SCIENTIFIC OPINION

Risk assessment of *Xanthomonas citri* pv. *viticola* for the EU

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Abstract

Following a request from the European Commission, the EFSA Panel on Plant Health performed a risk assessment of *Xanthomonas citri* pv. *viticola* (Xcv). This pest causes bacterial canker of grapevine and is reported from Brazil and India. Two scenarios were considered: scenario A0 (current practice) and A2 (additional control measures). For the fresh grape import pathway, scenario A0 results in an order of magnitude of about one entry per 10 years (median; 90% uncertainty interval between ca. one entry per 18,000 years and ca. five entries per year). For the *Vitis* spp. plants for planting for research/breeding purposes import pathway, the risk of entry is several orders of magnitude smaller than the risk due to fresh grape import. This outcome is also obtained under scenario A2. The key entry uncertainties include import volume and transfer (for plants for planting), transfer and the disaggregation factor (for fresh grapes) and the limited availability of epidemiological data. The extent of the area favourable for Xcv establishment in the EU is uncertain, illustrating the limitations of climate suitability assessments when based on few data points and little epidemiological information. Nevertheless, the risk of Xcv establishment is only slightly lower than the risk of Xcv entry, i.e. no major establishment constraints are expected for most entries. Similarly, the risk of Xcv establishment is assessed as only slightly lower under current climate compared to the climate of 2041–2060. For grapevine growing areas in the EU with average yearly temperature above 17°C, the lag phase between establishment and spread is expected to be about 3 years (median; 90% range between ca. 6 months and ca. 6 years). Under the same scenario, the rate of spread by natural means is assessed to be ca. 300 m/year (median; 90% range between ca. 35 and ca. 800 m/year). The spread rate would be considerably higher considering movements of plants and cutting tools or machinery. The percentage of grapevine plants infected by Xcv in production sites as yearly average over a 30-year production cycle is estimated to be ca. 17% (median; 90% range between ca. 1.5% and ca. 46%) in table grapes and ca. 12% (median; 90% range between ca. 0.7% and ca. 37%) in wine grapes. Impacts have been reported to be severe in Brazil and India, but the estimates provided here show that there is considerable uncertainty about expected impacts in the EU.

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Summary

Following a request from the European Commission, the EFSA Panel on Plant Health performed a risk assessment of *Xanthomonas citri* pv. *viticola* (Xcv). This pest causes bacterial canker of grapevine and has been reported to lead to severe impacts in Brazil and India.

Entry was modelled by estimating the number of units (*Vitis* spp. plants, hereafter *Vitis* plants) infected by Xcv due to import in the EU of *Vitis* plants for planting for research/breeding purposes and fresh grapes. The calculation took into account prevalence at the origin, trade flow, sorting and transfer.

Two scenarios were considered for the entry assessment: scenario A0 (current practice) and scenario A2 (additional risk reduction options (RROs)). For the pathway plants for planting for research/breeding purposes, the additional RRO is hot water treatment at the origin. For the pathway fresh grapes, the additional RRO is pest-free places of production in affected areas, planted with clean (certified) material and subjected to surveys and proper disease and agricultural management.

According to the entry model results,

- For the fresh grape import pathway, scenario A0 results in an order of magnitude of about one entry per 10 years (median number; 90% uncertainty interval between about one entry per 18,000 years and about five entries per year). For scenario A2, these numbers are only slightly reduced.
- The risk of Xcv entry due to import of *Vitis* plants for planting for research/breeding purposes is several orders of magnitude smaller than the risk of Xcv entry due to fresh grape import, in both scenarios (i.e. with and without additional RROs).
- The effect of the considered RROs is small, i.e. the risk of Xcv entry is only slightly reduced by RROs for both pathways, because of the only limited effectiveness of the RROs.

Based on the sensitivity analysis, the factors included in the entry model most contributing to the variance in the outcome are:

- Import volume and probability of transfer (for plants for planting for research/breeding purposes).
- Probability of transfer and the disaggregation factor (for fresh grapes).

There is a lack of information on Xcv biology and disease epidemiology, due at least in part to the current restricted geographic distribution of the pathogen in Brazil and India. Other entry uncertainties include the pest distribution (e.g. the pest occurrence and prevalence in Thailand and some areas of Brazil and India), the role of fresh grapes as pest carrier as well as the role of other plant hosts. Furthermore, there is a lack of data on the proportion of sorting and transfer, as well as the effectiveness of RROs. More information is needed to reduce the uncertainty due to the lack of data regarding the proportion of infected berries in consignments and its possible decrease during post-harvest procedures. This lack of information is reflected in the parameter distributions and in the outcomes of the entry model.

Considering the paucity of available data on the distribution and ecophysiology of Xcv, bioclimatic variables were analysed using a simple approach whose objective was to identify the areas in the EU with climate conditions matching those of locations with reported Xcv presence. The extent of the climate types estimated as suitable for Xcv establishment in the risk assessment area is uncertain, as results are heterogeneous among bioclimatic variables. For some of them, values observed in most European areas are within the range observed in the areas where Xcv is currently reported, whereas for some others, there is no overlap between Europe and the areas where Xcv is reported. In parts of Southern Europe, several bioclimatic variables are found in the range of values observed in the areas where Xcv is reported. This suggests that the risk of Xcv establishment is higher in parts of Southern Europe compared to Central and Northern Europe. However, these conclusions are based on limited data on the climate in the locations where Xcv is currently reported and are thus fraught with uncertainty, which is reflected in the elicitation of the probability of establishment.

For the establishment assessment, under current climatic conditions, the risk of Xcv establishment is only slightly lower than the risk of Xcv entry, i.e. no major establishment constraints are expected for most entries.

The increasing trend of mean annual temperature over time may generally favour the thermophilic Xcv, especially if this temperature increase occurs during the wettest months of the growing season, where rains could have a positive impact on Xcv survival and dissemination. However, the influence on

Xcv establishment of considering climate change is likely to be minor, due to the relatively low importance of the probability of establishment in the establishment model, compared to the most influential factors of the entry model. Basically, there are already no major constraints on establishment, so this will apply also under climate change scenarios, at least over the period considered (2041–2060).

Should the pest manage to establish, for grapevine production areas in the EU with average yearly temperature above 17°C (a threshold based on available data) over the coming 30 years, the lag phase between establishment and spread in the area where Xcv can potentially establish is expected to be about 3 years (median; 90% range between about 6 months and about 6 years). Under the same scenario, the successive rate of spread by natural means is assessed to be about 300 m/year (median; 90% range between about 35 and about 800 m/year). The spread rate would be considerably higher considering human-assisted movement of plants and cutting tools.

Uncertainties affecting the assessment of spread include differences in agricultural practices between the EU and Brazil/India and the effect of differences in the duration of the vegetative period of the host. Moreover, the susceptibility of grapevine cultivars grown in the EU is uncertain.

For grapevine production areas in the EU with average yearly temperature above 17°C over the coming 30 years, the average yearly percentage of grapevine plants infected by Xcv in production sites over a 30-year production cycle is estimated to be about 17% (median; 90% range between about 1.5% and about 46%) in table grapes and about 12% (median: 90% range between about 0.7 and about 37%) in wine grapes. Impacts have been reported to be severe in Brazil and India, but the estimates provided here show that there is considerable uncertainty about expected impacts in the EU.

Uncertainties affecting the assessment of impact include the transferability to the EU of the climatic and agricultural conditions in Brazil and India under which Xcv is causing damage to grapevine.

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1. Introduction

1.1. Background and Terms of Reference as provided by the requestor

1.1.1. Background

The new Plant Health Regulation (EU) 2016/2031, on the protective measures against pests of plants, is applying from 14 December 2019. A focus on prevention and risk targeting is amongst the primary objectives of this legislation. Furthermore, conditions are laid down in this legislation for plant pests to qualify for listing as Union quarantine pests, protected zone quarantine pests or Union regulated non-quarantine pests. The lists of the EU regulated plant pests together with the associated import or internal movement requirements of commodities are included in Commission Implementing Regulation (EU) 2019/2072.

In line with the principles of the new plant health law, for a proactive approach, the European Commission with the Member States are discussing monthly the reports of the interceptions, together with data from horizon scanning for plant pests of concern of various sources. As outcome of those discussions, a number of plant pests of concern, not regulated in the EU, are identified, for which a risk assessment is needed to decide on potential EU regulation. *Leucinodes orbonalis* - which was recently spilt into two species *Leucinodes orbonalis* and *Leucinodes pseudorbonalis*, and *Xanthomonas citri* pv. *viticola* are amongst the species identified during these discussions.

In the EU, a number of actions are already in place to mitigate the various multilevel effects of climate change. The aim is to avoid adverse changes to the environment and to ensure food security. As the success of plant pests to establish in an area, depends on various abiotic and biotic parameters, it is anticipated that climate change might affect the risk that certain plant pests pose. Parameters as temperature, humidity, CO_2 concentration and salinity of soil affect the survival and pathogenicity of a number of plant pests, as reported in the scientific literature. Changes in temperature, drought and salinity can affect also the geographic distribution of the hosts of plant pests, and as a consequence the plant pests' establishment.

There is therefore a need to develop further the quantitative risk assessment methodology followed for plant pests and consider including the effect of climate change in the assessment of the risk that plant pests pose to the EU.

1.1.2. Terms of Reference

In accordance with Article 29(1) of Regulation (EC) No 178/2002, the Commission asks EFSA to develop further the quantitative risk assessment (phase 1 and phase 2) methodology followed for plant pests, to include in the assessments the effect of climate change for plant pests. Such inclusion of climate change scenarios can benefit of the quantitative methodology with comparison of risk assessment scenarios which has been already developed by the EFSA PLH Panel and included in its Guidance on quantitative pest risk assessment. Examples of abiotic parameters affecting the biology of the pests and their hosts' distribution are given in the background. The aim of this methodological development is to enable risk projections in the future, with models taking into account the relevant critical parameters for spread, establishment and potential impact that are affected in a scenario of 'climate change'.

The risk assessments of *Leucinodes orbonalis*, *Leucinodes pseudorbonalis* and *Xanthomonas citri* pv. *viticola* can be used for the development of the methodology.

1.2. Interpretation of the Terms of Reference

1.2.1. Pest categorisation

The EFSA Panel on Plant Health (hereafter Panel) published a pest categorisation on *Xanthomonas citri* pv. *viticola* (hereafter Xcv) (EFSA PLH Panel, 2021), which concluded that the pest meets the criteria for consideration as Union quarantine pest. The reader is referred to that document for information on the identity, biology, detection and identification, establishment, spread and impacts of the pest. Information provided in the pest categorisation is not repeated here, unless required for the purposes of this risk assessment.

1.2.2. Interpretation of the Terms of Reference

The Panel interpreted the terms of reference (ToR) as a request to perform a risk assessment on Xcv including all the steps (entry, establishment, spread and impact). In addition, climate change was studied in relation to establishment (see Section 4.2.4).

2. Data and methodologies

2.1. Data

A literature search on Xcv was conducted at the beginning of the risk assessment (September 2021), with updated searches during the risk assessment up to September 2022, in the ISI Web of Science bibliographic database, using the different scientific names of the pathogen (Xcv was previously regarded as a *Xanthomonas campestris* pathovar) and the common name of the disease (bacterial canker of grapevine) as search terms (search equation = '*Xanthomonas c** pv. *viticola*' OR 'bacterial canker of grapevine'), to retrieve relevant information and data appeared since the publication of the EFSA pest categorisation on this pathogen (EFSA PLH Panel, 2021). Relevant papers were reviewed and further references and information were obtained from experts, as well as from citations within the references and grey literature.

Information on the pest distribution was retrieved from the EPPO Global Database (EPPO, 2022) and relevant literature.

Data on interceptions and outbreaks of the pest within the risk assessment area were searched in the Europhyt and Traces databases (as of May 2022).

For this opinion, the following additional data were searched:

- Data on the prevalence of Xcv in Brazil, India and Thailand.
- Data on the EU import of *Vitis* plants for planting for research/breeding purposes. These data were obtained from the major grapevine-producing EU MSs (France, Italy and Spain).
- Data on the transfer rate of the pathogen from infected *Vitis* plants to other *Vitis* plants.
- Data on the effectiveness of RROs for this pathogen.

2.2. Methodologies

The Panel performed this risk assessment following the Panel's guidance on quantitative pest risk assessment (EFSA PLH Panel, 2018).

Entry via trade in imported *Vitis* plants for planting for research/breeding purposes and fresh grapes was assessed using pathway modelling in @Risk (https://www.palisade.com/risk/default.asp). The same software was used to perform a sensitivity analysis for the parameters included in the model (see Section 3.3).

Expert elicitation was used to estimate model input numbers for each sub-step of the pathway model, following the EFSA guidance on expert elicitation (EFSA, 2014) (see Section 3.2.2).

2.2.1. Conceptual model and definitions

2.2.1.1. Definition of the pathways

The only pathways of entry considered in the model were (i) *Vitis* plants for planting for research/breeding purposes and (ii) fresh grapes.

Vitis plants for planting can be imported in the EU for research/breeding purposes only (Commission Delegated Regulation (EU) 2019/829 of 14 March 2019). They should be kept under confined conditions, but no details in the legislation are provided about how to do that. The original material cannot be destroyed, since it is used to produce plant material for breeding or scientific evaluation. All experiments are performed under confined conditions. Research may last 2–3 years (all in quarantine premises). During that period, if suspicious symptoms are not observed, the material is considered free from relevant pathogens and may be used to produce propagating material (pers. comm. M. Cardoni, Faenza, Italy, March 2022). In some cases, living seeds can be imported as breeding material. Quantities of *Vitis* plants for planting imported for research/breeding purposes are limited. All imported material should be checked with diagnostic methods, but not specifically for Xcv. It is mandatory to notify those imports and they are subject to MS authorisation.

Fresh grapes can be a pathway for this pest, although there seems to be no epidemiological study on the importance of fruit as pathway. The pathogen can be hosted in the fruit, but the significance of such infections is unclear. Grape import data are available.

Other non-quantified pathways:

The *Vitis* plants for planting pathway (not for research/breeding purposes) is closed by legislation (Commission Implementing Regulation (EU) 2019/2072), so it is not considered here.

Regarding non-*Vitis* hosts, e.g. mango, these are experimental hosts. The pest might theoretically survive on mango fruit. However, mango fruits are not considered here as a risky pathway since reports of natural infections were not found (Ferreira et al., 2019). Moreover, mangoes are subject to post-harvest treatments to enhance quality and reduce the risk of pests and diseases (Asio and Quaresma, 2016).

Similarly, the risk of entry due to putative alternative hosts such as the herbaceous species *Phyllanthus maderaspatensis* or the cultivated *Azadirachta indica* (neem tree) was not quantified here, because of lack of data (EFSA PLH Panel, 2021).

2.2.1.2. Conceptual model

The entry process was modelled by estimating the number of founder populations of Xcv in the EU due to import in the EU of *Vitis* plants for planting for research/breeding purposes and fresh grapes. The calculation considered the parameters listed in Table 1 (prevalence at the origin, trade flow, sorting and transfer).

2.2.1.3. Formal model

The model is a basic pathway model,

$$N_{inf} = N_{trade} \times p_{prevalence} \times (1 - p_{sorting}) \times d \times p_{transfer}$$

where the meaning and the units of the parameters are defined for plants for planting in Table 1 and for fresh grapes in Table 2.

For the fresh grape pathway, a multiplication factor (d) was used to take into account the distribution of the infected material to different locations (e.g. retail markets) in the risk assessment area (see EFSA PLH Panel, 2017). For this pathway, it was assumed that one ton (the unit of measure of the fresh grape trade flow) of infected grapes could lead to several founder populations. For the *Vitis* plant pathways, this factor d is set equal to one as it is assumed that one infected plant cannot produce more than one founder population.

Table 1: Definitions of the output variable (N_{inf}) and parameters used in the entry model (pathway *Vitis* plants for planting imported for research/breeding purposes)

Name	Description	Units
N_{inf}	Number of founder populations of Xcv	Number of founder populations per year
N_{trade}	Total number of *Vitis* plants for planting (infected or not) imported by the EU for research/breeding purposes from areas of Brazil and India	Number of plants per year
$p_{prevalence}$	Prevalence of Xcv in Brazil and India where *Vitis* plants are collected for export to the EU for research/breeding purposes (expressed as the proportion of infected *Vitis* plants to all *Vitis* plants present in the areas considered)	Proportion of plants
$p_{sorting}$	Proportion of infected *Vitis* plants removed following pre-import inspection (identification and removal of infected plants before entry in the EU)	Proportion of plants
$p_{transfer}$	Probability that infected *Vitis* plants successfully transfer the pest from the EU points of entry to suitable hosts growing in the EU	Probability

Table 2: Definitions of the output variable (N_{inf}) and parameters used in the entry model (pathway fresh grapes)

Name	Description	Units
N_{inf}	Number of founder populations of Xcv	Number of founder populations per year
N_{trade}	Total quantity of fresh grapes (infected or not) imported by the EU from areas of Brazil and India	Tons (1,000 kg) per year
$p_{prevalence}$	Prevalence of Xcv in Brazil and India where fresh grapes are harvested for export to the EU (expressed as the proportion of infected fresh grapes to all fresh grapes harvested in the areas considered)	Proportion of fruits
$p_{sorting}$	Proportion of infected fresh grapes removed following pre-import inspection (identification and removal of infected fruits before entry in the EU)	Proportion of fruits
d	Disaggregation factor, reflecting the distribution of one ton of infected fresh grapes to locations in the risk assessment area	Number of disaggregated units of fresh grapes/ton
$p_{transfer}$	Probability that the pest in one disaggregated unit of fresh grapes is transferred to suitable hosts	Probability

The model includes four parameters for the *Vitis* plants for planting for research/breeding purposes pathway and five parameters for the fresh grapes pathway. Five quantiles were provided for each parameter based on data and expert judgement, following EFSA guidance documents on expert knowledge elicitation and uncertainty (EFSA, 2014, 2019a). In short: experts elicit five quantiles for each parameter (1, 25, 50, 75, and 99%) and a theoretical probability distribution is then fitted to these quantiles for each parameter, using least squares in @Risk. The fitted distributions reflect the plausible values of the different parameters.

The pathway model was run using Monte Carlo simulations, by repeatedly (10,000 times) drawing random realisations out of the elicited distributions for the nine parameters and calculating the resulting 10,000 values of the outcome variable: the number of founder populations per year in the EU as a result of import of infected units from Brazil and India. Thailand was not included in the model, due to uncertainties about the occurrence and prevalence of Xcv in that country (see Section 4.2.1), and the lack of evidence on relevant imports. The calculation was made under different scenarios for regulation (see Section 2.2.2). The model was implemented in @Risk (see Supplementary Information – Annex A).

2.2.1.4. Potential risk reducing options

The management options to reduce the probability of entry of Xcv must distinguish between those measures applied at the country of origin (pre-entry measures) and those applied at the point of entry (import control measures).

The following RROs may be considered for the present risk assessment, but only two (RRO3 and RRO4) were assessed quantitatively here (see Section 2.2.2):

Pre-entry measures

RRO1 – Banning the introduction of *Vitis* propagating and planting material (even for scientific purposes) from Xcv-affected areas.

Based on the literature, the disease is currently restricted to some areas of Brazil, India and possibly also in Thailand. Plants of *Vitis* were identified as a major pathway for the entry of Xcv in the EU.

Total prohibition of plants and propagation material of *Vitis* from affected areas of Brazil, India and Thailand, even for scientific purposes, germplasm trials and cultivar selection or breeding, may be implemented, excluding them from the permission of importation under the Commission Delegated Regulation (EU) 2019/829 of 14 March 2019.

Effectiveness: In itself, the control measure is effective, but its impact on the risk of entry would be limited for this pathway, due to the current low importation of these materials and control measures applied when *Vitis* plants are used for scientific purposes.

Technical feasibility: high.

RRO2 – Prohibition of fresh grapes importation from affected areas in Brazil, India and Thailand.

Fruits of *Vitis* imported as table grapes from India, Brazil and Thailand were identified as a pathway and prohibition of importation from affected areas of these countries mitigates the risk of entry in EU.

Effectiveness: high, exclusion of the putative inoculum source.

Technical feasibility: rather easy to set up, but there is the possibility that the measure is circumvented. More feasible if the ban could be implemented only during the period when transfer to suitable hosts is more likely (when *Vitis* plants are not dormant).

RRO3 – Requirements for fresh grapes exportation at point of origin (pest-free places of production).

Measures concerning the places of production could be required to exporting countries and may be supported by certification systems for assurance of Xcv-free consignments to be imported, especially from affected areas. Appropriate surveillance, management and traceability of the places of production could be a prerequisite for EU importation.

Effectiveness: high, if requirements are properly established and implemented.

Technical feasibility: high, based on international standards for phytosanitary measures.

RRO4 – Measures to reduce pest prevalence at origin.

Different sanitising agents have been tested and could be used at point of origin to suppress the possible bacterial epiphytic phase on plant materials. Sanitising agents (ozone, electrolyzed water, H_2O_2, SO_2) are described. Their efficacy is unknown on Xcv, though they may kill epiphytes, especially ozone and H_2O_2 treatments.

Plants of *Vitis* are generally imported in the dormant phase. Therefore, the presence of Xcv as an epiphyte is uncertain. However, in other *Xanthomonas*, epiphytic bacterial survival has been demonstrated even in adverse conditions due to resistance mechanisms adopted by the bacteria (e.g. biofilms).

Thermal treatments could also be used in plants of *Vitis*. Silva et al. (2013) failed to eliminate Xcv from *in vitro* plants using thermotherapy at 38°C for 30 days. Thermo-therapeutic treatments with dormant plant materials of *Vitis* at 48–52°C for 30–45 min (according to grapevine cultivars) are recommended for other bacterial plant pathogens (EFSA PLH Panel, 2015).

Silva et al. (2013) published data on the production of Xcv-free grapevine material. This was done by the meristem propagation technique, which can effectively eliminate the pathogen from grapevine plants.

Effectiveness: unknown for most sanitising agents and thermal treatments. Meristem propagation can be effective.

Technical feasibility: high, for thermal treatments considering the limited quantities of *Vitis* plants for planting imported for research/breeding purposes. Doubtful, for most sanitising agents owing to the endophytic phase of Xcv.

Import control measures

RRO5 – Visual inspection of the consignment at points of entry.

Disease symptoms are visible in infected plants and sometimes in fresh grapes. Nevertheless, asymptomatic (symptoms may develop starting from 12 to 14 days after inoculation; EFSA PLH Panel, 2021) but infected material is common due to bacterial survival as an epiphyte or endophyte in plants and fresh grapes. Symptoms caused by Xcv can be confused with other diseases or abiotic disorders.

Effectiveness: medium, considering the presence of asymptomatic but infected materials, and the possible confusion with other diseases.

Technical feasibility: high, considering the methodologies for sampling of consignments (ISPM, 2008).

RRO6 – Inspection of the consignment at points of entry to determine the presence of Xcv by appropriate techniques.

The presence of Xcv can be tested, from symptomatic and asymptomatic plant materials, by using appropriate techniques that include bacterial isolation in culture media and identification by microbiological and molecular biology techniques, or direct detection methods such as ELISA and PCR (Villela et al., 2019).

Effectiveness: high, considering the detection methods available for Xcv.

Technical feasibility: high, for *Vitis* plants for planting considering the limited quantities imported for research/breeding purposes. Very low, for fresh grapes considering the relatively large quantities imported.

2.2.1.5. Ecological factors and conditions in the chosen scenarios

The risk assessment was performed under current ecological factors and conditions for the grapevine growing areas of the EU (risk assessment area) and Brazil and India (countries of origin).

2.2.1.6. Temporal and spatial scales

The risk assessment area was the EU territory.

The temporal horizon considered for the risk assessment was 10 years (2022–2032). This temporal horizon delimits the scope of the parameter elicitations. Entry was considered as a separate process for each year. No time-cumulative processes were accounted for in the entry model.

2.2.2. Specification of the scenarios

The following scenarios were considered:

Entry:

- Scenario A0 (current practice),
- Scenario A2 (additional RROs)

A scenario A1 (deregulation) was not considered, given that the pest is currently not regulated in the EU.

For the pathway *Vitis* plants for planting for research/breeding purposes, the additional RRO is hot water treatment at the origin (RRO4).

For the pathway fresh grapes, the additional RRO is pest-free places of production in infected areas, planted with clean (certified) material and subjected to surveys and proper disease and agricultural management (RRO3).

Establishment:

- Scenarios A0a and A2a (climate of the RA time horizon; 10 years, see Section 2.2.1.6),
- Scenarios A0b and A2b (climate change, i.e. climate projections for 2041–2060, Shared Socio-Economic Pathway (SSP)2–4.5, i.e. intermediate greenhouse gas (GHG) emissions; see Section 4.2.4).

Scenario 'a' refers to current climate, whereas scenario 'b' refers to climate change, see Section 4.2.7.

Spread and impact:

- Grapevine production areas in the EU with average yearly temperature above 17°C (threshold based on available data, please see Section 5) as average of the coming 30 years.

3. Entry

This section presents background information, including the evidence dossier used for the elicitation of the model parameters. The scenarios used for the entry assessment are then recapitulated and the results presented. The main uncertainties are described, and an assessment of the overall uncertainty and of the dependencies among parameters is included.

3.1. Background information

3.1.1. Pest prevalence at the origin ($p_{prevalence}$)

Limited information is available on pest prevalence at the origin (Table 3; Appendix A). While disease prevalence is reported from Brazil, yield losses and disease severity are provided in India. No information was found on Xcv prevalence in Thailand. Reported prevalence is within orchards. Prevalence at the regional scale will tend to be lower, and this was taken into account in the elicitation (Section 3.2.2).

Table 3: Summary of the evidence on pest prevalence, disease severity and crop losses at the origin

Disease prevalence (% plants)	Impact (yield loss or disease severity)	Country	Reference
70–80		Brazil	Rodrigues Neto et al. (2011)
100		Brazil	Peixoto and Ramos (2004)
55		Brazil	Lima et al. (2000)
100		Brazil	Lima and Ferreira (2000)
100		Brazil	Lima et al. (1998)
Nearly 100	Nearly complete yield loss	Brazil	Lima et al. (1999)
	60–80% yield loss	India	Chand and Kishun (1990)
	16–50% disease severity	India	Jambenal et al. (2011)

Most of the Brazilian production of table grapes comes from the same area (i.e. Vale do Submédio São Francisco, states of Pernambuco and Bahia) (Leão et al., 2020). This is not the case in India, where table grape production is distributed in the country. In both Brazil and India, mangoes are cultivated in the same areas of table grape production, but no reports of the disease on this crop were found (see Section 2.2.1.1).

