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Clavibacter michiganensis subsp. *sepedonicus* 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, 2019). 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 *Clavibacter michiganensis* subsp*. sepedonicus* the following documents were used as key references: the EPPO standards for the diagnostic protocol (2006) and for the national regulatory control system (2011) and the EFSA survey card (EFSA, 2019c).

[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

Clavibacter michiganensis subsp. *sepedonicus* is a single taxonomic entity, recently reclassified by Li et al. (2018) *Clavibacter sepedonicus* comb. nov. As only the name changes but not the taxonomic entity, in this document the pest is still referred to as *Clavibacter michiganensis* subsp. *sepedonicus*. *Clavibacter michiganensis* ssp. *sepedonicus* (Cms) is a Gram-positive aerobic bacterium that causes bacterial ring rot in potatoes. In the field the bacterium causes wilting, chlorosis, necrosis and collapse of the plant. As the disease progresses, the tubers' tissue becomes soft and cheesy in texture. As the rot progresses, surface cracks and dark blotches immediately beneath the periderm may become visible (Van der Wolf et al., 2005). The development of the disease is favoured by high temperatures at the end of the growing season and depends on the susceptibility of the cultivar (Van der Wolf et al., 2005).

The bacterium enters the plant through wounds especially when the machines used for harvesting are contaminated (Robert, 2013). The bacterium is unlikely to spread from one plant to another in the field, but it can spread from one tuber to another by physical contact or tubers can become contaminated by, for example, the use of contaminated machinery and containers (Robert, 2013).

2.2. Host plants

2.2.1. List of hosts

The host plants for Cms are potato, tomato and eggplant and some solanaceous weeds (Van der Wolf et al., 2005). The bacterium only causes disease problems in potatoes (Van der Wolf., 2005). Slack (1987) considered potatoes as the only natural host for Cms.

Appendix A provides the full list of hosts.

2.2.2. Selection of hosts for the evaluation

Among the solanaceous hosts of economic importance the bacterium only causes disease problems in potatoes (Van der Wolf., 2005).

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.

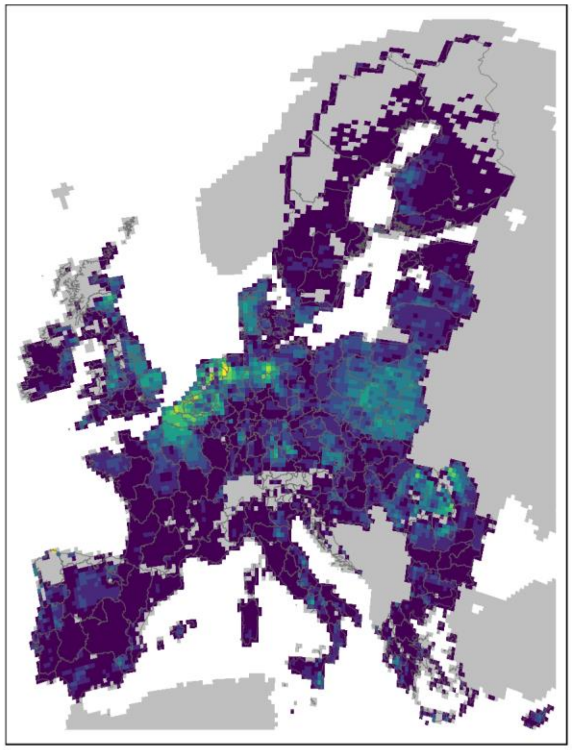

Figure 1 Map of the estimated area of potato production in the EU (based on JRC "Yearly modeled crop area in EU-28 at grid level" at http://agri4cast.jrc.ec.europa.eu/DataPortal/Index.aspx with categories following "jenks" algorithm).

2.3. Area of potential distribution

2.3.1. Area of current distribution

Figure 2 provides an overview of the current area of distribution of the pest. EU outbreaks occurred in Austria (eradicated), Belgium (eradicated), Bulgaria (few occurrences), Cyprus (eradicated), Czech Republic (restricted distribution), Denmark (eradicated), Estonia (restricted distribution), Finland (restricted distribution), France (eradicated), Germany (few occurrences), Greece (restricted distribution, except for Crete where it is widespread), Hungary (few occurrences), Latvia (restricted distribution), Lithuania (restricted distribution), the Netherland (under eradication), Poland (restricted distribution), Romania (restricted distribution), Slovakia (few occurrence), Spain (few occurrences), Sweden (restricted distribution), UK (eradicated).

