to the worst case.

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 7: 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	12					40		70		90					120
Fitted distribution	13	15	19	25	33	42	50	67	83	92	101	109	116	120	123

Fitted distribution: BetaGeneral(1.3061,1.3493,10,126), @RISK7.5

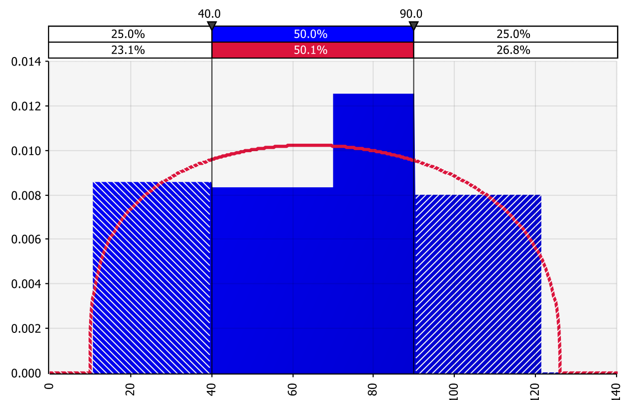

Figure 8 Comparison of judged values (histogram in blue) and fitted distribution (red line) for time to detection.

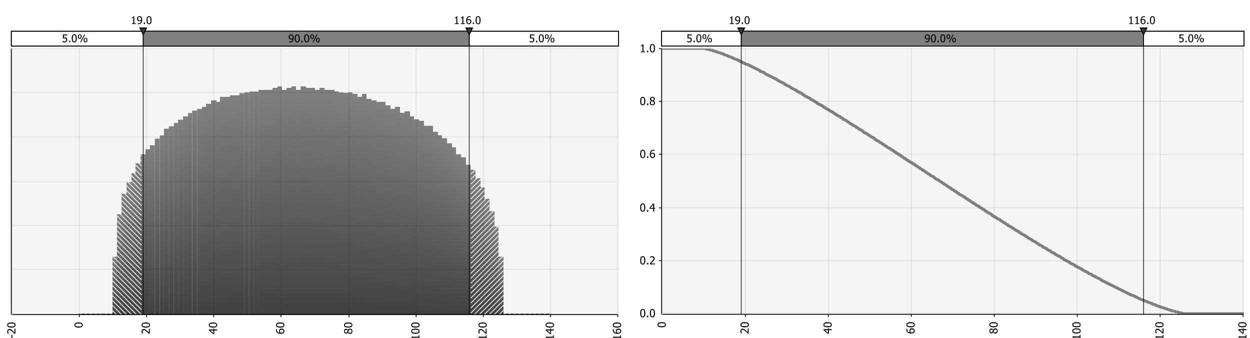

Figure 9 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for time to detection.

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 approximately 5.5 years (with a 95% uncertainty range of 1.25 - 10 years).

4. Conclusions

Hosts selection

Only potatoes were assessed for impact because this is the only host on which disease symptoms are recorded in the EU.

Area of potential distribution

All the current area of production of potato in the EU is considered to be suitable for *S. endobioticum* and was therefore used as the area of potential distribution in this assessment. The mean abundance of the pest, the main driver of the pest impact, is considered to be the same throughout the whole area of potential distribution.

Expected change in the use of plant protection products

Due to the fact that no effective treatments with plant protection products are currently available, the most suitable indicator is Case "A" and the category is "0".

Yield and quality losses

Based on the general and specific scenarios considered in this assessment, the proportion (in %) of yield losses is estimated to be 1.0% (with a 0.1% uncertainty range of 2.6%).

Spread rate

Based on the general and specific scenarios considered in this assessment, the maximum distance expected to be covered in one year by *S. endobioticum* is 400 m (with a 95% uncertainty range of 53 – 2,467 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 approximately 5.5 years (with a 95% uncertainty range of 1.25 - 10 years).

5. References

Baayen RP, Bonthuis H, Withagen JCM, Wander JGN, Lamers JL, Meffert JP, Cochius G, van Leeuwen GCM, Hendriks H, Heerink BGJ, van den Boogert PHJF, van de Griend P and Bosch RA, 2005. Resistance of potato cultivars to *Synchytrium endobioticum* in field and laboratory tests, risk of secondary infection, and implications for phytosanitary regulations. EPPO Bulletin, 35, 9–23.

Baayen R, Cochius G, Hendriks H, Meffert J, Bakker J, Bekker M, van den Boogert P, Stachewicz H, van Leeuwen G. 2006. History of potato wart disease in Europe—a proposal for harmonisation in defining pathotypes. European Journal of Plant Pathology, 116, 21–23.