The high crop losses noted in the literature are consistent with the reported disease prevalence in terms of percentage of infected plants, reaching 100% in most cases in some orchards. An example of a disease affecting *Vitis* with high crop losses and high proportion of affected plants is Flavescence doree (EFSA PLH Panel, 2016).

Xcv is a systemic pathogen, consistently colonising the vines, the tendrils and the trunk. Crop losses might be thus due to the death of vines bearing grape bunches, tendrils and whole plants. Disease progression can be slowed down to some extent by implementing strong sanitation pruning, thereby reducing yields but avoiding the death of plants. Nonetheless, the pathogen was reported to survive for at least 80 days in grapevine-infected tissues on the soil surface (Silva et al., 2012).

If disease prevalence is high, but proper management practices are implemented to keep disease severity low, commercial production may be possible at least for a few years. This is plausible considering that infected but asymptomatic plants and grapes can be present. In addition, an overall high incidence level can be reached with a low number of infected orchards, but high levels of incidence within the infected orchards. Furthermore, data are lacking on whether all grapes from infected plants are also infected.

3.1.2. Trade flow (N_{trade})

Plants for planting

Data on the import of *Vitis* plants for planting for research/breeding purposes were obtained on request from the French, Italian and Spanish NPPOs. No import of such material from Brazil and India to France and Italy was officially recorded over the last 10 years (2011–2021), whereas one such import was reported from Spain over this time period.

Fresh grapes

Data on yearly fresh grape EU import from Brazil and India (2011–2020) were extracted from EUROSTAT (Table 4, which presents data for the last 5 years). A trend analysis was performed on the sum of the imports from both countries (Figure 1).

Table 4: Fresh grape EU import from Brazil and India (2016–2020) in tons. Source: EUROSTAT, accessed October 2021

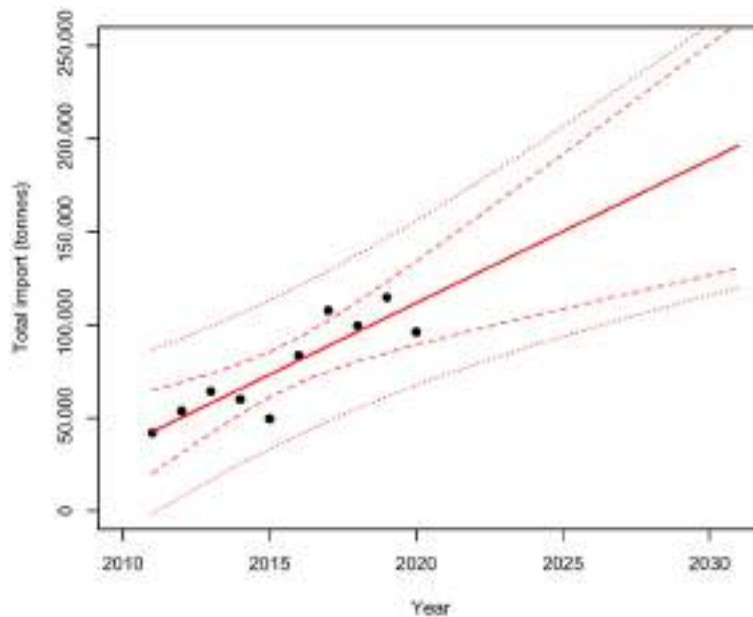| Year	2016	2017	2018	2019	2020	Average
Brazil	19,415	24,928	27,199	19,646	22,809	~ 22,800
India	64,093	82,747	72,280	95,091	73,388	~ 77,520

Figure 1: Trend analysis of the import of fresh grapes (tons) from Brazil and India into the EU, based on 2011–2020 Eurostat data, over the 10 years of the PRA time horizon (2023–2032). Dashed and dotted lines indicate the 95% confidence and prediction intervals

3.1.3. Sorting ($p_{sorting}$)

In the case of *Vitis* plants for planting for research/breeding purposes, materials are usually prepared in the form of cuttings for propagation. Visual inspection and specific detection methods for Xcv can be applied to those cuttings. The pathogen could be detected in most, but not all cuttings because of uneven bacterial distribution and low bacterial concentration. Detection of Xcv is more difficult in infected but asymptomatic cuttings.

The rate of infected fresh grapes imported from Brazil or India and the prevalence of Xcv in consignments are difficult to assess because of the current lack of specific inspection for this pest. Infected grapes may have some lesions, spots or discoloration (non-specific for Xcv), but most of the time they are asymptomatic. The confirmed existence of asymptomatic berries from infected plants makes prevalence estimation even more difficult. High inoculum levels in an infected area (Table 3) may result in the presence of asymptomatic but infected grape berries in the consignments. Therefore, visual inspection is not expected to be effective.

Limited information is available about the persistence of the bacteria on grape berries, although this is plausible because of the potential bacterial biofilm formation on fruit surface and reported Xcv presence in seeds (de Oliveira et al., 2014). Moreover, the pathogen causes lesions and cankers on the pedicels and rachis of the bunches (Chand and Kishun, 1990; Trindade et al., 2007). The only found publication with information regarding bacteria on fruits and seeds showed that the presence of Xcv was confirmed in 10 of 10 symptomatic seeds in the Red Globe cultivar, whereas 8 of the 10 asymptomatic seeds samples also carried the bacterium (de Oliveira et al., 2014).

Bagging of grape bunches is frequently done during the cultivation of high-value table grapes in order to harvest fruits without blemishes suitable for the export markets. Thinning of bunches is done three times during cultivation, to prune away misshapen and symptomatic berries and increase berry size (Larrington-Spencer, 2014), so not all infected grapes will be harvested.

Quality sorting is later done at the packing house, but no inspection for export specific to this particular pest is foreseen. Although no specific selection for Xcv-infected fruits is performed, regular sorting for quality checks of the defective fruit could prevent the exportation of Xcv symptomatic berries (Australian Government Department of Agriculture and Water Resources, 2016). Grape bunches with symptoms can be removed during harvesting and postharvest processes. However, as indicated above, this practice does not eliminate those apparently healthy but nevertheless contaminated berry lots. Usually, bunches are thinned/trimmed, or cut into smaller parts to allow packaging (usually 500 g punnets or polythene pouches): therefore, damaged wings or cluster parts (laterals) are cut and discarded (Anonymous, 2009).

Although no data were found on the proportion of grape berries removed because of Xcv, the incidence of insect pests and other diseases was described as a major cause of post-harvest losses. These losses were identified at farm level and during sorting and grading with a value from about 7% to about 13% in India and from about 6% to about 9% in Brazil (Kumar Sharma and Sawant, 2016; da Costa Ferreira et al., 2020). These losses include also those due to symptomatic Xcv berries. Nonetheless, according to quality standards for the export markets, only fruits without any blemishes are exported (Anonymous, 2009; Dorr and Grote, 2009).

3.1.4. Transfer rate ($p_{transfer}$)

The intended use of fresh grapes is human consumption, thus reducing the likelihood of transfer to suitable plant hosts in the risk assessment area.

The role of infected grape berries, petioles and raquis in the vicinity of vineyards as a source of primary inoculum allowing the transfer of Xcv to a suitable host is not documented. No studies addressing this question were found but bacterial presence has been proven both in symptomatic and asymptomatic grape berries. Such kind of transfer may occur as in other *Xanthomonas* (EFSA PLH Panel, 2014), but uncertainties remain.

Possible transfer from infected grapes in waste to suitable hosts may be possible from infected fruit by regular xanthomonads transmission pathways, i.e. rain splash or wind-driven rain under proper climatic conditions.

Heavy rains and storms typical of subtropical climates can cause wounds and detach leaves, where infection can take place. Murcia, the most important growing area of table grapes in Spain, has no more than 680 mm per year, most of them concentrated in autumn (Anonymous, 2004), when there are still leaves and thus there is still chance for infection by Xcv.

Another possibility is the transfer of Xcv after germination of infected seeds from fruit waste. This is considered unlikely because grapevine seeds do not germinate without stratification (Wang et al., 2022) and Xcv seed to seedling transmission has not been demonstrated.

Transfer from infected propagating plant material is a more likely process than transfer from infected fresh grapes. *Vitis* plants for planting for research/breeding purposes are usually imported in the form of cuttings for propagation. Buds or pieces from those cuttings are then grafted onto grapevine plants in the risk assessment area.

3.2. Entry assessment

3.2.1. Scenario recapitulation

The following scenarios for entry were considered:

- Scenario A0 (current practice)
- Scenario A2 (additional RROs)

For the pathway *Vitis* plants for planting for research/breeding purposes, the considered RRO is compulsory hot water treatment at the origin. This RRO was considered in the PRA because *Vitis* cuttings for propagation are often treated with hot water to suppress the presence of phytoplasmas and other pests (EFSA PLH Panel, 2015).

For the pathway fresh grapes, the considered RRO is pest-free places of production in affected areas, planted with clean (certified) material and subjected to surveys and proper disease and agricultural management. This measure was considered in this PRA as it is already in place for other pests (ISPM, 2016).

A scenario A1 (deregulation) was not considered, given that the pest is currently not regulated in the EU. The scenario with additional RROs (A2) was not called A1 to be consistent with previous EFSA PLH PRAS (e.g. EFSA PLH Panel, 2019b), where A2 was the scenario with additional RROs, and A1 was the deregulation scenario.

3.2.2. Definition of the parameters and elicitation of their distribution

3.2.2.1. Prevalence at the origin

Two types of prevalence at the origin ($p_{prevalence}$) are defined in Table 5.

Table 5: Definition of the parameter prevalence at the origin ($p_{prevalence}$)

Name	Definition	Sources
$p_{prevalence}$ (plants)	Prevalence of Xcv in Brazil and India where *Vitis* plants are collected for export to the EU for research/breeding purposes (expressed as the proportion of infected *Vitis* plants to all *Vitis* plants present in the areas considered)	Literature (see Section 3.1.1) and expert knowledge
$p_{prevalence}$ (grapes)	Prevalence of Xcv in Brazil and India where fresh grapes are harvested for export to the EU (expressed as the proportion of infected fresh grapes to all fresh grapes harvested in the areas considered)	Literature (see Section 3.1.1) and expert knowledge

The elicited distributions of the prevalence at the origin and of the effectiveness of RROs, defined as the prevalence reduction (%) compared to scenario A0, are reported in Tables 6 and 7 and Figures 2–5.

Table 6: Elicited quantiles of prevalence at the origin ($p_{prevalence\ (plants)}$) under current practice (scenario A0) and RRO effectiveness (scenario A2) for *Vitis* plants for planting for research/breeding purposes

Quantile:	1%	25%	Median	75%	99%
A0 ($p_{prevalence\ (plants)}$)	0	0.002	0.005	0.0055	0.006
A2 (RRO effectiveness)*	55%	63%	70%	74%	80%

*: % of prevalence reduction compared to scenario A0.

Justification – plants for planting scenario A0 (current practice):

When importing *Vitis* plants for planting for research/breeding purposes, the material should be grown and kept in screenhouses, tested for regulated pests (Xcv is not currently regulated in the EU) and provided with a certificate. Another key point is that Xcv is apparently not regulated in India (Anonymous, 2003), which increases the risk, because specific surveys for this pathogen might not be carried out systematically.

The elicitation was conducted first for fresh grapes. It was reasoned that prevalence for plants for planting for research purposes is higher than for fresh grapes, as in an infected plant not all bunches may be necessarily infected due to the uneven bacterial distribution. Nevertheless, in contrast to fresh grapes, plants for research/breeding purposes are likely to be subjected to surveillance, although not specifically for this pest. The reported high yield losses would translate in prevalence close to 100% of diseased plants, but not all grapevine-growing areas in Brazil and India are currently affected by Xcv (Ferreira et al., 2019; Kamble et al., 2019).

Justification – plants for planting scenario A2 (mandatory hot water treatment):

Hot water treatments of dormant cuttings are not currently mandatory for *Vitis* plants for planting for research/breeding purposes, but can be used as described for other pests (Gramaje et al., 2014; EFSA PLH Panel, 2015). For the 99% quantile, it was considered that high effectiveness of the hot water treatment should be around 80%, if a good protocol efficient for other systemic plant pathogens is followed (EPPO, 2012; EFSA PLH Panel, 2015). For the median, it was considered that the effectiveness of the hot water treatment is lower than the one of the suggested RROs for grapes, as in that case pest-free places of production follow a systems approach combining different RROs. Values for the 25% and 75% quantiles were chosen to reflect the uncertainty in the effectiveness of this treatment.
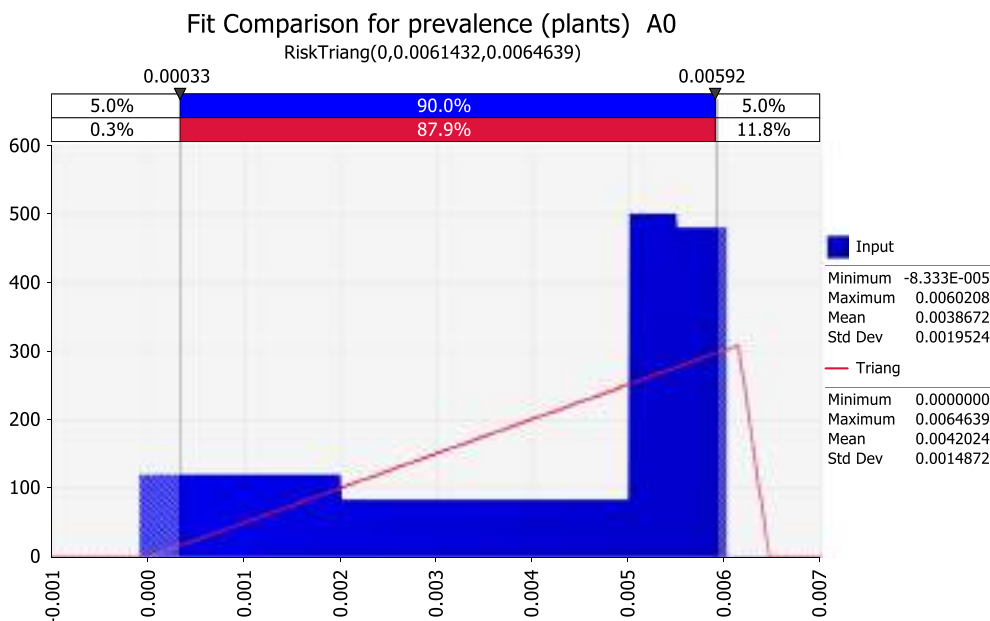
Figure 2: Fitted distribution for prevalence at the origin ($p_{prevalence\ (plants)}$) for *Vitis* plants for planting for research/breeding purposes under current practice (scenario A0)
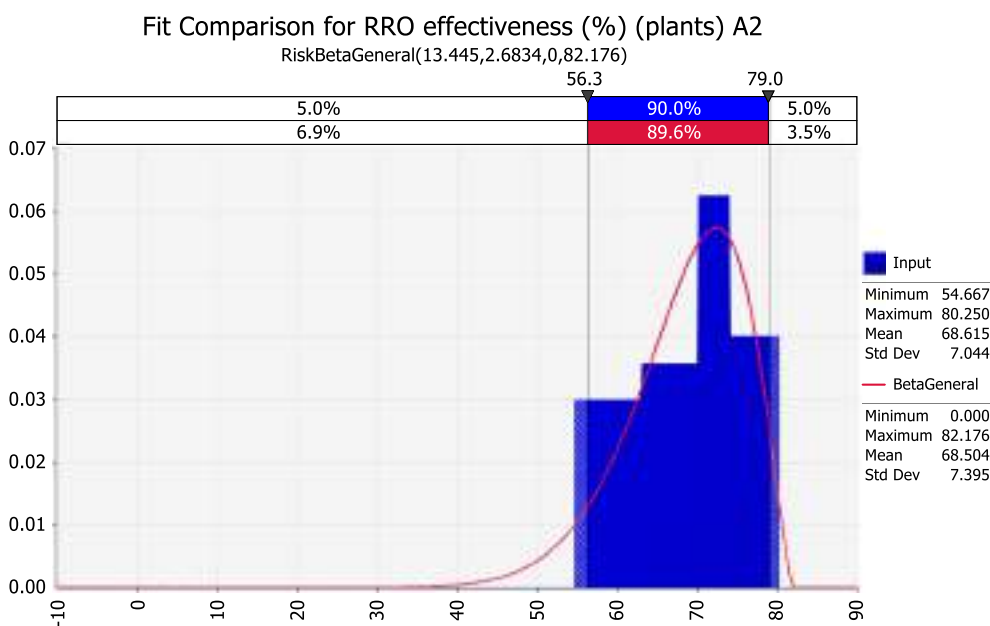
Figure 3: Fitted distribution for the effectiveness of RROs (scenario A2) for *Vitis* plants for planting for research/breeding purposes

Table 7: Elicited quantiles of prevalence at origin ($p_{prevalence\ (grapes)}$) under current practice (scenario A0) and RRO effectiveness (scenario A2) for fresh grapes

Quantile:	1%	25%	Median	75%	99%
A0 ($p_{prevalence\ (grapes)}$)	0	0.015	0.003	0.004	0.005
A2 (RRO effectiveness)*	60%	75%	80%	85%	92.5%

*: % of prevalence reduction compared to scenario A0.

Justification – fresh grapes scenario A0 (current practice):

Values refer to the overall imports of fresh grapes from Brazil and India, not just from areas affected by Xcv. This is because export volumes in Eurostat for Brazil and India, used for N_{trade}, were available only at country level. In Brazil, most of the production of table grapes is concentrated in an area across the states of Pernambuco and Bahia, where Xcv has been reported. However, table grape production in India is more widespread. The disease is likely to be present where grapevine cultivation is more intensive (Ferreira et al., 2019; Kamble et al., 2019). It was assumed that most of the export production of fresh grapes to the EU in both countries of origin is coming from affected areas.

For the 1% quantile, it was considered that infection of grapevine plants might not always lead to infection of grapes, due to the likely uneven distribution of the bacteria. Moreover, not all areas where grapes are harvested for export to the EU are affected.

For the 99% quantile, an upper value of 0.5% of fresh grapes was assumed for export infected by Xcv, including both symptomatic and asymptomatic berries. For the median, it was considered that the pathogen was detected in seeds (de Oliveira et al., 2014).

This justified choosing the median value closer to the upper boundary. For each ton of harvested fresh grapes, a median prevalence of 0.003 implies 3 kg of infected fresh grapes.

The 25% and 75% quantiles were chosen away from the median, to reflect the large uncertainties in the estimation of this distribution.

Justification – fresh grapes scenario A2 (pest-free places of production):

It was considered that pest-free places of production in affected areas should be planted with clean (certified) material and subjected to surveys and proper disease and agricultural management. Nevertheless, complete efficacy is not expected for this RRO. Vineyards can be infested by incoming inoculum from neighbouring fields where Xcv is present, but this may affect mainly the plants on the borders. Wounds produced during harvest facilitate infections, but harvest is normally done in the dry season, when environmental conditions are less conducive to infection. Rain occurs more often in early phenological phases, the period most favourable to the disease. Then, infections can progress systemically, colonising the vines even during the dry season. This kind of epidemiological events and the presence of infected but asymptomatic plants imply that even if a place of production is surveyed, it might not be free of the pest. The use of copper compounds against Xcv does not rule out the presence of the pest in vineyards, because, even if properly applied against the disease, the efficacy of copper compounds is limited. Summer pruning is often done to increase light penetration into the canopy and to increase nutrient flow to the grapes. Nevertheless, it produces wounds through which Xcv can enter plants, even if using good sanitation practices such as cleaning of pruning tools.
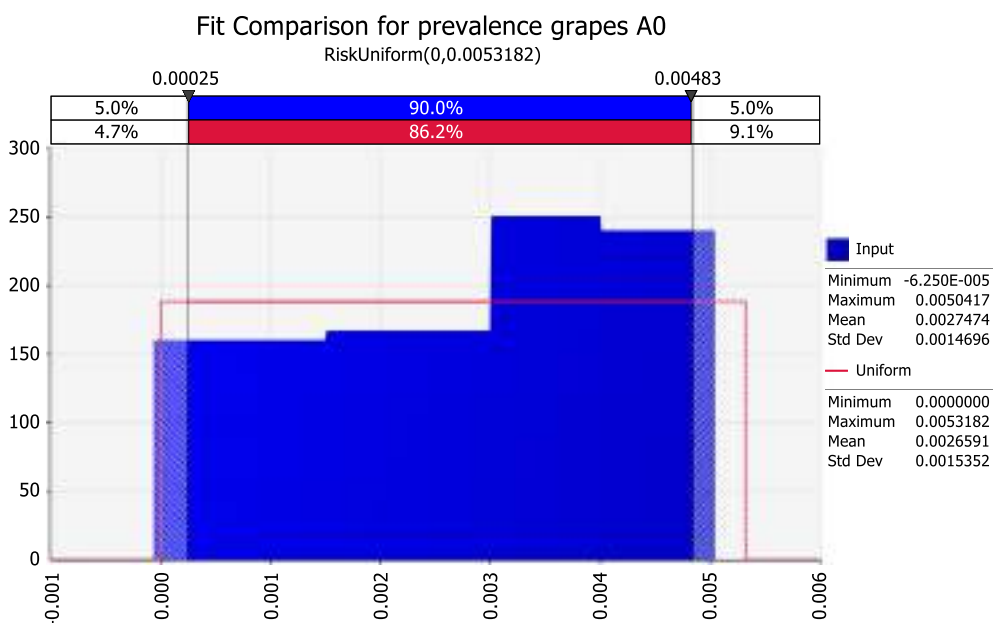
Figure 4: Fitted distribution for prevalence at the origin ($p_{prevalence\ (grapes)}$) for fresh grapes under current practice (scenario A0)
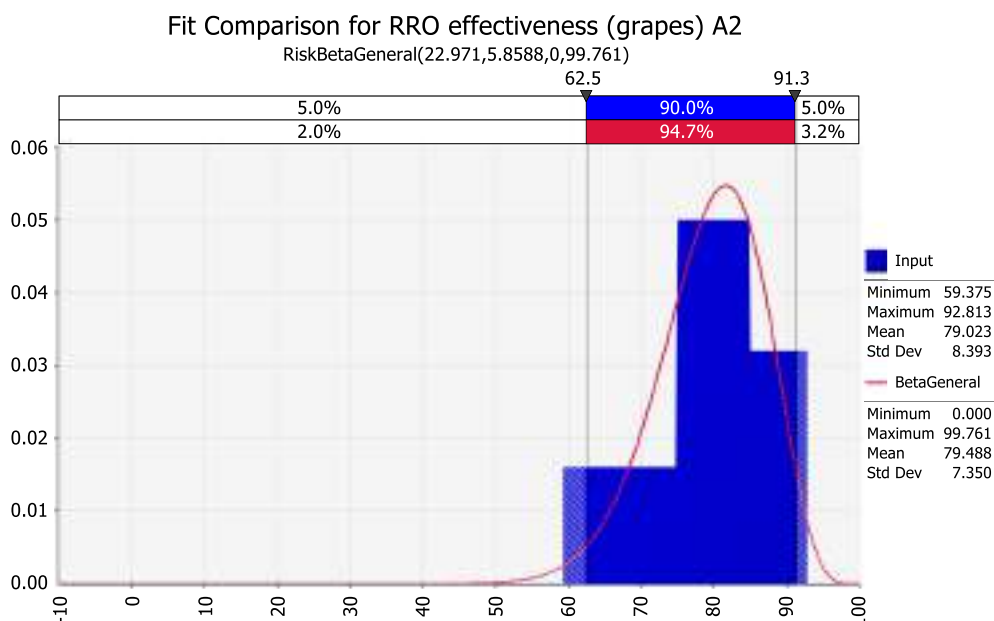
Figure 5: Fitted distribution for the effectiveness of RROs (scenario A2) for fresh grapes

3.2.2.2. Trade flow

Trade flow is defined in Table 8.

Table 8: Definition of the parameter trade flow (N_{trade})

Name	Definition	Sources
$N_{trade\ (plants)}$	Total number of *Vitis* plants for planting (infected or not) imported by the EU for research/breeding purposes from Brazil and India	NPPOs
$N_{trade\ (grapes)}$	Total quantity of fresh grapes (infected or not) imported by the EU from Brazil and India	Eurostat

The elicited distribution of the trade flow is reported in Table 9 and Figures 6 and 7.