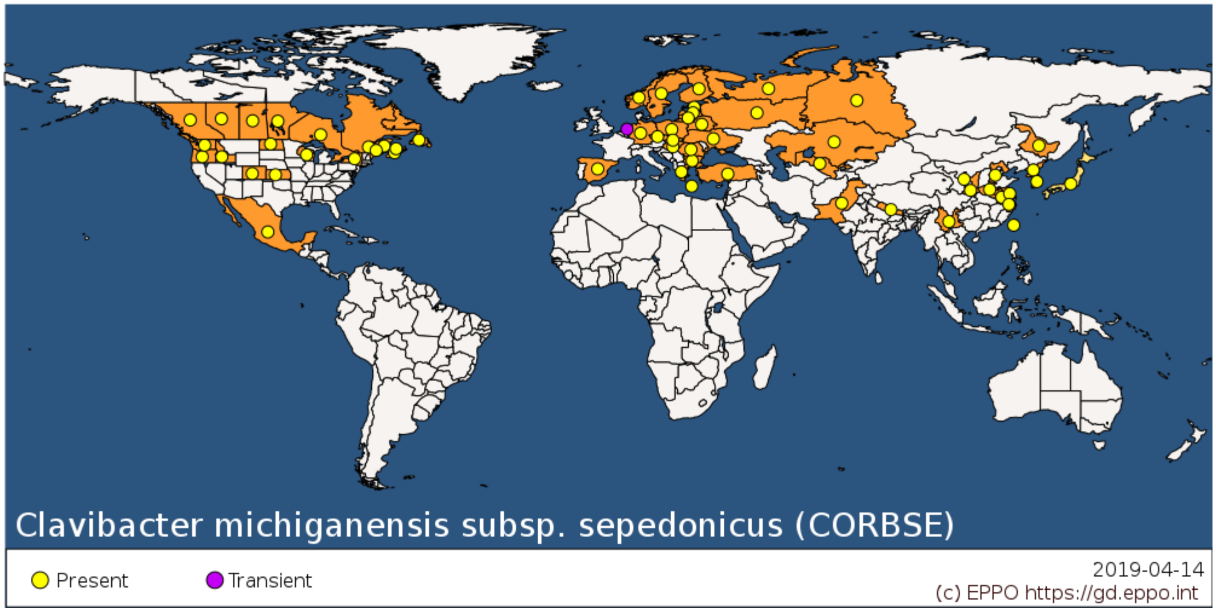

Figure 2 Distribution map of *Clavibacter michiganensis* subsp. *sepedonicus* from the EPPO Global Database accessed 14/04/2019.

2.3.2. Area of potential establishment

The optimum temperature for Cms growth is about 20-23 °C, these temperatures stimulate infection development and symptoms expression, but the survival in field conditions is facilitated by lower temperature (Van der Wolf et al., 2005; Pietraszko et al., 2018).

Experiments in greenhouses showed that symptoms appeared earlier at 22-35°C than at 16-18°C or 4°C (Van der Wolf et al., 2005). Climate chamber studies showed that symptoms appeared earlier at 24°C for 24h compared to 24°C for only 12h followed by 5°C for the next 12h (Van der Wolf et al., 2005). The fastest disease development was observed at soil temperatures of 18-22°C; at temperatures of 26-30°C disease progress was delayed (Van der Wolf et al., 2005).

Furthermore, Cms can only survive in soil over 1 year at low temperatures, when the temperature increases to 15°C, the bacteria can only survive for a few weeks. The persistence of Cms in soil is influenced by the soil type (Van der Wolf et al., 2005).

Cms can persist for long periods (>2 years) on the surface of different materials, especially in low humidity (<10%) and in temperature below 10°C, while under higher temperatures (> 15 °C) and a high humidity (> 50% field capacity) the decline is rather fast (months) (van der Wolf et al., 2005).

2.3.3. Transient populations

Clavibacter michiganensis subsp. *sepedonicus* 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 *C. michiganensis* subsp. *sepedonicus* 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 pest impact, is considered to be the same throughout the area of potential distribution.