Baker AH, Bell D, Bourgoin T, Brown L, Bulluck R, Floyd R, Goldner L, Hammerschmidt R, Hesvick S, Jess L, Johnson S, Kirk W, Lopez L, Perry S, Poe S, Secor G, Sheldon J, Smith K and Stevenson W, 2007. Recover plan for potato wart disease caused by *Synchytrium endobioticum* (Schilberszky) Percival. USDA APHIS, Beltsville, MD, USA. p. 23. Available from: https://www.ars.usda.gov/ARSUserFiles/opmp/PotatoWart70109.pdf (accessed on 11/05/2019)

Ballvora A, Flath K, Lübeck J, Strahwald J, Tacke E, Hofferbert H-R and Gebhardt C, 2011. Multiple alleles for resistance and susceptibility modulate the defense response in the interaction of tetraploid potato (Solanum tuberosum) with Synchytrium endobioticum pathotypes 1, 2, 6 and 18. Theoretical and Applied Genetics, 123, 1281-1292.

CABI (Centre for Agriculture and Bioscience International), 2018. Datasheet report for *Synchytrium endobioticum*. Crop Protection Compendium. Last modified: 15-11-2018. Available online: https://www.cabi.org/cpc/datasheet/43599

Efremenko TS and Yakovleva VA, 1981. Destruction of *Synchytrium endobioticum* (Schilb.) Perc. in waste products of the potato processing-industry. Mikologija i Fitopatologija, 15, 501–504.

EFSA (European Food Safety Authority), Baker R, Gilioli G, Behring C, Candiani D, Gogin A, Kaluski T, Kinkar M, Mosbach-Schulz O, Neri FM, Siligato R, Stancanelli G and Tramontini S, 2019a. Scientific report on the methodology applied by EFSA to provide a quantitative assessment of pest-related criteria required to rank candidate priority pests as defined by Regulation (EU) 2016/2031. EFSA Journal 2019;17(5):5731, 64 pp. https://doi.org/10.2903/j.efsa.2019.5731

EFSA (European Food Safety Authority), Schenk M, Camilleri M, Diakaki M, Schrader G and Vos S, 2019b. Pest survey card on *Synchytrium endobioticum*. EFSA supporting publication 2019:EN-1591. 20pp. doi:10.2903/sp.efsa.2019.EN-1591

EFSA PLH Panel (EFSA Panel on Plant Health), Jeger M, Bragard C, Caffier D, Candresse T, Chatzivassiliou E, Dehnen-Schmutz K, Gilioli G, Gregoire J-C, Jaques Miret JA, MacLeod A, Navajas Navarro M, Niere B, Parnell S, Potting R, Rafoss T, Urek G, Van der Werf W, West J, Winter S, Van Bruggen A, Vloutoglou I, Bottex B and Rossi V, 2018. Pest categorisation of Synchytrium endobioticum. EFSA Journal 2018;16(7):5352, 39 pp. doi:10.2903/j.efsa.2018.5352

EPPO (European and Mediterranean Plant Protection Organization), online. EPPO Global Database. Available online: https://gd.eppo.int/ [Accessed: 31 January 2019]

EPPO (European and Mediterranean Plant Protection Organization), 2017. First report of *Synchytrium endobioticum* in Greece. EPPO Reporting Service no. 06 - 2017 Num. article: 2017/121.

EPPO (European and Mediterranean Plant Protection Organization), 2018. *Synchytrium endobioticum* detected in Romania. Reporting Service no. 11 - 2018 Num. article: 2018/226.

Franc GC, 2007. Potato wart. The American Phytopathological Society. Accessed on 29.05.2019. Available online: https://www.apsnet.org/edcenter/apsnetfeatures/Pages/PotatoWart.aspx

Hampson MC, 1976. Infection of additional hosts of *Synchytrium endobioticum*, the causal agent of potato wart disease: I. Tomato. Canadian Plant Disease Survey, 56, 93–94.

Hampson MC, 1979. Infection of additional hosts of *Synchytrium endobioticum*, the causal agent of potato wart disease: 2. Tomato, tobacco and species of *Capsicastrum*, *Datura*, *Physalis* and *Schizanthus*. Canadian Plant Disease Survey, 59, 1–3.

Hampson MC, 1986. Sequence of events in the germination of the resting spore of *Synchytrium endobioticum*, European pathotype 2, the causal agent of potato wart disease. Canadian Journal of Botany, 64, 2144–2150.

Hampson MC, 1993. History, biology and control of potato wart disease in Canada. Canadian Journal of Plant Pathology, 15, 223-244.

Hampson MC, 1996. A qualitative assessment of wind dispersal of resting spores of *Synchytrium endobioticum*, the causal agent of wart disease of potato. Plant Disease, 80, 779–782.