Table 9: Elicitation of the trade flow for *Vitis* plants for planting for research purposes ($N_{trade\ (plants)}$) and fresh grapes ($N_{trade\ (grapes)}$)

Quantile:	1%	25%	Median	75%	99%
$N_{trade\ (plants)}$ (n cuttings per year)	0	1	2	20	500
$N_{trade\ (grapes)}$ (tons per year)	100,000	150,000	190,000	250,000	300,000

Justification – plants for planting:

Based on the available data provided by the French, Italian and Spanish NPPOs, only one import of *Vitis* plants for planting for research/breeding purposes was recorded over the last 10 years. For the 99% quantile, it was considered that the import of plants for planting for research/breeding purposes could increase in the future in several EU MSs associated with the interest in tropical table grape cultivars (Kok, 2014). There is already such an interest in new table grape cultivars and India has a long tradition of growing local cultivars. The median was considered close to the current situation. Nevertheless, the information available is based in the data provided by three EU MSs. Currently, there are two main centres for development of new grapevine cultivars, in Italy and Spain, but in the future, other EU MSs might also import non-EU material.
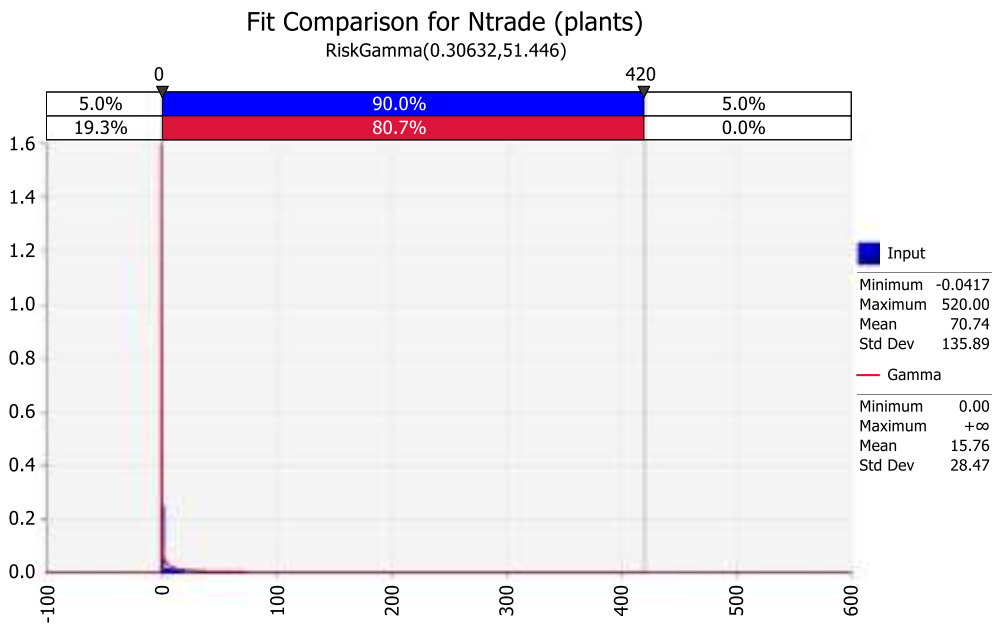
Figure 6: Fitted distribution for trade flow ($N_{trade\ (plants)}$) for *Vitis* plants for planting for research/breeding purposes as the number of cuttings per year (both scenarios)
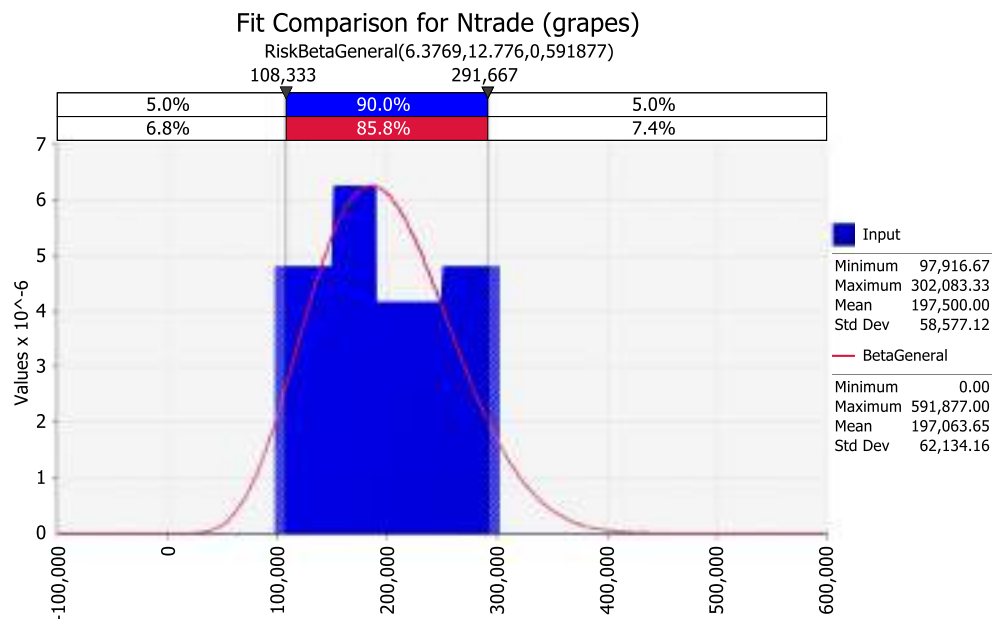
Figures 7: Fitted distribution for trade flow ($N_{trade\ (grapes)}$) for fresh grapes as tons per year (both scenarios)

Justification – fresh grapes:

The elicitation was based on a trend analysis (2011–2020) of import data of fresh grapes from Brazil and India into the EU (Figure 1), including additional uncertainties such as competition from other countries. The calculated values were rounded so as not to give the impression of overconfidence in the prediction. The EU import of fresh grapes from India has substantially increased over the last years, but whether it will plateau or further increase is unknown. It was assumed that a plateau will be reached in the next years, and the median was thus reduced. The 25% and 75% quantiles were set to obtain a flat distribution, because of the uncertainty in future trade developments.

3.2.2.3. Sorting

The parameter sorting is defined in Table 10 for each pathway.

Table 10: Definition of the parameter sorting ($p_{sorting}$)

Name	Definition	Sources
$p_{sorting\ (plants)}$	Proportion of infected *Vitis* plants removed following pre-import inspection (identification and removal of infected plants before entry in the EU)	Expert knowledge (see justification below)
$p_{sorting\ (grapes)}$	Proportion of infected fresh grapes removed following pre-import inspection (identification and removal of infected fruits before entry in the EU)	Expert knowledge (see justification below)

The elicited distribution of the proportion of sorting is reported in Table 11 and Figure 8.

Table 11: Proportion of infected imported material that is removed from trade due to sorting ($p_{sorting}$)

Quantile:	1%	25%	Median	75%	99%
$p_{sorting\ (plants)}$	0	0.02	0.05	0.40	0.70
$p_{sorting\ (grapes)}$	0	0	0	0	0

Justification – plants for planting:

A lower boundary of 0 (i.e. no infected plants removal) was considered when *Vitis* cuttings are asymptomatic and no specific detection methods are applied. The upper boundary was set at 70%, when the source origin comprises a certification plant material scheme that includes Xcv analysis. No measures to certify plants free from Xcv are currently mandatory, but this scenario cannot be discounted. In this case, the pathogen could be detected in most cuttings for propagation, but not all because of uneven bacterial distribution and low bacterial concentration. Considering the presence of asymptomatic infections and since no specific detection methods are usually applied, the median was set as 5%. Because of the uncertainties, 2% and 40% were chosen as 25% and 75% quantiles.

Justification – fresh grapes:

Unspecific sorting is already performed at the origin and is thus implicitly considered in the import trade flow (Section 3.2.2.2). Moreover, infection is mostly asymptomatic and thus Xcv is difficult to detect visually.
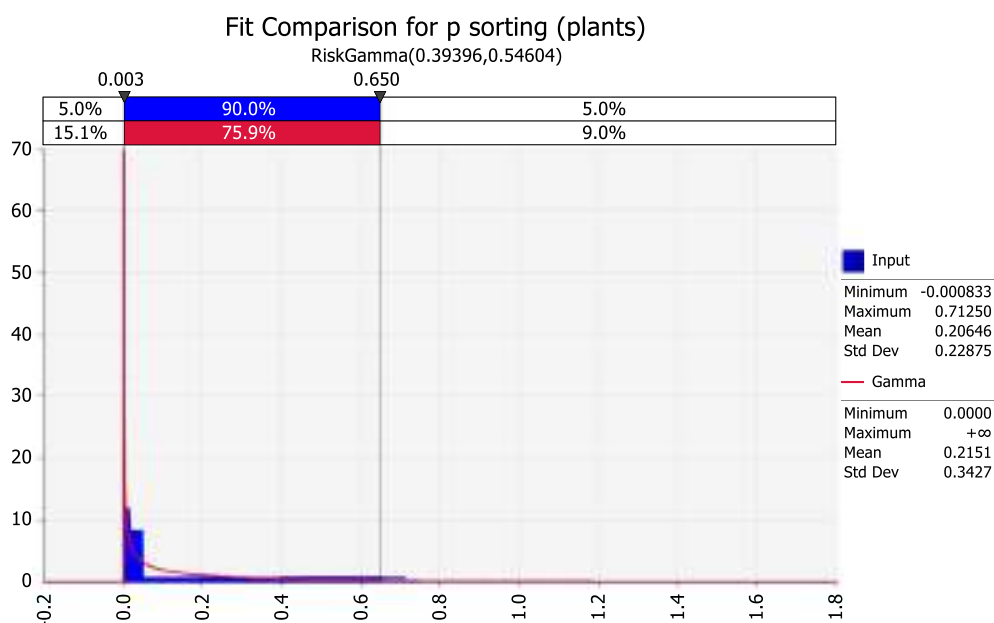

Figure 8: Fitted distribution for sorting ($p_{sorting\ (plants)}$) for *Vitis* plants for planting for research/breeding purposes (both scenarios)

3.2.2.4. Transfer

The probability of transfer is defined in Table 12 for each pathway.

Table 12: Definition of the parameter transfer ($p_{transfer}$)

Name	Definition	Sources
$p_{transfer\ (plants)}$	Probability that infected *Vitis* plants successfully transfer the pest from the EU points of entry to suitable hosts	Expert knowledge (see justification below)
$p_{transfer\ (grapes)}$	Probability that the pest in one disaggregated unit of infected fresh grapes is transferred to suitable hosts	Expert knowledge (see justification below)

The elicited distribution of the probability of transfer is reported in Table 13 and Figures 10 and 11.

Table 13: Probability of transfer for *Vitis* plants for planting for research/breeding purposes ($p_{transfer\ (plants)}$) and fresh grapes ($p_{transfer\ (grapes)}$)

Quantile:	1%	25%	Median	75%	99%
$p_{transfer\ (plants)}$	0	1 out of 100,000 0.00001	1 out of 10,000 0.0001	1 out of 3,000 0.003	1 out of 1,000 0.001
$p_{transfer\ (grapes)}$	0	1 out of 1,000,000 0.000001	1 out of 100,000 0.00001	1 out of 33,000 0.00003	1 out of 10,000 0.0001

Justification – plants for planting:

For plants for planting, transfer of Xcv can take place more easily than with fresh grapes, because of better bacterial survival and easier bacterial dissemination through natural events or during grape cultivation management (e.g. pruning and contaminated tools) (Lima et al., 1999). Nevertheless, plants for research/breeding purposes are kept in confined facilities, which should reduce the probability of transfer. The 99% quantile was set as 10 times greater than for fresh grapes, to reflect the higher probability noted above. Uncertainty was similar to the elicitation of probability of transfer for fresh grapes.

Justification – fresh grapes:

The unit of flow is 1 ton of fresh grapes. Once the ton is disaggregated to different locations, the unit becomes a disaggregated unit of fresh grapes, which can represent a batch of e.g. 1 kg (if d = 1,000), of 1 ton (if d = 1, i.e. no disaggregation), or 100 kg (if d = 10). Here, we are estimating the probability of transfer of the infection from such disaggregated units of fresh grapes to suitable hosts. As disaggregated units of fresh grapes can be small or large in size, the elicitation took into account that transfer will tend to be more likely for large, disaggregated units than for small ones.

A value of 0 was set for the 1% quantile considering that the transfer process is hampered by the fast desiccation process of the rachis, which makes it difficult for the bacteria to evade and transfer to suitable hosts. Moreover, if sorting is zero, then the import is on the whole asymptomatic, which implies no lesions, thus making transfer very difficult. For the 99% quantile, it was considered the case of eating fresh grapes and throwing the stalks in a vineyard afterwards. The bacteria should then evade from the rachis and reach a susceptible plant host during a rainstorm with suitable temperature and humidity. Nevertheless, soil saprophytes can overgrow the bacteria, which would thus not survive long. In addition, when fresh grapes are imported in autumn, winter and spring (Figure 9), temperatures in the EU are relatively low and thus less suitable for transfer.

An even worse case was considered, when packing houses in the EU importing fresh grapes from Brazil or India are repacking for high quality grapes and then discarding low quality ones. Nevertheless, the biggest importers are the Netherlands, Germany and Finland which are not the EU major grape growers. Imported fresh grapes might be re-exported to southern countries, but mostly in winter. In summary, import of fresh grapes takes place mainly in autumn, winter and spring and the main importing EU MSs are in North Europe, thus reducing the probability of transfer under current climatic conditions.
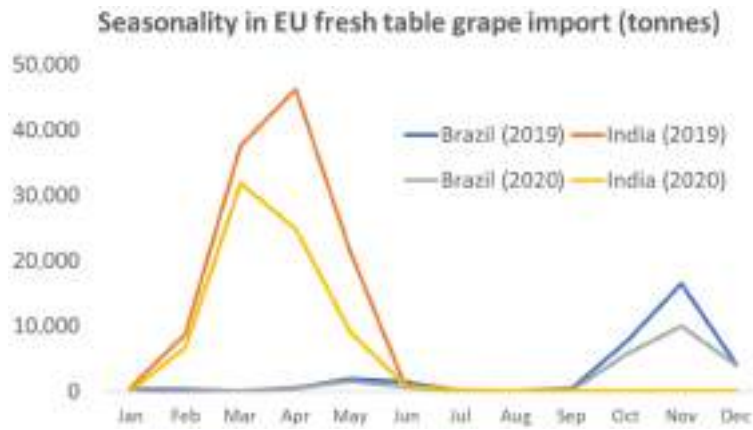
Figure 9: Seasonality in EU fresh table grape import from Brazil and India, for 2019 and 2020. Data from EUROSTAT (code: 08061010), as of August 2022
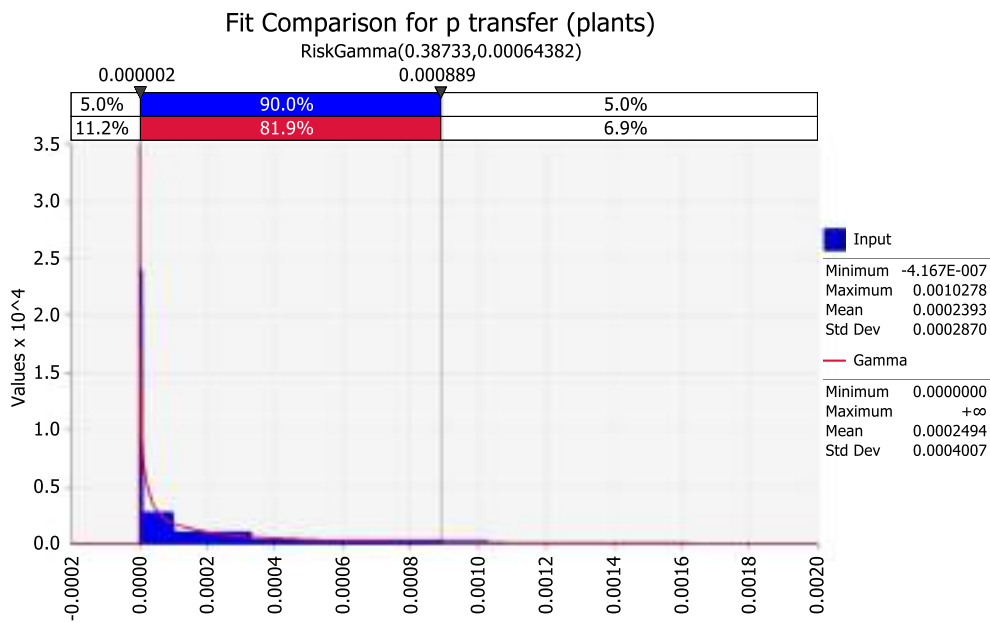
Figure 10: Fitted distribution for the probability of transfer ($p_{transfer\ (plants)}$) for *Vitis* plants for planting for research/breeding purposes (all scenarios)
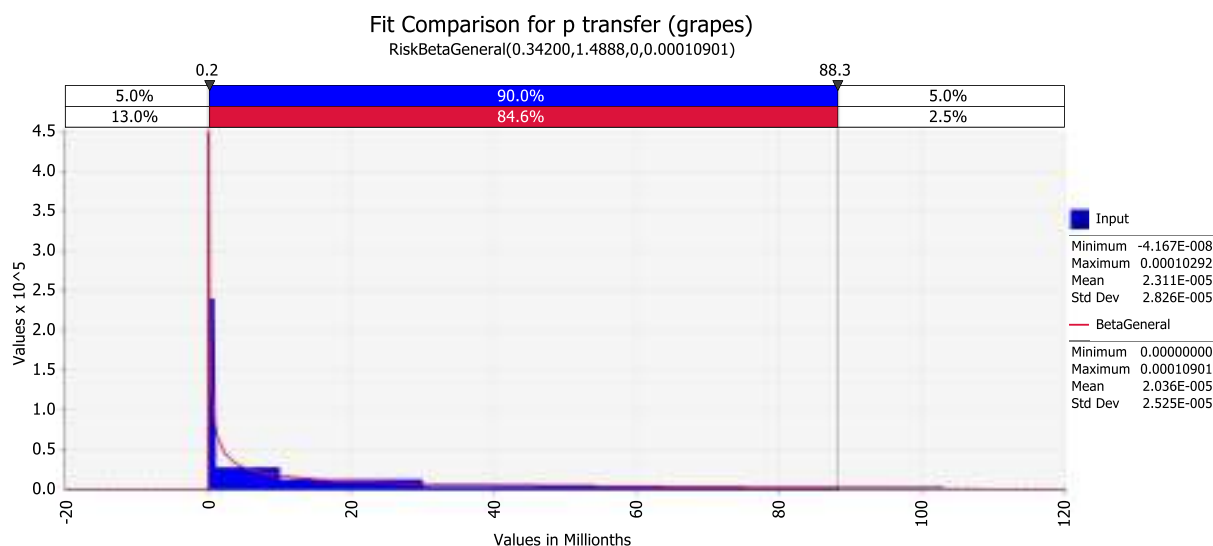
Figure 11: Fitted distribution for the probability of transfer ($p_{transfer\ (grapes)}$) for fresh grapes (all scenarios)

3.2.2.5. Disaggregation factor

The disaggregation factor is defined in Table 14.

Table 14: Definition of the parameter disaggregation factor (d)

Name	Definition	Sources
d	Disaggregation factor for one ton of infected fresh grapes, to take into account the number of suitable locations for transfer to which one ton of infected fresh grapes is delivered	Expert knowledge (see justification below)

The elicited distribution of the disaggregation factor is reported in Table 15 and Figure 12.

Table 15: Disaggregation factor (d) for fresh grapes

Quantile:	1%	25%	Median	75%	99%
d	1	6	10	60	1,000

Justification – fresh grapes:

One ton of fresh grapes is usually up to five to six pallets and trucks usually carry much more than that. For the 1% quantile, it was considered that one ton of infected fresh grapes is all delivered to one single location. For the 99% quantile, it was considered that one ton of infected fresh grapes is delivered to 1,000 different locations (one kg per location). The median reflects the situation when one ton of infected fresh grapes is delivered to 10 different locations (100 kg per location). The 25 and 75% quantiles were set to reflect the uncertainty on this distribution.
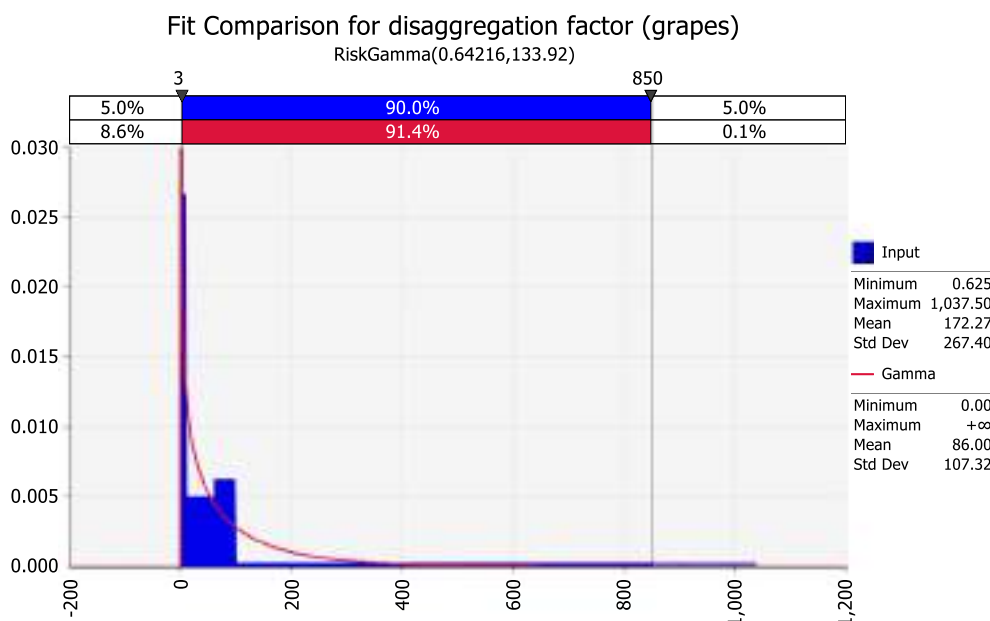
Figure 12: Fitted distribution for the disaggregation factor (d) for fresh grapes (both scenarios)

3.2.3. Entry assessment results

Table 16 shows the outcome of the model calculations for N_{inf} (number of founder populations of Xcv per year due to import into the EU of infected *Vitis* plants for planting for research/breeding purposes and fresh grapes) for the two considered scenarios, current practice (A0) and additional RROs (A2). The results are visualised in Figures 13–16.

According to model results (Table 16),

- For fresh grapes, scenario A0 results in an order of magnitude of about one entry per 10 years (median number; 90% uncertainty interval between about one entry per 18,000 years and about five entries per year). For scenario A2, these numbers are only slightly reduced.
- The risk of Xcv entry due to import of *Vitis* plants for planting for research/breeding purposes is several orders of magnitude smaller than the risk of Xcv entry due to import of fresh grapes for both scenarios (A0 and A2).
- The effect of the considered RROs is relatively small, i.e. the risk of Xcv entry due to import of *Vitis* plants for planting for research/breeding purposes and the risk of Xcv entry due to import of fresh grapes are only slightly reduced by including the considered RROs.

Table 16: Outcome of the model calculation for the response variable N_{inf} (number of founder populations of Xcv per year in the EU due to import of infected *Vitis* plants for planting for research/breeding purposes and fresh grapes) under the considered scenarios A0 (current practice) and A2 (additional RROs), using 10,000 simulation runs