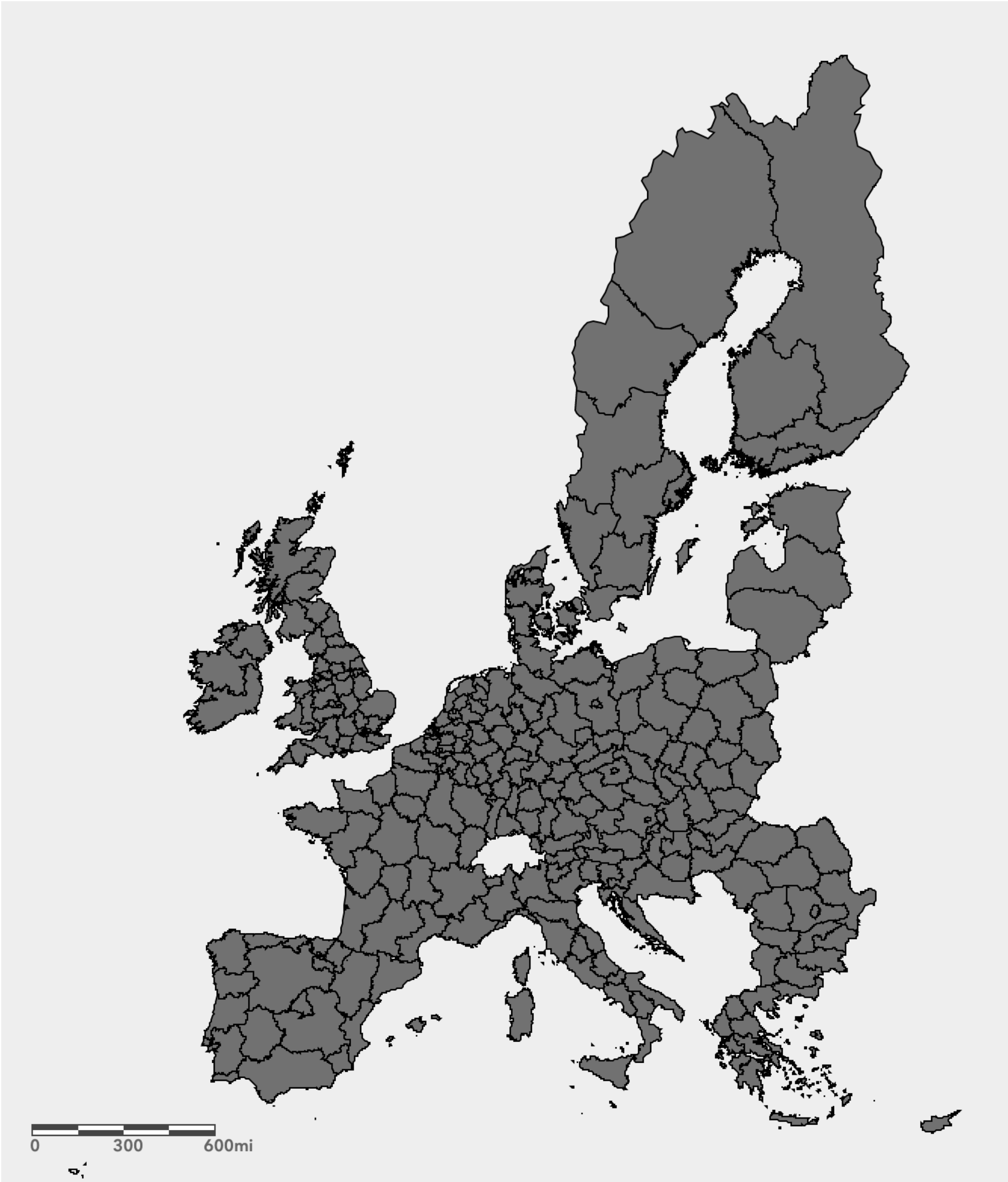

Figure 3 The potential distribution of the pest in the EU NUTS2 regions based on the scenarios established for assessing the impacts of the pest by the EFSA Working Group on EU Priority Pests (EFSA, 2019a). This link provides an online interactive version of the map that can be used to explore the data further: https://arcg.is/y1jH5

2.4. Expected change in the use of plant protection products

Control of Cms is practically impossible as no chemical neither or biological control options are available (Van der Wolf et al., 2005). The only way to control the disease is to prevent infection by hygiene measures (Robert, 2013).

In conclusion, based on the table below, this pest belongs to Case "A" and category 0 because, under current conditions, only crop hygiene can prevent infection.

Table 1: Expected changes in the use of Plant Protection Products (PPPs) following *Clavibacter michiganensis* subsp. *sepedonicus* 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

- Yield loss for seed potatoes and for ware potatoes are included in the estimation
- The impact is estimated in terms of plant decline and tuber losses
- The effect of specific yield losses due to internal EU quarantine measures such as the rejection of full lots, downgrading of seeds potato to ware potato, etc, are also included the most relevant cropping practices to be taken into account are planting of certified or higher class seed potatoes; planting uncut seed tubers only and hygiene measures
- Infection rates at EU level are estimated from data reported in national surveys. Infection rates for MS where the pest is not reported or data are not available are assumed as equivalent to the mean value of data reported in the annual European survey.

3.1.1.3. Selection of the parameter(s) estimated

According Council Directive 93/85/EEC the member states are required to carry out surveys for *Clavibacter michiganensis* subsp. *sepedonicus.* In this Pest Report the infection data for domestic production of seed and ware potatoes for the years of 1995 to 2015 were used (DG Health and Food Safety, 2017). To calculate the mean European infection rate, the reported national rates were weighted by the relative production in the EU of 2015 (EUROSTAT).

The percentage of yield loss is estimated from the rate of infested lots retrieved from the annual European survey. The European average is calculated as the weighted mean of all countries based on the relative production area in 2015. Finally, a smooth distribution is fitted to interpolate missing percentiles.

The quality loss is considered to be negligible compared to the yield losses and is therefore not included in the assessment.

The annual variation of the infection rate during the survey period is used as a proxy for the estimation of the uncertainty of the annual impact. Having these survey data, the need to perform an additional Expert Knowledge Elicitation was not given.

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 *Clavibacter michiganensis* subsp. *sepedonicus*, 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 *Clavibacter michiganensis* subsp. *sepedonicus*, 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 annual European survey data were judged as sufficient to calculate the yield and quality loss. For this reason, the table in the appendix has been provided for the use of the reader although not directly applied to this parameter.

3.1.1.6. Uncertainties identified

- The uncertainty of the future yield loss is estimated by the year by year variability in a time series of infection data.

