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Grapevine flavescence dorée phytoplasma

Pest Report to support the ranking of EU candidate priority pests

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Abstract

In 2022, EFSA was mandated by the European Commission's Directorate-General for Health and Food Safety (M-2022-00070) to provide technical assistance on the list of Union quarantine pests qualifying as priority pests, as specified in Article 6(2) of Regulation (EU) 2016/2031 on protective measures against plant pests. As part of Task C, EFSA conducted expert knowledge elicitations for candidate priority pests, focusing on the lag period, expansion rate and the impact on production (yield and quality losses) and the environment. This report provides the rationale for the dataset on grapevine flavescence dorée phytoplasma, delivered to the European Commission's Joint Research Centre, to feed into the Impact Indicator for Priority Pests (I2P2) model and complete the pest prioritisation ranking exercise.

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Keywords: Grapevine flavescence dorée phytoplasma, lag period, spread, impact, EU quarantine pests, pest prioritisation

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1 Introduction

In 2022, EFSA was mandated by the European Commission's Directorate-General for Health and Food Safety to provide technical assistance in identifying Union quarantine pests that qualify as priority pests, as per Article 6(2) of Regulation (EU) 2016/2031¹ on protective measures against plant pests.

Under this mandate (M-2022-00070), EFSA published two technical reports in December 2023 covering Tasks A and B: (i) analysing potential hosts of Union quarantine pests and (ii) supporting the short-listing of candidate priority pests based on their spread and impact potential (EFSA et al., 2023a,b).

For Task C, EFSA was requested to conduct full expert knowledge elicitations (EKEs) on candidate priority pests pre-selected by the European Commission and Member States based on the outcome of Task B. The EFSA data provided under Task C feed into the Joint Research Centre's Impact Indicator for Priority Pests (I2P2) model to support the ranking of these candidate priority pests as a potential revision of Regulation (EU) 2019/1702² (European Commission et al., 2019).

This technical report on grapevine flavescence dorée phytoplasma is one of the pest reports prepared by EFSA's Working Group on Priority Pests under Task C. This assessment follows the methodology outlined in EFSA's methodology report (EFSA et al., 2025).

The report is structured as follows:

- Section 1: Provides the framework of this ongoing work.
- Section 2: Summarises relevant information on grapevine flavescence dorée phytoplasma, covering its biology and taxonomy, host range (including hosts selected for the EKE on impact), potential distribution within the EU and available pest control options.
- Section 3: Describes the estimation process and results of the assessment of the lag period and rate of expansion. Each assessment is supported by general and specific assumptions, a description of the parameters for estimation, definitions of the questions, a review of the evidence and an analysis of the uncertainties. The results for each quantile are supported by the rationale provided by the experts and are presented in tables and graphs to illustrate uncertainty, along with a concise conclusion.
- Section 4: Describes the process and results of the assessment of yield and quality losses, with the same approach applied as for the lag period and rate of expansion (Section 3).
- Section 5: Provides the results on the selected environmental impact indicator.
- Section 6: Summarises the main conclusions from the other parts of the report.
- Appendices: Appendix A provides a comprehensive list of hosts compiled from the European and Mediterranean Plant Protection Organization (EPPO) Global Database (EPPO, 2025), the Centre for Agriculture and Bioscience International (CABI) Compendium (CABI, 2025), and further evidence, if any. Appendix B summarises the sources of evidence collected from the literature and provided to the experts in support of the EKE.

¹ Regulation (EU) 2016/2031 of the European Parliament of the Council of 26 October 2016 on protective measures against pests of plants, amending Regulations (EU) No 228/2013, (EU) No 652/2014 and (EU) No 1143/2014 of the European Parliament and of the Council and repealing Council Directives 69/464/EEC, 74/647/EEC, 93/85/EEC, 98/57/EC, 2000/29/EC, 2006/91/EC and 2007/33/EC. OJ L 317, 23.11.2016, p. 4–104.

² Commission Delegated Regulation (EU) 2019/1702 of 1 August 2019 supplementing Regulation (EU) 2016/2031 of the European Parliament and of the Council by establishing the list of priority pests. OJ L 260, 11.10.2019, p. 8–10.



Priority pests – Grapevine flavescence dorée phytoplasma

This report reflects the information available up to the date of the final meeting of EFSA's Working Group on Priority Pests tasked with assessing this pest³.

Key references include various EFSA outputs (EFSA et al., 2019, 2020; EFSA PLH Panel, 2014; EFSA PLH Panel et al., 2016), as well as the CABI (2024) and EPPO (2022) datasheets on grapevine flavescence dorée phytoplasma.

³ The minutes of the Working Group on EU Priority Pests are available online: <https://www.efsa.europa.eu/sites/default/files/2022-11/wq-plh-priority-pests.pdf>

2 Biology, ecology and distribution of the pest

2.1 Summary of the biology and taxonomy

Grapevine flavescence dorée phytoplasma (FDp) belongs to the genus '*Candidatus* Phytoplasma', which includes pleiomorphic, non-culturable bacteria that lack a cell wall (EPPO, 2022; IRPCM Phytoplasma/Spiroplasma, 2004). The species name has not yet been defined in accordance with the requirements proposed by the Subcommittee on the Taxonomy of Mollicutes (Malembic-Maher et al., 2011). Nevertheless, FDp is considered a sufficiently well-defined organism for regulatory purposes (EFSA PLH Panel, 2014). FDp *sensu stricto* refers to strains belonging to subgroups 16SrV-C and 16SrV-D, which are transmissible from vine to vine by the Deltocephalinae leafhopper *Scaphoideus titanus* Ball (Caudwell, 1990; Martini et al., 1999).

FDp is one of the causal agents of grapevine yellows diseases and is specifically responsible for flavescence dorée, first reported in the vine growing area of Armagnac in southwestern France (Caudwell, 1957; Caudwell et al., 1971). Symptoms may affect the branches and include stunted growth or absent bud break, yellowing or reddening and downward curling of the leaves, drying and death of inflorescences and berries, a lack of lignification, black spots on new canes and premature leaf fall. The impact ranges from total yield loss to reduced grape quality. Recovered plants typically no longer contain detectable levels of FDp, but they may remain less productive (Morone et al., 2007).

FDp is a phloem-obligate parasite that is vector-transmitted, surviving during winter in roots and canes and moving to the upper part of the plant during spring (EPPO, 2022). *Scaphoideus titanus* Ball (Cicadellidae, Deltocephalinae) is an ampelophagous (mainly feeding on *Vitis* sp. in Europe) univoltine leafhopper and the only known vector of FDp able to transmit the pathogen from one grapevine to another (EFSA et al., 2020). *S. titanus* is a well-defined taxonomic entity and requires grapevine for oviposition and completion of the life cycle. This insect overwinters in the dormant egg stage, and cold winters enhance the precocity and synchrony of egg hatching, which typically begins in May (Chuche and Thiéry, 2009). The first adults appear from late June to July (Gonella et al., 2024). The females lay eggs from August to October in the exoriated bark of woody vines, where they overwinter. Notably, host plants must be at least two years old for the bark to be suitable for egg deposition (Bagnoli and Gargani, 2011; Bocca et al., 2020). Both nymphs and adults can transmit FDp to grapevines (Arricau-Bouvery et al., 2021; Galetto et al., 2014). *S. titanus* remains infectious for life, including through moulting, and can transmit the pathogen to plants during feeding from early June to late September (EFSA PLH Panel, 2014). The earlier a nymph acquires FDp, the longer its potential period for disease transmission. Males are more efficient at spreading FDp (Chuche and Thiéry, 2014).

Other leafhoppers and planthoppers, such as *Orientus ishidae*, *Dictyophara europaea* and *Allygus* spp., have been shown to harbour or transmit FDp (Filippin et al., 2009; Lessio et al., 2016; Malembic-Maher et al., 2020; Trivellone et al., 2016). However, these species are polyphagous and not primarily associated with grapevines. They are more likely to contribute to phytoplasma spread in wild environments and only sporadically transmit FDp to cultivated grapevines. Notably, *O. ishidae* may transmit 16SrV phytoplasma genotypes (compatible with the FDp epidemiological cycle) from alders to grapevines, although this occurs at a low frequency (Kogej Zwitter et al., 2023; Malembic-Maher et al., 2020). In contrast, *S. titanus* is considered the principal vector of the disease, as it is strictly associated with *Vitis* spp. and is responsible for both primary transmission (from wild to cultivated vines) and secondary spread (in vineyards) (Ripamonti et al., 2020a). Other potential vector species are not a significant threat (EFSA PLH Panel, 2014). Transmission can also occur via grafting (Boudon-Padieu, 2002; Osler et al., 2002).

2.2 Host plants

2.2.1 List of hosts

According to CABI (2025) and EPPO (2025), *Vitis vinifera* (grapevine) is the main host plant of FDp and its vector, *Scaphoideus titanus*, in terms of pest preference and plant susceptibility.

Other *Vitis* species, such as *V. acerifolia*, *V. amurensis*, *V. berlandieri*, *V. coignetiae*, *V. labrusca*, *V. pentagona*, *V. riparia* and *V. rupestris*, as well as interspecific *Vitis* hybrids used as rootstocks, are also known to host FDp, although they generally remain symptomless upon infection (EPPO, 2022; Eveillard et al., 2016). Rootstock cultivars appear tolerant to the phytoplasma and act as symptomless carriers of FDp, which they can transmit to *Vitis vinifera* scions through grafting (Caudwell et al., 1994).

Other perennial hosts of FDp, such as *Ailanthus altissima*, *Alnus* spp. (alders), *Clematis vitalba* (clematis), *Corylus avellana* and *Salix* spp., are widespread across the EU (Angelini et al., 2004; CABI, 2024; Malembic-Maher et al., 2020; Radonjić et al., 2013). These plants are typically symptomless carriers, often showing a high incidence of FDp infection in alders and clematis (EFSA PLH Panel et al., 2016; Malembic-Maher et al., 2020). The risk transmission of FDp from alders and clematis to grapevine is considered low, and it cannot lead to an outbreak without the presence of *S. titanus*, the only known vector capable of vine-to-vine transmission (CABI, 2024).