Quantile	Mean	St. dev.	1%	25%	Median	75%	99%
Vitis plants for planting							
A0	1×10^{-5}	5×10^{-5}	2×10^{-13}	2×10^{-8}	5×10^{-7}	5×10^{-6}	2×10^{-4}
A2	8×10^{-6}	4×10^{-5}	7×10^{-14}	9×10^{-9}	2×10^{-7}	2×10^{-6}	1×10^{-4}
Fresh grapes							
A0	0.9	2.5	0.000	0.01	0.09	0.61	11.8
A2	0.8	2.2	0.000	0.01	0.09	0.54	10.0
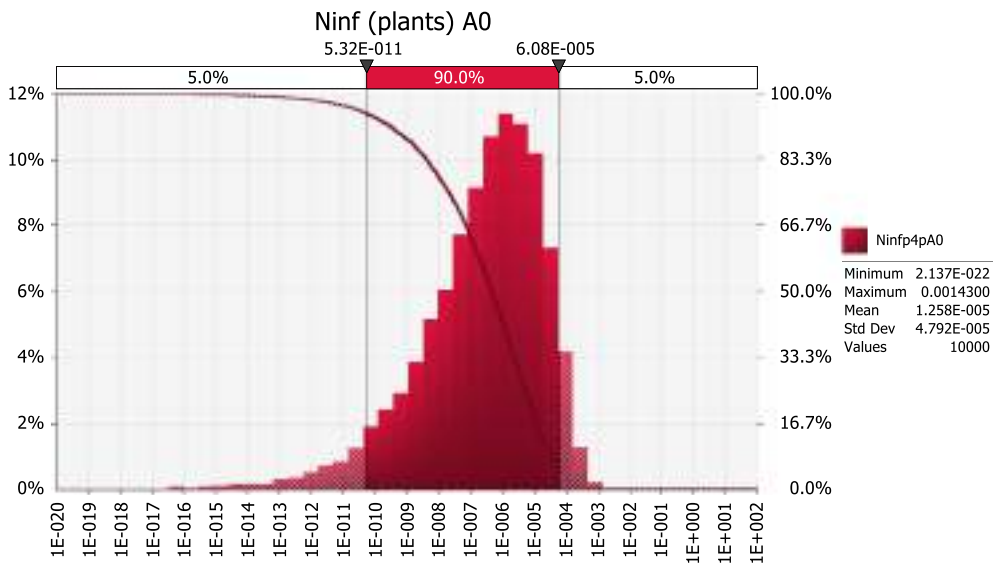
Figure 13: Outcome of the model simulations for scenario A0 (current practice) for *Vitis* plants for planting for research/breeding purposes, showing the relative frequency and cumulative descending probability with log-scale x-axis. The number of founder populations of Xcv per year in the EU is estimated between about 5×10^{-11} and 6×10^{-5} with a 90% probability
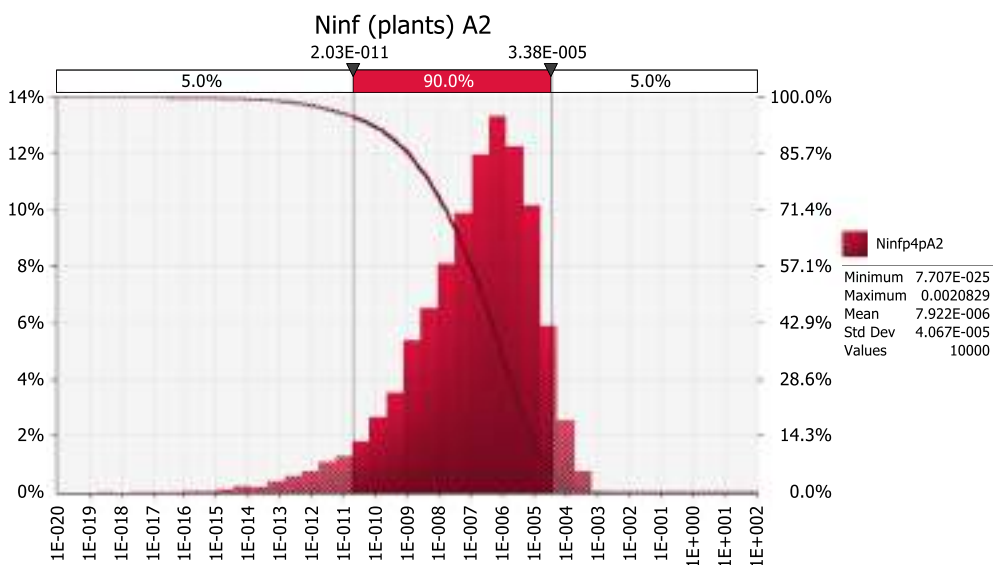
Figure 14: Outcome of the model simulations for scenario A2 (additional RROs) for *Vitis* plants for planting for research/breeding purposes, showing the relative frequency and cumulative descending probability with log-scale x-axis. The number of founder populations of Xcv per year in the EU is estimated between 2×10^{-11} and 3×10^{-5} with a 90% probability
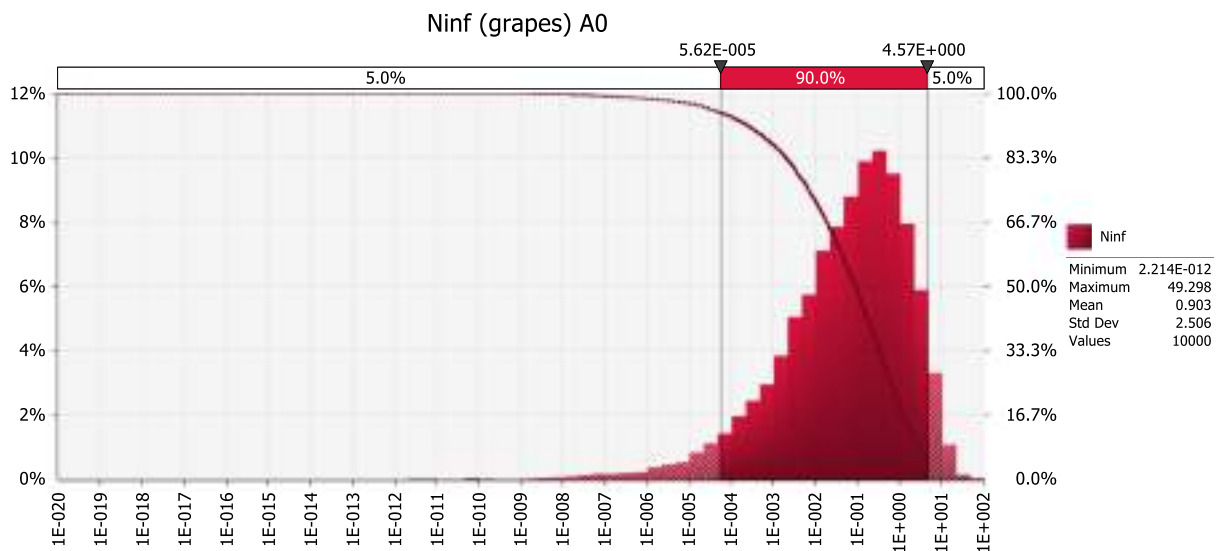
Figure 15: Outcome of the model simulations for scenario A0 (current practice) for fresh grapes, showing the relative frequency and cumulative descending probability with log-scale x-axis. The number of founder populations of Xcv per year in the EU is estimated between 6×10^{-5} and 4.6 with a 90% probability
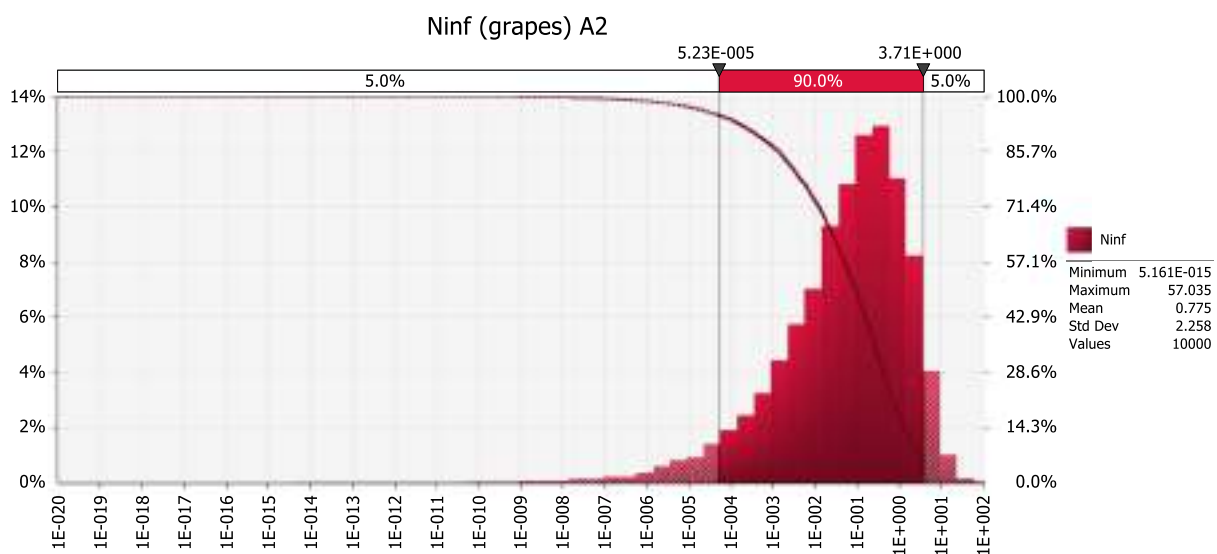
Figure 16: Outcome of the model simulations for scenario A2 (additional RROs) for fresh grapes, showing the relative frequency and cumulative descending probability with log-scale x-axis. The number of founder populations of Xcv per year in the EU is estimated between 5×10^{-5} and 3.7 with a 90% probability

The outcome of the model simulations is more uncertain for the pathway *Vitis* plants for planting for research/breeding purposes than for the pathway fresh grapes. The 90% uncertainty interval spans several orders of magnitude in the former case, and only a few orders of magnitude in the latter (Table 16).

3.3. Sensitivity analysis of the assessment of entry

A sensitivity analysis was conducted, where correlations between the output variable (N_{inf}) and the parameters of the entry pathway model were explored using the Spearman rank coefficient (Figures 17–20). The factors included in the entry model most correlated with the output variable are:

- Trade flow volume and probability of transfer for *Vitis* plants for planting for research/breeding purposes.
- Probability of transfer and the disaggregation factor for fresh grapes.

Ninf (plants) A0
Correlation Coefficients (Spearman Rank)
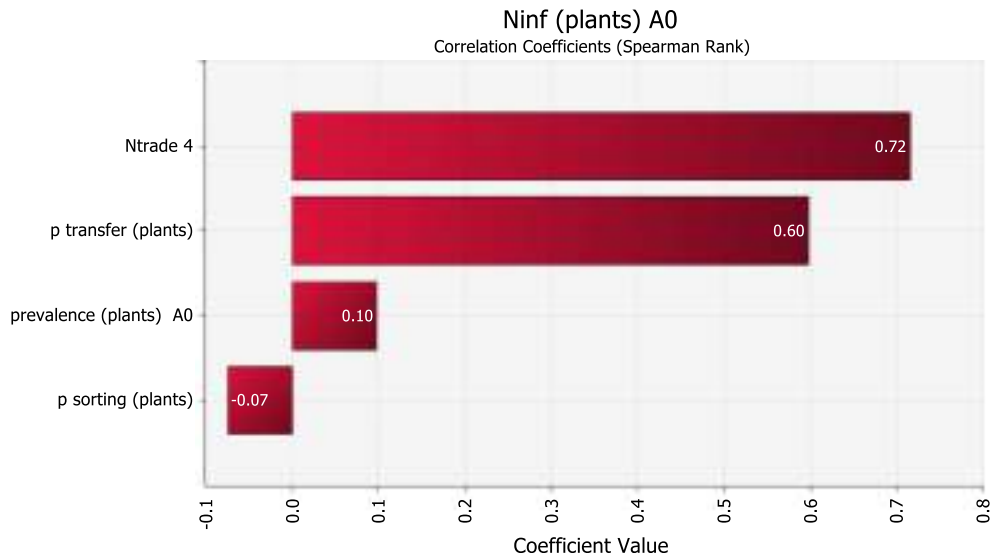
Figure 17: Correlation with the output variable (N_{inf}) of the parameters of the entry pathway model for *Vitis* plants for planting for research/breeding purposes for scenario A0 (current practice)

Ninf (plants) A2
Correlation Coefficients (Spearman Rank)
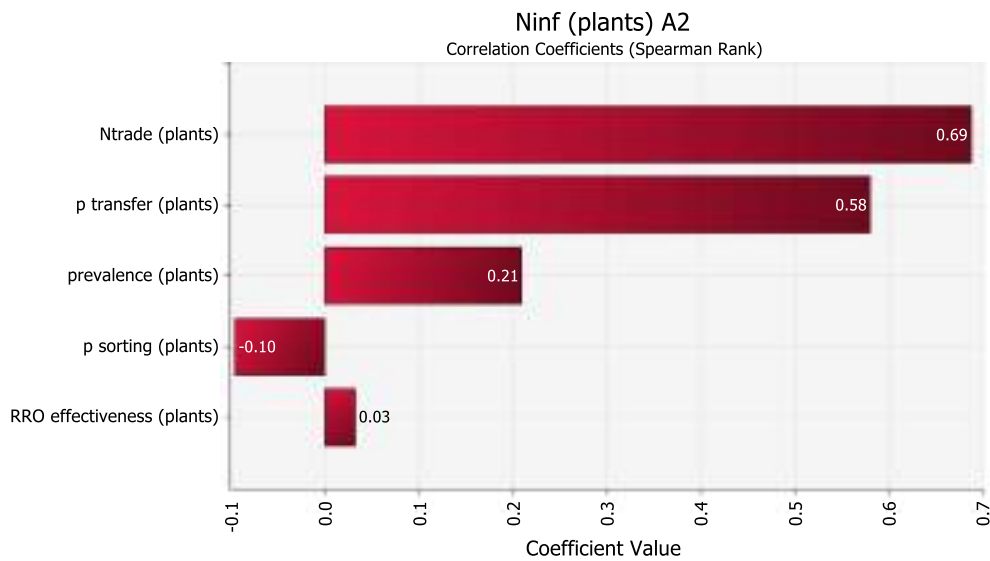
Figure 18: Correlation with the output variable (N_{inf}) of the parameters of the entry pathway model for *Vitis* plants for planting for research/breeding purposes for scenario A2 (additional RROs)

Ninf (grapes) A0
Correlation Coefficients (Spearman Rank)

Parameter	Coefficient Value
p transfer (grapes)	0.74
disaggregation factor (grapes)	0.50
prevalence grapes A0	0.27
Ntrade (grapes)	0.10
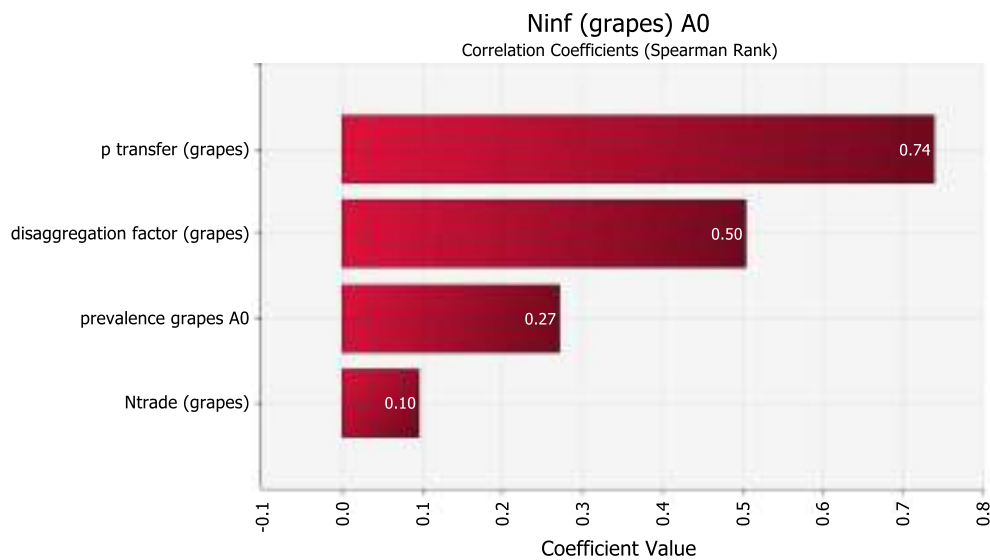
Figure 19: Correlation with the output variable (N_{inf}) of the parameters of the entry pathway model for fresh grapes for scenario A0 (current practice)

Ninf (grapes) A2
Correlation Coefficients (Spearman Rank)

Parameter	Coefficient Value
p transfer grapes	0.77
disaggregation factor	0.53
prevalence (grapes)	0.19
Ntrade grapes A2	0.12
RRO effectiveness (grapes) A2	0.03
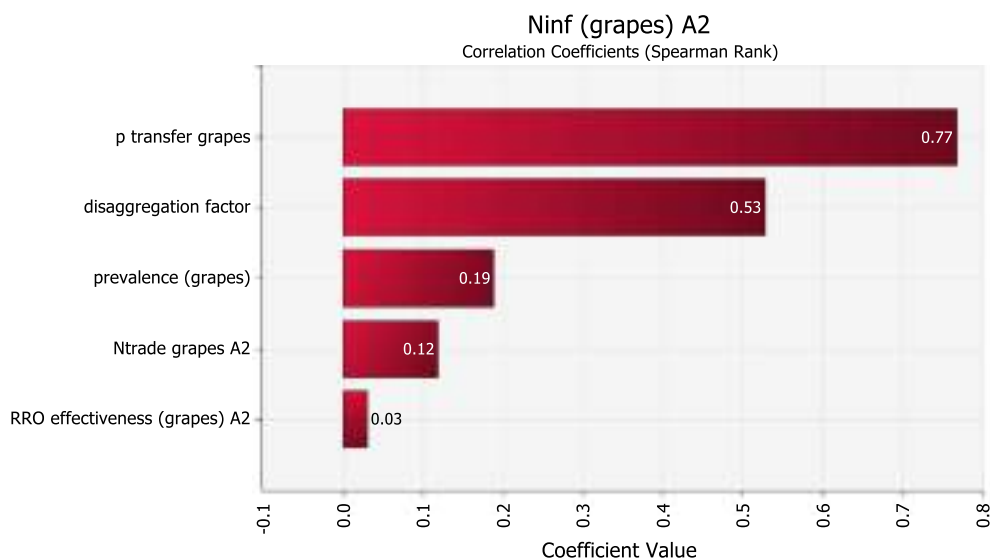
Figure 20: Correlation with the output variable (N_{inf}) of the parameters of the entry pathway model for fresh grapes for scenario A2 (additional RROs)

3.4. Additional uncertainties

From a biological point of view, various uncertainties regarding Xcv have been listed by the Panel in a previous pest categorisation (EFSA PLH Panel, 2021). These uncertainties include:

- Uncertainty on the pest distribution (e.g. the pest occurrence and prevalence in Thailand and some areas of Brazil and India).
- Uncertainty on the role of fresh grapes as pest carrier.
- Uncertainty on the roles of other possible hosts for pest establishment and spread.

Furthermore, there is a lack of data to estimate the proportion of sorting and the probability of transfer, as well as the effectiveness of RROs. More information is needed to reduce the high uncertainty due to the lack of knowledge regarding the proportion of infected berries in consignments and its possible decrease during post-harvest procedures. This lack of information is reflected in the parameter distributions and in the outcomes of the entry model.

Uncertainties that were not quantified in the entry model include:

- Entries from countries other than Brazil and India (e.g. Thailand).
- Entries from pathways other than *Vitis* plants for planting for research/breeding purposes and fresh grapes.
- Market changes (e.g. switch in EU imports due to possible outbreaks in third countries other than Brazil and India).
- Effects of RROs other than hot water treatment for the pathway *Vitis* plants for planting for research/breeding purposes.
- Effects of RROs other than pest-free places of production in affected areas for the pathway fresh grapes.

The Panel expects the conclusions of the entry model not to be modified substantially by the additional uncertainties not quantified in this assessment.

3.5. Dependencies between parameters

The Panel considers the parameters of the entry model to be independent of each other, with the possible exception of prevalence at the origin and proportion of sorting (the higher the prevalence at the origin, the more likely the sorting), but this dependency is expected (i) to be weak due to the often asymptomatic nature of the disease and thus (ii) not to affect the conclusions of the assessment.

It could also be that increased prevalence at the origin might lead to a reduction of trade volumes. Nevertheless, exporting growers might move the production to other areas less affected by the disease, thus making the conclusions of this assessment robust to this potential parameter dependency. Indeed, in recent years, EU import of fresh grapes from India has increased substantially despite the Xcv outbreaks and the high yield losses reported at the origin.

3.6. Conclusion on the assessment of entry for the different scenarios

The risk of Xcv entry due to import of fresh grapes is in an order of magnitude of about one entry per 10 years. The risk of Xcv entry due to import of *Vitis* plants for planting for research/breeding purposes is expected to be several orders of magnitude smaller than the risk of Xcv entry due to fresh grape import.

This outcome is not affected by the inclusion of RROs (scenario A2), i.e. the risk of Xcv entry due to import of *Vitis* plants for planting for research/breeding purposes is several orders of magnitude smaller than the risk of Xcv entry due to fresh grape import also when including RROs for the two pathways.

The effect of the considered RROs is relatively small, i.e. the risk of Xcv entry due to *Vitis* plants for planting for research/breeding purposes and due to fresh grape import is only slightly reduced by including the considered RROs.

4. Establishment

4.1. Background information and host distribution

In Brazil and India, the pest mostly affects seedless table grapes (EFSA PLH Panel, 2021). This could be due to higher susceptibility of table grape genotypes or to their cultivation as the main crop in the outbreak areas. Apparently, in India, the pathogen is not a problem for wine production, although the disease can also affect those varieties. However, as wine and table grape plants belong to the same species, both are considered in this PRA.

The map for grapevine production areas (95% of *Vitis* cultivation in the EU) presented in EFSA PLH Panel (2019a) was used to define the PRA area (Figure 21). Statistical data of production areas for grapevine were collected at NUTS 2 level from the websites of the national statistical institutes of each country. If data were not available in those websites, the statistical institutes were contacted directly, or the EUROSTAT database was consulted. Statistical data referred to 2015.
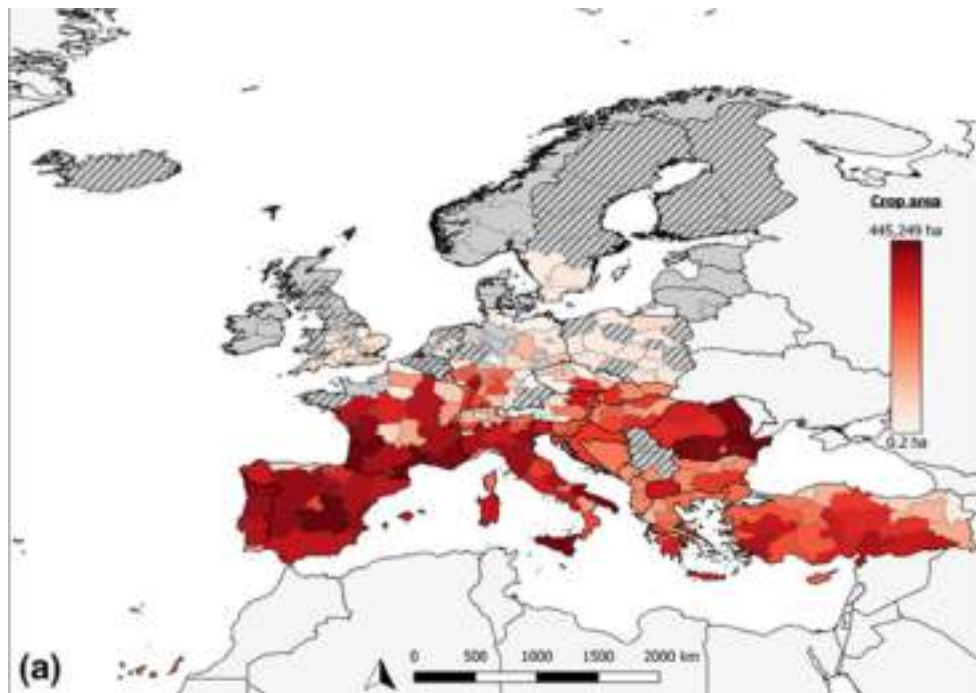
Figure 21: European grapevine-growing areas based on data of crop area at NUTS 2 level (from EFSA PLH Panel, 2019a). Hatched areas indicate where data are missing

4.2. Climate suitability

Xanthomonas bacteria are generally thermophilic. As most bacteria, they are efficiently disseminated by rains and showers. In the presence of rain during a susceptible phenological phase (e.g. vines development, bloom and fruit set), infection is favoured, thus making pest establishment more likely (EFSA PLH Panel, 2021).

The presence of Xcv is reported in tropical and subtropical areas of Brazil and India where rains and high temperatures occur simultaneously in different seasons alternating with long dry periods. Temperatures around 25–30°C and high relative humidity result in optimal conditions for pathogen development (Chand and Kishun, 1990; Melo et al., 2000; Peixoto and Ramos, 2004); however, the bacterium has also been detected in areas of India with lower temperature or more constrained rainy season (Jambenal et al., 2011).

Moreover, by homology, the closely related *Xanthomonas* citri pv. *citri*, causal agent of citrus bacterial canker, which is a closely related tropical or subtropical pathogen, is able to infect plants between a minimum of 12°C and a maximum of 40°C, with an optimum range of 25–35°C, i.e. in conditions similar to bacterial canker of grapevine (Nascimento et al., 2005; Dalla Pria et al., 2006). Extended dry periods do not stop citrus bacterial canker epidemics because bacteria survive in dry conditions and can reinfect plants when a wet spell occurs.

Although the Mediterranean summer is relatively dry compared to areas where Xcv is currently reported, several table grape production areas in the EU are potentially at risk. Indeed, table grapes (under cover) in South-East Spain start leaf flush around end of January–February and berries start ripening from May (pers. communication, Diego Intrigliolo, CSIC, Spain, Oct 2022) when rainfalls can be frequent (Jones, 2010).

In summary, even if the climate conditions in the EU are not totally optimal for the development of the disease, it cannot be excluded that the climate of several EU grapevine-growing areas would be compatible with the establishment of Xcv.

4.2.1. Climate suitability methodology

To date, Xcv has a still limited geographic distribution, as it is mainly present in some table grape production areas in Brazil and India. Even if the disease was first described decades ago, the number of confirmed disease presence locations is rather restricted. Therefore, the use of comprehensive modelling approaches such as species distribution models and fundamental niche models is not

recommended here. Because not all potentially suitable habitats may have yet been colonised by Xcv and since the transferability in space and time of the above-mentioned models is often limited, their implementation could lead to unreliable projections in large parts of the PRA area.

4.2.2. Köppen–Geiger climate comparison

Building on the Xcv pest categorisation (EFSA PLH Panel, 2021), a more refined Köppen–Geiger climate comparison was performed in this PRA. Records of the presence of Xcv were collected in Brazil and India (Campese et al., 2022), of which:

- 43 records were location-specific (punctual) observations reporting coordinates, or small administrative units for which coordinates from Google Earth were used,
- 19 records were related to larger administrative units such as regions,
- 5 records were excluded from the final maps due to uncertainties, i.e. imprecise observations (reports at countries and continents level, unclear locations).

The pest presence in Thailand is uncertain (EFSA PLH Panel, 2021). No information on the presence of Xcv in Thailand was found in peer-reviewed journals. The only available document reporting the presence of the pest in the country is an MSc thesis (Buensanteai, 2004), where detection and identification of the pest were done with ELISA (which might give false-positive results) and not confirmed by PCR (considered as more reliable, e.g. in the *Xylella* host database; Delbianco et al., 2019). Therefore, these observations were mapped but not included in this PRA.

The SCAN-Clim tool (EFSA and Maiorano, 2022) was used to produce climate suitability maps based on the Köppen–Geiger climate classification. The Köppen–Geiger climate classification used in this PRA is based on the period 1986–2010 and on a 10-km grid from the Institute for Veterinary Public Health of the University of Vienna based on Kottek et al. (2006) rescaled after Rubel et al. (2017) (http://koeppen-geiger.vu-wien.ac.at/present.htm).

Figures 22 and 23 show the distribution of Köppen–Geiger climate types where Xcv was observed, focusing on the areas where the pest is currently reported, i.e. South-East Asia and South America, respectively. Figure 24 shows the same information for the world. Since the area of the assessment is the EU, the output maps consider only climate types that are also present in the EU. Administrative units where the pest was observed are highlighted with black borders. Pest observations at specific locations were indicated with red dots. In Figure 25, the same information is reported, focusing on the EU. Based on this Köppen–Geiger climate comparison, virtually all the grapevine production areas in the EU (Figure 21) would be suitable for the establishment of Xcv.

