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Phyllosticta citricarpa
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, 2019).

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 *Phyllosticta citricarpa*, the following documents were used as key references: the EFSA risk assessments on *Phyllosticta citricarpa* for the EU territory (EFSA PLH Panel 2014; 2016; 2018).

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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

Citrus black spot disease (CBS) is caused by the fungus *Phyllosticta citricarpa* (McAlpine) van der Aa. Following the new code of fungal nomenclature approved by the International Botanical Congress in Melbourne in 2011, the use of the anamorph name, *P. citricarpa*, is preferable to the teleomorph name *Guignardia citricarpa* Kiely, and it is now used as the only identifier of this species. Recently, new *Phyllosticta* species have been described from citrus (e.g. Wulandari et al., 2009; Glienke et al., 2011; Wikee et al., 2011, 2013ab; Wang et al., 2012; Guarnaccia et al., 2017), however the present assessment deals with the single taxonomic entity *P. citricarpa*.

A detailed description of the life cycle of *P. citricarpa* can be found in EFSA PLH Panel (2014).

2.2. Host plants

2.2.1. List of hosts

All commercial citrus species and cultivars are considered to be susceptible to CBS, except for sour orange (*C. aurantium*) (Kotzé, 1981) and Tahiti lime (*C. latifolia*) (Baldassari et al., 2008).

In the case of sour orange, *P. citricarpa* was isolated in Brazil from asymptomatic leaves (Wickert et al., 2009), although no evidence of reproduction on this citrus species was found.

Tahiti lime is reported not to exhibit CBS symptoms under field conditions, even in areas with high inoculum pressure. However, *P. citricarpa* was isolated in Sao Paulo, Brazil, from asymptomatic fruit and leaves of Tahiti lime (Baldassari et al., 2008; Wickert et al., 2009). Although there is no documented evidence of *P. citricarpa* reproduction on Tahiti lime fruit, it can colonise and form viable ascospores in Tahiti lime leaves, suggesting that this citrus species may well play a role in CBS epidemiology (Baldassari et al., 2008).

Lemon (*C. limon*) is considered to be the citrus species that is most susceptible to CBS, and it has been stated that the first disease outbreaks in a region always occurred in lemon orchards and later spread to adjacent citrus orchards (Kotzé, 1981). However, CBS emerged in Florida (USA) directly in sweet orange orchards (Schubert et al., 2012). Late-maturing cultivars of sweet orange were considered more susceptible than early maturing ones (Timmer, 1999). Moreover, cultivar field trials conducted in Brazil as well as studies comparing the rate of disease progress indicated that cultivar reaction to the disease is more linked to the interaction of environmental factors with the dynamics of fruit maturation (Spósito et al., 2004; Sousa and de Goes, 2010).

In Australia, Miles et al. (2013) failed to detect CBS symptoms in pomelo (*C. maxima*). Surveys were conducted in two commercial orchards, citrus arboretums and fruit markets in areas of the Northern Territory, Queensland and New South Wales, where CBS is prevalent. However, the same study indicated that only 22 ha of pomelo are commercially cultivated in Australia, which is a rather limited sampling area. Recent surveys conducted in China also indicated that pomelo (*C. maxima*) is not affected by *P. citricarpa* (Wang et al., 2012). More data from other geographic regions as well as proper pathogenicity tests are needed to completely exclude this citrus species as a potential host of *P. citricarpa*. With regard to kumquat (*Fortunella* spp.), this species was recorded by Kiely (1948) in Australia as moderately susceptible to CBS under conditions of natural infection, but no further experimental information is available. No definitive information has been found on the susceptibility of *Poncirus* Raf. (trifoliate orange) to *P.*

citricarpa while susceptibility has been observed on its hybrid Troyer citrange (*Citrus sinensis* Osbeck x *Poncirus trifoliata* Raf.) by Tran et al. (2018).

Appendix A provides the full list of hosts.

2.2.2. Selection of hosts for the evaluation

The main citrus production in the EU is given by sweet oranges, mandarins, clementines, lemons, limes, satsumas, grapefruits. All commercial citrus species grown in the assessment area are included in the evaluation. Although EFSA assessment (EFSA PLH Panel, 2014) indicates that the impact is strongly dependent from the harvesting time, with different impact expected for early and late-maturing varieties, the varietal scenario of cultivated genotypes in the EU is constantly changing (Aleza et al., 2012), therefore all commercial citrus species potentially affected by CBS are assessed together.

2.2.3. Conclusions on the hosts selected for the evaluation

All commercial citrus species and cultivars except for sour orange (*C. aurantium*) and Tahiti lime (*C. latifolia*) were assessed for impact since they are all considered to be susceptible to CBS.

2.3. Area of potential distribution

2.3.1. Area of current distribution

There are uncertainties on the distribution in Asia due to the discovery of other *Phyllosticta* species associated with citrus diseases. In Europe, Guarnaccia et al. (2017) reported *P. citricarpa* from leaf litter of four backyard gardens, however such results were not repeated by the authors with a confirmatory sampling and surveys carried out up to now by the competent national plant health authorities were not able to confirm such findings (EFSA PLH Panel, 2018).

Figure 1 provides an overview of the current area of distribution of the pest. In the EU no outbreaks have yet been reported.