A comprehensive list of hosts from CABI (2025) and EPPO (2025) is presented in Appendix A.

2.2.2 Considerations for the selection of hosts

Eveillard et al. (2016) observed differences in the level of susceptibility among 28 *V. vinifera* cultivars, rootstocks and *Vitis* species, classifying them into three groups: (1) high FDp titres with many infected plants, (2) intermediate titres with many infected plants, and (3) intermediate to low titres with few infected plants. Nineteen *Vitis* species and rootstocks fell across these categories, showing that even wild rootstocks can be significantly infected by FDp in nature. Transmission efficiency and FDp titres may depend on distinct plant traits, with titres correlating with symptom severity only in *V. vinifera*. In contrast, rootstocks can carry high FDp titres without symptoms and are considered tolerant. Using a similar approach, Ripamonti et al. (2021) grouped 14 *V. vinifera* accessions (from 12 cultivars) into three FDp susceptibility clusters. For four cultivars, spanning the susceptibility range, they confirmed that scion genotype determines disease susceptibility.

Grapevine is of major economic importance in the EU, contributing significantly to the agricultural sector and rural economies. In 2020, vineyards in the EU covered 3.2 million hectares, being approximately 45% of the world's total wine-growing area (Eurostat, 2022). The EU counted 2.2 million vineyard holdings for wine that year, and 83.3% had less than 1 ha of vines. Spain, France and Italy together accounted for 75% of the EU's vineyard area and about 39% of its vineyard holdings in 2020.

2.2.3 Hosts selected for the impact assessment

Taking into account the points outlined above and the evidence presented in Appendix B (Table B.1), the impact of FDp will be assessed for wine and table grape production (*Vitis vinifera*).

2.3 Area of potential distribution

2.3.1 Area of current distribution

Figure 1 presents an overview of the current distribution of FDp, which is restricted to Europe. The phytoplasma has been reported in 11 grape-growing EU countries (Austria, Croatia, Czechia*, France, Hungary, Italy, Portugal, Romania*, Slovakia*, Slovenia and Spain) as well as in Montenegro*, Serbia and Switzerland. Since 2019, four of those (marked with *) have newly reported the presence of FDp, which is still spreading.

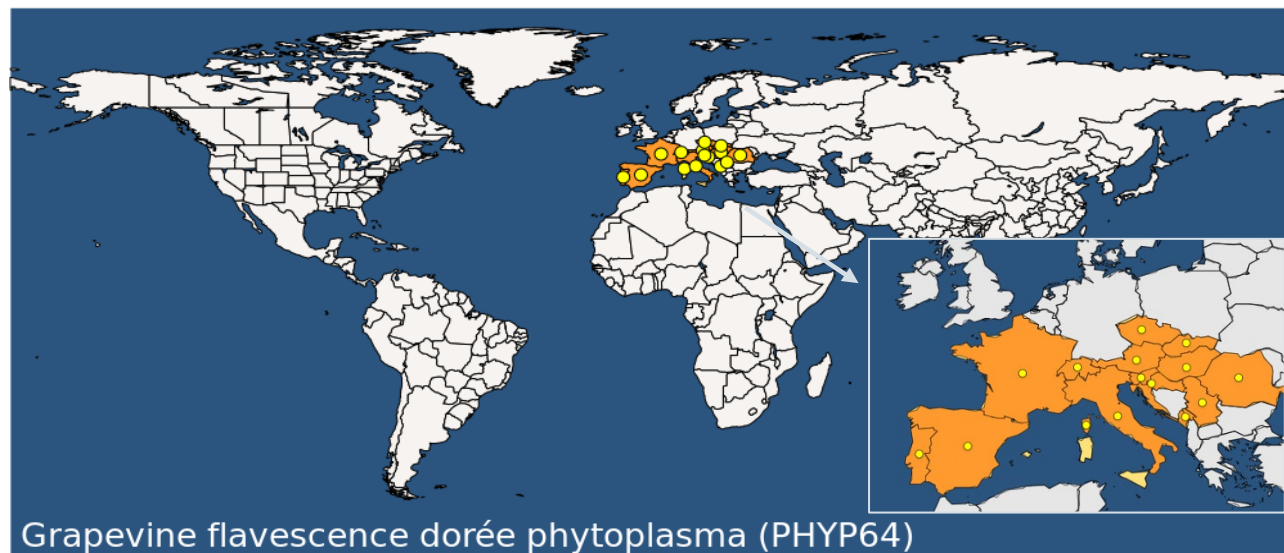


Figure 1: Distribution map of Flavescence dorée phytoplasma (FDp) from EPPO (2025), as of 31 January 2025. The distribution is at the country level, with points representing the centroids of country polygons.

Figure 2 shows the current distribution of the North American leafhopper *Scaphoideus titanus*, the FDp vector introduced to the EU in the 1950s (EFSA et al., 2020).

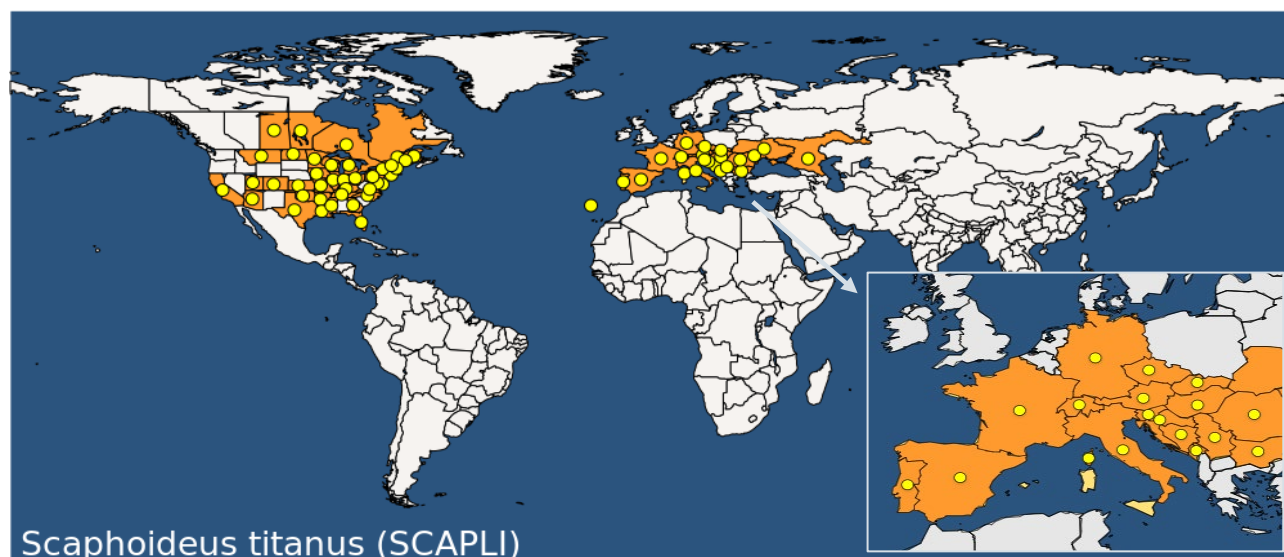


Figure 2: Distribution map of *Scaphoideus titanus* from EPPO (2025), as of 3 February 2025. The distribution is at the country level, with points representing the centroids of country polygons.

S. titanus has spread to 13 EU Member States: Austria, Bulgaria, Croatia, Czechia, France, Germany, Hungary, Italy, Portugal, Romania, Slovakia, Slovenia and Spain, and to six non-EU countries in Europe (EPPO, 2025; Gjinovci et al., 2022; Gnezdilov and Orlov, 2022). Its distribution exceeds that of FDp.

2.3.2 Area of potential establishment

Experts confirm the conclusion of EFSA et al. (2019) that the area of potential establishment of FDp corresponds to the regions of grapevine production (wine and table grapes) in the EU, and that the phytoplasma is able to infect grapevine wherever it is cultivated. Furthermore, climate modelling indicates that the vector *S. titanus* can establish itself throughout the EU wherever grapevine is grown, including southern Spain, where some locations may be too hot and dry for survival during the summer months without irrigation. More specifically, the CLIMEX model showed that the establishment potential of *S. titanus* exceeds the current grapevine-growing areas in Europe (EFSA PLH Panel et al., 2016). In northern Europe, its potential distribution may thus be constrained more by the absence of host plants than by climatic conditions. In conclusion, the distribution of *V. vinifera* is probably the main factor limiting the range of *S. titanus*.

Grapevine can survive in arid environments with less than 200 mm of annual rainfall and withstand winter temperatures below -20°C (Kovaleski et al., 2019). Moreover, climate change is making central and northern Europe more suitable for grape cultivation, which may also facilitate the spread of grapevine pests and diseases (EFSA PLH Panel et al., 2016).

2.3.3 Seasonal occurrence outside the area of potential establishment

Neither FDp nor its vector are expected to form seasonal populations in the EU (EFSA et al., 2019).

2.3.4 Conclusion on the area of potential distribution

The area of potential distribution of FDp corresponds to the regions of grapevine production (wine and table grapes) in the EU, as the phytoplasma can persist wherever the crop is cultivated. Moreover, climate modelling indicates that the vector *S. titanus* can establish itself throughout the EU wherever grapevine is grown.

2.4 Pest control in the EU

Commission Implementing Regulation (EU) 2022/1630⁴ established measures for the containment of FDp with:

- the establishment of demarcated areas for containment comprising an infected zone and a buffer zone of a width of at least 2.5 km surrounding the infected zone (Article 3);
- measures to be taken within that demarcated area, including destruction of the specified plants found to be infected and treatments to control the specified vector (Article 4);
- specific surveys, including (a) visual examination of the specified plants to detect the specified pest, (b) sampling and testing where the presence of the specified pest is suspected, and (c) appropriate trapping for the detection of the vector (Article 5).