Figure 22: Climate suitability map of *Xanthomonas citri* pv. *viticola* for South East Asia, based on the Köppen–Geiger climate classification. Black borders indicate countries/regions where the pest was reported. Red dots indicate reports of the pest with coordinates. Climates not present in the EU are not mapped. The legend shows the list of Köppen–Geiger climates
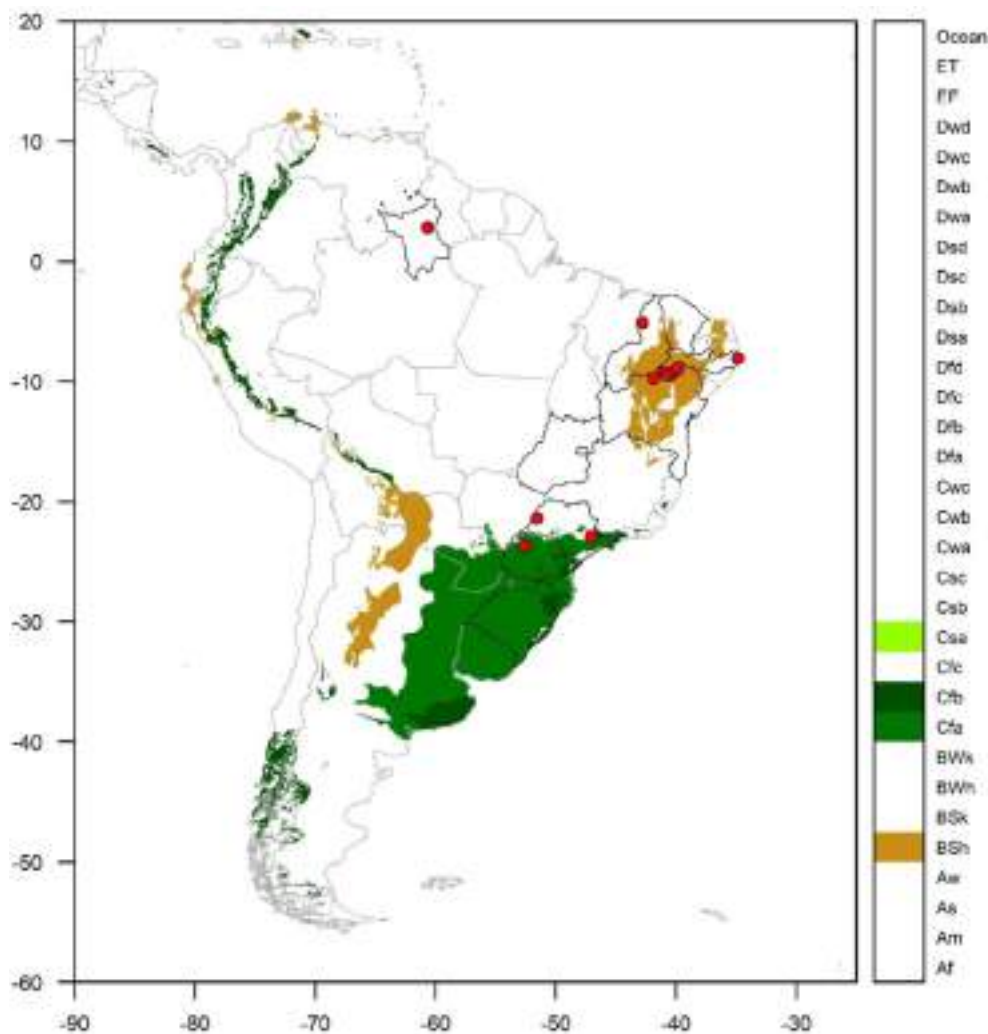
Figure 23: Climate suitability analysis map of *Xanthomonas citri* pv. *viticola* for South America, based on the Köppen–Geiger climate classification. Black borders indicate countries/regions where the pest was reported. Red dots indicate reports of the pest with coordinates. Climates not present in the EU are not mapped. The legend shows the list of Köppen–Geiger climates

Figure 24: Global climate suitability map of *Xanthomonas citri* pv. *viticola*, based on the Köppen–Geiger climate classification. Black borders indicate countries/regions where the pest was reported. Red dots indicate reports of the pest with coordinates. Climates not present in the EU are not mapped. The legend 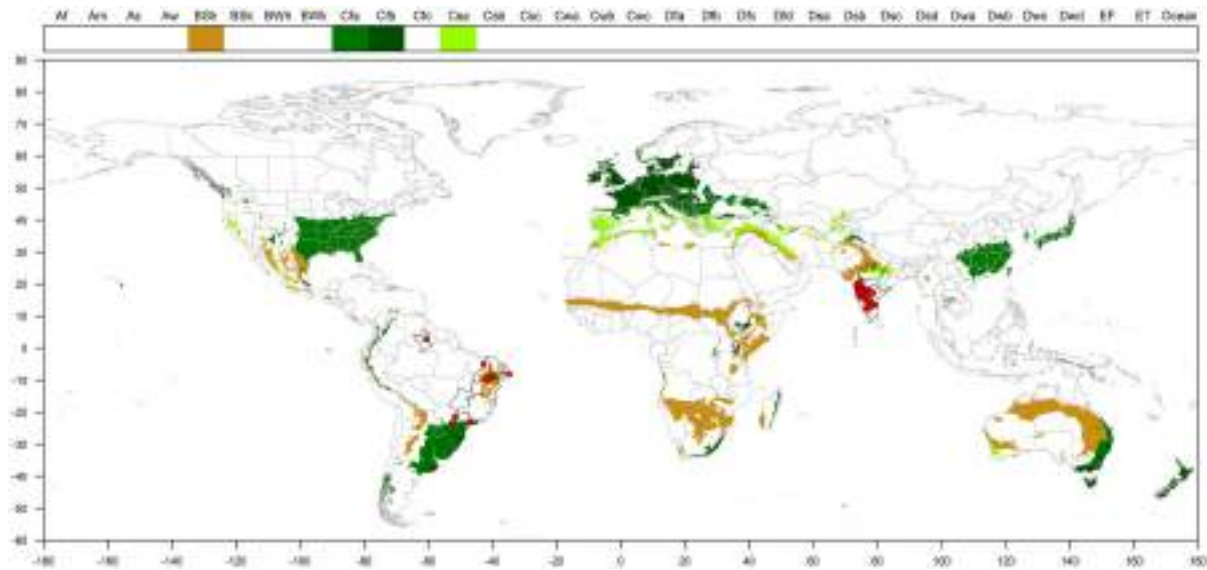shows the list of Köppen–Geiger climates. Figures 23 and 24 show the zoomed in the presence locations in India and Brazil
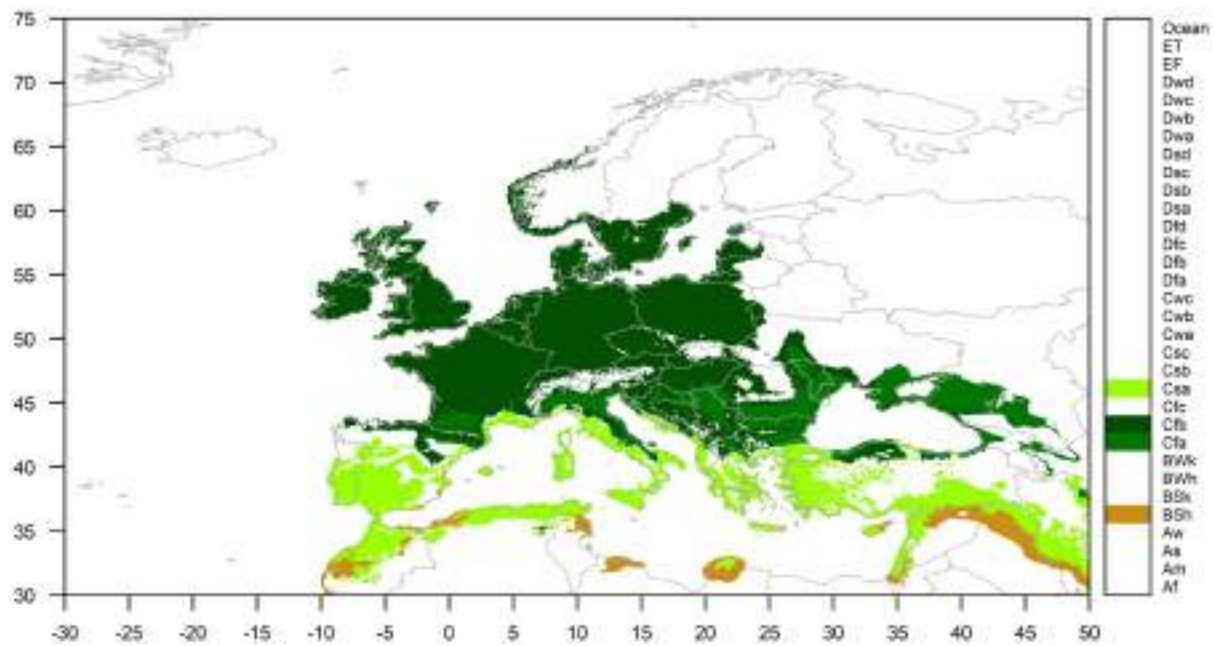

Figure 25: Climate suitability map of *Xanthomonas citri* pv. *viticola* for the EU and neighbouring regions based on the Köppen–Geiger classification. The legend shows the list of Köppen–Geiger climates

4.2.3. Bioclimatic variables

Considering the paucity of available data on the distribution and ecophysiology of Xcv, the areas in the EU with temperature and precipitation patterns matching those of locations with reported Xcv presence were identified based on different bioclimatic variables.

Bioclimatic variables for the observation points were downloaded from the WorldClim database (version 2.1) (Fick and Hijmans, 2017), containing the average values for the period 1970–2020 (i.e. current climate) with a spatial resolution of 5 arcminutes (~ 9 km). The bioclimatic variables in WorldClim 2.1 are calculated from the monthly temperature and rainfall values (Table 17).

Table 17: Code and description of the bioclimatic variables of WorldClim 2.1

Code	Description
BIO1	Annual mean temperature
BIO2	Mean diurnal range (mean of monthly (max temp–min temp))
BIO3	Isothermality (BIO2/BIO7) (×100)
BIO4	Temperature seasonality (standard deviation ×100)
BIO5	Max temperature of warmest month
BIO6	Min temperature of coldest month
BIO7	Temperature annual range (BIO5-BIO6)
BIO8	Mean temperature of wettest quarter
BIO9	Mean temperature of driest quarter
BIO10	Mean temperature of warmest quarter
BIO11	Mean temperature of coldest quarter
BIO12	Annual precipitation
BIO13	Precipitation of wettest month
BIO14	Precipitation of driest month
BIO15	Precipitation seasonality (coefficient of variation)
BIO16	Precipitation of wettest quarter
BIO17	Precipitation of driest quarter
BIO18	Precipitation of warmest quarter
BIO19	Precipitation of coldest quarter

For each bioclimatic variable, we first determined the range of values (min, max) observed in the locations in Brazil and India where Xcv is currently reported. Then, we identified and mapped the pixels located in Europe where the values of the bioclimatic variables are within that range (Figure 26).
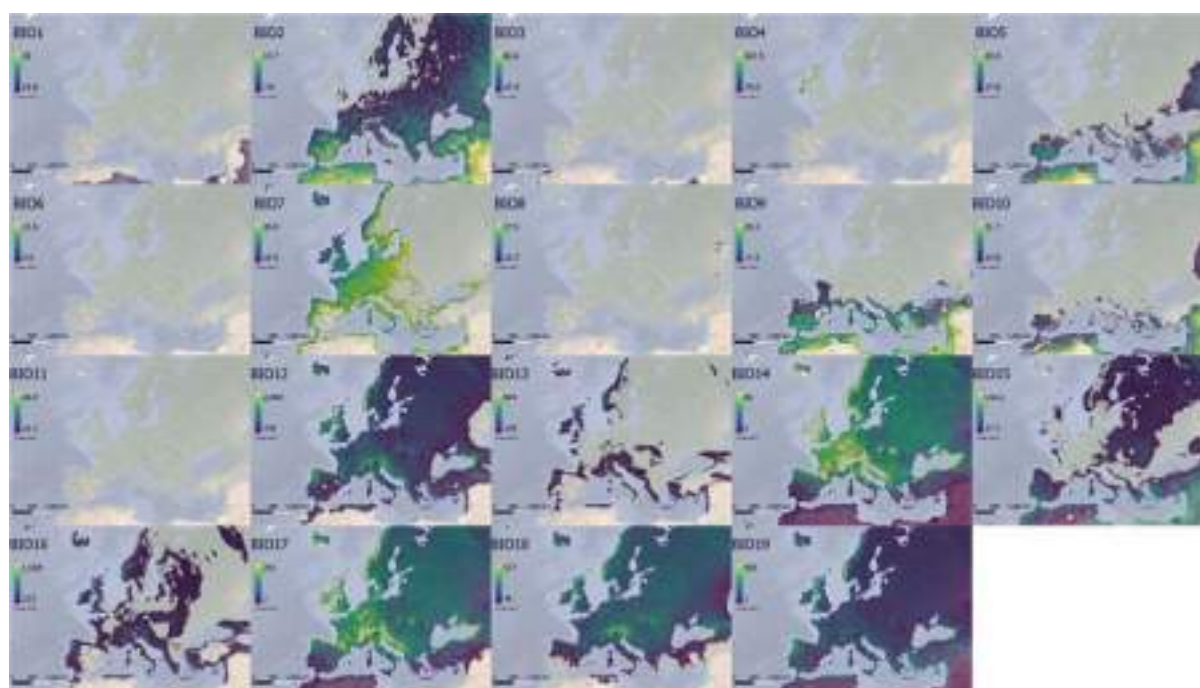
Figure 26: Areas in the EU and neighbouring regions where the ranges of values (under current climate: 1970–2020) of the bioclimatic variables listed in Table 17 are within the ranges observed in the areas where *Xanthomonas citri* pv. *viticola* is reported in Brazil and India. Colours indicate the values of the bioclimatic variables, in case of overlap with the locations in India and Brazil where Xcv is currently reported. Grey colour indicates no overlap

The maps presented in Figure 26 show that:

1) Results are heterogeneous among bioclimatic variables. For some of them (e.g. BIO7 and BIO17), values observed in most European areas are within the range observed in the areas where Xcv is currently reported, whereas for some others (BIO1, BIO4, BIO6, BIO8 and BIO11, all describing patterns of temperature), there is no overlap between Europe and the areas where Xcv is reported. This indicates that while some climatic features are suitable to Xcv establishment in the EU, other ones might not be so. This heterogeneity underlines the uncertainty inherent in assessing the risk of Xcv establishment in the EU.
2) In several areas located in Southern Europe, several bioclimatic variables (e.g. BIO2, BIO5, BIO7, BIO9, BIO10 and BIO12) are found in the range of values observed in the areas where Xcv is reported. This suggests that the risk of Xcv establishment is generally higher in Southern Europe compared to Central and Northern Europe (Figure 26).

4.2.4. Climate change analysis

In recent years, rains and showers frequently appear as heavy storms, due to the tropicalisation of climate around the Mediterranean, in particular in Europe (Sumner et al., 2003; De Luis et al., 2011). These violent rain events can generate lesions of the green and succulent plant parts (i.e. shoots, tendrils, leaves, green grape bunches) that can increase the risk of infection by Xcv. Indeed, damage on leaves contributes to diseases caused by different *Xanthomonas*, as for example described for *Xanthomonas arboricola* pv. *pruni* (Feliciano and Daines, 1970; Gasperini et al., 1984), where leaf scars may provide points of entry for Xcv propagules transported by wind-driven rains.

Lesions produced by hail can favour the penetration of Xcv as well, especially those on tender green parts. The increasing frequency of hailstorms in Europe during the last decades (Pucik, 2021) could make European climate more suitable for Xcv dissemination and disease outbreaks. The increasing trend of mean annual temperature over time may generally favour the thermophilic Xcv, particularly if this temperature increase occurs during the wettest months of the growing season, where rains could have a positive impact on Xcv survival, multiplication and dissemination.

The key methodological features of recent (2016–2021) studies on potential effects of future climate changes on *Vitis* distribution and phenology in Europe are summarised in Table 18. Methodological information on climate change studies for selected grapevine production regions in Europe are provided by Droulia and Charalampopoulos (2021). In this PRA, the distribution of *Vitis* under climate change was not modelled in detail, but the potential expansion of *Vitis* cultivation into northern areas of the EU over the coming decades was taken into account when eliciting the probability of establishment under climate change.

Table 18: Methodological features of studies on *Vitis* distribution/phenology in the EU under climate change

Study	Model	Time horizons	Emission scenarios	Other
Fraga et al. (2016)	process-based crop model coupled with climate, soil and terrain databases, taking into account physiological effects of water supply and CO_2 concentration	both for present (1980–2005) and future (2041–2070) climate scenarios	Representative Concentration Pathway (RCP) RCP4.5 and RCP8.5	European grapevine yields, phenology, water and nitrogen stresses were taken into account
Leolini et al. (2018)	The UniChill model calibrated for four grapevine varieties (with very early, early, middle-early and late phenological cycles) applied in Europe to assess phenological dynamics (budbreak and flowering)	2036–2065 and 2066–2095	RCP 4.5 and 8.5	The combined effect of mean climate change and extreme events (frost events at budbreak and suboptimal temperatures for fruit set) was studied

Study	Model	Time horizons	Emission scenarios	Other
Ponti et al. (2018)	PROTHEUS is a coupled atmosphere–ocean regional model that allows simulation of local extremes of weather via the inclusion of a fine-scale representation of topography and the influence of the Mediterranean Sea	1960–1970 (reference baseline) and 2040–2050 (climate change)	A1B regional climate change scenario that posits +1.8°C warming for the Euro-Mediterranean region, a scenario that is towards the middle of the IPCC range of greenhouse gas forcing scenarios	The grapevine/*Lobesia botrana* system was studied across the Euro-Mediterranean region using physiologically based demographic models
Cardell et al. (2019)	Modelling of the suitability of grape production across Europe using a suite of regional climate models (RCMs) from the European CORDEX project (ALADIN53, CCLM4-8-17, HIRHAM5, RACMO22E and RCA4)	2021–2045 (early future 21st century), 2046–2070 (mid-21st century), and 2071–2095 (late 21st century).	RCP 4.5 and 8.5	1981–2005 as a climate baseline

For each bioclimatic variable listed above (Figure 26) and considering the climate conditions projected for the period 2041–2060 by five climate models (IPSL-CM6A-LR, MPI-ESM1-2-HR, MRI-ESM2-0, UKESM1-0-LL, MIROC6), we identified and mapped the pixels located in Europe where the values of the bioclimatic variables are at least partly in the ranges (min–max) covered by the locations where Xcv is currently reported. Three emission scenarios (Riahi et al., 2017) (Figures 27–29) were considered for climate change:

- SSP1-2.6 = Sustainability (Taking the green road) Scenario, with 2.6 W/m^2 radiative forcing (low GHG emissions).
- SSP2-4.5 = Middle of the Road Scenario, with 4.5 W/m^2 radiative forcing (intermediate GHG emissions).
- SSP5-8.5 = Fossil-fuelled Development (Taking the Highway) Scenario, with 8.5 W/m^2 radiative forcing (high GHG emissions).

The variability among the climate model outputs was measured using the coefficient of variation (CV), based on Kelvin degrees for the temperature-related variables (Appendix B).
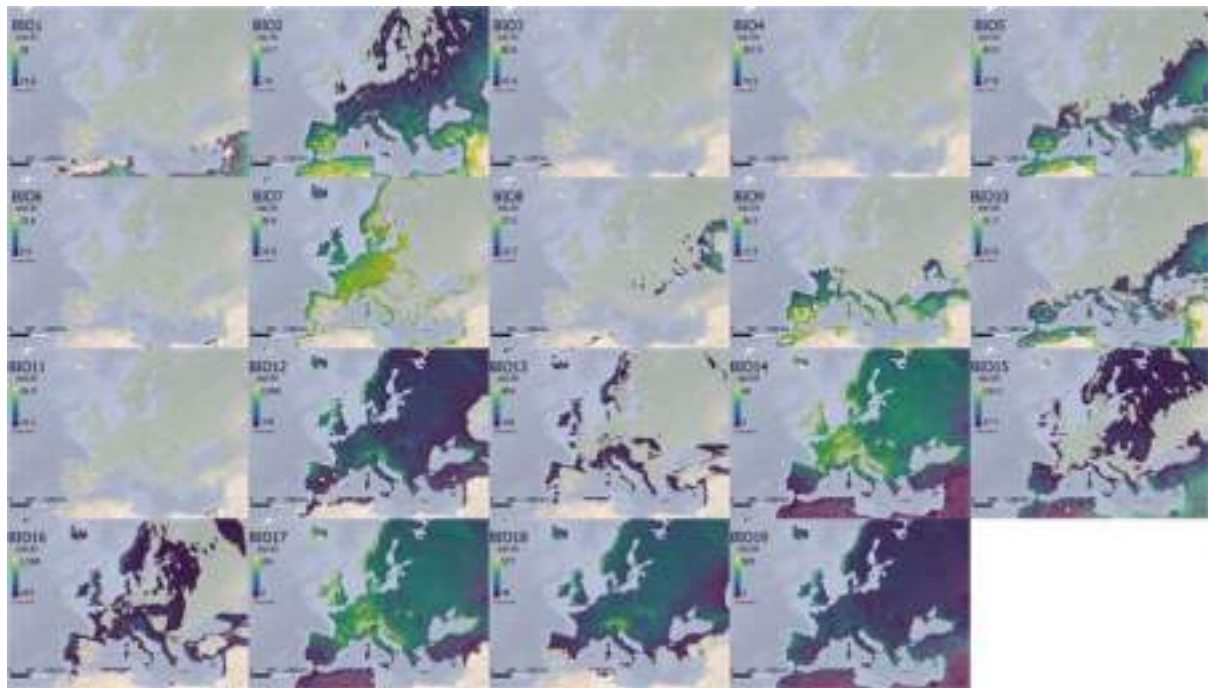
Figure 27: Areas in the EU and neighbouring regions where the ranges of values of the bioclimatic variables listed in Table 17 are within the ranges observed in the areas where *Xanthomonas citri* pv. *viticola* is reported in Brazil and India. Climate conditions predicted for the period 2041–2060 (Shared Socio-Economic Pathway SSP1-2.6). Grey colour indicates no overlap

Figure 28: Areas in the EU and neighbouring regions where the ranges of values of the bioclimatic variables listed in Table 17 are within the ranges observed in the areas where *Xanthomonas citri* pv. *viticola* is reported in Brazil and India. Climate conditions predicted for the period 2041–2060 (Shared Socio-Economic Pathway SSP2-4.5). Grey colour indicates no overlap
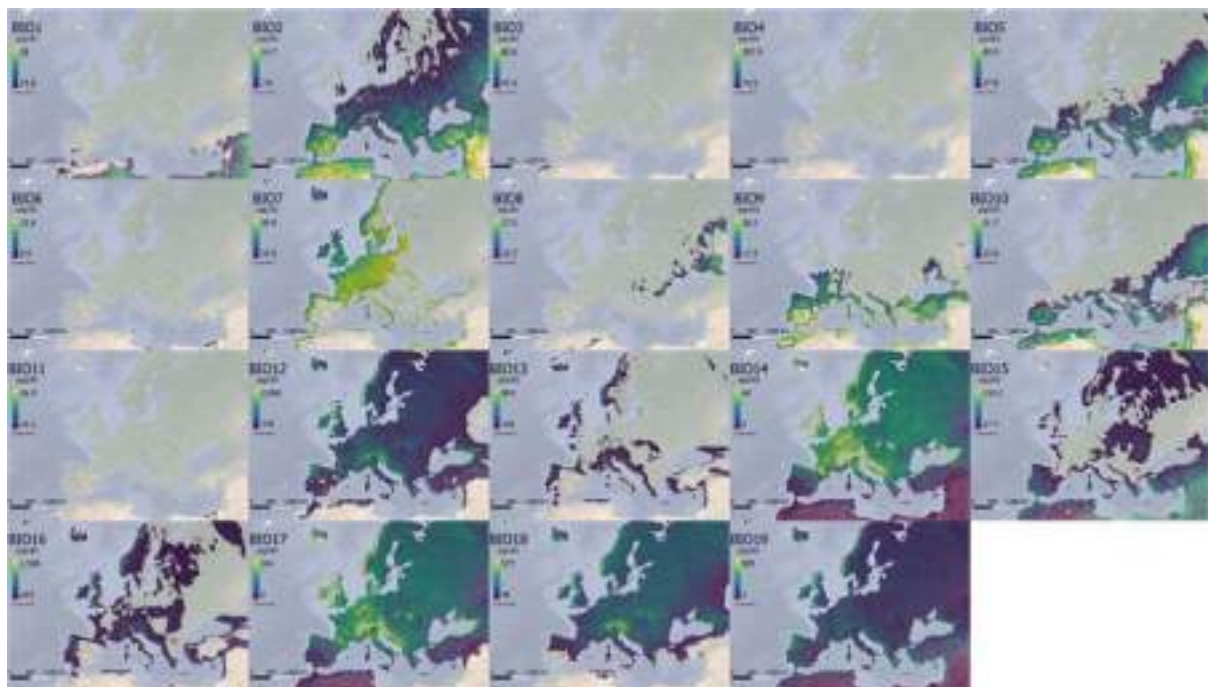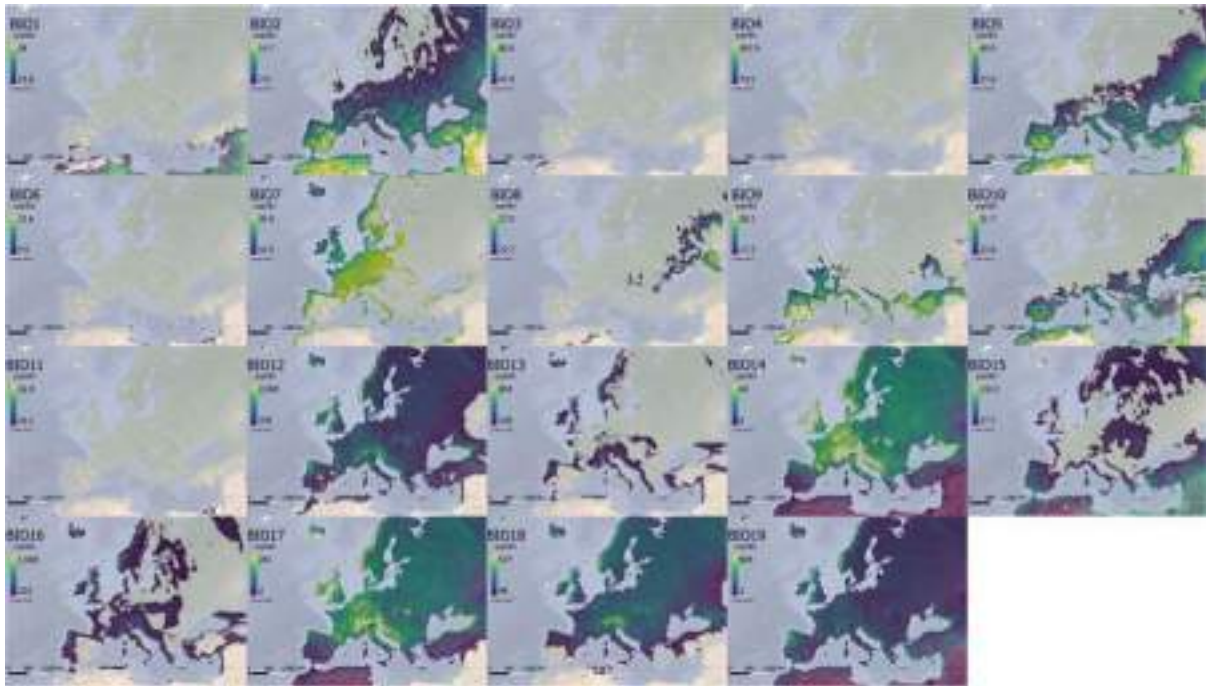
Figure 29: Areas in the EU and neighbouring regions where the ranges of values of the bioclimatic variables listed in Table 17 are within the ranges observed in the areas where *Xanthomonas citri* pv. *viticola* is reported in Brazil and India. Climate conditions predicted for the period 2041–2060 (Shared Socio-Economic Pathway SSP5-8.5). Grey colour indicates no overlap

The maps presented in Figures 27–29 show that:

1) Under climate change (2041–2060), results are heterogeneous among bioclimatic variables, similar to results under current climate. For some variables (e.g. BIO7 and BIO17), values found in large parts of Europe are within the range observed in the areas where Xcv is currently reported, whereas for some others (e.g. BIO1, BIO4, BIO6 and BIO11), there is no overlap. This heterogeneity among bioclimatic variables highlights the uncertainty inherent in assessing the risk of Xcv establishment in the EU under climate change.