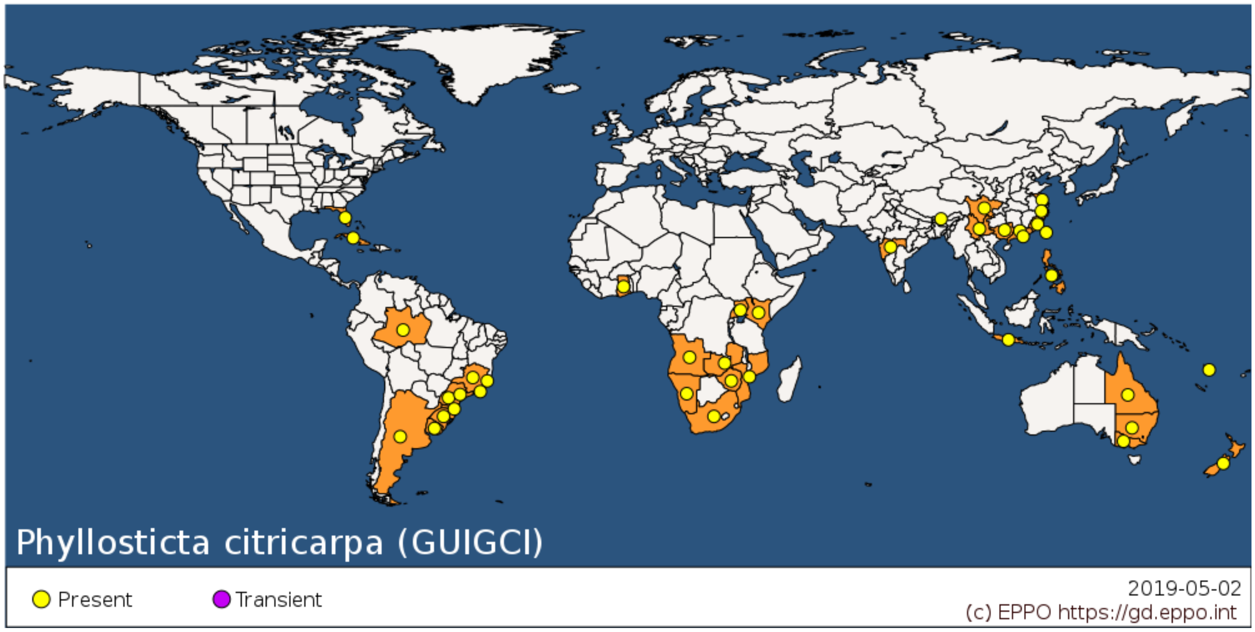

Figure 1 Distribution map of *Phyllosticta citricarpa* from the EPPO Global Database accessed 02/05/2019.

2.3.2. Area of potential establishment

CBS occurs mainly in subtropical citrus-growing regions characterised by a summer rainfall pattern (Kotzé, 1981, 2000) and high annual precipitation. However, the disease is also present in semi-arid areas such as the Eastern Cape province in South Africa with an annual rainfall of about 400 mm (Paul et al., 2005). The full range of temperatures and wetness durations suitable for ascospore infection have not been determined experimentally and only ascospore germination rates and field infection data are available in the literature. According to Kotzé (1963), the conditions required for ascospore germination varied from 15 to 29.5°C and from 15 to 38 hours of wetness. McOnie (1967) found that ascospores were able to infect with at least 15 hours of continuous wetness. In field studies conducted in Sao Paulo, Brazil, sweet orange fruit were infected with nearly 14 hours of wetness per day and 22 to 25 °C, but temperatures outside this range were not evaluated (Reis et al., 2006).

Recently, Tran et al. (2018) were able to induce CBS symptoms in seedlings of the cultivar Troyer inoculated with ascospores or pycnidiospores of *P. citricarpa* at 25 °C for 96 hours. Likewise, CBS symptoms developed on fruit inoculated in a shadehouse (20-35 °C) for 48 hours.

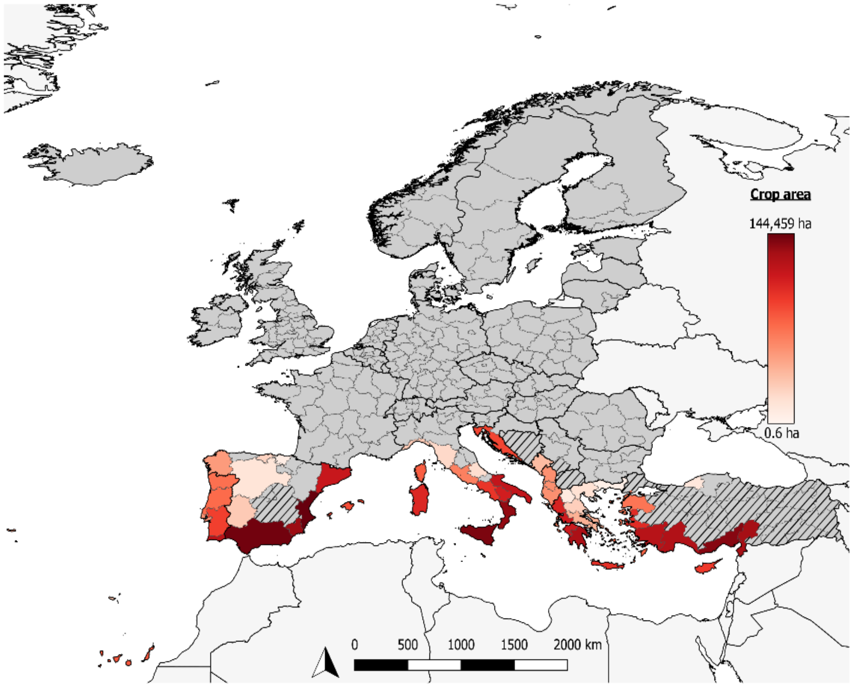

Figure 2 *Citrus* spp. growing areas. Statistic data of crop area at NUTS 2 level. Areas with lines indicate areas with no data (figure from EFSA PLH Panel, 2019)