Once a plant is infected with FDp, curative treatment is practically impossible. Therefore, control efforts in the EU focus on managing its vector, *S. titanus*. These measures include the use of plant protection products (PPPs) authorised at the national level to target *S. titanus* nymphs and adults in vineyards. Depending on the Member State, authorised PPPs may contain the following insecticide active substances approved in the EU⁵ (European Commission, 2025):

- For conventional viticulture: acetamiprid, flupyradifurone, sulfoxaflor and pyrethroids such as cypermethrin, deltamethrin, esfenvalerate, etofenprox, lambda-cyhalothrin and tau-fluvalinate.
- For organic viticulture: azadirachtin, *Beauveria bassiana*, kaolin, potassium salts of fatty acids and pyrethrins (Prazaru et al., 2023; Tacoli et al., 2017).

Insecticide treatments are generally effective against the vector at young stages. According to Prazaru et al. (2023), efficacy trials conducted in four vineyards in northeastern Italy identified etofenprox and deltamethrin as the most effective conventional insecticides, while pyrethrins were the most effective of the organic options. In semi-field trials, most pyrethroids showed good residual activity, but their efficacy declined under field conditions. Organic insecticides exhibited limited residual effectiveness. These findings are discussed in the context of integrated pest management strategies for both conventional and organic viticulture.

Organic vineyards are expanding worldwide, accompanied by a strong trend toward certification. In 2020, there were 381,000 ha of certified organic vineyards in Europe, accounting for about 12% of the total vineyard area (3.2 million hectares) (Agrovin, online; Eurostat, 2022).

The control of the disease includes production of disease-free material for planting, and removal and destruction of infected plants. Hot water treatment of the propagation material is known to be effective in killing both FDp and vector eggs and is applied in the EU (Caudwell et al., 1997; EFSA PLH Panel et al., 2016; EPPO, 2012; Linder et al., 2010).

⁴ Commission implementing Regulation (EU) 2022/1630 of 21 September 2022 establishing measures for the containment of Grapevine flavescence dorée phytoplasma within certain demarcated areas, OJ L 245/27, 22.09.2022. Annex I 'Lists of demarcated areas for containment' is regularly updated (see Regulation (EU) 2025/358).

⁵ The status of the pesticide active substances listed below may change (i.e. approved or not approved in the EU). Please consult the EU Pesticides Database (European Commission, 2025) for the most up-to-date information.

3 Estimation of the lag period and rate of expansion

3.1 Structured expert judgement

3.1.1 General scenario assumptions

The general scenario assumptions for assessing all candidate priority pests are outlined in EFSA's methodology report (EFSA et al., 2025).

3.1.2 Specific scenario assumptions

- The lag period and rate of expansion are estimated across the potential distribution area of FDp (see Section 2.3) where the vector is present.
- As FDp is already established in many EU countries, current control measures (see Section 2.4) are considered in this scenario.
- The scenario accounts for the diversity of agro-climatic conditions across the EU. It includes organic viticulture, which currently accounts for approximately 12% of the total grapevine area and is expected to continue expanding in both surface and production volume (Agrovin, online; European Commission, 2023a,b; Eurostat, 2022).
- The assessment covers all EU agricultural practices (including FDp control management) and all *V. vinifera* cultivars, from less to highly susceptible.
- The scenario assumes that FDp and its vector are present only locally within the potential distribution area; for example, a few adult vectors on an infected plant.

Lag period

The lag period refers to the time between the introduction of the pest and the start of its exponential spread. For FDp, experts identify two key stages within this period:

- 1 initial infection of a plant by FDp and increase in phytoplasma load;
- 2 acquisition by the vector and transmission of FDp to other plants, leading to an exponential increase in infections.

Rate of expansion

- The spread of the disease is driven by the dispersal of infected vectors. FDp is not known to be transmissible by mechanical inoculation (CABI, 2024).
- For long-distance spread, only natural dispersal is considered here, in line with the general scenario assumptions. Long-distance human-assisted spread, such as through the trade of harvested products or plants for planting, is excluded. The scenario only accounts for agricultural practices within or between adjacent fields, including farmer movements and operations like planting. The hitchhiking component of vector dispersal is considered only in relation to short-distance spread via these local farming activities, as natural spread is the main scope of this assessment.
- Infected vines that remain in a vineyard will serve as a source of infection and will increase the percentage of infested vectors in the population and thereby increase the risk of planting material being infected (EFSA PLH Panel et al., 2016).

3.1.3 Parameters to estimate

- The lag period is expressed in months.
- The rate of expansion is expressed in metres per year (m/year).

3.1.4 Defined questions

What is the duration (months) of the lag phase for FDp under the scenario assumptions in the EU area under assessment, as defined in the Pest Report?

What is the rate of expansion (m/year) of FDp under the scenario assumptions in the EU area under assessment, as defined in the Pest Report?

3.1.5 Evidence selected

The experts reviewed the evidence from the literature (see Table B.2 in Appendix B), selecting key data and references, complemented by field observations, to support the EKE. A few general points were noted:

Lag period

1. Initial infection of a plant by FDp and increase in phytoplasma load:

- The pathogen is expected to be able to infect any *V. vinifera* cultivar across the EU. Climate and cultivar have an influence on *S. titanus* fitness and on FDp transmission and multiplication, and may influence the probability of initial infection.
- Both nymphs and adults of *S. titanus* can transmit FDp to grapevines (Alma et al., 2018; Arricau-Bouvery et al., 2021; Bressan et al., 2005b; Chuche and Thiéry, 2014; Galetto et al., 2014). Evidence suggests that transovarial (adult-to-egg) transmission of FDp is exceptional. For example, Bressan et al. (2005a) found no adult-to-egg transmission in 72 *S. titanus* nymphs individually tested for FDp presence using PCR.
- The concentration of phytoplasma in a plant will influence the lag period. These concentrations of FDp will depend on several factors including cultivar susceptibility (Galetto et al., 2016) and temperature: FDp grows faster at 25–26°C than at 20–22°C (EFSA PLH Panel, 2014; Galetto et al., 2011; Salar et al., 2013). Roggia et al. (2014) showed that a seasonal trend in FDp concentration (low in spring, high in early summer and intermediate in late summer) was consistent for two different cultivars in both years and vineyards.
- The phytoplasma multiplies in the plant the year after transmission by the vector. If grafted onto infected rootstocks, the phytoplasma's development can be slower (Boudon-Padiou 2002). The available evidence implies that FDp multiplication within grapevines occurs over a period of several months, depending on plant susceptibility, temperature and vector activity. Based on the literature, experts considered that the time required for the phytoplasma to multiply within a plant ranges from 7 to 12 months (Boudon-Padiou, 2002).
- Higher concentrations of FDp in the plant are associated with higher transmission rates (Galetto et al., 2014).

2. Acquisition by the vector and transmission of FDp to other plants

- Experts noted the univoltine cycle of *S. titanus* (i.e. one generation per year) and the existence of a dormancy phase (both for the plants and the eggs of the vector).
- Consistent with its North American origin, diapause termination, and thus egg hatch timing, requires cold winters, which promote earlier and more synchronised hatching, typically beginning in May (Chuche and Thiéry, 2009).
- Higher spring temperatures favour *S. titanus* development and phytoplasma multiplication (Rigamonti et al. 2011; Salar et al. 2013), while very high temperatures appear less favourable for the insect (Rigamonti et al. 2011).

- Acquisition by nymphs results in insects able to spread the disease over a long period. In contrast, acquisition by adults leads to a shorter transmission period, as adults have a limited lifespan (Galetto et al., 2014). However, the latency period differs between nymphs and adults: it lasts about 3 to 5 weeks in nymphs, whereas adults can infect plants within a few days (Alma et al., 2018).
- The lag period tends to be longer when vector populations are low, infection rates are reduced and/or control measures are effective.
- There is a temperature-dependent latency period of 3 to 6 weeks between the acquisition of the phytoplasma by *S. titanus* and the insect's ability to transmit it to another host plant (EFSA PLH Panel, 2014; Galetto et al., 2011; Schvester et al., 1961, 1969).
- At plot scale, Drakey et al. (2023) estimated a 3-year lag period without plant removal or insect control, assuming infection starts from a single infected plant at the plot centre.

Rate of expansion

- EFSA PLH Panel et al. (2016) concluded that:
 - The analysis of infection history suggests that vector-mediated spread may have contributed two thirds of the introductions of FDp into additional EU NUTS 2 regions. Disease propagation through infected planting material and dispersion via the insect vector from vineyards contributed an estimated 37% and 57% of cases, respectively, while local transmission from wild plants by alternative vectors accounted for 6% (EFSA PLH Panel et al., 2016).
 - Despite current EU control measures, the spread of FDp is expected to continue over the next decade, with an estimated expansion into up to approximately 20 additional EU NUTS 2 regions. This highlights the limitations of existing measures to effectively contain FDp spread.
- The role of intermediate host plants (e.g. border vegetation, wild grapevines) is considered fundamental by experts in assessing the rate of expansion (EFSA et al., 2020).
- FDp is not mechanically transmitted (e.g. via pruning tools) (Caudwell, 1957), though machines can move infected material (e.g. branches, leaves) between plots. Transmission through grafting is possible but with a very low efficiency (EFSA PLH Panel, 2014; Osler et al., 2002).
- Under low wind conditions in a field study in northern Italy, Lessio and Alma (2004a) found that *S. titanus* rarely dispersed beyond a 24 m radius outside the vineyard, suggesting that vineyards isolated from nearby sources are unlikely to be colonised by this leafhopper. Another field study in Italy showed that 80% of *S. titanus* individuals dispersed over short distances of up to 30 m (Lessio et al., 2014), although occasional long-distance dispersal events of up to 330 m were also observed. Similarly, in the study by Mori et al. (2014), most adults were captured within 40–50 m of the untreated vineyard, with a few individuals found as far as 80–100 m away.
- In Austria, Strauss et al. (2014) showed that *S. titanus* adults spread over a distance of at least 75 m. On average, 4% of a given population migrated with a high population density.
- In France, Drakey et al. (2023) modelled the epidemiological dynamics of FDp, including the spread of the disease from infected plants in Bordeaux vineyards. Mean dispersal values ranged from 10 to 15 m depending on the mode. On average, 50%, 80% and 95% of the new infections occurred within 10.5, 22 and 55 m of the source, respectively.
- In North America, Beanland et al. (2006) found that *S. titanus* is unlikely to travel more than 40 m from alternative host plants to reach vineyards. Traps at 30 m from the edge of the vineyard and 40 m from the forest edge rarely captured any individual.