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 *C. michiganensis* subsp. *sepedonicus*, 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 2: The 5 elicited values on yield loss (%) on seed potato

Percentile	**10%**	**25%**	**50%**	**75%**	**90%**
Expert elicitation	0.008%	0.014%	0.031%	0.071%	0.072%

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 3: 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				0.008 %	0.012 %	0.014 %	0.020 %	0.031 %	0.047 %	0.071 %	0.072 %	0.072 %			
Fitted distribution	0.002 %	0.004 %	0.007 %	0.011 %	0.015 %	0.020 %	0.025 %	0.035 %	0.047 %	0.055 %	0.065 %	0.076 %	0.090 %	0.103 %	0.118 %

Fitted distribution: Weibull(1.5653,0.00044547), @RISK7.5

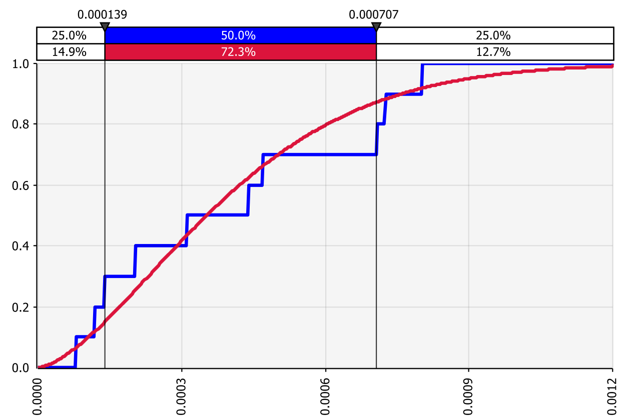

Figure 4 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on seed potato.

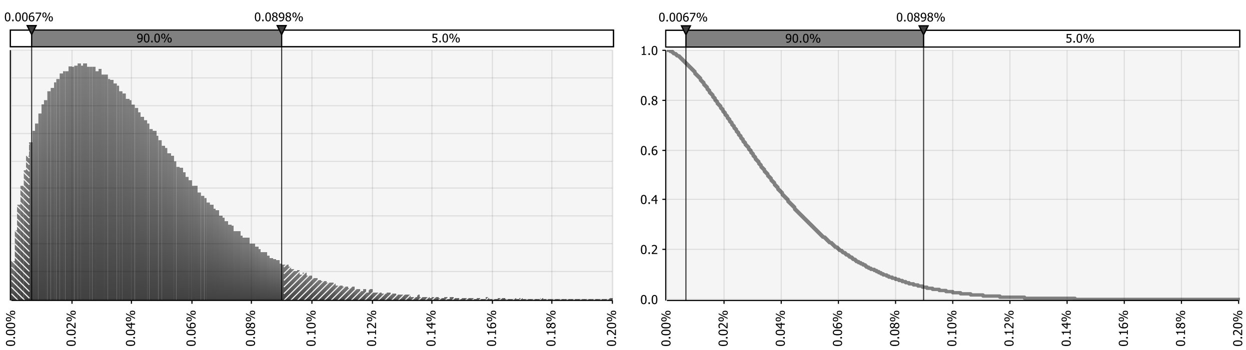

Figure 5 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on seed potato.

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 *C. michiganensis* subsp. *sepedonicus*, 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 4: The 5 elicited values on yield loss (%) on ware potato

Percentile	**10%**	**25%**	**50%**	**75%**	**90%**
Expert elicitation	0.008%	0.014%	0.031%	0.071%	0.072%

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 5: 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				2.31%	2.68%	2.80%	2.86%	2.88%	3.05%	3.81%	3.86%	3.86%			
Fitted distribution	2.03%	2.17%	2.30%	2.45%	2.60%	2.74%	2.86%	3.09%	3.34%	3.49%	3.68%	3.89%	4.16%	4.40%	4.70%

Fitted distribution: Lognorm(0.03142,0.0057031), @RISK7.5

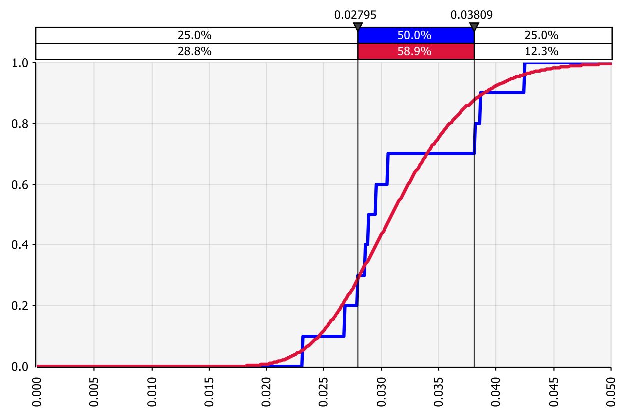

Figure 6 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on ware potato.

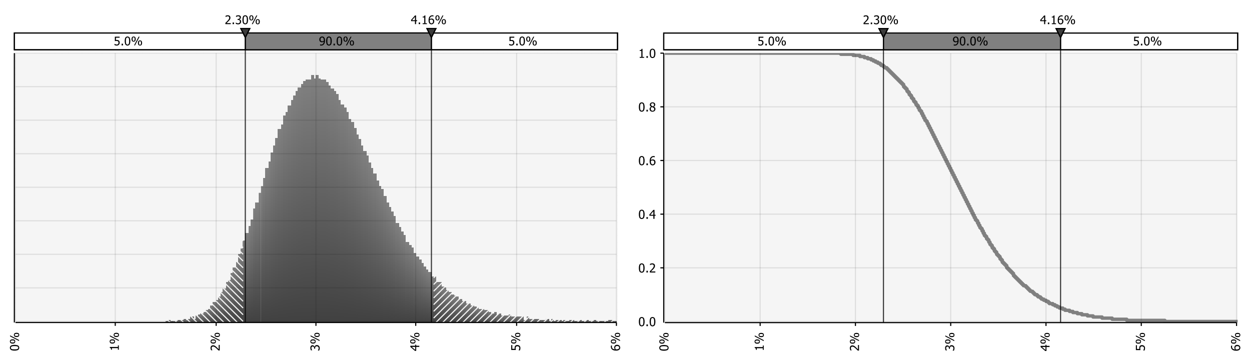

Figure 7 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on ware potato.