The climate suitability of EU citrus growing regions (Fig. 2) for the establishment of *P. citricarpa* and its uncertainties has been thoroughly reviewed by the EFSA PLH Panel (EFSA PLH Panel 2008, 2014, 2016 and 2018). In particular a generic infection model developed by Magarey et al. (2005) has been applied to EU 25x25 Km interpolating climate data (JRC MARS, online) to predict the number of hours suitable for starting a successful infection by *P. citricarpa* ascospores and pycnidiospores. The maps for ascospore infections include ascospore maturation and release based on a model developed by Fourie et al. (2013)

for *Phyllosticta* spp. Maps showing average EU modelling results for ascospores and pycnidiospores infections, considering a 7 month fruit susceptibility period, are provided in figures 5 and 9 of the assessment by EFSA PLH Panel (2018). The model results show a higher number of predicted pycnidiospores infections compared to ascospores. In particular, for the locations where Guarnaccia et al. (2017) reported the finding of *P. citricarpa* in leaf litter, it was shown that pycnidiospores infections were predicted every years and values were of the same order as those predicted for Addo in the Eastern Cape province in South Africa (EFSA PLH Panel, 2018).

An hourly infection model was also developed and validated in 18 locations with known CBS prevalence with 9 years of weather data (Magarey et al., 2015). Simulations suggested that locations in Florida were at high risk while most locations in California and Europe were not at risk. The European location with the highest risk score was Andravida, Greece, which had 67% of years suitable for ascosporic infection but only 11% of years suitable for pycnidiosporic infection. There were six other sites in Europe for which the frequency of years suitable for ascosporic infection was greater than 22%. These included: Pontecagnano, Italy; Kekrya, Greece; Reggio Calabria, Italy; Cozzo Spadaro, Italy; Messina, Italy; and Siracusa, Italy. The difference between these simulations and those by EFSA (EFSA PLH Panel, 2008; 2014) were thoroughly discussed by the EFSA (EFSA PLH Panel, 2016).

2.3.3. Transient populations

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

2.3.4. Conclusions on the area of potential distribution

Although there is a high level of uncertainty, the current area of production of citrus in the EU was considered to be potentially vulnerable to *P. citricarpa* infection and was therefore used as the area of potential distribution for 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 area of potential distribution.

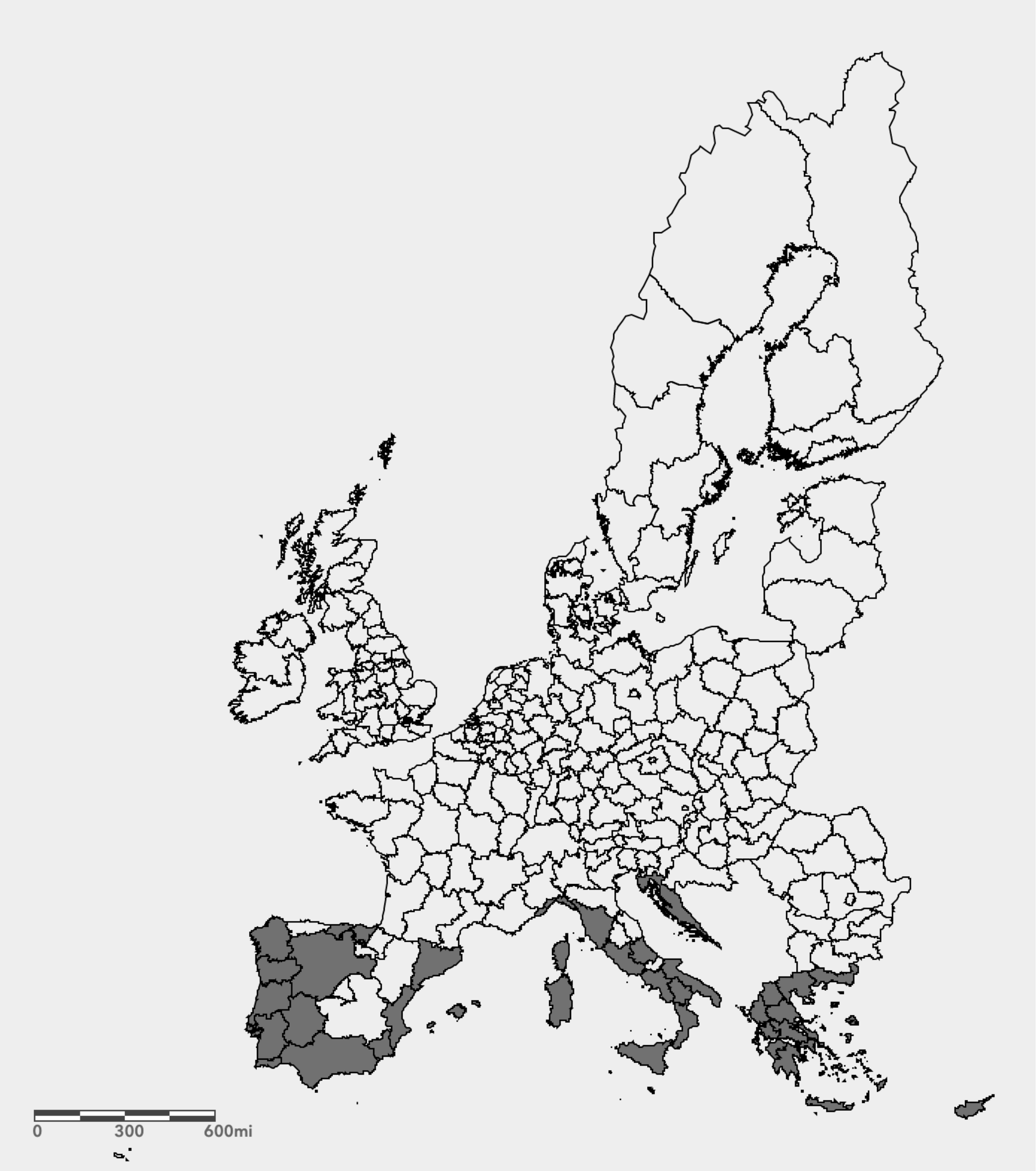

Figure 3 The potential distribution of the pest in the EU NUTS2 regions based on the scenarios established for assessing the impacts of the pest by the EFSA Working Group on EU Priority Pests (EFSA, 2019). This link provides an online interactive version of the map that can be used to explore the data further: https://arcg.is/14XmTb