- To estimate the lowest spread rate, experts will consider Maggi et al. (2017) reporting 90% of occurrences within 3 m.
- Vector spread is facilitated by wind, and under windy conditions, dispersal can extend over several kilometres as shown in several studies:
 - During an FDp outbreak in France in 2012–2013, experts reported significant disease spread (up to approximately 4 km per year) from the Drôme to Vaucluse departments, likely due to passive dispersal of the vector by strong mistral winds (Alice Dubois and Brigitte Barthelet, personal communication to the expert group, 16 November 2023).
 - Torres et al. (2003) suggested that the Tramontana wind (a dry, cool northerly wind in the Mediterranean) facilitated the spread of *S. titanus* from infested areas to healthy plots. Similarly, Steffek et al. (2007) and Zeisner (2008) hypothesised that passive dispersal by wind could explain the spread of the vector from Slovenia to Austria.
 - In a 10-year field survey in central-eastern Italy, *S. titanus* individuals dispersed up to 600 m from the scion mother plant nursery where they were first recorded, aided by favourable winds and the absence of natural barriers such as hedges or woods.

3.1.6 Uncertainties identified

- There is a lack of knowledge regarding the susceptibility levels of the numerous *V. vinifera* cultivars grown in the EU (thousands are listed in the official catalogue).
- Agricultural practices, the distribution of grapevine cultivars and their associated susceptibility, as well as climatic conditions, may change rapidly.
- A threshold value for the vector population density required to initiate acquisition during the lag period is currently lacking.

3.2 Elicited values of the lag period

What is the duration (months) of the lag phase within the scenario defined for the assessment? The five elicited values agreed upon by the expert group are given in Table 1.

Table 1: The five elicited values of the lag period (months).

Percentile	1	25	50	75	99
Elicited values	8	32	44	60	110

3.2.1 Justification for the elicited values of the lag period

This assessment is supported by the evidence presented in Section 3.1.5.

Rationale for a scenario which would lead to a long lag period (99th percentile)

This scenario assumes unfavourable agro-climatic conditions for the development of the FDp vector and/or multiplication of the phytoplasma, such as very high temperatures less favourable for *S. titanus* development (Rigamonti et al. 2011). Additionally, it assumes effective agricultural practices, including strong control of *S. titanus* by farmers, strict compliance with regulatory management measures, and a lower proportion of susceptible grapevine cultivars. Under these combined conditions, the vector population is expected to remain at a low density for several years before significant FDp spread can occur. This scenario may also apply to fields where FDp is not yet present, resulting in an extended acquisition phase before transmission begins.

Rationale for a scenario which would lead to a short lag period (first percentile)

This scenario assumes favourable agro-climatic conditions for vector development and FDp multiplication, including cold winters, warm springs and moderate summer temperatures. Additionally, it assumes a lack of control of *S. titanus* by farmers, poor compliance with regulatory management measures and the use of susceptible cultivars. The vector population can rapidly increase, leading to a short lag period before significant FDp spread occurs. This scenario applies to fields where FDp is already present, facilitating a quicker transition from acquisition to transmission. Experts considered the winter period during which the phytoplasma might not multiply. FDp symptoms were observed on plots during one single year but this could be due to infected nurseries rather than field transmission. Roggia et al. (2014) found FDp levels peak in early summer, coinciding with vector emergence.

Rationale for a central scenario equally likely to over- or underestimate the lag period (50th percentile/median)

The estimated median represents average EU agro-climatic conditions for FDp and vector development. This scenario assumes most cultivars are moderately to highly susceptible. Despite generally good pest management, some areas and farms face challenges in achieving effective control.

Rationale for the precision of the judgement describing the remaining uncertainties (first and third quartiles/interquartile range)

The median is considered quite realistic by the experts and therefore the uncertainty is relatively low.

3.2.2 Estimation of the probability distribution of the lag period

The comparison between the fitted values of the probability distribution and the values agreed by the group of experts is given in Table 2.

Table 2: Fitted values of the probability distribution of the lag period (months).

Percentile	1	2.5	5	10	17	25	33	50	67	75	83	90	95	97.5	99
Elicited values	8					32		44		60					110
Fitted distribution	12	15	18	23	27	32	36	44	54	60	67	76	88	98	111

Fitted distribution: Gamma(4.8719,9.7501), @RISK8.6. The values highlighted in green represent the elicited values, while those highlighted in orange are the fitted values reported in the conclusion.

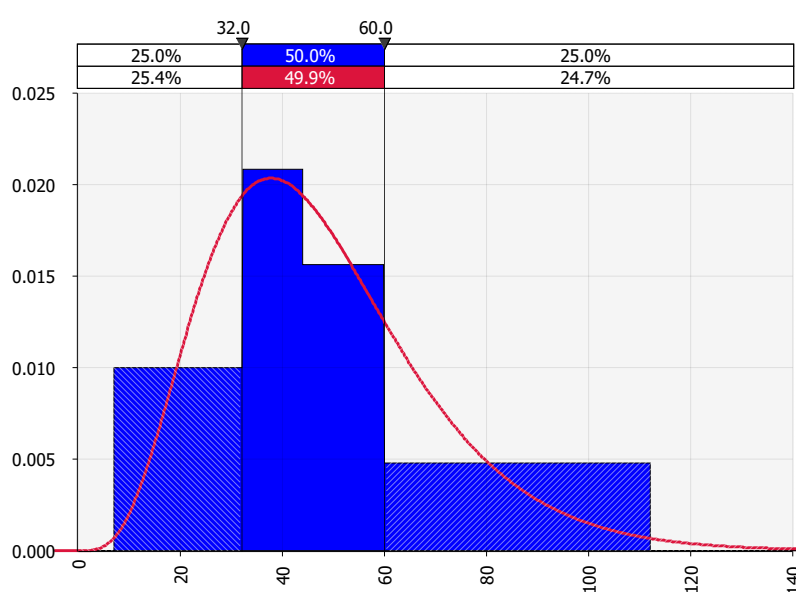


Figure 3: Comparison of elicited values (histogram in blue) and fitted distribution (red line) of the lag period. Values are given in Table 2.

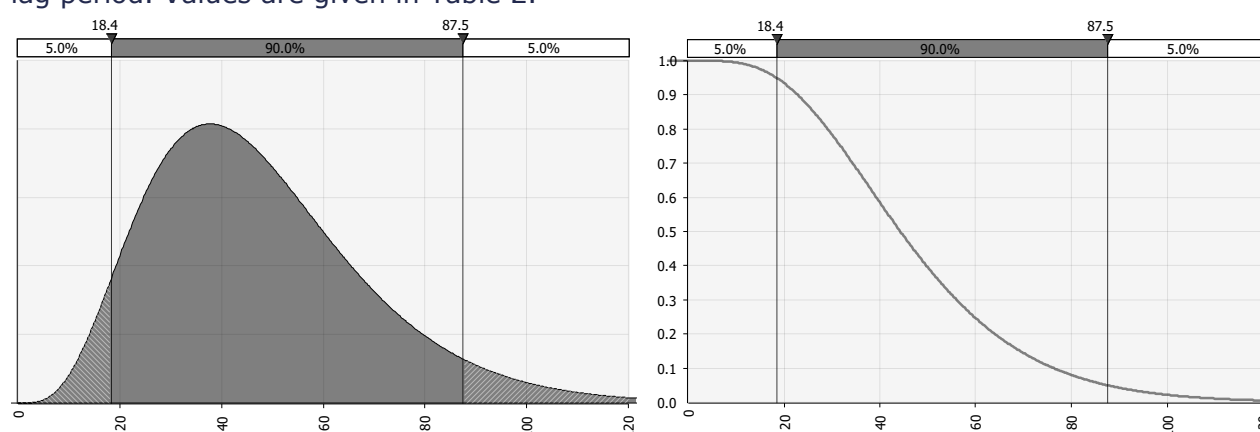


Figure 4: Fitted density function describing the uncertainties with a 90% uncertainty interval (left) and fitted descending distribution function showing the probability (y-axis) that a given lag period (x-axis) may be exceeded (right).

3.3 Elicited values of the rate of expansion

What is the rate of expansion (metres/year) within the scenario defined for the assessment?

The five elicited values agreed upon by the expert group are given in Table 3.

Table 3: The five elicited values of the rate of expansion (metres/year).

Percentile	1	25	50	75	99
Elicited values	3	25	40	250	1000

3.3.1 Justification for the elicited values of the rate of expansion

This assessment is supported by the evidence presented in Section 3.1.5.

Rationale for a scenario which would lead to a high rate of expansion (99th percentile)

This worst-case scenario assumes optimal conditions for the spread of *S. titanus*, such as passive dispersal driven by strong winds without topographical barriers, low effectiveness of pest control measures, a high proportion of susceptible cultivars, and/or dense vector populations. Corridors of host plants connecting different agricultural areas are also present. The scenario includes the possibility of human-assisted dispersal (e.g. via infected planting material or local hitchhiking of the vector) within a field or between adjacent fields. Three references presume passive wind-driven dispersal of the vector with high spread values.

Rationale for a scenario which would lead to a low rate of expansion (first percentile)

This low-risk scenario reflects less favourable conditions for vector spread, such as the absence or low intensity of winds, effective pest control and compliance with regulatory measures that maintain low vector populations and a lower proportion of susceptible cultivars.