3.1.4. Conclusions on yield and quality losses

Based on the general and specific scenario considered in this assessment, the proportion (in %) of yield losses (here with the meaning of reduction in tubers production) is estimated to be

- 0.035% (with a 95% uncertainty range of 0.004-0.103%) on seed potato
- 3.09% (with a 95% uncertainty range of 2.17-4.4%) on ware potato

Quality losses have not been included in the assessment because they are considered negligible compared to the yield losses.

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

- The usage of farm saved seed potatoes is included among the mechanisms for human assisted spread relevant to the estimation

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 general points were made:

- Spread occurs via infected potatoes, where infected seed potatoes represent the main pathway
- There are no observations of plant-to-plant dissemination via the soil
- Human assisted spread via machineries and potatoes
- Effect of the practice of saving seed potatoes is taken into account among the mechanisms of spread
- Part of machineries used are owned by external contractors who would travel longer distances
- Natural spread is negligible

3.2.1.6. *Uncertainties identified*

No main uncertainties were noted.

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

Table 6: The 5 elicited values on spread rate (m/y)

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	25	200	300	550	1,500

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)

Most of the spread is caused by movement of harvested potatoes and machinery travelling between fields and farms. In the worst case, machinery is owned by contractors facilitating the spread along wide distances.

However, low pest population abundance is expected in presence of current measures, reducing the spread capacity of the pest populations.

The same spread by machinery was rated for *Synchytrium endobioticum* as 2,000 metres per year (although here spread is mainly by infected potato and not by infested soil as for *S. endobioticum*) (EFSA, 2019b). 1000 m/y is considered too short distance among fields or between field and farm.

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

There is no spread between fields and between farms.

Only the natural component of the spread is considered. The dispersal capacity of the pest, without movement of infected tubers, is negligible.

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

The spread is mainly caused by the movement of infected potatoes, which supports the establishment of the pest in other fields.

It can easily spread within a farm when the practice of saving its own seeds potato is done.

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

A slightly higher uncertainty is located on the right side of the curve.

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 7: 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					800		1,000		1,500					2,000
Fitted distribution	128	206	297	430	569	716	848	1,093	1,335	1,462	1,602	1,732	1,852	1,932	1,999

Fitted distribution: BetaGeneral(1.9779,1.8461,0,2100), @RISK7.5

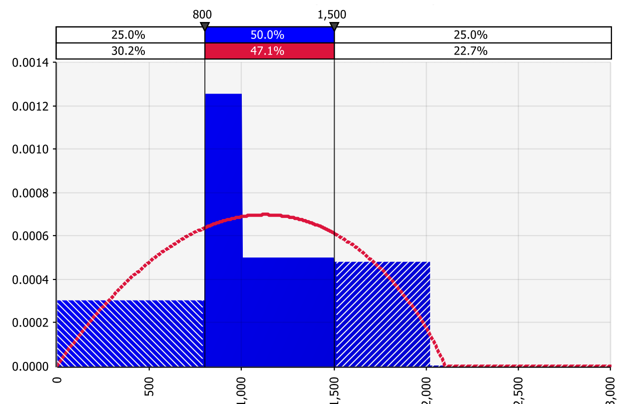

Figure 8 Comparison of judged values (histogram in blue) and fitted distribution (red line) for spread rate.

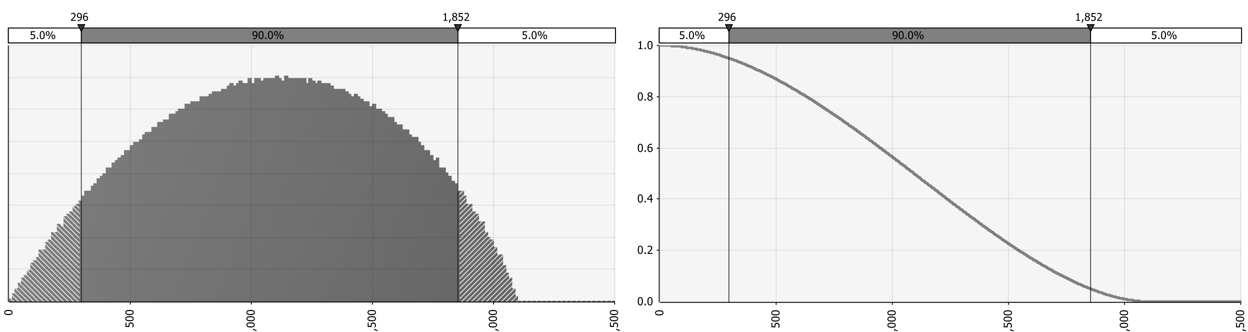

Figure 9 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for spread rate.

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 *Clavibacter michiganensis* subsp. *sepedonicus* is around 1,100 m (with a 95% uncertainty range of 200 – 2,000 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.3 in Appendix B) selecting the data and references used as the key evidence for the EKE on spread rate. A few general points were made:

- Infections can remain undetected
- All seed potatoes are tested, not ware potatoes.
- Infected potatoes stored under 10 °C symptoms do not appear.
- The time for detection is not calculated on ware potatoes but on seed potatoes only

3.3.1.6. Uncertainties identified

- Level of control in saved seed potatoes

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 8: 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)

Longer period at low pest prevalence (proportion of infested potatoes)

Disease expression can be low driving to undetected outbreaks.