2.4. Expected change in the use of plant protection products

Copper compounds and mancozeb (dithiocarbamate) are the only fungicides currently registered for citrus in the EU (Council Directive 91/414/EEC[3]) than may have some effect against *P. citricarpa*. Strobilurin fungicides (QoI) and benzimidazoles, which are highly effective for CBS control (de Goes et al., 2000; de Goes, 2002; Schutte et al., 2003; Miles et al., 2004), are not currently labelled for citrus in the EU (EFSA PLH Panel, 2014).

Fungicides treatment strategy should take into account resistance to molecules within the pathogenic populations. Natural cases of resistance to high concentrations to benomyl (benzimidazoles) were observed in South Africa (Herbert and Grech, 1985). In vitro studies showed that Azoxystrobin (a strobilurin) even at high concentrations did not inhibit mycelial growth in any of the 10 strains tested from Australia and Africa, but significantly reduced sporulation rates (Possiede et al., 2009).

Due to the fact that some of the fungicides currently used in the EU could have some effect against this pathogen, and therefore an increase in their application is expected to be the most likely control strategy, the most suitable PPP indicator is Case "C" and the category is "1" based on Table 1.

Table 1: Expected changes in the use of Plant Protection Products (PPPs) following *Phyllosticta citricarpa* 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.

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[3] Council Directive (EEC) No 91/414 of 15 July 1991 concerning the placing of plant protection products on the market. Official Journal of the European Communities OJ L, 230, 1-32.

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, 2019).

3.1.1.2. Specific scenario assumptions

CBS is not expected to affect the citrus processing industry.

3.1.1.3. Selection of the parameter(s) estimated

This pest causes two type of damages

- Premature fruit drop: it causes significant yield loss in Brazil, and probably in other citrus producing regions of the world. Not to be confused with the physiological fruit drop, which happens even before the fruit is potentially susceptible to CBS
- Symptoms on fruit rind: hard spot, virulent spot, and false melanose, reduce the fruit commercial value for the fresh market (Kotzé, 2000)

According to international quality standards, although not specific to CBS, the presence of more than one necrotic spot per fruit affects the quality, and fruits with more than six necrotic spots are unmarketable (OECD, 2010; EFSA PLH Panel 2014). In Sao Paulo, Brazil, fruits with more than three CBS lesions are considered unacceptable for the fresh market (Goes, 2002).

The parameters estimated are therefore

- Proportion of yield loss due to the CBS under the assessment scenario compared to the current situation.
- Proportion of quality loss due to the CBS under the assessment scenario compared to the current situation.

3.1.1.4. Defined question(s)

What is the percentage yield loss in citrus production under the scenario assumptions in the area of the EU under assessment for *Phyllosticta citricarpa*, as defined in the Pest Report?

What is the percentage of the harvested citrus fruit damaged by *Phyllosticta citricarpa* 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?

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. One additional point was made:

- CBS has no substantial impact on juice quality (Carvalho et al., 2014).

3.1.1.6. *Uncertainties identified*

- All the information on yield losses are from Brazil where climate is likely to be more favorable to disease development
- No information from South Africa
- Information is only on sweet orange (and probably on 1 or very few varieties). Information on other important hosts (e.g. lemon) are not available
- The meta-analysis provided by EFSA (EFSA PLH Panel, 2014; section 3.6.1) is not considered as representative of the average situation but rather as worse cases
- The absence of considerations on the possible temporal variations of the establishment could result in an overestimation of the impacts
- In some areas of the EU the pathogen could be present not in a stable condition
- The expression of symptoms is influenced by the citrus variety (difference between early and late maturing varieties): early maturing varieties (about half of Spanish production of sweet oranges and mandarins) are harvested before symptoms expression
- Lack of knowledge on geographic distribution and proportion of different citrus species and varieties in the EU

3.1.2. Elicited values for yield losses

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

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

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

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	0%	1%	2%	4%	10%

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

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

The upper value of 10 % was agreed considering that in Brasil the percentage of premature fruit drop (crop loss) reached the 26.9% in oranges. However, fruit drop only occurs when the severity of the disease is very high and climatic conditions in Brasil increase the severity. Climatic conditions in Europe are less favourable and then the upper value is expected to be lower than in Brasil.

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

The lower value of 0% was agreed based on the evidence that in a South African study on oranges, in an infected crop there was 0% of fruit drop even without treatment. The same can occur on lemon in Europe in the best-case scenario.

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

The experts agreed the median estimate can be set to 2% to represent the possibility, although it is low, that fruit drop occurs also in Europe.

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

The precision interval reflects the low uncertainty around the lower estimate and a higher uncertainty around the upper estimate.

3.1.2.2. Estimation of the uncertainty distribution for yield loss on citrus

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 citrus

Percentile	**1%**	**2.5%**	**5%**	**10%**	**17%**	**25%**	**33%**	**50%**	**67%**	**75%**	**83%**	**90%**	**95%**	**97.5%**	**99%**
Expert elicitation	0%					1%		2%		4%					10%
Fitted distribution	0%	0%	0%	0%	1%	1%	1%	2%	3%	4%	5%	6%	8%	10%	12%

Fitted distribution: Gamma (1.2133,0.023111), @RISK7.5

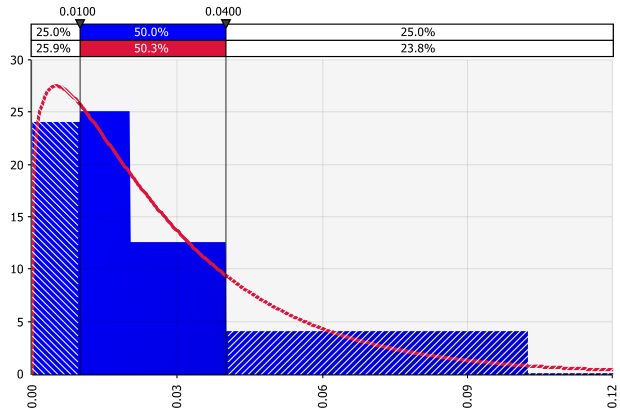

Figure 4 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on citrus.