Rationale for a central scenario equally likely to over- or underestimate the rate of expansion (50th percentile/median)

The estimated median value is derived from studies conducted in various EU countries (e.g. Drakey et al., 2023). Experts noted that under low to moderate wind conditions, the dispersal of *S. titanus* tends to remain limited, typically confined to short distances from the source vineyard. Most values reported in the literature range from 30 to 50 m and reflect average EU climatic conditions. In addition, a high proportion of large vineyards and farms across the EU implement effective pest control measures, which further limit active dispersal within plots.

Rationale for the precision of the judgement describing the remaining uncertainties (first and third quartile/interquartile range)

The possibility of values being close to the median is considered high, and the possibility that the vector moves over distances of several hundred metres is well supported.

3.3.2 Estimation of the probability distribution of the rate of expansion

The comparison between the fitted values of the probability distribution and the values agreed by the group of experts is given in Table 4.

Table 4: Fitted values of the probability distribution of the rate of expansion (metres/year).

Percentile	1	2.5	5	10	17	25	33	50	67	75	83	90	95	97.5	99
Elicited values	3					25		40		250					1000
Fitted distribution	1	2	4	7	11	19	28	58	121	183	301	511	946	1612	2,997

Fitted distribution: Lognorm(244.79,995.42), @RISK8.6. The values highlighted in green represent the elicited values, while those highlighted in orange are the fitted values reported in the conclusion.

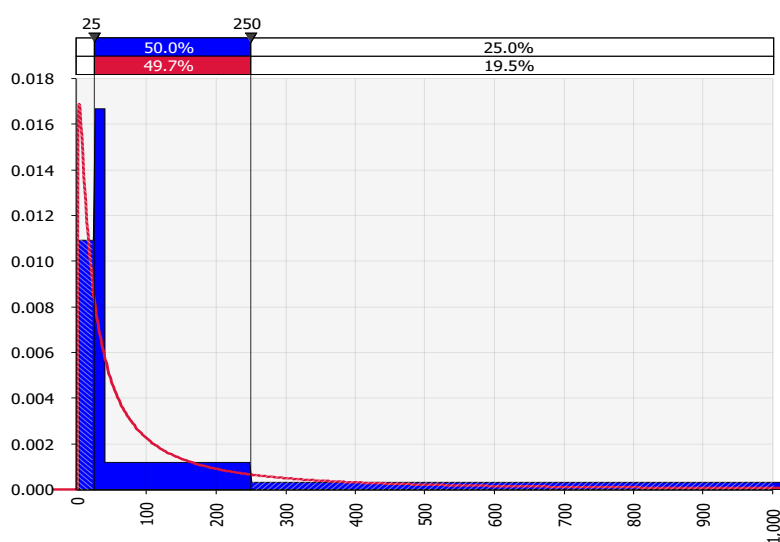


Figure 5: Comparison of elicited values (histogram in blue) and fitted distribution (red line) of the rate of expansion. Values are given in Table 4.

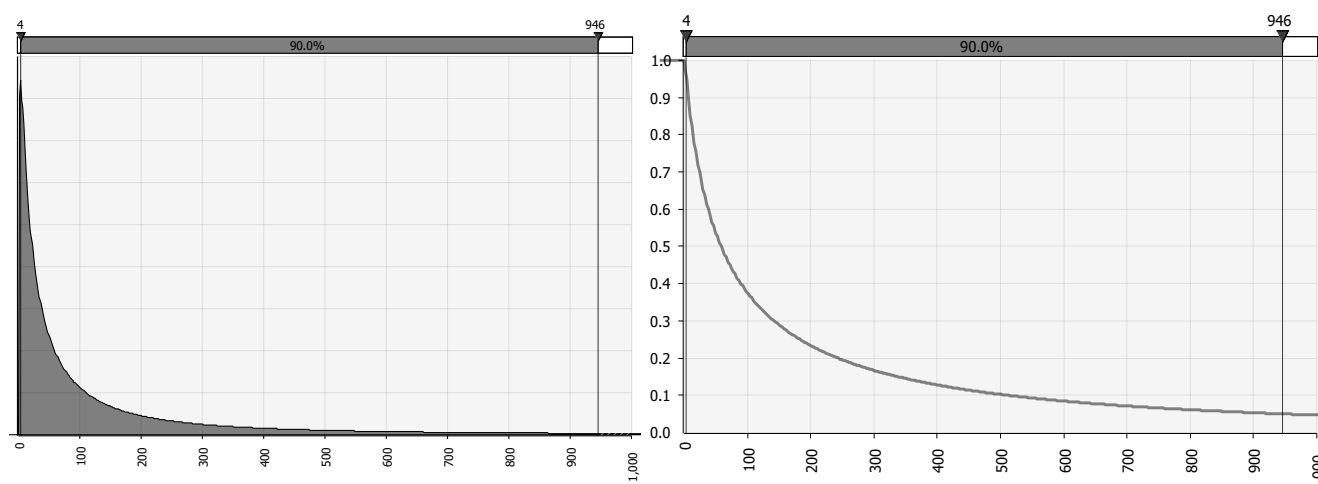


Figure 6: Fitted density function describing the uncertainties with a 90% uncertainty interval (left) and fitted descending distribution function showing the probability (y-axis) that a given rate of expansion (x-axis) may be exceeded (right).

4 Estimation of the yield and quality losses

4.1 Structured expert judgement

4.1.1 General scenario assumptions

The general scenario assumptions for assessing all candidate priority pests are outlined in EFSA's methodology report (EFSA et al., 2025).

4.1.2 Specific scenario assumptions

- The impact is assessed across the potential distribution area of FDp (see Section 2.3), where the pest and its vector *S. titanus* are assumed to be widely present, according to the general scenario assumptions.
- As FDp is already present in many EU countries, current control measures (see Section 2.4) are considered in this scenario.
- The scenario accounts for the diversity of agro-climatic conditions across the EU. It includes organic viticulture, which accounts for approximately 12% of the total grapevine area and is expected to continue expanding (Agrovin, online; European Commission, 2023a,b; Eurostat, 2022).
- The assessment covers all agricultural practices and all *V. vinifera* cultivars, from less to highly susceptible.
- The impact on nurseries is not considered in this scenario.
- The estimated damage is assumed to be the same for both wine and table grapes.
- Plant replacement is considered a part of standard agricultural practices.

4.1.3 Parameter to estimate

The impact of FDp is estimated as the percentage of yield loss in wine and table grape production assessed together, considering the entire production period of the vineyards. Quality losses are included in this estimate but are considered minor compared to the direct quantitative impact on yield, as noted by EFSA PLH Panel et al. (2016).

4.1.4 Defined questions

What is the estimated percentage yield loss in wine and table grape (*V. vinifera*) production, under the scenario assumptions for the EU area under assessment, as defined in Section 2.3?

4.1.5 Evidence selected

The experts reviewed the evidence gathered from the literature (see Table B.1 in Appendix B), selecting key data and references to support the EKE. This was supplemented with additional information from direct observations and expert experience. A few general points were raised:

- The lifespan of a vineyard typically ranges from 25 to 35 years, depending on factors such as grapevine cultivar and rootstock, climate, soil conditions, disease pressure and vineyard management practices. Vineyards generally do not begin commercial production before 3–5 years after planting.
- Control measures typically include the removal of abandoned plots, wild *Vitis* spp., and cultivated vineyards when infection levels exceed 20% (EFSA PLH Panel et al., 2016).

- Infected plants may survive for up to 3 years or more before dying, although a significant decline or cessation in production is observed during this period. Recovered plants may remain less productive than healthy ones (Maggi et al., 2017; Morone et al., 2007).
- Host susceptibility is expected to vary with grapevine age and cultivar. No grapevine cultivars are resistant to FDp. Instead, they exhibit a continuum of susceptibility to FDp, ranging from low (e.g. Merlot, Nebbiolo) to high susceptibility (e.g. Barbera, Cabernet Sauvignon, Chardonnay, Grenache, Muscadelle, Sangiovese, Sauvignon blanc, Trebbiano toscano) (Adrakey et al., 2022; CABI, 2024; Eveillard et al. 2016; Oliveira et al. 2019; Ripamonti et al. 2021; Roggia et al., 2014).
- *S. titanus* can transmit the disease from May to late October, with disease severity unaffected by the inoculation date (Bocca et al., 2020, Chucho and Thiéry, 2014).
- The estimated yield losses under current management practices range from 0.5 to 1% of the EU's wine and table grape production, reflecting the effectiveness of the current control measures against impact (EFSA PLH Panel et al., 2016).
- In northeastern Italy, a field experiment reported average yield losses of 40% to 50% in symptomatic Merlot and Chardonnay cultivars (Bellomo et al., 2007), while observational data indicated losses of 34% in Merlot, 56% in Chardonnay, and 81% in Perera (Pavan et al., 2012). In Portugal, symptomatic plants of the Loureiro cultivar showed average yield losses of up to 65% (Oliveira et al., 2019). Adrakey et al. (2022) describe a situation where FDp was detected in 7.6% of the 34,581 fields surveyed in southwestern France.
- Yields from recovered plants were consistently lower than those of healthy plants, regardless of the recovery duration over the five-year observation (Morone et al., 2007; Ripamonti et al., 2020b).
- Experts considered the 12% organic viticulture in the EU.
- Ay et al. (2022) estimated the cost of non-compliance with mandatory collective insecticide applications to control FDp vector. They found that a 10% increase in the average non-compliance rate raises the average probability of disease presence by 4.5%.

4.1.6 Uncertainties identified

General uncertainties:

- The underlying cause of symptom reappearance in recovered plants remains unclear (i.e. new infections vs reactivation of latent infections).
- Influence of current agricultural practices on plant recovery is not well understood.
- Climatic factors affecting disease dynamics and recovery are not fully characterised.
- Trends in pesticide use, including overall reductions in application rates and the decreasing availability of approved active substances, may affect future disease management.
- Transmission of FDp strains from alternative hosts (reservoirs) to *V. vinifera* cannot be excluded (see host list in Appendix A).