The time to identify the pest could be longer in those countries where the pest is at its first outbreak compared to countries where the pest is regularly found, since the monitoring effort and efficacy are lower.

The use of farm saved seed potatoes is expected to prolong the time period for detection. Seventy percent of the seed potatoes used in the EU are farm saved.

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

The lower value gets very close to one productive cycle: the productive cycle is at least 4 months + testing phase as the minimum time to detect it. Even in a system with quite intensive sampling (e.g., in The Netherlands) it is not so easy to find the pest in the first season. 1-2 years is already an optimistic scenario.

The number of potatoes that is being tested is limited. Therefore, even in cases where seed potatoes are tested it may take several years before the pathogen is detected.

This timing averages the time needed to identify the pest on certified potato seeds (1/3 of the total, shorter time) and on farm saved potatoes (2/3 of the total, longer time).

For *Ralstonia solanacearum* and *S. endobioticum* (EFSA, 2019b), 16 months were also estimated to be the lower limit for detection in the EU.

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

70% of farms do not use certified potato seeds on EU average.

Main potato production is done in countries with higher awareness on the pest (see EU report), which would lead to a shorter time to detection.

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

Higher values are more unlikely while for lower values the uncertainty is large.

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 9: 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	91	104	113	123

Fitted distribution: BetaGeneral(0.89145,2.4421,15,144), @RISK7.5

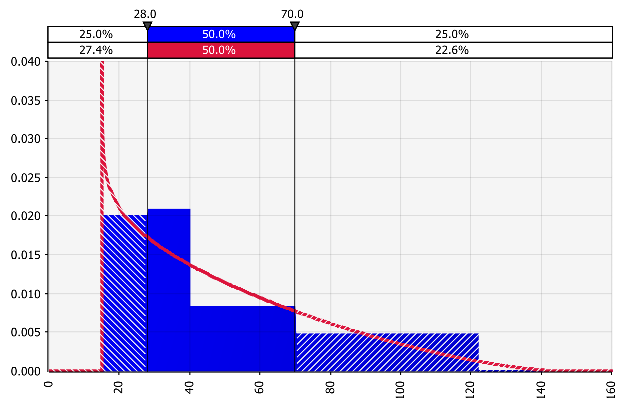

Figure 10 Comparison of judged values (histogram in blue) and fitted distribution (red line) for time to detection.

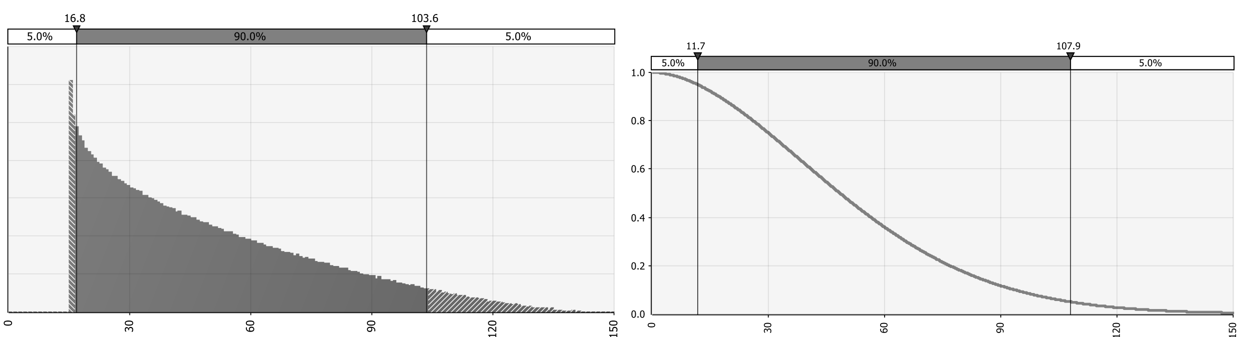

Figure 11 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for time to detection.

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 3.5 years (with a 95% uncertainty range of 1.3-9.5 years).

4. Conclusions

Hosts selection

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

Area of potential distribution

All the current area of production of potato in the EU is considered to be suitable for *C. michiganensis* subsp. *sepedonicus* and was therefore used as the area of potential distribution in this assessment.

The mean abundance of the pest, the main driver of pest impact, is considered to be the same throughout the area of potential distribution.

Expected change in the use of plant protection products

This pest belongs to Case "A" and category 0 because, under current conditions, only crop hygiene can prevent infection.

Yield and quality losses

Based on the general and specific scenario considered in this assessment, the proportion (in %) of yield losses (here with the meaning of reduction in tubers production) is estimated to be

- 0.035% (with a 95% uncertainty range of 0.004-0.103%) on seed potato
- 3.09% (with a 95% uncertainty range of 2.17-4.4%) on ware potato

Quality losses have not been included in the assessment because considered negligible compared to the yield losses.

Spread rate

Based on the general and specific scenarios considered in this assessment, the maximum distance expected to be covered in one year by *C. michiganensis* subsp. *sepedonicus* is around 1,100 m (with a 95% uncertainty range of 200 – 2,000 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 3.5 years (with a 95% uncertainty range of 1.3 - 9.5 years).