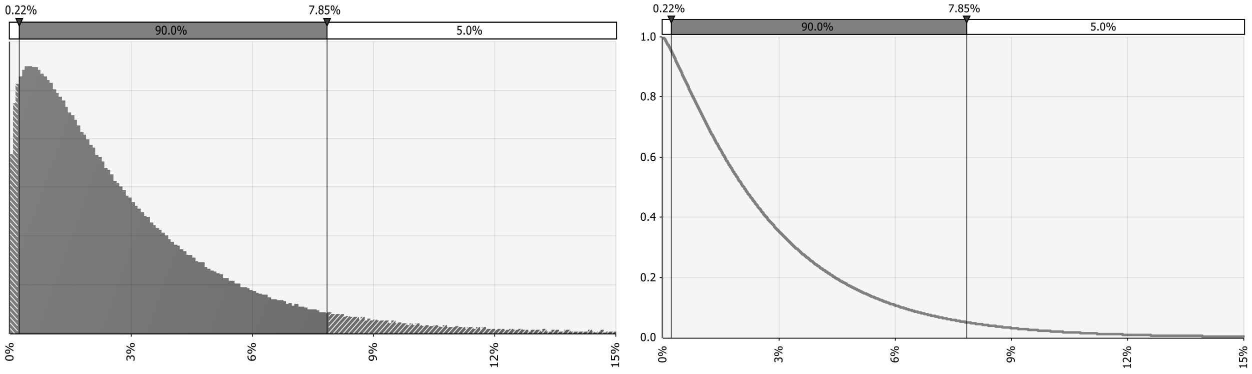

Figure 5 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on citrus.

3.1.3. Elicited values for quality losses

What is the percentage of the harvested citrus fruit damaged by *P. citricarpa* 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 elicited values on quality loss on citrus on which the group agreed are reported in the table below.

Table 4: The 5 elicited values on quality loss (%) on citrus

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	2%	9%	15%	40%	70%

3.1.3.1. Justification for the elicited values for quality loss on citrus

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

The upper value of 70% was agreed to represent the worst case scenario in which fruits are not harvested before symptom expression.

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

The lower value of 2% was agreed because most of fruits are harvested before symptom expression.

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

The experts agreed the median quality loss is estimated to be 15% to represent the quality loss of late maturing varieties of EU citrus.

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

The precision interval reflects a very high uncertainty around the upper estimate.

3.1.3.2. Estimation of the uncertainty distribution for quality loss on citrus

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 quality loss (%) on citrus

Percentile	**1%**	**2.5%**	**5%**	**10%**	**17%**	**25%**	**33%**	**50%**	**67%**	**75%**	**83%**	**90%**	**95%**	**97.5%**	**99%**
Expert elicitation	2%					9%		15%		40%					70%
Fitted distribution	0%	1%	1%	3%	5%	8%	11%	19%	29%	35%	43%	52%	62%	70%	78%

Fitted distribution: BetaGeneral (0.92566,2.9797,0,1), @RISK7.5

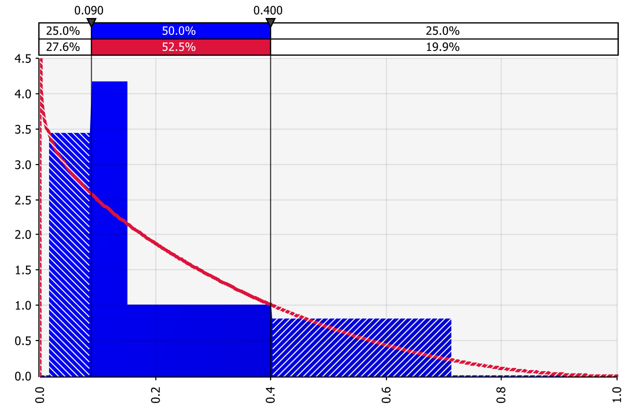

Figure 6 Comparison of judged values (histogram in blue) and fitted distribution (red line) for quality loss on citrus.

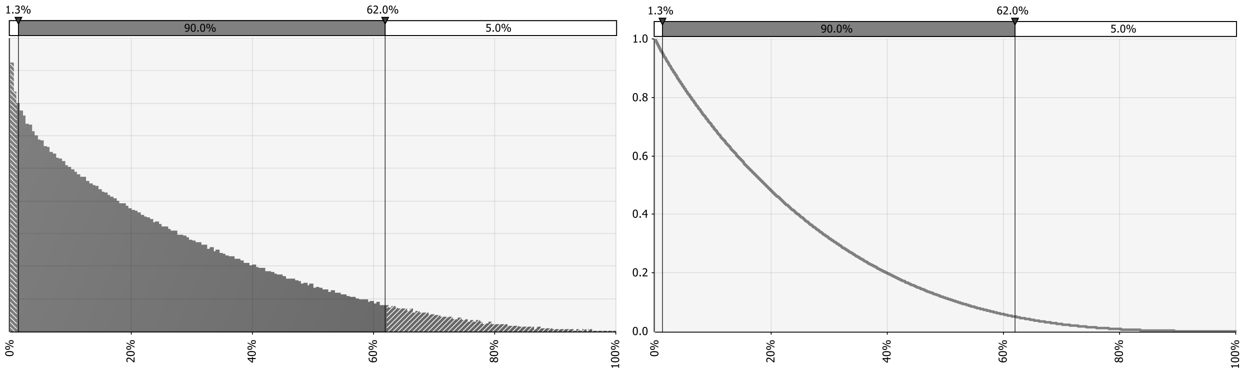

Figure 7 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for quality loss on citrus.