Uncertainties related to *V. vinifera*:

- Varietal susceptibility to FDp varies, and full susceptibility profiles are still incomplete.
- Future substitution of susceptible varieties with less susceptible ones is difficult to predict.
- The presence of FDp reservoirs in wild or abandoned vines may sustain disease pressure.
- The proportion of organic vineyards is increasing, potentially influencing the disease dynamics and control strategies.
- In some regions, the abandonment of vineyards (due to declining profitability of wine production) may lead to more unmanaged vines acting as pathogen reservoirs.

4.2 Elicited values of yield loss in wine and table grape production

What is the percentage yield loss in wine and table grape production under the scenario assumptions in the EU area under assessment for FDp, as defined in the Pest Report? The five elicited values of yield loss agreed upon by the expert group are given in Table 5.

Table 5: The five elicited values of yield loss (%) in wine and table grape production.

Percentile	1	25	50	75	99
Elicited values	0.5	1.5	4	9	25

4.2.1 Justification for the elicited values of yield loss in grape production

This estimation is based on the evidence presented in Appendix B (Table B.1) and summarised in Section 4.1.5, complemented by expert observations from multiple EU countries where FDp is present.

Rationale for a scenario associated with high yield loss (99th percentile)

This high-risk scenario assumes favourable agro-climatic conditions for FDp vector development and disease spread. It involves a high proportion of susceptible grapevine cultivars, limited surveillance and control, and low compliance with mandatory measures and/or ineffective collective strategies (see Sections 2.4 and 4.1.5). Very high yield losses have been reported in outbreaks in Austria, France, Italy and Portugal, though such extreme conditions are not expected uniformly across the potential distribution area. Experts noted that FDp management may be more challenging in organic vineyards, on small farms and in newly affected areas where containment takes longer than in regions with more experience. High agritourism pressure may also affect vineyard management, as conflicts can arise between tourism expectations and the need for rapid vector control. Finally, uncertainties persist regarding the implementation of effective control strategies in countries where FDp has only recently emerged.

Rationale for a scenario associated with low yield loss (first percentile)

This low-risk scenario considers unfavourable agro-climatic conditions for vector development, a very low proportion of susceptible cultivars, excellent surveillance and control and high compliance with mandatory measures. Experts agreed that the first percentile cannot be null: once FDp is present, the established vector population can still cause measurable yield loss, even with effective control. In France, for example, average yield losses were around 0.2% in the Bordeaux area and even lower nationally, despite incomplete compliance with regulations.

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

This median is primarily based on Adrakey et al. (2022), EFSA PLH Panel et al. (2016) and EFSA et al. (2019), and accounts for the wide diversity of agro-ecological conditions across the EU. Reservoirs of FDp and its vector pose ongoing challenges for effective pest management, as the disease is endemic, and the vector relies on these habitats.

Rationale for the precision of the judgement describing the remaining uncertainties (first and third quartile/interquartile range)

The P99 reflects high uncertainty, due to potential severe yield losses during outbreaks.

4.2.2 Estimation of the probability distribution of yield loss in wine and table grape production

The comparison between the fitted values of the probability distribution and the values agreed by the group of experts is given in Table 6.

Table 6: Fitted values of the probability distribution of yield loss (%) in grape production.

Percentile	1	2.5	5	10	17	25	33	50	67	75	83	90	95	97.5	99
Elicited values	0.5					1.5		4		9					25
Fitted distribution	0.1	0.1	0.3	0.6	1.1	1.7	2.4	4.2	6.7	8.5	11.2	14.6	19.5	24.5	31.6

Fitted distribution: Pareto2(0.90754,15.414), @RISK8.6. The values highlighted in green represent the elicited values, while those highlighted in orange are the fitted values reported in the conclusion.

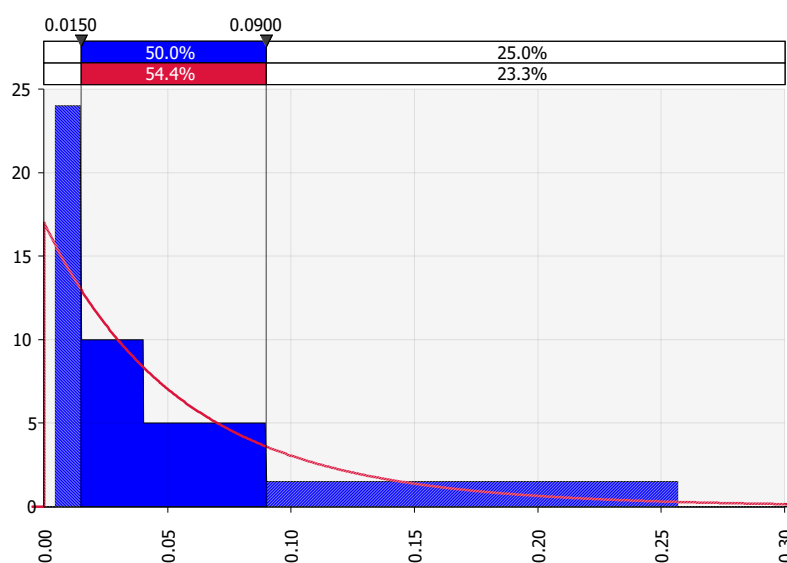


Figure 7: Comparison of elicited values (histogram in blue) and fitted distribution (red line) of yield loss in wine and table grape production. Values are given in Table 6.

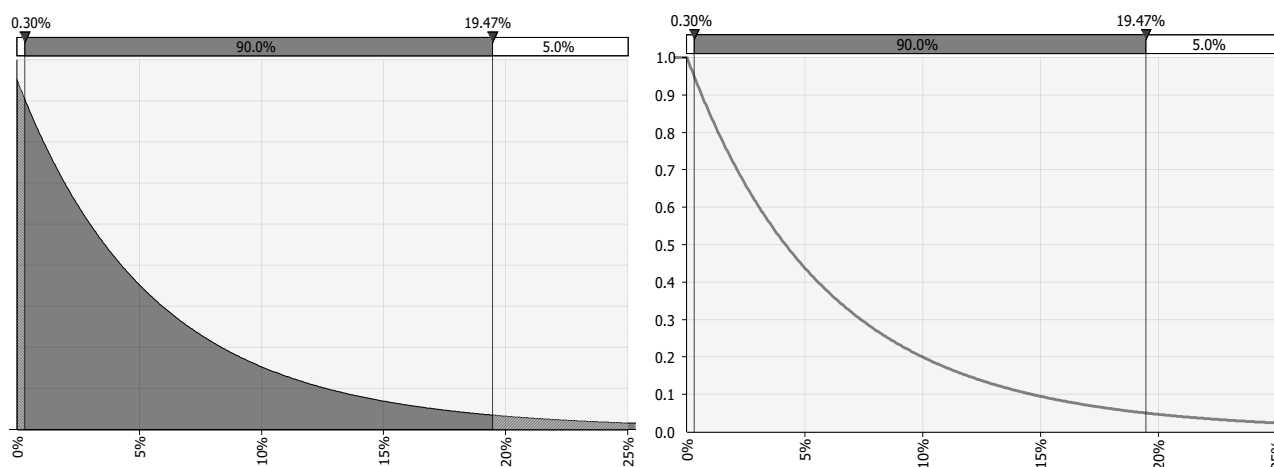


Figure 8: Fitted density function describing the uncertainties with a 90% uncertainty interval (left) and fitted descending distribution function showing the probability (y-axis) that a given yield loss percentage (x-axis) may be exceeded (right) in wine and table grape production.

5 Estimation of the environmental impact

The method used to estimate environmental impact indicators for all candidate priority pests is described in EFSA's methodology report (EFSA et al., 2025).

Vitis vinifera is the only main host of FDp and its vector (Appendix A). As requested, the environmental impact indicator evaluated for FDp is the "increase in the use of plant protection products (PPPs)".

5.1 Increase in the use of plant protection products

Based on the information provided in Section 2.4 ("Pest control in the EU"), PPPs authorised against the FDp vector *Scaphoideus titanus* in EU countries where the pest is already present, may also be used in newly infected countries or regions.

As a result, the introduction of FDp into a new area of the EU is expected to lead to increased use of PPPs to control *S. titanus*, resulting in a greater environmental impact in this area. Therefore, FDp falls under case B (score 1) for this indicator, as specified in EFSA et al. (2025).

6 Conclusion

Host selected for the impact assessment

The impact was assessed for wine and table grape (*Vitis vinifera*) production, considered jointly.

Area of potential distribution

The area of potential distribution of FDp corresponds to the regions of grapevine production (wine and table grapes) in the EU, as the phytoplasma can persist wherever the crop is cultivated. Moreover, climate modelling indicates that the vector *Scaphoideus titanus* can establish itself throughout the EU wherever grapevine is grown.

Lag period

Based on the scenario assumptions considered for this assessment, the estimated duration from pest transfer to a suitable host to the start of FDp spread (lag period) is 44 months, with a 95% probability interval of 15–98 months.

Rate of expansion

Based on the scenario assumptions, the estimated rate of expansion of FDp is 58 meters per year, with a 95% probability interval of 2–1,612 metres.

Yield and quality losses

Based on the scenario assumptions, the estimated percentage yield loss in wine and table grape production due to FDp is 4.2%, with a 95% probability interval of 0.1–24.5%. Quality losses are included in this estimation.

Environmental impact

A potential increase in the use of plant protection products due to the presence of this pest is expected (score 1).

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Abbreviations

CABI	Centre for Agriculture and Bioscience International
CREA	Council for Agricultural Research and Economics
EFSA	European Food Safety Authority
EKE	Expert knowledge elicitation
EPPO	European and Mediterranean Plant Protection Organization
EU	European Union
FDp	Flavescence dorée phytoplasma
I2P2	The Impact Indicator for Priority Pests
NUTS 2	European Commission's Nomenclature of Territorial Units for Statistics – level 2
PPP	Plant protection product

Appendix A – CABI/EPPO host lists

These comprehensive lists of hosts compile information from the CABI (2025) and EPPO (2025) databases, excluding experimental and doubtful hosts.