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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
Beta	*vulgaris*
Solanum	*lycopersicum*
Solanum	*melongena*
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**	**Uncertainty**
	Incidence	***Severity***	***Losses***			
Potatoes	In the forties, incidentally, seed lots with BRR symptoms were rejected in the USA with an infection percentage up to 80%. From latently infected tubers, still 1.5% BRR diseased tubers were harvested.				Eddins, 1939; Kreutzer and Mclean, 1943.	
Potatoes		Observations in Moscow: 15-30% infected tubers (probably expressing symptoms) in a single farm. Observations in Minsk: 12.6% infected tubers.	In experimental conditions, infected tubers resulted in a yield loss up to 47%	Reports from Russia; under the conditions of the Krasnoyarsk,	Muller and Ficke, 1974	
Potatoes			Yield loss Up to 50%	Yield losses were mainly reported from North America	Easton GD, 1979	
Potatoes		Over 50%	Yield loss	Field experiments reports from USA and Norway; in practice such large yield losses are usually not detected.	J.G. Elphinstone, Central Science Laboratory, Sand Hutton, York, YO41 1LZ	

Potatoes	9-12% of the farms infected, covering 6-12% of the inspected area			surveys in Ottawa (Canada) from 1943 to 1947	Richardson and Goodin, 1949 cited by van der Wolf et al., 2005	
Potatoes	1939: 11.5 and 1940: 7.5% of all certified seed lots were rejected due to BRR .			Maine (USA)	Baribeau, 1948 cited by van der Wolf et al., 2005	
Potatoes	1944 the disease was present in c. 16% and in 1945 in c. 9% of all lots of potatoes tested.			Quebec		Original data sources also from Canada and US not provided
Potatoes	Weight of tubers per plant Cv: • 'Hansa' (susceptible to Cms) • 'Desiree' (moderately tolerant to Cms)	Tuber and stem symptoms emerged 80–100 days after planting in 'Hansa', but no visual symptoms observed in 'Desiree' 'Hansa' in Denmark > 50 % of showed external symptoms (heavy infection) in tubers at the time of harvest and foliar symptoms emerged in few stems after 100 days from planting in both years.	Yield loss Hansa 41-56% Desiree no yield or growth reduction despite of relatively high numbers of bacteria found in stems and tubers	sprout inoculated Cms inoculated plants compared to control. Difference was significant.	Hukkanen et al., 2005	Severity: different strains development on tubers and stems provided as cells/g

Potatoes			The economic damage caused by direct crop losses is low in Europe but the indirect costs of preventing infections (e.g. repeated surveillance which include visual inspections and laboratory testing; control measures; certification) ensuring zero tolerance for the presence of Cms are high.		Van der Wolf et al., 2005	
Potatoes	% infected lots			EU annual surveys till 2015		

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										Production (2015)	
Member State	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	abs (ha)	rel
Malta											0.00	0.0%
Portugal	0.00%	0.00%	0.00%	0.00%					0.00%	0.00%	9.10	0.0%
Slovenia	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	30.29	0.0%
Croatia							0.00%	0.00%	0.00%	0.00%	52.81	0.0%
Cyprus	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	75.11	0.1%
Lithuania	0.00%	0.53%	0.00%	0.00%	0.66%	0.00%	0.00%	0.00%	0.00%	0.00%	124.54	0.1%
Hungary	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	198.00	0.2%
Estonia	0.00%	0.00%	0.88%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.40%	203.86	0.2%
Ireland	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	238.00	0.2%
Bulgaria	0.45%	1.75%	0.73%	0.00%	0.34%	0.00%	0.51%	0.00%	0.00%	0.75%	254.15	0.2%
Italy	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	306.00	0.3%
Luxembourg		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	338.41	0.3%
Greece	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	339.13	0.3%

Latvia	0.48%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	354.11	0.3%
Slovakia	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.34%	0.00%	0.00%	488.63	0.4%
Romania	1.28%	2.22%	4.75%	3.16%	2.04%	0.00%	1.97%	0.16%	0.37%	0.40%	713.18	0.6%
Sweden	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	945.60	0.9%
Finland	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1014.70	0.9%
Austria	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1508.95	1.4%
Spain	0.00%	0.05%	0.00%	0.11%	0.00%	0.00%	0.00%	0.09%	0.00%	0.00%	2257.15	2.0%
Belgium	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2284.85	2.1%
Czech Republic	0.15%	0.00%	0.00%	0.14%	0.15%	0.07%	0.04%	0.00%	0.17%	0.16%	2854.90	2.6%
Denmark	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4785.00	4.3%
Poland	0.95%	0.93%	0.64%	0.39%	0.13%	0.18%	0.21%	0.07%	0.10%	0.22%	5657.00	5.1%
United Kingdom	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	14397.50	13.0%
Germany	0.09%	0.03%	0.02%	0.01%	0.05%	0.01%	0.03%	0.00%	0.00%	0.00%	15814.00	14.2%
France	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	19314.00	17.4%
Netherlands	0.00%	0.00%	0.00%	0.00%	0.03%	0.00%	0.01%	0.00%	0.00%	0.00%	36581.00	32.9%
EU AVERAGE	**0.08%**	**0.07%**	**0.07%**	**0.05%**	**0.04%**	**0.01%**	**0.03%**	**0.01%**	**0.01%**	**0.02%**		100.0%