2) Under climate change (2041–2060), in parts of Southern Europe, values of many bioclimatic variables (e.g. BIO2, BIO5, BIO7, BIO9, BIO10, BIO12) are within the ranges observed in the areas where Xcv is reported. Also this result was already observed under current climate. This pattern suggests that the risk of Xcv establishment is higher in Southern Europe than in Central and Northern Europe also under climate change.

3) Overall, the maps obtained under current (Figure 26) and future climate conditions (Figures 27–29) are similar, with only a slight increase by 2041–2060. It is likely that there would have been more divergence between the two sets of maps if climate conditions at the end of the century instead of mid-century had been considered.

4.2.5. Conclusions on climate suitability

Although the climate conditions in the EU do not appear to be optimal for the development of the disease, the climate characteristics of several EU grapevine-growing areas are compatible with the establishment of Xcv. However, the geographic distribution of the areas with climate conditions suitable for Xcv establishment in the EU is uncertain, due to the diverging patterns shown by different bioclimatic variables. For some bioclimatic variables, the values found in large parts of the EU overlap with those observed in the areas where Xcv is reported. For other variables, no overlap is present. Therefore, the extent of climatically suitable areas based on some bioclimatic variables is much narrower than that revealed by the Köppen–Geiger climate comparison.

Considering the little information available on Xcv distribution and its ecophysiology as well as the contrasting results obtained with different bioclimatic variables (both under current climate and climate

change), the evaluation of climatic suitability of this pest is not straightforward and an EKE approach is thus required. Overall, the case of Xcv illustrates well the limitations of climate suitability assessments when based on few data points and limited epidemiological information.

4.2.6. Probability of establishment

The parameter probability of establishment (p_{estab}) is defined in Table 19.

Table 19: Definition of the parameter probability of establishment (p_{estab})

Name	Definition	Units	Sources
p_{estab}	Probability that one founder population (from a successful entry) will establish. Once transfer occurs, the probability of establishment is the same for all founder populations, regardless of the entry pathway	Probability	Based on host distribution and climate suitability maps

The elicited distribution of the probability of establishment (under current climate and climate change) is reported in Table 20 and Figures 30–31. In both cases, the extent of the area with climate conditions suitable for Xcv establishment is uncertain, given the differences between the Köppen–Geiger map (Figure 25) and the maps of different bioclimatic variables (Figures 26–29). This uncertainty is reflected in the elicitation of the probability of establishment. This probability applies to the entire EU area where grapes are grown. Contrary to what was done for spread and impact (Sections 5 and 6), the probability of establishment does not apply to the area with average yearly temperature above 17°C (see Sections 5 and 6), because that temperature was considered as a constraint on spread and impact, but not on establishment.

Table 20: Probability of establishment (p_{estab}) under current climate (a) and climate change (b)

Quantile:	1%	25%	Median	75%	99%
$p_{estab\ (a)}$ current climate	0.05	0.20	0.30	0.40	0.75
$p_{estab\ (b)}$ climate change (2041–2060, SSP2-4.5)	0.10	0.25	0.35	0.45	0.80

Justification – current climate (a):

The value for the 1% quantile was based on the maps of some bioclimatic variable maps (e.g. BIO3, BIO4; Figure 26) showing high constraints to establishment. The median was closer to the 1% value, as Xcv is a thermophilic pathogen known to occur mainly under humid subtropical conditions. The 99% quantiles was based on the Köppen–Geiger map (Figure 25) and other bioclimatic variable maps (e.g. BIO14; Figure 26) which suggest little climatic constraints to Xcv establishment. The elicitation also considered that agricultural practices are important for pest establishment. Moreover, grapevine behaves as an evergreen plant in Brazil and India, while it is a deciduous plant in the EU.
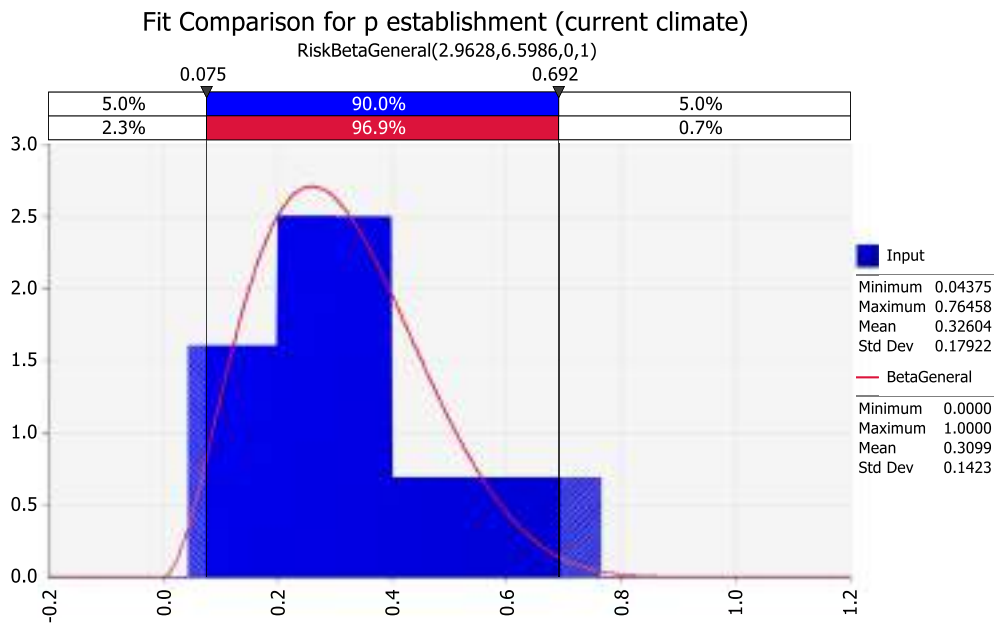
Figure 30: Fitted distribution for the probability of establishment (p_{estab}) under current climate (scenarios A0a and A2a)
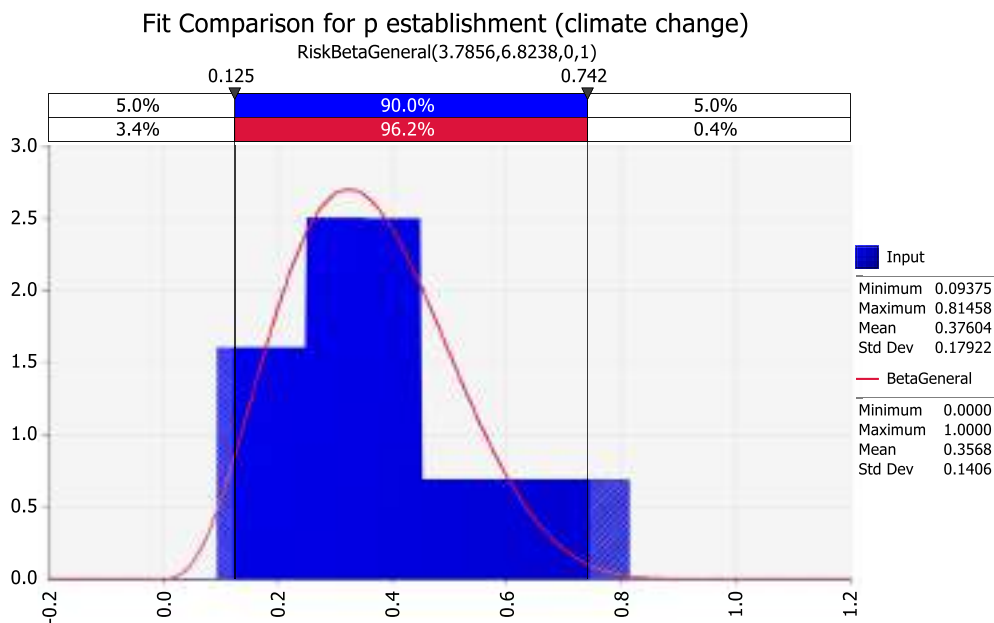
Figure 31: Fitted distribution for the probability of establishment (p_{estab}) under climate projections for 2041–2060, SSP2-4.5 (scenarios A0b and A2b)

Justification – climate change (b):

For several grapevine-producing EU countries, the average difference across all bioclimatic variables comparing the current climate with the climate projections for 2041–2060 (SSP2-4.5) is close to 5%, for example, for Croatia the average increase is about 6.4%, for France 5.4%, Portugal 3.8%, Italy 3.6%. It was thus decided to increase the elicited values for p_{estab} under current climate by 5% to obtain p_{estab} under climate change (2041–2060, SSP2-4.5).

4.2.7. Number of established populations

The output variable (N_{est}) defined in Table 21 is obtained through the following equation:

$$N_{est} = N_{inf} \times p_{estab}$$

Table 21: Definition of the of the output variable (N_{est})

Name	Definition	Units
N_{est}	Number of Xcv populations established in the EU	Number of established populations per year

Table 22 and Figures 32–35 show the outcome of the model calculations for N_{est} (number of Xcv populations established in the EU) for the considered scenarios:

- A0a: current practice and current climate,
- A0b: current practice and climate change projection for 2041–2060 (SSP2-4.5),
- A2a: additional RROs and current climate,
- A2b: additional RROs and climate change projection for 2041–2060 (SSP2-4.5).

The risk of Xcv establishment is only slightly lower than the risk of Xcv entry, i.e. no major establishment constraints are expected for most entries, as reflected in the distribution of the probability of establishment.

Similarly, the risk of Xcv establishment under current climate is only slightly lower than under climate change (2041–2060, SSP2-4.5).

Table 22: Outcome of the model calculation for N_{est} (number of Xcv populations established per year due to entries) under the considered scenarios A0 (current practice), A2 (additional RROs), a (current climate) and b (climate change projection for 2041–2060, SSP2-4.5), using 10,000 simulation runs

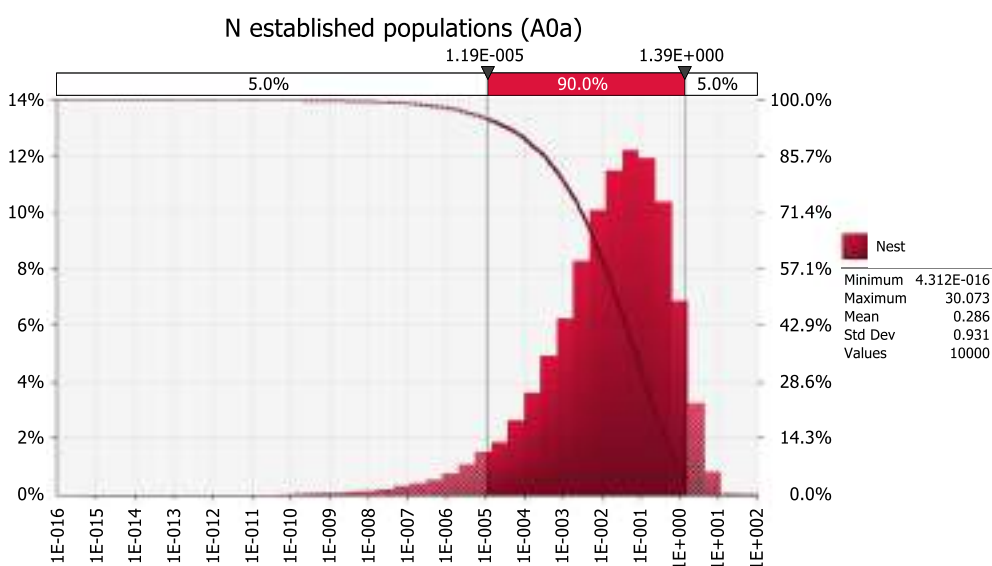| Scenario	Mean	St. dev.	1%	25%	Median	75%	99%
A0a	0.3	0.9	0.000	0.002	0.02	0.17	4.4
A0b	0.3	1.1	0.000	0.002	0.03	0.21	4.6
A2a	0.2	0.7	0.000	0.002	0.02	0.15	3.3
A2b	0.3	1.0	0.000	0.002	0.03	0.18	3.8

Figure 32: Outcome of the model simulations for scenario A0a (current practice and current climate) showing the relative frequency and cumulative descending probability with log-scale x-axis. The number of Xcv populations established in the EU per year is estimated between 1.4×10^{-5} and 1.4 with a 90% probability

N established populations (A0b)
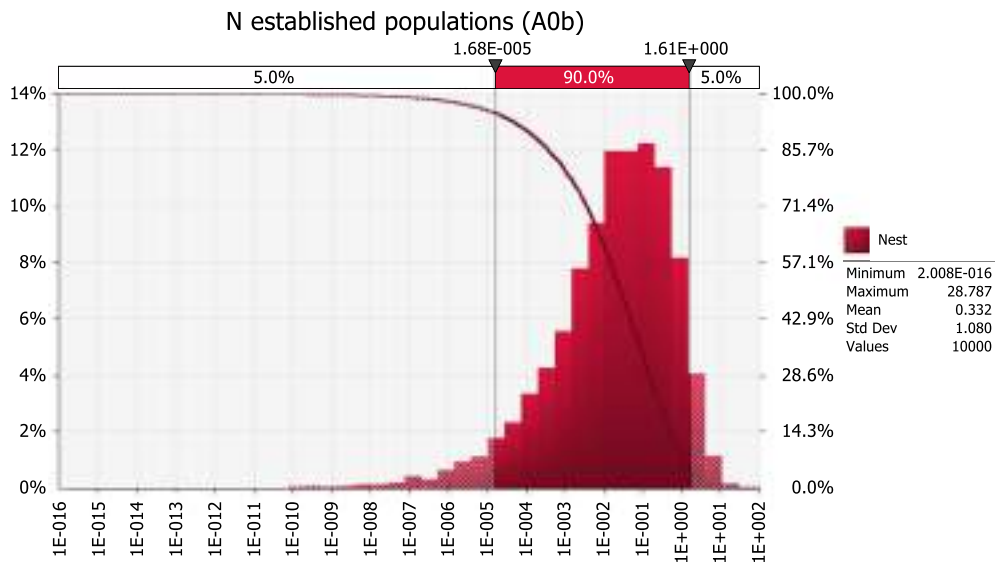
Figure 33: Outcome of the model simulations for scenario A0b (additional RROs and climate change projection for 2041–2060, SSP2-4.5), showing the relative frequency and cumulative descending probability with log-scale x-axis. The number of Xcv populations established in the EU per year is estimated between 1.7×10^{-5} and 1.6 with a 90% probability

N established populations (A2a)
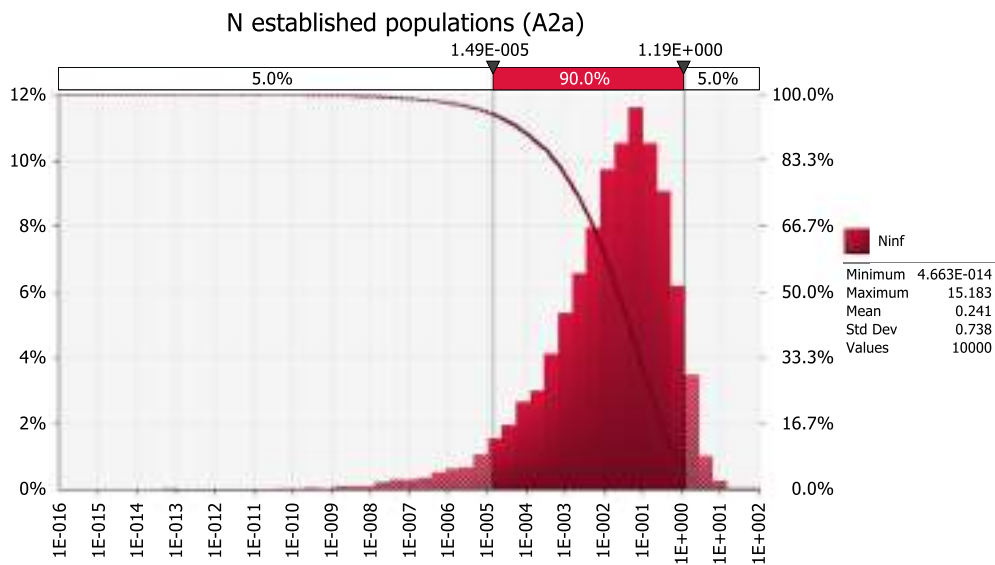
Figure 34: Outcome of the model simulations for scenario A2a (additional RROs and current climate), showing the relative frequency and cumulative descending probability with log-scale x-axis. The number of Xcv populations established in the EU per year is estimated between 1.5×10^{-5} and 1.2 with a 90% probability
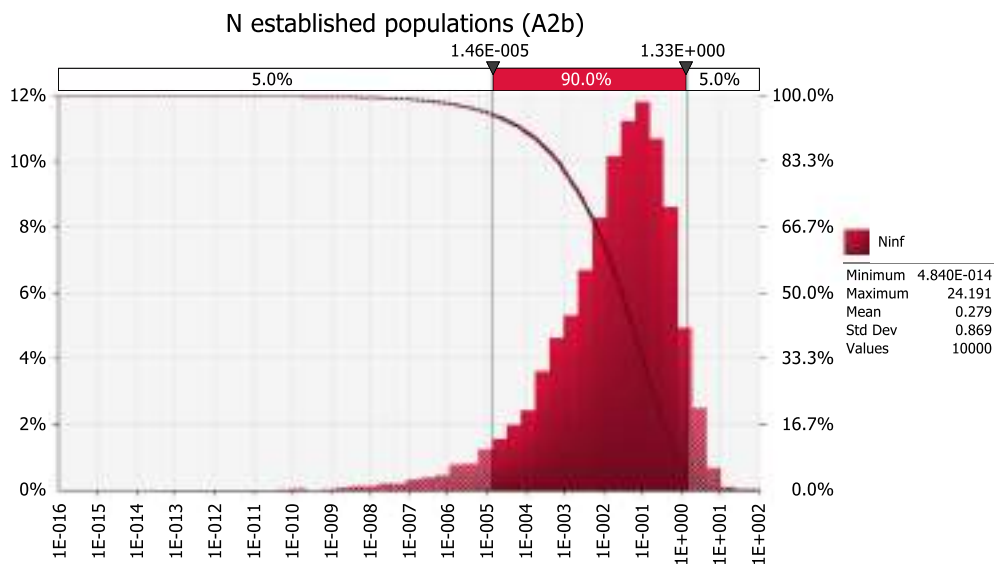
Figure 35: Outcome of the model simulations for scenario A2b (additional RROs and climate change), showing the relative frequency and cumulative descending probability with log-scale x-axis. The number of Xcv populations established in the EU per year is estimated between 1.5×10^{-5} and 1.3 with a 90% probability

According to the model results, the risk of Xcv establishment is only slightly lower than the risk of Xcv entry. Therefore, no major constraints for establishment are expected for most entries, as reflected in the distribution of the probability of establishment.

4.3. Uncertainties affecting the assessment of establishment

The assessment of the risk of Xcv establishment in the EU is affected by large uncertainties. Nevertheless, based on the sensitivity analysis (Figures 36–39), the probability of establishment is less correlated with the outcome variable (the number of established populations) than the most influential factors of the entry model.

Figure 36: Correlation with the output variable (N_{est}) of the model parameters for scenario A0a (current practice and current climate)

Figure 37: Correlation with the output variable (N$_{est}$) of the model parameters for scenario A0b (current practice and climate change projection for 2041–2060, SSP2-4.5)
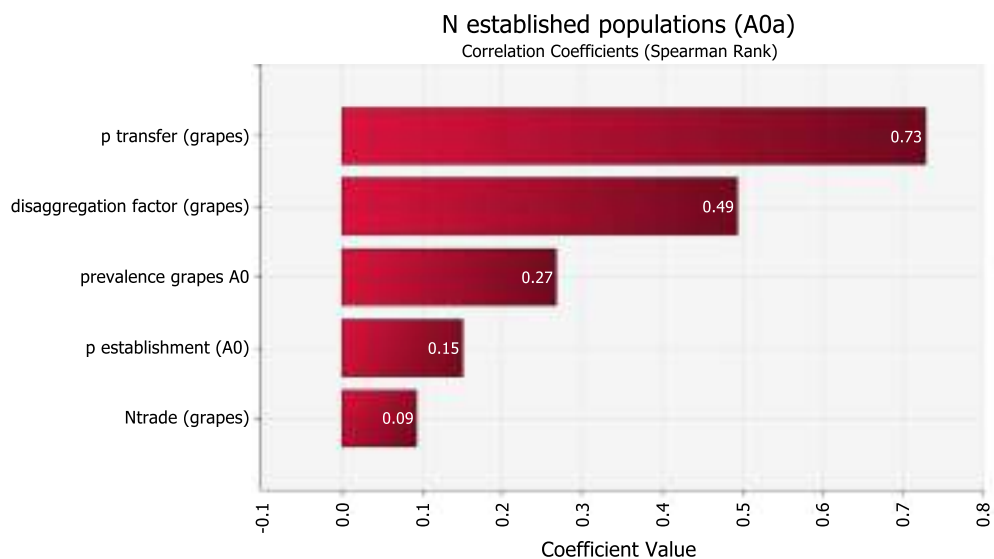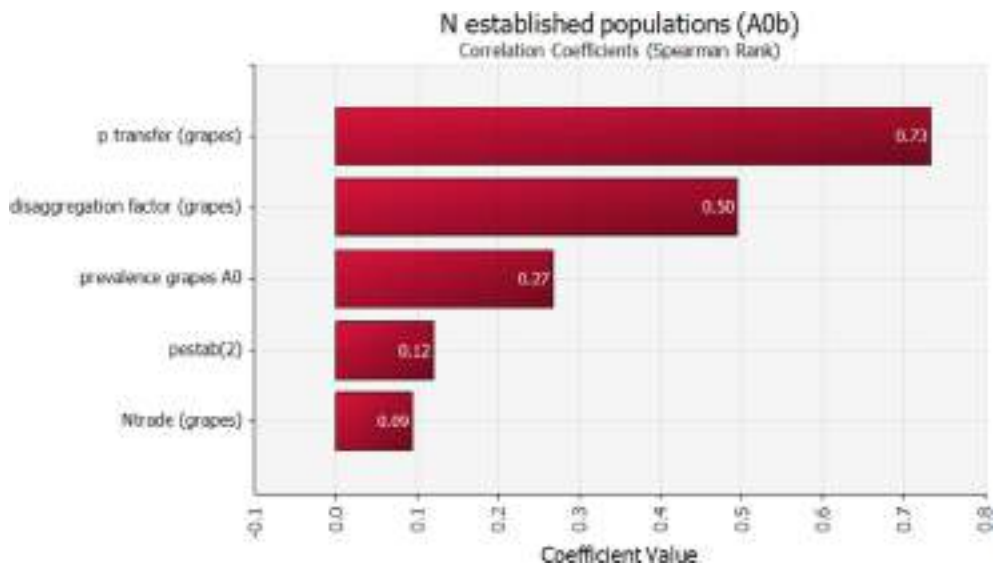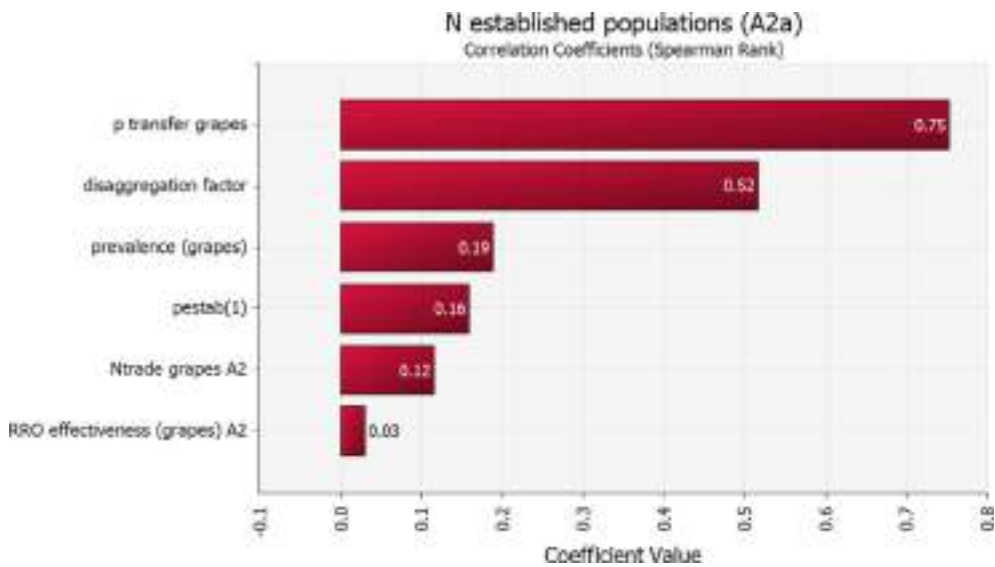

Figure 38: Correlation with the output variable (N$_{est}$) of the model parameters for scenario A2a (additional RROs and current climate)
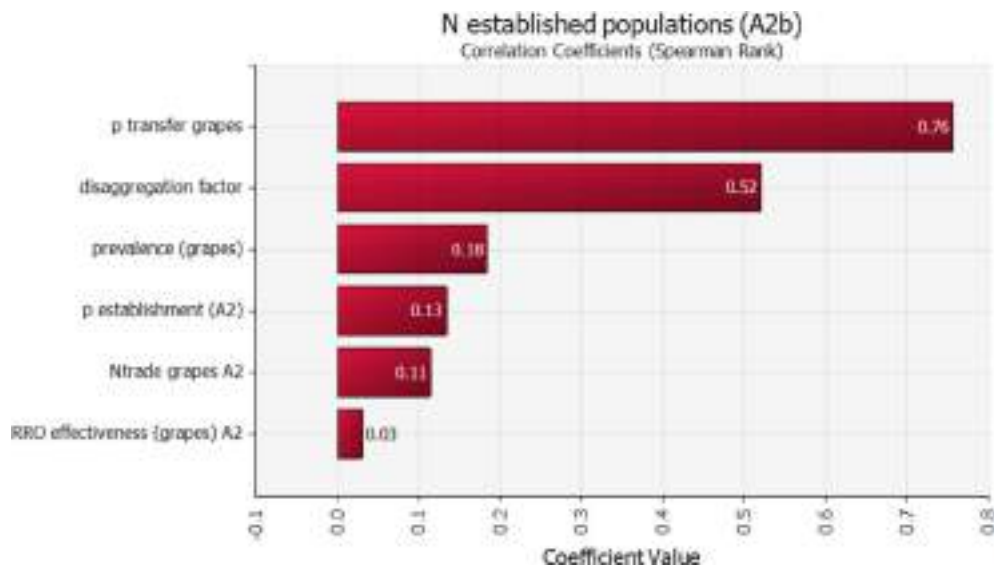
Figure 39: Correlation with the output variable (N_{est}) of the model parameters for scenario A2b (additional RROs and climate change projection for 2041–2060, SSP2-4.5)

4.4.   Additional uncertainties

Unquantified uncertainties in the establishment assessment include:

- Potential future increases in table grape productivity (Sellers-Rubio et al., 2016; Roselli et al., 2020).
- The assessment was based on the overall grapevine production area in the EU, but the table grape production area, which might be more at risk for Xcv, is much smaller. This level of detail was not considered in the model, for simplicity and due to lack of epidemiological information.
- Divergence in emission scenarios and climate change models were ignored, again for simplicity. This divergence is relatively small given the choice of the climate change time horizon closer to the present day, rather than at the end of the century.