3.1.4. 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 2% (with a 95% uncertainty range of 0 - 10%).

The proportion (in %) of quality losses is estimated to be 19% (with a 95% uncertainty range of 1 - 70%).

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, 2019).

3.2.1.2. Specific scenario assumptions

No specific scenario assumptions are introduced in the assessment of spread rate.

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

- Information is available for spores dispersal but not for disease spread
- Information is available on pycnidiospores dispersal but not on spatiotemporal dispersal of ascospores
- Relevant study from Florida but without hurricanes effect and in absence of ascospores
- Ascospores are expected to have a higher dispersal potential
- Lag phase duration: it could require years to obtain some epidemiological significance
-

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 the 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	4	400	800	1500	5000

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 of 5000 m was agreed to be the maximum dispersal rate considering the combination of spread due to movement of machinery among different fields.

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

The absence of hurricane or tropic storm conditions in Europe makes the best-case scenario equal to the minimum distance from trees. The lower limit was set to 4 metres.

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

The median value of 800 metres was agreed based on the assumption that the spread remains assisted by machinery movement within the same field.

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

The precision reflects some uncertainty around the median. However, much of the uncertainty relate to the upper limit.

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	4					400		800		1500					5000
Fitted distribution	27	56	97	173	269	391	520	816	1212	1485	1861	2326	2948	3562	4365

Fitted distribution: Gamma (1.2965,830.81), @RISK7.5

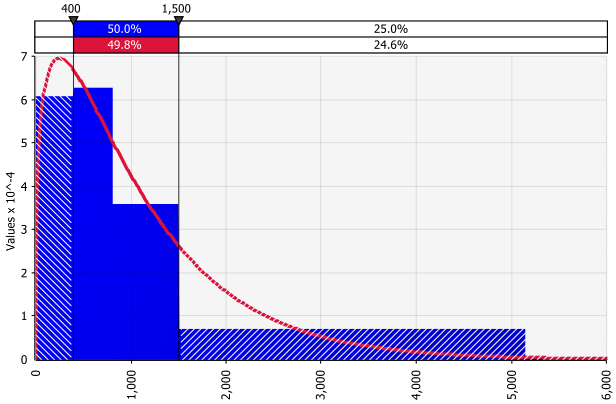

Figure 8 Comparison of judged values (histogram in blue) and fitted distribution (red line) for spread rate.

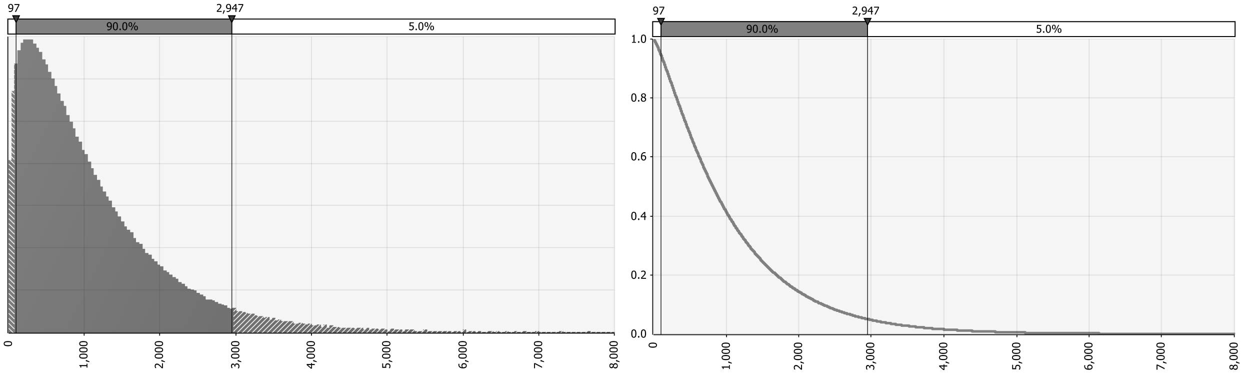

Figure 9 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for spread rate.

d

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 *P. citricarpa* is approximately 800 m (with a 95% uncertainty range of 56 – 3,562 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, 2019).

3.3.1.2. Specific scenario assumptions

No specific scenario assumptions are introduced in the assessment of 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

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 the time to detection.

3.3.1.6. Uncertainties identified

- Symptoms on leaves are not distinctive in commercial orange plantations, but only on lemon
- Two complementary mating types necessary for sexual reproduction → inoculum pressure → symptoms development

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	6	22	36	40	48

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 48 months was agreed based on the fact that the disease may remain undetected during the early stages of introduction. The experts agreed that 2 years are the maximum amount of time before symptoms are noticed at the second harvesting.

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

The elicitation group agreed that it may take several months before the pathogen is detected and in the best-case scenario at least 6 months are needed from the inoculum to symptom expression.

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

The value of 36 months was agreed representing the median time needed for detection of the symptoms in the EU citrus populations.

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

The precision reflects the fact that the experts are more uncertain on the estimate for the shorter time needed for detection.