Table A.1 Host plants of Flavescence dorée phytoplasma (FDp)

Genus	Species epithet	Comments
<i>Ailanthus</i>	<i>altissima</i>	
<i>Alnus</i>	<i>glutinosa</i>	
	<i>incana</i>	
<i>Clematis</i>	<i>vitalba</i>	
<i>Corylus</i>	<i>avellana</i>	Found in Slovenia only
<i>Salix</i>	sp.	
Vitis	spp.	
	vinifera	Main host

Table A.2 Host plants of the FDp vector, *Scaphoideus titanus*

Genus	Species epithet	Comments
<i>Parthenocissus</i>	<i>quinquefolia</i>	
Vitis	<i>labrusca</i>	
	<i>riparia</i>	
	vinifera	Main host

Appendix B – Evidence tables

The following tables, prepared by CREA, compile the evidence reviewed by the experts during the EKE meetings. In most cases, the text provided is directly sourced from the references indicated in the last column, without amendment. Full citations for these sources can be found in the References section. In addition, the experts provided further information directly in Sections 3 and 4 during the EKE meetings.

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

Host plant	Pest distribution		Impact			Additional notes	Reference
	Prevalence	Incidence	Severity	Yield loss	Quality loss		
<i>Vitis vinifera</i>	FDp was detected in 7.6% of the 34,581 fields surveyed.					Field survey in France (Bordeaux area), from 2012 to 2016: 83,912 ha of grapevine monitored for FDp.	Adrakey et al., 2022
<i>Vitis vinifera</i> cv. Cabernet Sauvignon and Merlot		<p>FDp: proportions of infected plants in three adjacent plots (F1, F2 and F3) between 2014 and 2019.</p> <p>F1 (Cabernet Sauvignon): 2014: 7/2259 (0.3%); 2015: 18/2259 (0.8%); 2016: 26/2259 (1.15%); 2017: 12/2259 (0.5%); 2018: 668/2259 (30%); 2019: removed.</p> <p>F2 and F3 (Merlot): 2014: 0/3025; 2018: 45/3025 (1.4%); 2019: 592/2975 (19.9%).</p>	<p>Estimated using the severity score (1–4):</p> <p>Of the 668 Cabernet Sauvignon plants in 2018: 328 scored 1, 126 scored 2, 87 scored 3 and 127 scored 4. Mean severity score value of 2.02.</p> <p>Of the 637 Merlot plants in 2018 and 2019: 437 scored 1, 147 scored 2, 38 scored 3 and 15 scored 4. Mean severity score value of 1.42.</p> <p>Accordingly, confidence interval was set to 1.42 (2.02/1.42) if the cultivar of the source</p>			Field survey, Faleyras, Bordeaux area.	Adrakey et al., 2023

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Host plant	Pest distribution		Impact			Additional notes	Reference
	Prevalence	Incidence	Severity	Yield loss	Quality loss		
			plant is Cabernet Sauvignon and to 1 if the cultivar is Merlot.				
<i>Vitis vinifera</i> cv. Merlot and Chardonnay			Chardonnay was more susceptible to and more seriously affected by FDp than Merlot and showed a lower propensity for recovery. Average grapevine recovery in 2 years: Merlot: 80% of infected plants. Chardonnay: 45% of infected plants.	Average yield loss in symptomatic grapevines: Merlot: 40% production Chardonnay: 50% production		Field experiment in 2004–2006 in Italy (Friuli-Venezia Giulia).	Bellomo et al., 2007
<i>Vitis vinifera</i> cv. Chardonnay and Tocai friulano		Transmission trial. <i>S. titanus</i> resulted positive for FDp, corresponding to 28% of the insects collected. 10 micro-propagated plantlets were infected (6 out of 11 in Chardonnay; 4 out of 19 in Tocai friulano).				Laboratory experiment.	Bertazzon et al., 2019
<i>Vitis vinifera</i> cv. Pinot gris and Tocai friulano		Pinot gris: 5% (2019). Tocai friulano: 0% (2019), 0.43% (2020), 5.4% (2021).	Information on severity can be retrieved from Fig. 1 [of the paper]: (Class 1) symptoms limited to a small part of one 2-year-old arm; (Class 2) symptoms in most of one 2-year-old arm; (Class 3) both 2-year-old arms with Flavescence dorée symptoms.			Field experiment; Friuli; Venezia Giulia, northeastern Italy.	Casarin et al., 2023

Priority pests – Grapevine Flavescence dorée

Host plant	Pest distribution		Impact			Additional notes	Reference
	Prevalence	Incidence	Severity	Yield loss	Quality loss		
<i>Vitis vinifera</i> (all cultivars)				Median: 4.3% CI 95%: 0.8–21.9%		Previous EFSA expert knowledge elicitation on FDP	EFSA et al., 2019
<i>Vitis vinifera</i>				Under current control measures, FDP has a 0.5–1% impact on the overall EU grapes and wine production.			EFSA PLH Panel et al., 2016
<i>Vitis vinifera</i> cv. Cabernet Sauvignon and Merlot		In the three vineyard plots, were identified 38% (2,411) and 3% (307) symptomatic Cabernet Sauvignon and Merlot, respectively.	Of the Cabernet Sauvignon stocks, 70% showed over 75% symptomatic branches whereas 55% of Merlot stocks showed less than 25% symptomatic branches.			Field experiments in France (Bordeaux area).	Eveillard et al., 2016
<i>Vitis</i> spp. 28 different cultivars, including 12 wild cultivars		Accessions with high FDP titres and high proportion of infected plants: Cabernet Sauvignon, <i>V. rubra</i> , <i>V. labrusca</i> , <i>V. berlandieri</i> , Sauvignon. Accessions with intermediate FDP titres and high proportion of infected plants: <i>Vitis amurensis</i> , Riparia Gloire de Montpellier, Cabernet Franc, 3,309 Courdec, <i>V. rupestris</i> , <i>V. longii</i> , Grenache, Chardonnay, Sélection Oppenheim 4, 41 B Millardet et de Grasset, <i>V. doaniana</i> , 110 Richter, <i>V. pentagona</i> , <i>V. coignetiae</i> . Accessions with intermediate to low FDP titres and low proportion of infected plants: Syrah,				Laboratory experiment.	Eveillard et al., 2016

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Host plant	Pest distribution		Impact			Additional notes	Reference
	Prevalence	Incidence	Severity	Yield loss	Quality loss		
		Magdeleine Noire des Charentes, Pinot Noir, Merlot, <i>V. simpsonii</i> , Nemadex Alain Bouquet, <i>V. vinifera</i> subsp. <i>sylvestris</i> , <i>V. champinii</i> , Kober 5 BB.					
<i>Vitis vinifera</i>	In the Province of South Tyrol, the first report of FDp in grapevines was in 2016 in Valle Isarco. In 2018, eight grapevines in the locality of Salorno (South Tyrolean Bassa Atesina) were found infected by FDp. This area is located close to the neighbouring province of Trentino, an area highly infected by FDp. In 2019, 16 single plants, distributed over the Bassa Atesina region, were found to be infected by FDp.					Field experiment; South Tyrol (northern Italy).	Gallmetzer et al., 2020
<i>Vitis vinifera</i>	The grapevine samples were collected between 2017 and 2021 in 107 different sites in three different wine-growing regions of Slovenia: the northeast, southeast and southwest.	The 5-year overall percentage of 16SrV FDp+ grapevines was 29%. <i>O. ishidae</i> : 13 16SrV positive samples out of 65. <i>S. titanus</i> : 7 16SrV positive samples out of 21.				Field experiment.	Kogej Zwitter et al., 2023
<i>Vitis vinifera</i>		Results of grapevine FDp surveys in 2007–2008 (Table 2 [of the paper]).				Field experiment.	Kriston et al., 2019

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Host plant	Pest distribution		Impact			Additional notes	Reference
	Prevalence	Incidence	Severity	Yield loss	Quality loss		
<i>Vitis vinifera</i>		During the period 2003–2005 the number of symptomatic plants increased: Area 1: from 45.5% to 93%. Area 2: from 12.4% to 19.6%. Cultivar Plovdina: from 5% to 90%.				Field experiment in Serbia.	Kuzmanovic et al., 2008
<i>Vitis vinifera</i>	Sampling sites were in FDp-free vineyards and in FDp-infected vineyards.	Sampling plan and infection status of the samples.					Malembic-Maher et al., 2020
<i>Corylus avellanae</i>	Slovenska Bistrica Slovenian region. 2/2 intensive orchards.	19/28 positive/symptomatic.	1,600 hazelnut trees planted 12 to 15 years ago, decline of some of the trees appeared in 2012. By October 2018, 10% of these trees had died and been removed, an additional 14% showed decaying symptoms.			Field experiment in Slovenska Bistrica (eastern Slovenia).	Mehle et al., 2019
<i>Vitis vinifera</i> cv. Barbera, Bonarda, Cortese and Dolcetto			Productivity of recovered vines, although lower than that of healthy ones, was always higher than that of vines with symptoms and was not influenced by the time elapsed from date of recovery, i.e. up to 5 years of observation.	Yield of recovered plants was always approximately 80% more than that of the symptomatic vines. Grapevine varieties did not affect the efficiency of recovery.		Field experiment in northwestern Italy.	Morone et al., 2007
<i>Vitis vinifera</i>	Two vineyards surveyed (Gussago; Provaglio)	In the infected patch of Provaglio d’Iseo: 32/55				Field experiment; Franciacorta, Italy.	Moussa et al., 2023