Hampson MC and Coombes JW, 1985. Stress and stimulus modifications of disease severity in the wart disease of potato. Phytopathology, 75, 817–820.

Hampson MC and Coombes JW, 1989. Pathogenesis of *Synchytrium endobioticum*: 7. earthworms as vectors of wart disease of potato. Plant and Soil, 116, 147–150.

Hampson MC and Haard NF, 1980. Pathogenesis of *Synchytrium endobioticum*: 1. Infection responses in potato and tomato. Canadian Journal of Plant Pathology, 2, 143–147.

Hampson MC, Wood SL, and Coombes JW, 1996. Detection of resting spores of *Synchytrium endobioticum* in soil from vehicles at Port-aux-Basques, Newfoundland. Canadian Journal of Plant Pathology, 18, 59–63.

Hartman RE and McCubbin WA, 1924. Potato wart. Pennsylvania Department of Agriculture Bulletin, 394, 28 pp.

Khiutti A, Afanasenko O, Antonova O, Shuvalov O, Novikova L, Krylova E, Chalaya N, Mironenko N, Spooner DM and Gavrilenko T, 2012. Characterization of resistance to *Synchytrium endobioticum* in cultivated potato accessions from the collection of Vavilov Institute of Plant Industry. Plant Breeding, 131, 744–750.

Obidiegwu JE, Flath K and Gebhardt C, 2014. Managing potato wart: a review of present research status and future perspective. Theoretical and Applied Genetics, 127, 763–780.

Przetakiewicz J, 2015. The viability of winter sporangia of *Synchytrium endobioticum* (Schilb.) Perc. from Poland. American Journal of Potato Research, 92, 704–708.

Steinmöller S, Bandte M, Büttner C and Müller P, 2012. Effects of sanitation processes on survival of *Synchytrium endobioticum* and *Globodera rostochiensis*. European Journal of Plant Pathology, 133, 753–763.

Ünlenen LA and Çalışkan ME, 2014. Screening some potato cultivars and breeding lines for resistance to potato wart disease under field conditions. 19th Triennial Conference of the European Association for Potato Research, 6-11 July, Brussels, 174

Weiss FE and Brierley P, 1928. Factors of spread and repression in potato wart. Technical Bulletin 56, USDA, Washington DC. 13 pp.

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**
Solanum	
Solanum	*tuberosum*

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***			
Potatoes	Infection in presence of earthworms and water stress 69-78% at single stress regime			Canada Experiment	Hampson and Coombes, 1985	The watering regime affects disease incidence and severity
Potatoes	Badly infested soil		100%	Loss of potential tuber yield including loss in storage.	Hampson, 1993	
Potatoes			The economic impact of this disease is not from direct losses but from loss of international trade markets, long-term quarantines, and regulatory restrictions imposed in presence of outbreaks		Baker et al., 2007; Franc, 2007	
Potatoes	% infested tubers in three different populations Max variability observed on cv Alma from 3 populations: - Belarus: 44% infected tubers - Ukraine: 62% infected tubers - Moscow: 79% infected tubers			Russia Experiment on pathotype D1	Khiutti et al., 2012	
Potatoes	0,0% to 8,4% depending on cv 0,0 to 12,0% depending on family			Study on varietal resistance from Turkey	Ünlenen and Çalişkan, 2014	

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

Spread	Additional information	Reference
9-25 cm	Earthworms can disseminate of *S. endobioticum*	Hampson and Coombes, 1989
Limited capacity for spread	Resting sporangia dispersed by wind-blown soil or by flowing surface water.	Hampson, 1993, 1996; Obidiegwu et al., 2014
	Machinery, vehicles	Hampson et al., 1996; Obidiegwu et al., 2014
	Wastes used as fertilizers	Efremenko and Yakovleva, 1981; Steinmöller et al., 2012
	Irrigation water and dust from wart infested fields	Obidiegwu et al., 2014
75 cm	Water currents could increase the range of spore movement down a slope to about 75 cm	Hampson, 1993
	Animal manure	Hartman and McCubbin, 1924; Weiss and Brierley, 1928

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

Case	Results / evidence	Reference
detection	detected early in a seed field because in the early seed generations the potatoes are checked individually	Baker et al., 2007
detection	detection and identification of *S. endobioticum* on potato plant material is only possible by laboratory examination	Franc, 2007
Symptoms expression	small warts appear on artificially inoculated potato tubers after 4-5 weeks incubation in the dark, at temperatures 16-18^{0}C and high relative humidity (at least 85-90%).	EFSA PLH Panel, 2018
Symptoms expression	As symptoms most often appear on below ground plant parts (stolons, tubers), the disease is often not noticed before harvest	EFSA PLH Panel, 2018