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	6					22		36		40					48
Fitted distribution	5	8	11	15	20	24	27	33	39	41	44	46	48	49	49

Fitted distribution: BetaGeneral (2.1833,1.2337,0,50), @RISK7.5

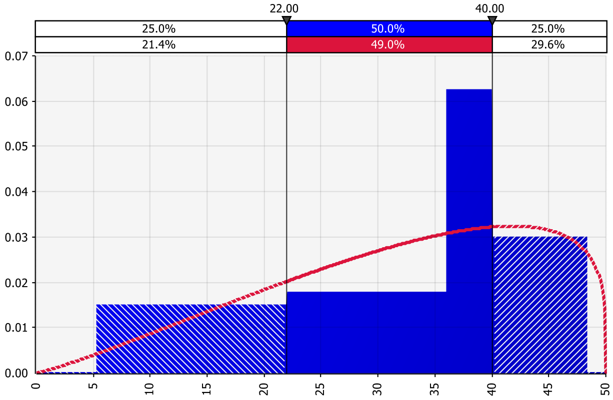

Figure 10 Comparison of judged values (histogram in blue) and fitted distribution (red line) for time to detection.

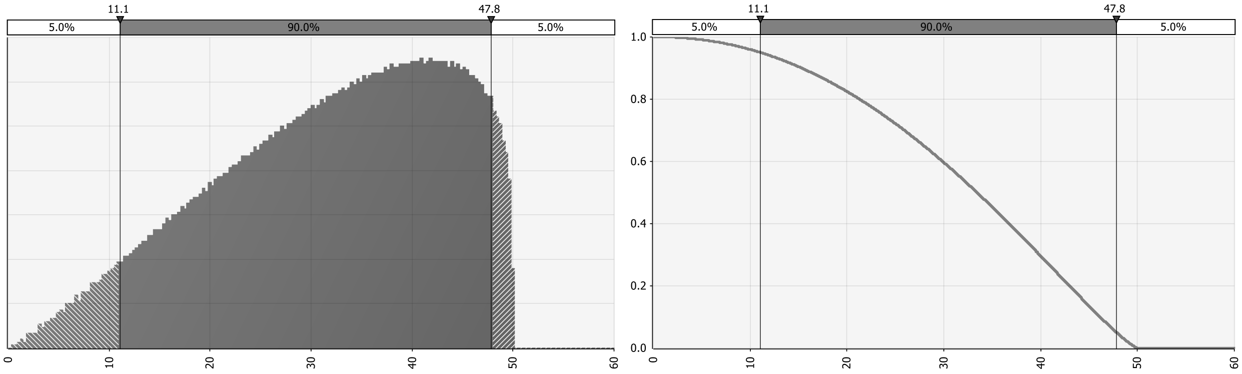

Figure 11 (a) Comparison of judged values (histogram in blue) and fitted distribution (red line); (b) fitted density function to describe the uncertainties with 90% uncertainty interval; (c) fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded

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 33 months (with a 95% uncertainty range of 8 - 49 months).

4. Conclusions

Hosts selection

All commercial citrus species and cultivars except for sour orange (*C. aurantium*) and Tahiti lime (*C. latifolia*) were assessed for impact since they are all considered to be susceptible to CBS.

Area of potential distribution

Although there is a high level of uncertainty, the current area of production of citrus in the EU was considered to be potentially vulnerable to *P. citricarpa* infection and was therefore used as the area of potential distribution for this assessment. The mean abundance of the pest, the main driver of the pest impact, is considered to be the same throughout the area of potential distribution.

Expected change in the use of plant protection products

Due to the fact that some of the fungicides currently used in the EU could have some effect against this pathogen, and therefore an increase in their application is expected to be the most likely control strategy, the most suitable PPP indicator is Case “C” and the category is “1”.

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 2% (with a 95% uncertainty range of 0 - 10%).

The proportion (in %) of quality losses is estimated to be 19% (with a 95% uncertainty range of 1 - 70%).

Spread rate

Based on the general and specific scenarios considered in this assessment, the maximum distance expected to be covered in one year by *P. citricarpa* is approximately 800 m (with a 95% uncertainty range of 56 – 3,562 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 33 months (with a 95% uncertainty range of 8 - 49 months).

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Appendix A – CABI/EPPO host list

The following list, defined in the Methodology Report (EFSA, 2019) 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**
Citrofortunella	*microcarpa*
Citroncirus	
Citrus	
Citrus	*aurantiifolia*
Citrus	*limon*
Citrus	*limonia*
Citrus	*nobilis*
Citrus	*paradisi*
Citrus	*reticulata*
Citrus	*sinensis*
Citrus	*tankan*
Fortunella	
Poncirus	*trifoliata*

Appendix B – Evidence tables

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

Citrus species / variety	**Infection**	**Symptoms**	**Impact**	**Additional information**	**Reference**
	Incidence	***Severity***	***Losses***		
Valencia sweet orange (*C. sinensis*)	% of fruit with CBS symptoms pre-harvest: 46-70% moving from low to high vertical sections of the plant harvest: 99.6-99.8%	Index on disease expression Pre-harvest: 1.03 Harvest: 6.56	Cumulative fruit drop (%) Day 15: 2% Day 29: 3% Day 44: 5% Day 58: 16% Day 72: 24% Day 89: 38% Day 103: 50%	Commercial citrus orchard with 16-year-old plants during one (2007) agricultural season	Araújo et al., 2013
Late-maturing 'Valencia' sweet orange (*C. sinensis*) grafted onto Rangpur lime (*C. limonia*)	Incidence progress curve Trial 1 May: 38% June: 76% July: 87% August: 88% September: 91% October: 95% Trial 2 May: 57% June: 79% July: 84% August: 97% September: 99% October: 100%	Severity progress curve Trial 1 May: 0.68 June: 1.97 July: 3.83 August: 3.65 September: 5.26 October: 5.03 Trial 2 May: 1.77 June: 1.81 July: 2.47 August: 3.21 September: 4.03 October: 5.19		Three seasons (2012-2015) in, commercial orchards non-irrigated commercial citrus orchards with 11-year-old plants during three consecutive agricultural seasons (2012-2015)	Silva Junior et al., 2016
Mature Valencia sweet orange (*C.*	Incidence of CBS (defined as % of fruit with CBS symptoms) exceeded 90% in untreated	Maximum CBS severity (measured as % of	% of premature fruit drop (crop loss) in untreated	Untreated control: both seasons were	Lanza et al., 2018