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										Production (2015)	
Member State	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	abs (ha)	rel
Luxembourg		0.00%		0.00%						0.00%	185.13	0.0%
Malta		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	701.00	0.0%
Slovenia	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3280.00	0.2%
Cyprus	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5000.00	0.3%
Slovakia	0.50%	3.30%	1.80%	1.88%	2.16%	1.99%	0.38%	0.98%	0.65%	1.14%	5506.35	0.4%
Estonia	1.12%	1.86%	1.52%	0.00%	0.59%	0.45%	0.59%	0.00%	0.58%	0.00%	5800.00	0.4%
Croatia							0.00%	0.00%	0.00%	0.00%	7500.00	0.5%
Ireland	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	8567.00	0.6%
Bulgaria	2.54%	4.32%	1.93%	0.38%	3.65%	1.81%	3.87%	3.58%	0.22%	1.05%	11993.85	0.8%
Lithuania	6.45%	3.61%	3.31%	2.09%	4.71%	3.40%	4.11%	1.55%	2.48%	1.94%	15578.00	1.1%
Hungary	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.29%	2.79%	18000.00	1.3%
Austria	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	18859.00	1.3%
Czech Republic	0.21%	0.59%	0.48%	0.25%	0.28%	0.90%	0.31%	0.45%	1.20%	0.34%	19857.00	1.4%
Finland	1.88%	1.86%	1.14%	0.45%	1.22%	0.72%	0.35%	0.92%	0.69%	0.48%	21000.00	1.5%

Greece	8.54%	3.01%	0.54%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	21462.40	1.5%
Sweden	0.00%	1.02%	0.00%	0.00%	0.00%	0.21%	0.00%	0.00%	0.00%	0.00%	23109.00	1.6%
Latvia	9.56%	10.43%	7.56%	4.35%	3.38%	2.86%	2.73%	3.23%	2.67%	1.18%	26445.84	1.8%
Portugal	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	27334.00	1.9%
Denmark	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	37174.00	2.6%
Italy	0.00%	0.00%	0.84%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	41026.00	2.9%
Romania	4.18%	9.02%	5.24%	9.13%	10.54%	6.63%	8.48%	5.15%	6.30%	4.48%	44388.11	3.1%
Spain	0.31%	0.00%	0.24%	0.25%	0.00%	0.00%	0.20%	0.00%	0.00%	0.00%	63816.26	4.5%
Belgium	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.16%	0.00%	0.00%	0.00%	78620.44	5.5%
United Kingdom	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.01%	0.00%	0.00%	0.00%	115202.00	8.1%
Netherlands	0.00%	0.03%	0.03%	0.19%	0.13%	0.63%	0.26%	0.09%	0.00%	0.05%	115657.00	8.1%
France	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.11%	0.00%	0.00%	149500.00	10.5%
Germany	0.22%	0.14%	1.87%	0.12%	0.12%	0.10%	0.04%	0.00%	0.29%	0.04%	222444.00	15.6%
Poland	16.13%	13.84%	13.90%	10.76%	10.72%	10.57%	10.33%	12.17%	10.25%	9.12%	322305.00	22.5%
EU AVERAGE	**4.25%**	**3.81%**	**3.86%**	**2.88%**	**2.95%**	**2.80%**	**2.86%**	**3.05%**	**2.68%**	**2.31%**		100.0%

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

Spread	Additional information	Reference
Natural spread	Plant-to-plant dissemination in the field plays no role in the epidemiology of Cms	Dykstra, 1941; Mansfeld-Giese, 1997; Van der Wolf et al., 2005
Natural spread	Plant to plant transmission of Cms: 0.00 – 0.96%	Mansfeld-Giese, 1997
Natural spread	Transfer of Cms from soil to potato was only described in one report.	Dykstra, 1941
Natural spread	Several insects have been determined as a vector of Cms but the actual significance of insects in the epidemiology of Cms is unclear. No data are available on the persistence of Cms in insects.	van der Wolf et al., 2005
Natural spread	Colorado beetle (*Leptinotarsa decemlineata*) and the green peach aphid (*Myzus persicae*) are relatively efficient vectors of Cms. However, their role in the epidemiology is unclear	van der Wolf et al., 2005
Natural spread	Cms can survive in non-sterile surface water for maximum period of 7 days at 10°C	van der Wolf and van Beckhoven, 2004
Human assisted spread	CMS can be spread by contaminated machinery (e.g. pickertype planters) and other equipment (e.g. cutting knives) used in potato production	Evans et al., 1998

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

Category of factors	case	Effects on incidence	Effects on symptoms expression	Effects on detectability	Additional information	Reference
Infection mechanism			Since actual infection rates arising from contaminated machinery can be quite low, it can be several generations until the disease builds up to detectable levels or symptoms are observed.			Van der Wolf et al., 2005
Biology of the pest		Symptomless plants (potato tubers) may act as vectors/carriers of Cms	Potato can latently be infected by Cms but symptoms may be fuzzy	Symptoms caused by Cms can be overlooked during visual inspections.		Van der Wolf et al., 2005[b]
Biology of the pest			The latent infection can occur up to three seasons before the macroscopic effects will be seen.			Pietraszko and Boguszewska-Mankowska, 2012