The Panel expects the conclusions of the assessment model not to be modified substantially by the additional uncertainties not quantified in this assessment.

4.5.   Dependencies between parameters

There is a possible dependence between the strength of climate changes and the shift in host distribution, but this dependence is expected to be relatively weak for the climate change time horizon assessed in this PRA, thus not affecting substantially the conclusions on establishment.

4.6.   Conclusions on establishment

According to the model results, the risk of Xcv establishment is only slightly lower than the risk of Xcv entry, i.e. no major establishment constraints are expected.

Similarly, the risk of Xcv establishment under current climate is only slightly lower than under the expected climate change for the period 2041–2060.

5.   Spread

In the assessment of potential spread, the Panel assumed that the founder population of Xcv occupies only a small proportion of habitats (plants or vineyards located in a restricted area) with small local population sizes that is some fraction of the habitat's carrying capacity (Perry et al., 2017). It is expected that Xcv has an initial slow increase of population size and a limited dispersal that can be due to:

   a) genetic factors related to the lack of fitness of the species in a relatively new environment,
   b) suboptimal environmental conditions limiting the biological performance of the bacteria,
   c) limited availability of hosts and their patchiness.

In this phase, defined as 'lag period', the spread is limited and not homogeneous (it can change in the different directions; EFSA PLH Panel, 2022). At the end of this phase, Xcv is expected to reach a level of adaptation to local conditions to allow it to survive, reproduce and infect enough plants to effectively spread between vineyards by natural means (e.g. by rain, wind, water splash).

In the specific case of Xcv, an important role in the spread is likely to be played by the agricultural practices, in particular by harvesting and pruning activities, which are frequent in vineyards and an important mechanism of Xcv infection among grapevine plants. While contaminated tools favour Xcv transmission, pruning residues and plant debris do not seem to play an important role, as the pathogen cannot survive long on those substrates (EFSA PLH Panel, 2021).

5.1. Assessment of spread via expert knowledge elicitation

Based on the scenario defined for this assessment, the average duration of the lag phase in the area where Xcv can potentially establish is almost 3 years (with a 90% uncertainty range of 6 months–6 years). After this phase, Xcv is expected to reach an expansion rate of 270 m/year (with a 90% uncertainty range of about 35–800 m/year). More details are available in Appendix C.

5.2. Uncertainties affecting the assessment of spread

- The duration of the lag period is mainly driven by the effect of the agricultural practices and by the duration of the vegetative period of the host in the EU, both aspects differing from the conditions in the areas where the pest is currently present.
- The expansion rate is mainly driven by the different grapevine cultivars grown in the EU and their unknown susceptibility and by the effect of climatic conditions (e.g. number of infection cycles) in the EU.

More details are available in Appendix C.

5.3. Conclusions on spread

In the grapevine-producing areas of the EU with average yearly temperature above 17°C over the coming 30 years, the lag phase in the area where Xcv can potentially establish is expected to be about 3 years (median; 90% range between about 6 months and about 6 years). Under the same scenario, the expansion rate reached after the lag phase is assessed to be about 300 m/year (median; 90% range between about 35 and about 800 m/year).

The threshold temperature (average yearly temperature above 17°C) was based on evidence from similar xanthomonads infecting citrus, as well as few reliable scientific data available on Xcv. Biological data on *X. citri* pv. *citri* revealed minimum and maximum bacterial multiplication following infection at 12°C and 40°C, respectively, with the optimum range for disease development ranging from 25 to 35°C (Dalla Pria et al., 2006). Data available in the literature suggest similar conditions for Xcv, with an optimal temperature for disease development ranging from 25°C to 30°C and, under experimental conditions, bacterial growth at 15°C and symptoms development in greenhouse from 18°C to 43°C (Lima et al., 2009; Nascimento et al., 2005).

6. Impact

The impact of Xcv is mainly due to the leaf blight and cankers happening on stems and petioles and connected foliage death of grapevine plants. The berries of infected plants can develop irregularly in size and colour, with lesions (Naue et al., 2014). Given the absence of information about yield losses as a function of the level of infection, the impact is assessed using the yearly average infection rate (i.e. disease prevalence) over a 30-year production cycle for the whole EU grapevine-growing area. However, considering that most of the evidence extracted from the literature refers to the infection rates on seedless table grapes, the impact is assessed for the table and wine grapes growing areas separately. These two types of grapevine production are known to differ substantially in several agricultural practices that can modify the level of impact: cultivars, training, pruning, irrigation,

covering, canopy development, harvesting time and level of mechanisation. Quality losses are not included in the assessment, due to the lack of supporting evidence.

In the case of nurseries, a quantitative assessment of the impact was not conducted. Grapevine mother plant fields are in fact managed according to the <u>Directive 68/193/EEC</u>: the stock nurseries and the cutting nurseries are regularly inspected, sampled and tested for the possible presence of quarantine and RNQPs pests, e.g. a set of viruses, '*Candidatus* Phytoplasma solani' and *Xylophilus ampelinus*. In addition, Commission Implementing Regulation (EU) 2019/2072 provides specific rules applying to grapevine planting material, which are expected to have an effect on the Xcv population (e.g. hot water treatment). Finally, the use of pesticides, in particular copper-based products is remarkably higher than that in commercial vineyards, as suggested by the good agricultural practices (EIP AGRIS, 2019). In particular, the use of copper spray that is recommended among other measures to ensure freedom from the bacterium *X. ampelinus* could also reduce the dissemination of Xcv (Malavolta et al., 1999). Nonetheless, due to the subtropical origin of the pest and the need for relatively high temperature and humidity, an infection by Xcv may stay latent for more than one growing season. If management options are already in place, the presence of plants infected by Xcv would represent a complete loss (100%) in the production of the nursery. However, the limited host range and natural spread capacity would allow the setting of pest-free zones around a nursery.

More details are available in Appendix C.

6.1. Assessment of impact via expert knowledge elicitation

Based on the scenario defined for this assessment, the mean impact (here assessed by the percentage of grapevine plants infected by Xcv in EU production sites as yearly average over a 30-year production cycle) is estimated to be about 17% (median; 90% range between about 1.5 and 46%) in table grapes and about 12% (median; 90% range between about 0.7 and 37% in wine grapes).

More details are available under Appendix C.

6.2. Uncertainties affecting the assessment of impact

The main uncertainties affecting the impact assessment are related to the transferability to EU conditions of the agricultural and climatic conditions in Brazil and India under which Xcv is causing damage to grapevines, in particular for

- main grapevine cultivars
- differences in agricultural systems and growing conditions
- the heterogeneity of the EU production areas

More details are available under Appendix C.

6.3. Conclusions on impact

In the grapevine-producing areas of the EU with average yearly temperature above 17°C over the coming 30 years, the average percentage of grapevine plants infected by Xcv in EU production sites over a 30-year production cycle is estimated to be about 17% (median; 90% range between about 1.5% and about 46%) in table grapes and about 12% (median; 90% range between about 0.7 and about 37%) in wine grapes.

7. Conclusions of the PRA

The risk of Xcv entry due to import of fresh grapes is in an order of magnitude of about one entry per 10 years. The risk of Xcv entry due to import of *Vitis* plants for planting for research/breeding purposes is expected to be several orders of magnitude smaller than the risk of Xcv entry due to fresh grape import.

This difference between the two considered pathways is not affected by the inclusion of RROs (scenario A2), i.e. the risk of Xcv entry due to import of *Vitis* plants for planting for research/breeding purposes is several orders of magnitude smaller than the risk of Xcv entry due to fresh grape import also when including RROs for the two pathways.

The effect of the considered RROs is in fact small, i.e. the risk of Xcv entry due to *Vitis* plants for planting for research/breeding purposes and the risk of Xcv entry due to fresh grape import are only slightly reduced by including the considered RROs.

The extent of the area favourable for Xcv establishment in the EU is uncertain, illustrating the limitations of climate suitability assessments when based on few data points and limited epidemiological information. Nevertheless, according to the model results, the risk of Xcv establishment is only slightly lower than the risk of Xcv entry, i.e. no major establishment constraints are expected. Likewise, the risk of Xcv establishment under current climate is only slightly lower than under the expected climate change for the period 2041–2060.

Should the pest manage to establish in the grapevine-producing areas of the EU with average yearly temperature above 17°C over the coming 30 years, the lag phase is expected to be about 3 years (median; 90% range between about 6 months and about 6 years). Under the same scenario, spread rate by natural means is assessed to be about 300 m/year (median; 90% range between about 35 and about 800 m/year) after the lag phase. The spread rate would be considerably higher considering movements of plants and cutting tools or machinery.

In the grapevine-producing areas of the EU with average yearly temperature above 17°C over the coming 30 years, the average percentage of grapevine plants infected by Xcv in EU production sites over a 30-year production cycle is estimated to be about 17% (median; 90% range between about 1.5% and about 46%) in table grapes and about 12% (median; 90% range between about 0.7 and about 37%) in wine grapes. Impacts have been reported to be severe in Brazil and India, but the estimates provided here show that there is considerable uncertainty about expected impacts in the EU.

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Abbreviations

A0	Scenario reflecting current requirements
A1	Scenario reflecting deregulation (not considered in this PRA)
A2	Scenario reflecting additional RROs
CV	Coefficient of Variation
EKE	Expert Knowledge Elicitation
EPPO	European and Mediterranean Plant Protection Organisation
FAO	Food and Agriculture Organisation of the United Nations
GHG	Greenhouse gases
IPPC	International Plant Protection Convention
MS	Member State
N_{est}	Number of established populations
N_{inf}	Number of founder populations
N_{trade}	Trade flow
$P_{prevalence}$	Prevalence at the origin
$p_{sorting}$	Proportion of sorting
$p_{transfer}$	Probability of transfer
PLH	Plant Health
RRO	Risk reduction option
SSP	Shared Socio-economic Pathway
ToR	Terms of Reference
Xcc	*Xanthomonas citri* pv. *citri*
Xcv	*Xanthomonas citri* pv. *viticola*

Appendix A – Evidence dossier on pest prevalence, disease severity and crop losses at the origin

Grapevine cultivars	Disease incidence	Symptoms	Impact	Additional information	Reference
'Red Globe' grafted on the rootstock IAC 572	Disease incidence: 70–80% of diseased plants	The symptoms observed in the field were cankers on twigs as well as brown to black leaf spot lesions surrounded or not by a chlorotic halo, sometimes along the veins, and numerous depressed dark lesions on berries. In some cases, a pale white exudation was observed over the lesions.		Tupi Paulista county, São Paulo, Brazil in 2009 It was assumed that the disease had been introduced through infected propagating material for grafting obtained from the Petrolina region in 2001. In the same property another plot was cultivated with 'Niagara Rosada' (*Vitis labrusca x vinifera* hyb.), but no bacterial infection was detected. No symptoms were observed on the sprouts emerging from rootstocks in the infected plot of 'Red Globe'. The pathogen has been eradicated from the State of São Paulo.	Rodrigues Neto et al. (2011)
Seedless cultivars Red Globe, Brasil, Piratininga, Patrícia, Benitaka, Ribier and Catalunha	Disease observed 2–3 years after grafting. 100% disease incidence on 'Red Globe' and other seedless cultivars. Variable disease incidence in cultivars Itália, Festival, Brasil, Piratininga, Patrícia, Benitaka, Ribier and Catalunha. The cultivars Itália and Benitaka appear more tolerant			Initially, the disease was found in 2–3 years old plants, but the disease was later found in older plants. Abundant epiphytic colonisation of the pathogen was detected on both symptomatic and asymptomatic vines and leaves. From one production cycle to the next one the bacteria survive in infected plants as epiphyte/endophyte.	Peixoto and Ramos (2004)

Pest risk assessment of *Xanthomonas citri* pv. *viticola*

Grapevine cultivars	Disease incidence	Symptoms	Impact	Additional information	Reference
'Red Globe' (207 = 58%), 'Itália' (51 = 14,2%), 'Festival' (19 = 5,3%), 'Piratininga' (11 = 3,1%), 'Benitaka' (10 = 2,8%), 'Catalunha' (8 = 2,2%) and others (52 = 14,5%).	From 358 analysed samples, Xcv was detected in 197 (55%), from Bahia, Piauí and Pernambuco.			1998–1999, a total of 358 grapevine samples analysed, 290 from Pernambuco, 63 from Bahia, 3 from Piaui, 2 from Minas Gerais, Brazil	Lima et al. (2000)
'Red Globe' on the rootstock Tropical 576	100% diseased plants	3–4 years old with typical symptoms		Latent infection in rootstocks Brazil	Lima and Ferreira (2000)
Young plants (2–3 years) Mainly in seedless cultivars Red Globe and Thompson Seedless, Found disease foci in cvs. Itália, Festival, Brasil, Piratininga, Patrícia, Benitaka, Superior and Catalunha.	100% diseased plants	Plants with symptoms as necrotic spots, with or without halo and necrotic leaf areas, necrotic veins, dark spots along the petiole and cankers.		São Francisco Valley, Bahia, Brazil	Lima et al. (1998)
Seedless cultivars Red Globe, Thompson Seedless. Other cultivars: Italia, Festival, Piratininga, Patricia, Ribier, Catalunha, Brasil and Benitaka.	'Red Globe' and the seedless cultivars originated from 'Thompson Seedless', on which the incidence was nearly 100% diseased plants. Variable disease incidence on 'Italia', 'Festival', 'Piratininga', 'Patricia', 'Ribier', 'Catalunha', 'Brasil' and 'Benitaka'. Cultivar Italia showed tolerance to the disease under field conditions.	Symptoms of stem canker and necrotic spots on leaves, leaf veins, petioles, rachis, peduncles, cap stems and berries were observed on plants	Nearly complete yield loss	Plants in vineyards in the 'Submédio' of the São Francisco Valley, Brazil	Lima et al. (1999)

Pest risk assessment of *Xanthomonas citri* pv. *viticola*

Grapevine cultivars	Disease incidence	Symptoms	Impact	Additional information	Reference
Seedless cultivars Thompson Seedless, Tas-e-Ganesh, Sonaka and Manik Chaman		Symptoms in leaves, petioles and canes	Disease causes about 60–80% yield loss in severely affected vineyards	Optimal conditions for pathogen development are temperatures between 25–30°C and high humidity. Maharashtra, Andhra Pradesh and Karnataka, India	Chand and Kishun (1990)
No information on the cultivars			16–50% disease severity depending on the location and season	Bijapur, India The field trials were laid out in ten years old vineyards, spaced under different disease control treatments 60% disease index resulted in non-treated plants.	Jambenal et al. (2011)

Appendix B – Bioclimatic variables and climate change analysis

Figures B.1–B.3 show the coefficient of variation (CV) for the bioclimatic variables under climate change (2041–2060, for the 3 studied emission scenarios).
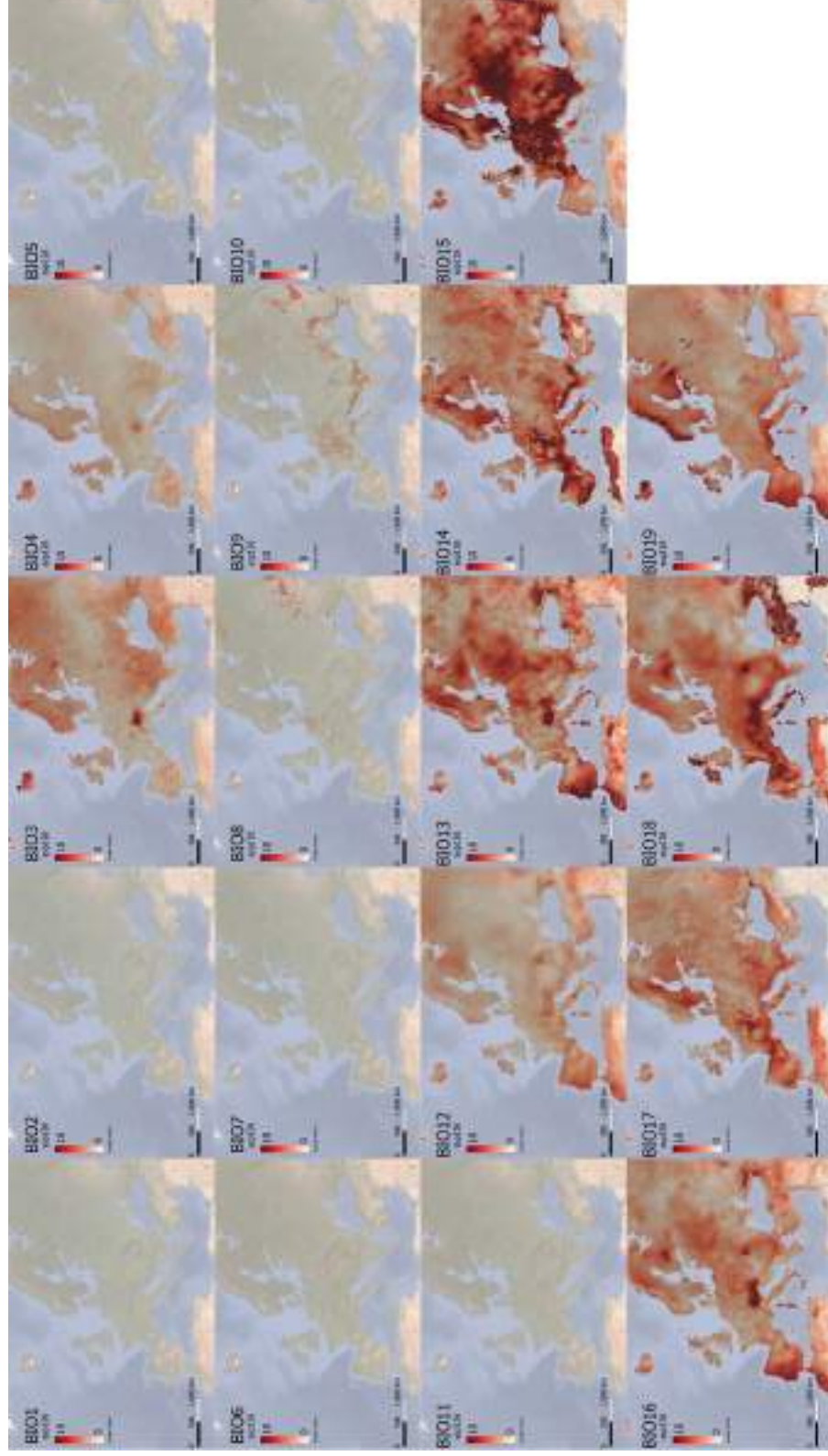

Figure B.1: Coefficient of variation for the bioclimatic variables under climate change (2041–2060, SSP1-2.6)
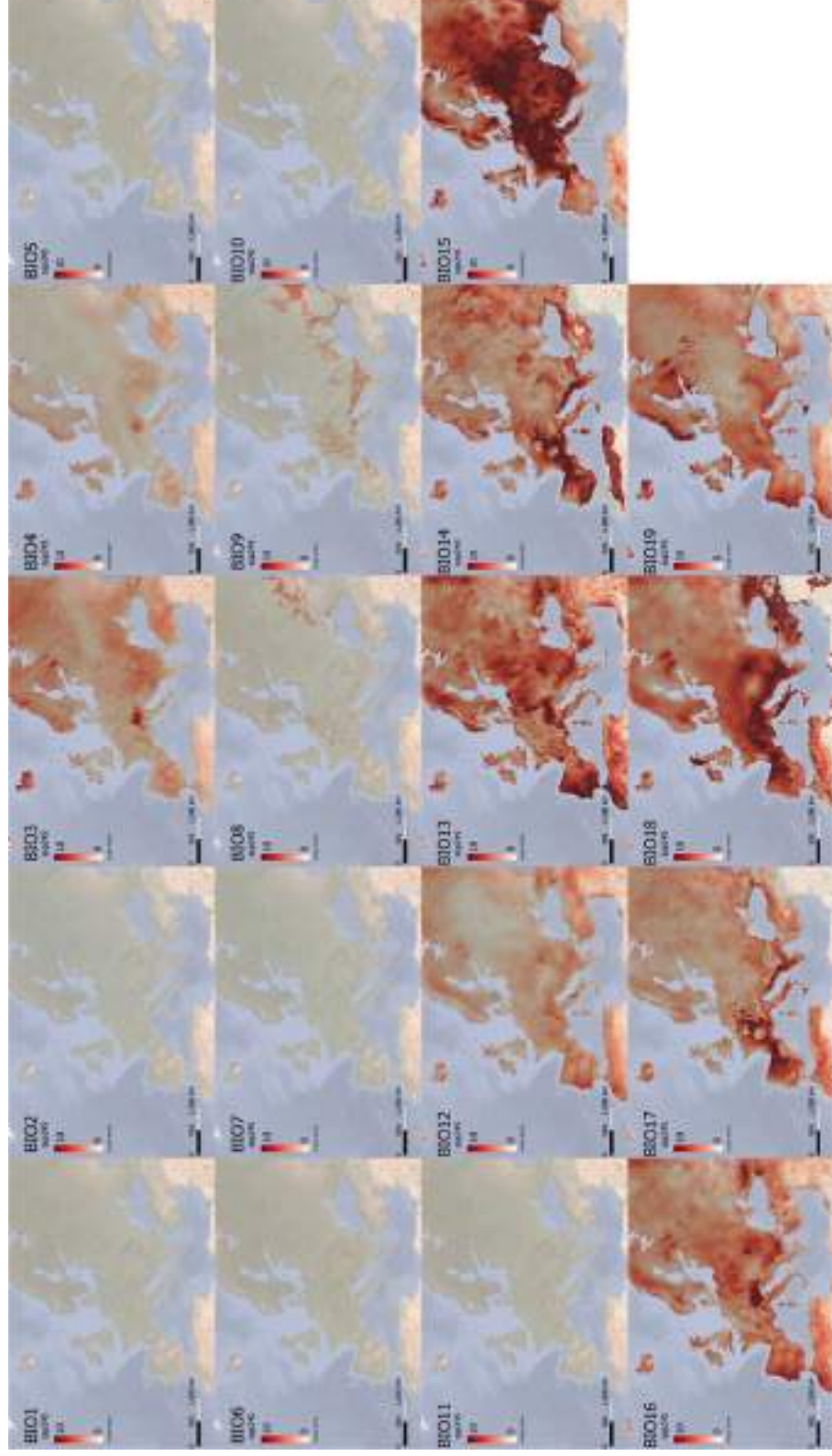
Figure B.2: Coefficient of variation for the bioclimatic variables under climate change (2041–2060, SSP2-4.5)
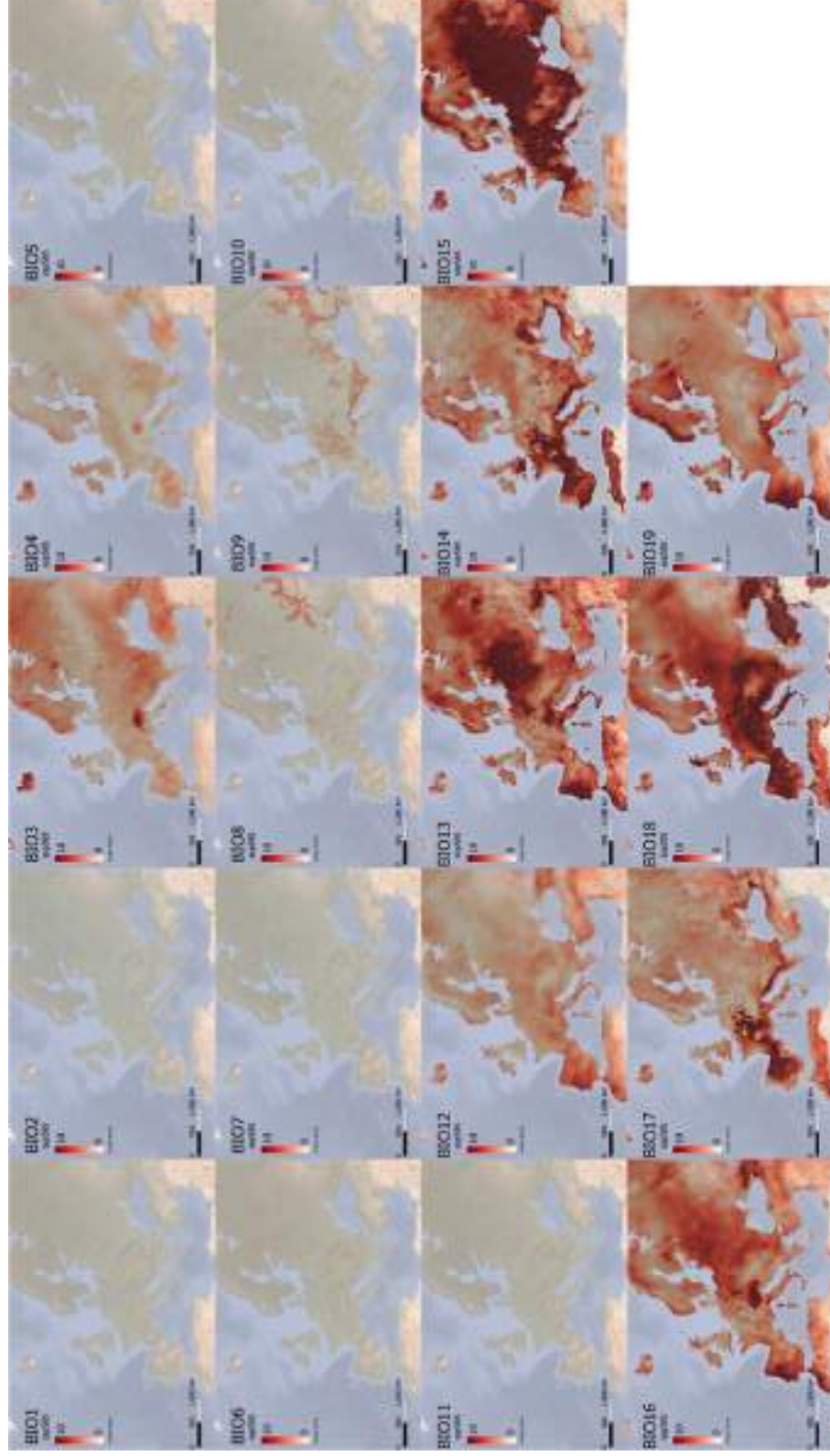
Figure B.3: Coefficient of variation for the bioclimatic variables under climate change (2041–2060, SSP5-8.5)