sinensis) orchard in Mogi Guaçu in São Paulo (SP), Brazil	control in both 2010/2011 and 2011/2012 (peak of 98% in first season and 88% in second season)	diseased area on the outer canopy-facing portion of the fruit) in untreated control was lower than 4 % in first season and lower than 3% in second season	control was 16.8% in 2010/2011 and 31% in 2011/2012	conducive for CBS occurrence	
Mature Valencia sweet orange (*C. sinensis*) orchard in Mogi Guaçu in São Paulo (SP), Brazil	CBS incidence of 15% in first season for both 180 and 220 DFP. In second season CBS incidence was 44% with 180 DFP (5 treatments: 2 Cu + 3 QoI) and 34% with 220 DFP (6 treatments: 2 Cu + 4 QoI)	Maximum CBS severity was respectively 0.2% and 0.6% in the two seasons with 180-220 DFP (5-6 treatments: 2 Cu + 3-4 QoI)	% of premature fruit drop (crop loss) for both 180 and 220 DFP (5-6 treatments = 2 Cu + 3-4 strobilurin (QoI)) were around 4% in first year and around 10-11% in second year	Period of protection in Days of Fruit Protection DFP = 180-220 DFP Number of treatments = 5-6 (2 Cu + 3-4 strobilurin (QoI)) (Copper used in the first two sprays starting at 70% petal fall)	Lanza et al., 2018
Mature Valencia sweet orange (*C. sinensis*) orchard in Mogi Guaçu in São Paulo (SP), Brazil	Incidence of CBS (defined as % of fruit with CBS symptoms) was 75% for 60 DFP (2 treatments = 2 Cu) in both 2010/2011 and 2011/2012 seasons	Maximum CBS severity (measured as % of diseased area on the outer canopy-facing portion of the fruit) for 60 DFP (2 copper treatments) was 2.3% and 2% in the two seasons	% of premature fruit drop (crop loss) for 60 DFP (2 treatments = 2 Cu) was 8.8% in first year but 26.9% in second year, without significant differences from untreated control	Period of protection in Days of Fruit Protection DFP = 60 DFP Number of treatments = 2 (2 Cu) (Copper used in the first two sprays starting at 70% petal fall)	Lanza et al., 2018
Citrus	This paper provides a comparative analysis on CBS incidence per type and number of treatments				Makowski et al., 2014

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

Spread	**Additional information**	**Reference**
By wind dispersal	*Ascospores*	EFSA PLH Panel, 2014
By splash dispersal	*Pycnidiospores*	EFSA PLH Panel, 2014
At kilometres of distance	*Ascospores*	Pazoti et al., 2005. No data available
Vertically at a height of over 60 cm and horizontally at a distance of at least 70 cm.	In still air, pycnidiospores in infected fruit were rain splashed	Perryman and West, 2014
Max distance evaluated: up to eight metres downwind, reaching heights up to 75 cm and even higher as a result of fine droplets becoming aerosolised	With the combined effect of rain and wind, pycnidiospores in infected fruit were rain splashed	Perryman and West, 2014
Over greater distances as seen with citrus canker	Likely that under hurricane or tropic storm conditions, diseased twigs and branches (with or without fruit) may disseminate the disease over greater distances as seen with citrus canker	Hendricks et al., 2017
Four to six metres	Mean distances between symptomatic trees were close to the spacing between neighbouring trees (four to six metres), indicating dispersion of the disease over short distances	Spósito et al., 2007
Maximum radius of symptom aggregation was 24.7 metres	Observed only in one year and in one orchard	Spósito et al., 2007
The disease expanded to new locations in south Florida in 2011 and 2012, and spread to polk county in central Florida in 2013, about 150 km away from the initial outbreak in the south	Human assisted spread in Florida, along the fruit transportation corridors from the regulated area (south) to the central areas, where juice factories and packinghouses are located.	Riley, 2013; USDA APHIS,2013

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

Reference	**Results / evidence**
Kotzé, 1981 and 2000	Foliar lesions are small sunken necrotic spots surrounded by a dark-brown ring. They are rare (infected leaves are generally asymptomatic) and present in only lemons or trees in poor condition
Timmer, 1999; Spósito et al., 2004; Sousa and de Goes, 2010	In fruit, CBS is characterised by a relatively long incubation period, and fruit symptoms become visible several months after infection. Lesion formation is driven by phenology and environmental factors and CBS symptoms are visible when fruit mature and reach the ripening stage
Aguiar et al., 2012	In artificial inoculations conducted under greenhouse conditions, the incubation period ranged from over 200 days for 3-cm-diameter sweet orange fruit to about 50 days for 7-cm-diameter fruit
EFSA PLH Panel, 2014 Figure 51	citrus fruit in the Mediterranean Basin may ripen from September to July depending on the cultivar. Therefore, fruit symptoms may be easily overlooked if surveys were not conducted to coincide with the specific ripening season for each cultivar
Kotzé, 1981	It may take 5-30 years from the time the first symptoms are noticed until the disease reaches epidemic proportions, depending on climate conditions and host susceptibility
Whiteside, 1967	In Zimbabwe, CBS was first discovered in 1961 and in 1967 was still considered rare and very localized
Garrán, 1996	In the northeast of Entre Rios, Argentina, CBS was first reported in 1986 but in 1996 it was not yet prevalent in the area with only a few foci showing slight to moderate disease severity