Pest risk assessment of *Xanthomonas citri pv. viticola*

# Appendix C – Overview of the evaluation of spread and impact

SPREAD

Table C.1:   Lag period

Overview of the results of the Expert Knowledge Elicitation (1st EKE question)

Parameter	Duration of the lag period									
Stratification	Grapevine production areas in the EU with average yearly temperature above 17°C as average of the coming 30 years									
Question	How long is the average duration of the lag period, i.e. the time from the first infectious plant(s) present in a vineyard to the expression of symptoms in enough plants to allow spread between vineyards by natural means, e.g. by rain, wind? [months]									

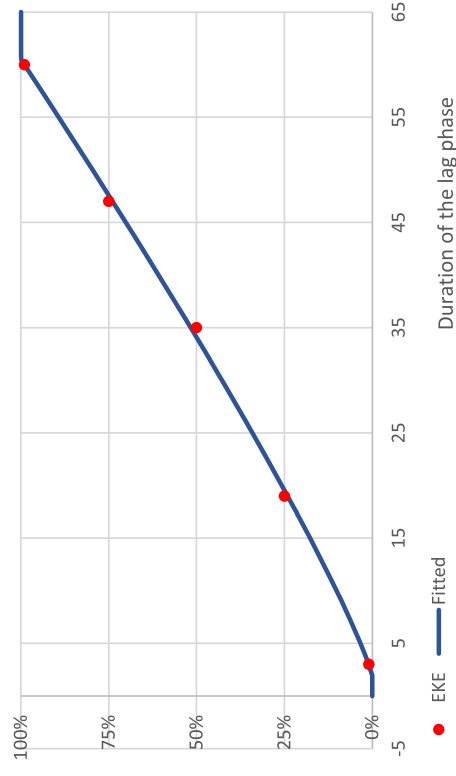| Results	P1%	P2.5%	**P5%**	P10%	P16.7%	P25%	P33.3%	**P50%**	P66.7%	P75%	P83.3%	P90%	**P95%**	P97.5%	P99%
Elicited values	3					19		35		47					60
EKE results	2.99	4.31	6.29	9.90	14.3	19.6	24.6	34.1	43.2	47.6	52.0	55.4	58.0	59.2	60.0
Fitted distribution	BetaGeneral (1.1563,1.0001,1.9,60.5)														

Fitted density
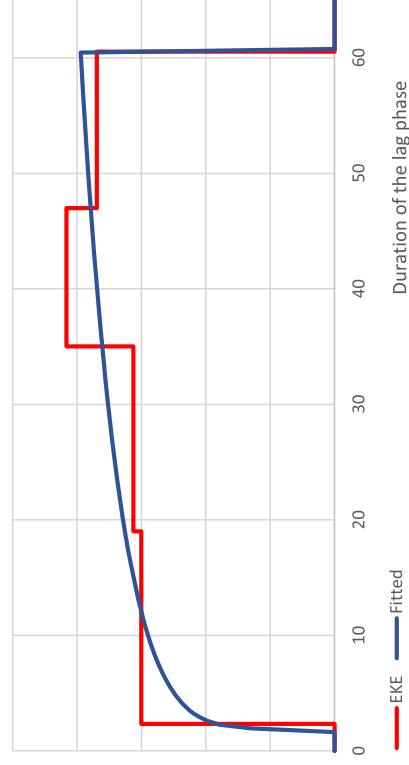
Fitted distribution function

Figure (C.1a): Comparison of elicited and fitted values/density function to describe the remaining uncertainties of the parameter

Figure (C.1b): Cumulative distribution function (CDF) of the likelihood of the parameter

Pest risk assessment of *Xanthomonas citri* pv. *viticola*

Summary of the evidence used for the evaluation

The experts considered several factors influencing the presence and the length of a lag phase, in particular

- Literature on the incubation time of Xcv, esp. Naue et al. (2014) and Zucal et al. (2016).
- Production seasons, esp. the length of the winter dormancy period, in the EU.
- The probability of bacterial transmission via pruning, e.g. manual and mechanic.
- Agricultural practices in the EU, esp. pruning, mechanisation, treatments (esp. with copper), rain/hail protection.
- Product profile of vineyards in the area under consideration, i.e. the EU area with average yearly temperature above 17°C as average of the coming 30 years.

Main uncertainties

- Unknown susceptibility of EU cultivars, esp. with/without seeds.
- Pest development of Xcv under EU climatic conditions, e.g. efficacy of the inocula, number of infection cycles per year.
- Expression of symptoms / duration of a latent phase under EU climatic conditions.
- The role of viticultural practices for local spread, e.g. mechanisation.

|	
Reasoning for a scenario which would lead to a reasonable high duration	The judgement on the upper limit considers that - Spread within a vineyard is triggered by natural means compared to human activities, e.g. pruning, machinery. - Natural events, e.g. hail, thunderstorms, are less frequent. - High proportion of vineyards, esp. table grapes, are protected. - Regular treatments with copper are effective against evaded Xcv.
Reasoning for a scenario which would lead to a reasonable low duration	The judgement on the lower limit considers that - Large number of infected plants are introduced in the vineyard. - During the vegetation period Xcv will quickly develop and spread within the vineyard due to its polyclicic nature. - High degree of mechanisation for pruning and harvest. - Prolonged vegetation period of the production system.
Fair estimate as judgement on the weighted evidence	The judgement on the median considers that - EU climatic conditions are less favourable for pest development than in the tropical countries of origin, e.g. Brazil, India. - EU viticultural practices include several measures delaying the development/spread of Xcv.
Precision of the judgement as description of remaining uncertainties	The judgement on the interquartile range considers that - High uncertainties on lower values due to possible high infectivity and unknown starting conditions. - High uncertainties on higher values due to unknown effect of EU climatic conditions and viticultural practices.

Pest risk assessment of *Xanthomonas citri* pv. *viticola*

Table C.2: Expansion rate

Overview of the results of the Expert Knowledge Elicitation (2nd EKE question)

Parameter	Expansion rate after the lag phase											
Stratification	Grapevine production areas in the EU with average yearly temperature above 17°C as average of the coming 30 years.											
Question	Assuming that human assisted spread between vineyards is excluded by perfect sanitary measures or prohibited exchange of tools/workers. What is the 95th percentile of the distance newly infected vineyards have to the nearest existing one already infected one year before? [m/year]											

Results	P1%	P2.5%	**P5%**	P10%	P16.7%	P25%	P33.3%	**P50%**	P66.7%	P75%	P83.3%	P90%	**P95%**	P97.5%	P99%
Elicited values	20					135		250		500		697			1,000
EKE results	20.0	25.1	34.4	54.5	83.8	124	168	270	401	483	586	697	817	911	1,003
Fitted distribution	BetaGeneral (0.92036,2.6668,17,1,230)														

Fitted density
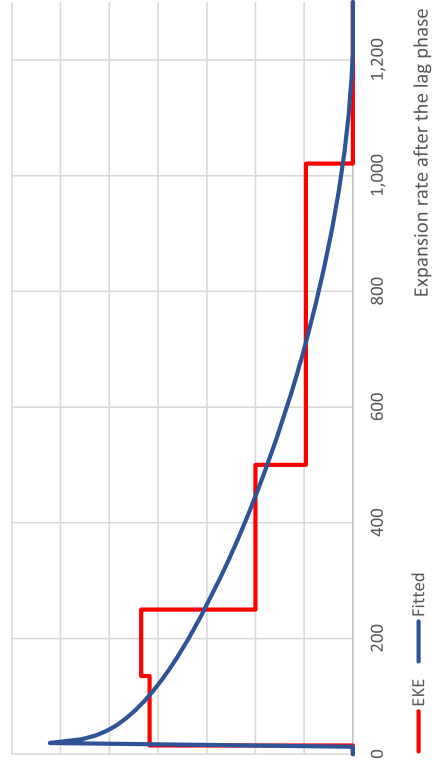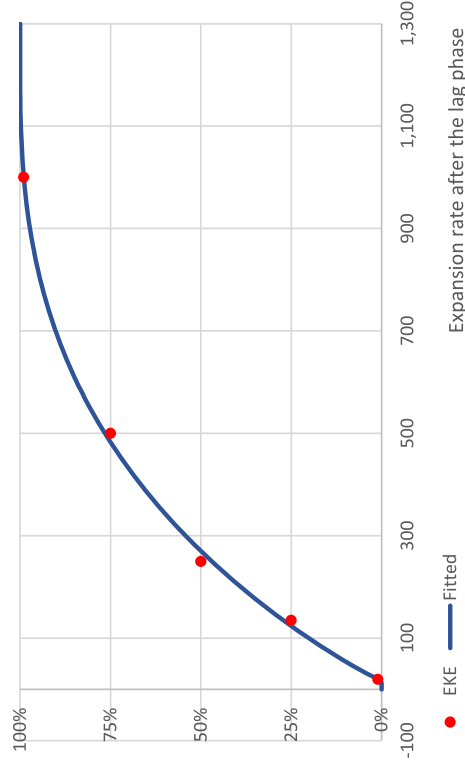

Fitted distribution function

Figure (C.2a): Comparison of elicited and fitted values/density function to describe the remaining uncertainties of the parameter

Figure (C.2b): Cumulative distribution function (CDF) of the likelihood of the parameter

Pest risk assessment of *Xanthomonas citri* pv. *viticola*

Summary of the evidence used for the evaluation

- In this assessment only spread by natural means is considered (movement of workers or machinery is excluded).
- Results on the spread rate of *Xanthomonas citri* pv. *citri* (Xcc) were reviewed (EFSA et al., 2019b), incl. Original references on spread of Xcc in Florida (Gottwald et al., 2001).
- Distribution and product profile of vineyards in the area under consideration (this is the EU area with average yearly temperature above 17°C as average of the coming 30 years).

Main uncertainties

- Comparability of results from Xcc and Xcv regarding esp. differences in host systems (citrus orchards vs vineyards), influence of human assisted spread in the Xcc assessment.
- Unknown susceptibility of EU cultivars to Xcv.
- Pest development of Xcv under EU climatic conditions, e.g. efficacy of the number of infection cycles; esp. compared to Florida.
- Influence of barriers to spread between vineyards.
- Movement of the bacteria via droplets, plant parts during extreme weather events, esp. hail, thunderstorms.

Reasoning for a scenario which would lead to a reasonable high proportion	The judgement on the upper limit considers that • Grapevine is more vulnerable against strong weather events causing wounds (points of inoculum) and contributing to the spread (e.g. wind, thunder/hail storms), than citrus. • The spatial distribution and distance among vineyards in the EU do not represent a major limitation for the spread of the species.
Reasoning for a scenario which would lead to a reasonable low proportion	The judgement on the lower limit considers that • High proportion of vineyards, esp. table grapes, are protected against weather events. • The spatial distribution and distance among vineyards in the EU limit the spread of the species. • EU grapevine production area is more extended and heterogeneous than EU citrus growing area and therefore the probability of having environmental conditions unfavourable to the fast growing of the inoculum is taken into account.
Fair estimate as judgement on the weighted evidence	The judgement on the median considers that • The spread of Xcv on grapevine is greater compared to spread of Xcc on citrus.
Precision of the judgement as description of remaining uncertainties	The judgement on the interquartile range considers that • High uncertainties on lower values due to the lack of reports on spatial spread. • Medium uncertainties on higher values due to the possibility of extrapolation of results from Xcc.

Pest risk assessment of Xanthomonas citri pv. viticola

IMPACT

Table C.3: Yield loss on table grapes

Overview of the results of the Expert Knowledge Elicitation (3rd EKE question)

Parameter	**Incidence in table grape plants**
Stratification	Grapevine production areas in the EU with average yearly temperature above 17°C as average of the coming 30 years
Question	What is the average **percentage of infected plants** by *Xanthomonas citri* pv. *viticola* in **table grape production sites** as **yearly average of a 30 years production cycle** in the risk area? [%]

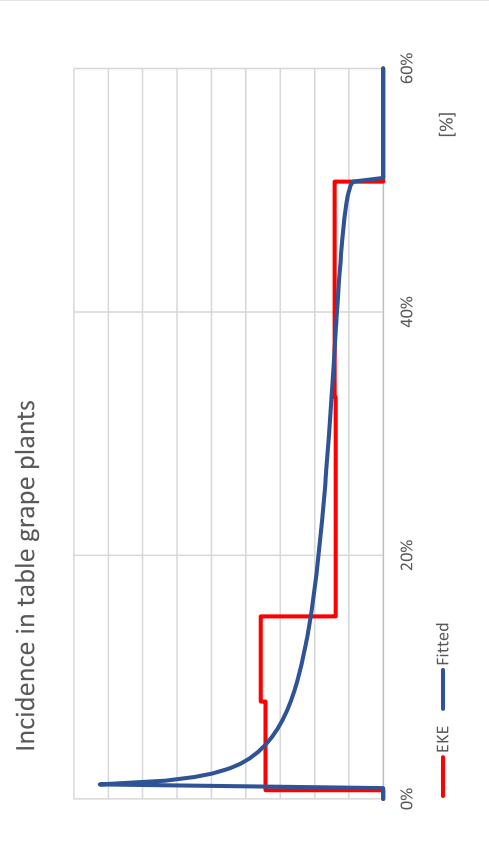| Results	P1%	P2.5%	**P5%**	P10%	P16.7%	P25%	P33.3%	**P50%**	P66.7%	P75%	P83.3%	P90%	**P95%**	P97.5%	P99%
Elicited values	1.00%					8.00%		15.0%		33.0%			50.0%		
EKE results	1.00%	1.13%	1.47%	2.40%	4.07%	6.69%	9.8%	17.3%	26.5%	31.7%	37.3%	42.3%	46.3%	48.5%	49.9%
Fitted distribution	BetaGeneral(0.66958,1.0945,0.0095,0.51)														

Incidence in table grape plants

Figure (C.3a): Comparison of elicited and fitted values/density function to describe the remaining uncertainties of the parameter
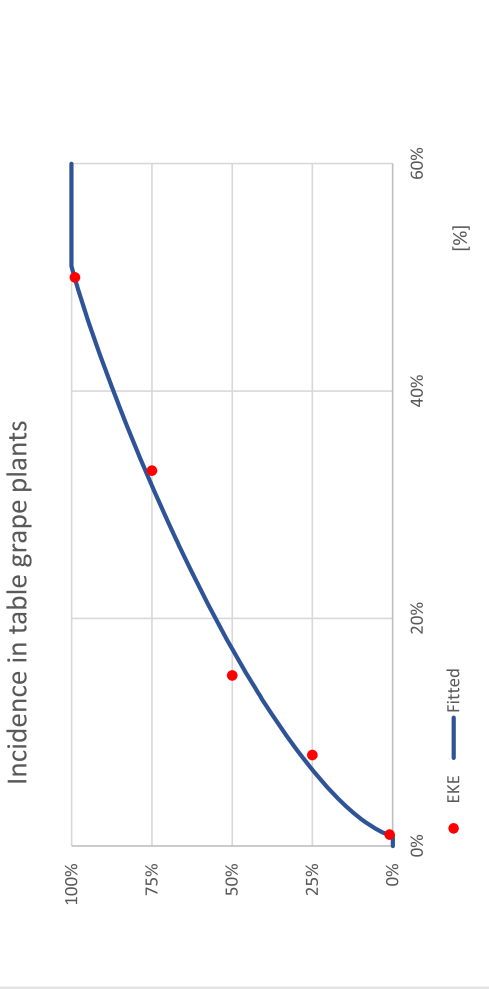

Incidence in table grape plants

Figure (C.3b): Cumulative distribution function (CDF) of the likelihood of the parameter

Summary of the evidence used for the evaluation

- References discuss differences between rootstock varieties, rootstock vs. main plants, white/red grapevine plants, and seed/seedless grapevine plants.
- Grapevine varieties used in EU grapevine production.
- Differences in the production cycles (pruning, winter period) between EU and countries of origin, i.e. India, Brazil.
- Some references report natural incidence: Lima et al., 2000; Melo et al., 2000; Rodrigues Neto et al., 2011.

Main uncertainties

- References may report new outbreaks, highest observed incidences, and/or only incidence on symptoms on leaves/plants.
- Composition of EU grapevine varieties, esp. for table grapes (red/white, seed/seedless).
- Influence of climatic differences between reporting countries (e.g. India) and the EU, as well as possible adaptations of Xcv.
- Proportion of asymptomatic grapevine plants in the EU or duration of the asymptomatic period of infections.
- Influence of artificial inoculation on the infection rate.
- Effect of measures applied in the countries of origin as well as treatments already applied in the EU.
- Frequency of existing spread mechanisms including pest pressure from natural environments in the EU.

Reasoning for a scenario which would lead to a reasonable high proportion	The judgement on the upper limit considers - High proportion of red and seedless varieties in the EU. - Less importance of climatic differences or adaptation of Xcv to EU climates. - High proportion of asymptomatic infected plants (not reported with the incidence of symptoms). - Infection level of artificial inoculation is similar to the stable infection level after long term presence of Xcv. - Specific measures at the county of origin lower the prevalence, while treatments non-specific to Xcv in the EU are less effective. - High pest pressure from the environment with effective spread into the vineyards.
Reasoning for a scenario which would lead to a reasonable low proportion	The judgement on the lower limit considers - High proportion of white varieties with seeds is grown in the EU. - Tropical climate with high humidity promotes infections, thus EU climate is less suitable. - Short symptomless period of infections. - Artificial inoculation overestimates the incidence under natural conditions. - Ineffective measures at origin countries, while EU vinicultural practices are effective, e.g. pruning. - Low pest pressure from the environment with slow spread into the vineyards.
Fair estimate as judgement on the weighted evidence	The judgement on the median considers That the EU situation is less favourable for infections, due to different climatic and vinicultural conditions.
Precision of the judgement as description of remaining uncertainties	The judgement on the interquartile range considers The uncertainty below the median is high and above the median is as well high due to missing specific information on the behaviour of Xcv under EU conditions.

Pest risk assessment of *Xanthomonas citri pv. viticola*

Table C.4: Yield loss on vine grapes

Overview of the results of the Expert Knowledge Elicitation (4th EKE question)

Parameter		Incidence in vine grape plants												
Stratification		Grapevine production areas in the EU with average yearly temperature above 17°C as average of the coming 30 years												
Question		What is the average **percentage of infected plants** by *Xanthomonas citri* pv. *viticola* in **vine grape production sites** as **yearly average of a 30-year production cycle** in the risk area? [%]												

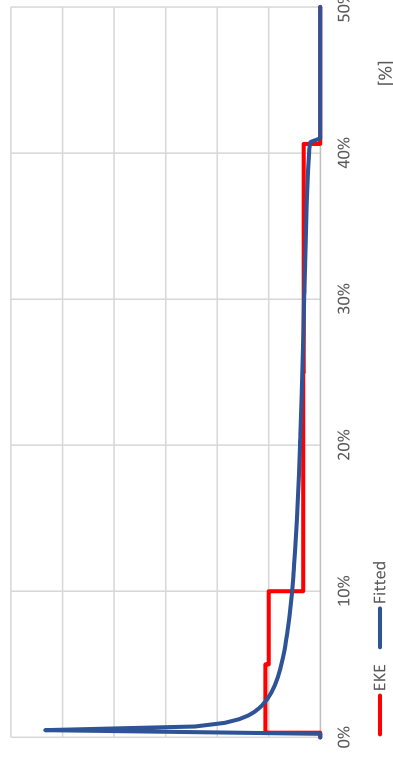| Results	P1%	P2.5%	**P5%**	P10%	P16.7%	P25%	P33.3%	**P50%**	P66.7%	P75%	P83.3%	P90%	**P95%**	P97.5%	P99%
Elicited values	0.50%		5.00%					10.0%		25.0%					40.0%
EKE results	0.50%	0.56%	0.71%	1.23%	2.25%	3.99%	6.2%	12.0%	19.4%	23.8%	28.7%	33.1%	36.7%	38.7%	40.0%
Fitted distribution	BetaGeneral(0.59122,1.0967,0.00485,0.41)														

Incidence in vine grape plants

Figure (C.4a): Comparison of elicited and fitted values/density function to describe the remaining uncertainties of the parameter
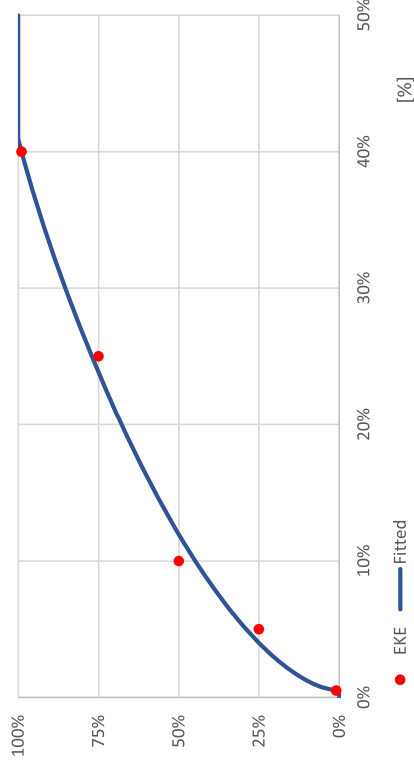

Figure (C.4b): Cumulative distribution function (CDF) of the likelihood of the parameter

Summary of the evidence used for the evaluation

- The assessment was done in comparison to the level of infection on table grape production sites, using the same evidence.
- The influences of the differences between the two productive systems (for table grapes vs wine production) on the infection rate were discussedesp. the influence of the higher frequency of pruning activity, the absence of covers, the different use of irrigation (vineyards are frequently rainfed) and mechanisation, the use of varieties that could be more tolerant to the pathogen, the different harvesting period.
- References suggest differences between rootstock varieties, rootstock vs. main plants, and white/red grapevine varieties.
- Grapevine varieties used in EU wine production systems.
- Differences in the production cycles (pruning, winter period) between the EU and countries of origin, i.e. India, Brazil.
- Some reference report natural incidence: Lima et al., 2000; Melo et al., 2000; Rodrigues Neto et al., 2011.

Main uncertainties

- References may report new outbreaks, highest observed incidences and/or only incidence on symptoms on leaves/plants.
- Composition and susceptibility of EU grapevine varieties in wine production systems.
- Influence of climatic differences between reporting countries (e.g. India) and the EU, as well as possible adaptations of Xcv.
- Proportion of asymptomatic grapevine plants in the EU or duration of the asymptomatic period of infections.
- Influence of artificial inoculation on the infection rate.
- Effect of measures applied in the countries of origin as well as treatments already applied in the EU.
- Frequency of existing spread mechanisms including pest pressure from natural environments in the EU.

Reasoning for a scenario which would lead to a reasonable high proportion

The judgement on the upper limit considers that

- Grapevine varieties used in wine production systems (with seeds) are susceptible.
- Higher proportion of mechanisation in grapevine for wine production systems.
- Stronger pruning, no protection in grapevine for wine production systems.

(The remaining scenario of table grapes remains unchanged)

- Less importance of climatic differences or adaptation of Xcv to EU climates.
- High proportion of asymptomatic infected plants (not reported with the incidence of symptoms).
- Infection level of artificial inoculation is similar to the stable infection level after long-term presence of Xcv.
- Specific measures at the country of origin lower the prevalence, while treatments non-specific to Xcv in the EU are less effective.
- High pest pressure from the environment with effective spread into the vineyards.

Reasoning for a scenario which would lead to a reasonable low proportion	The judgement on the lower limit considers that • Grapevine varieties used in wine production systems (with seeds) are less susceptible. • Less/no irrigation in grapevine for wine production systems. • Shorter vegetation period in grapevine for wine production systems. (The remaining scenario of table grapes remains unchanged) • Tropical climate with high humidity promotes infections, thus EU climates are less suitable. • Short symptomless period of infections. • Artificial inoculation overestimates the incidence under natural conditions. • Ineffective measures at origin countries, while EU vinicultural practices are effective, e.g. pruning. • Low pest pressure from the environment with slow spread into the vineyards.
Fair estimate as judgement on the weighted evidence	The judgement on the median considers that • Varieties for wine production seem in general less susceptible than table grapes. • That the EU situation is less favourable for infections, due to different climatic and vinicultural conditions.
Precision of the judgement as description of remaining uncertainties	The judgement on the interquartile range considers that • The uncertainty below the median is high and above the median is as well high due to missing specific information on the behaviour of Xcv under EU conditions.