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Host plant	Pest distribution		Impact			Additional notes	Reference
	Prevalence	Incidence	Severity	Yield loss	Quality loss		
	d'Iseo); plants found infected by 16SrV phytoplasmas only in Provaglio d'Iseo vineyard.	(58%) FDp+ symptomatic grapevines and 9/96 (9.4%) FDp+ groundcover plants.				Also ' <i>Candidatus</i> Phytoplasma solani' was detected at high rates in the same vineyards.	
<i>Vitis vinifera</i>	FDp: A map of the surveyed area and results of molecular analyses can be retrieved in Fig. 1 [of the paper]. 7/20 (35%) FDp+ plots, all in the Sottoceneri region. <i>S. titanus</i> : Presence of <i>S. titanus</i> and <i>O. ishidae</i> monitored with yellow sticky traps or hatching experiment can be retrieved in the map of Fig. 2 [of the paper]. <i>S. titanus</i> individuals captured with sticky traps in 6/15 plots; nymphs in 7/11 in hatching experiment.	FDp: 0–100% depending on the plot.	<i>S. titanus</i> : 0–3 captures per trap depending on the plot; 0–19 hatchings depending on the plot.			Field experiment, southern Switzerland.	Oggier et al., 2023
<i>Vitis vinifera</i> cv. Loureiro				Average yields: Healthy: 23.8±1.2 kg/plant FDp-infected: 8.3±0.3 kg/plant		Field experiment in 2015 in Portugal (Fafe).	Oliveira et al., 2019
<i>Vitis vinifera</i> cv. Merlot, Chardonnay and Perera		Index of new infections: Merlot: 32%. Chardonnay: 43%. Perera: 50%.	In 5 years: 19% death in Chardonnay, 10% death in Perera.	Average yield loss in symptomatic grapevines: 34% in Merlot. 56% in Chardonnay. 81% in Perera.		Data collected and analysed from 19 vineyards.	Pavan et al., 2012

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Host plant	Pest distribution		Impact			Additional notes	Reference
	Prevalence	Incidence	Severity	Yield loss	Quality loss		
<i>Alnus</i> spp., <i>Clematis vitalba</i> and <i>Vitis vinifera</i>		FDP+: 1 of 7 symptomatic grapevine plants analysed. 1/10 (positive/tested) Clematis. 6/6 (positive/tested) Alders.				Field experiment; different grapevine cultivation areas of Montenegro. The clematis plant in Godinje shared the same FDP Vectotype III as the infected vine, suggesting that <i>Clematis</i> was the likely source of infection.	Radonjić et al., 2023
<i>Vitis vinifera</i> cv. Barbera and Chardonnay		Cv. Barbera: 1–8% depending on plot (2011), 1–16% (2012), 0–34% (2013), 11–56% (2014), 13–52% (2015). Cv. Chardonnay: 15–41% (2013), 14–55% (2014), 14–49% (2015). For both cultivars, disease incidence in central plots lower than within edge plots (importance of primary infections by vectors coming from outside).			Recovery (i.e. spontaneous remission of symptoms) was observed in both cultivars under integrated pest management. Berry and wine quality was only slightly affected in recovered grapevines compared with healthy, in terms of composition, maturation curves, micro-vinification, oenological and sensory analyses.	Field experiment; Piedmont, northwestern Italy.	Ripamonti et al., 2020a

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Host plant	Pest distribution		Impact			Additional notes	Reference
	Prevalence	Incidence	Severity	Yield loss	Quality loss		
<i>V. vinifera</i> cv. Barbera, Brachetto and Moscato		Significant differences in vector feeding behaviour were observed on three different grapevine cultivars, namely the duration of the phloem feeding phase is longer and the frequency of salivation events inside the phloem is higher on Barbera than Brachetto and Moscato. These findings indicate a possible preference of <i>S. titanus</i> for the Barbera cultivar. This correlates with an enhanced FDP transmission efficiency on Barbera, and explains, at least in part, the higher susceptibility of this cultivar to FDP.				Laboratory experiments by means of electrical penetration graph technique to assess the feeding behaviour of <i>S. titanus</i> on different grapevine cultivars.	Ripamonti et al., 2022b
<i>Vitis vinifera</i> cv. Barbera and Nebbiolo			Significant positive correlation between FDP concentration and symptom severity.			Field experiment in northwestern Italy (Piedmont).	Roggia et al., 2014
<i>Vitis vinifera</i> , gone-wild <i>Vitis vinifera</i> and rootstocks, <i>Clematis</i> spp.	FDP on <i>V. vinifera</i> , wild <i>Vitis</i> , <i>S. titanus</i> : in all investigated sites. <i>Clematis</i> spp.: 3/7 (43%) investigated sites.						Rossi et al., 2019

B.2 Summary of the evidence supporting the elicitation of the lag period and rate of expansion

Elements of population dynamics		Dispersal capacity (at individual level)		Spread (at population level)		Additional notes	Reference
Population growth	Population capacity to colonise/recolonise patches	Documented self-dispersal capacity	Documented human-assisted spread	Pattern	Rate of expansion		
In the absence of plant removal, a lag period of 3 years was estimated.					On average, 50%, 80% and 95% of the new infections occur within 10.5, 22.2 and 55.2 m of the source, respectively.	Field survey in France (Bordeaux area): simulation of the disease dynamics and dispersal.	Adrakey et al. 2023
					Important dispersal of the disease from Drôme to Vaucluse departments in southern France, suspected to be due to passive dispersal of the vector by the Mistral wind: maximum spread: approximately 4 km per year.	Analysis of the 2012–2013 outbreak in France (Vaucluse and Drôme), from the French plant protection services of Auvergne-Rhône-Alpes and Provence-Alpes-Côte d’Azur.	Alice Dubois and Brigitte Barthelet, personal communication to the expert group, 16 November 2023
	<p><i>S. titanus</i>:</p> <p>The distance between North American vineyards and alternative North American grapevine yellow phytoplasma host plants beyond which this species is less apt to travel is at least 40 m (traps 30 m from the vineyard edge and 40 m from the forest edge rarely captured <i>S. titanus</i>).</p>					Field experiment, North America. Surveys. Sticky traps; sweep sampling. Logistic regression analyses; logistic regression model predictions. Natural spread.	Beanland et al., 2006

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<p>The abundance of <i>S. titanus</i> populations was highest at 19–21°C.</p>	<p>The abundance of <i>S. titanus</i> populations was: not significantly correlated with the distance between the vineyards and the surrounding forests; highest at wind speed <0.8 m/s.</p>					<p>Field experiment in three vineyards in Slovakia from 2019 to 2021.</p>	<p>Beranova et al., 2022</p>
<p><i>S. titanus</i> showed a high average lifespan (over 60 days for females and over 40 days for males). - Both egg-load trend and oviposition rate of <i>S. titanus</i> females remained constant until September and then decreased until the end of October. - Both longevity and female fecundity resulted to be higher than previously estimated. A serious implication of the high longevity is the prolongation of the adult inoculation period, and a temporal expansion of the risk of infecting the vineyards when these are no longer protected by insecticide treatments.</p>						<p>Field and semi-field experiments carried out in northwestern Italy in 2016 and 2017 to assess the longevity and fecundity of <i>S. titanus</i>.</p>	<p>Bocca et al., 2020</p>
<p>Data about lag phase after grafting infected rootstocks. 'Scions grafted on infected rootstock will most often express symptoms in the nursery. However, a few plants may retain a</p>	<p>The number of affected stocks in 2001 in one plot in Savoie was 20 times the number observed in 2000 (62).</p>						<p>Boudon-Padieu, 2002</p>

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<p>latent infection for several years. Experimental data have shown that symptom expression could be delayed for 3 years at least (Table 1 [of the paper]); moreover, documented field observations suggest that a 5-to-7-year latency would not be unusual.'</p> <p>Data about lag phase after insect transmission. 'Young leaves developing in May and June on stocks inoculated during the preceding Summer, contain phytoplasma that are available to acquisition by feeding larvae, before symptom expression. (Fig. 2 [of the paper]).'</p>							
	<p><i>S. titanus</i> individuals infected by FDp deposited on grapevine plants var. Cabernet Sauvignon (highly susceptible variety) and Merlot (poorly susceptible variety). 1 week post-infection (wpi): 100% leaves in contact with infected <i>S. titanus</i> positive for FDp with no statistical differences between Cabernet Sauvignon and Merlot. 7 wpi: higher FDp titre in Cabernet Sauvignon</p>					<p>Laboratory experiment in a high-confinement greenhouse in controlled conditions.</p>	<p>Deborde et al., 2023</p>

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	<p>than Merlot leaves in contact with infected <i>S. titanus</i>. 0% Merlot fifth leaves FDP-infected, 9% Cabernet Sauvignon fifth leaves FDP-infected.</p>						
				Continuous	<p>Estimated spread: Median: 44 m/y CI95%:1-1,335 m/y</p>	<p>Previous EFSA expert knowledge elicitation on FDP</p>	<p>EFSA et al., 2019</p>
					<p>With the current measures in place, spread of FDP is likely to continue during the forthcoming period with a progression of between a few and ca 20 newly infested NUTS 2 regions predicted for the 50% uncertainty interval.</p> <p>This analysis shows the limitations of the currently deployed control measures, which have not halted the progression of FDP in the EU.</p>		<p>EFSA PLH Panel et al., 2016</p>
	<p><i>S. titanus</i>:</p> <p>No significant spread outside the vineyard within a 24 m radius in normal wind conditions.</p> <p>Few specimens were caught by traps placed at a height of 2.40 m (therefore the pest does not seem to fly above the canopy).</p>					<p>Field experiment, northwestern Italy. Yellow sticky traps. Natural spread.</p>	<p>Lessio and Alma, 2004a</p>

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		<p><i>S. titanus</i>: 80% of <i>S. titanus</i> covered short distances of up to 30 m.</p> <p>However, there was evidence of long-range dispersal up to 330 m.</p> <p><i>S. titanus</i> adults have a crepuscular flight activity and do not rely on the wind for dispersal (Lessio and Alma, 2004b).</p> <p>Active wandering movement rather than a passive wind-borne transport.</p>				<p>Field experiment, northwestern Italy. Natural low dispersal ability.</p> <p>From wild to cultivated grapevines.</p> <p>Mark-capture techniques: yellow sticky traps.</p> <p>Modelling: data subjected to exponential regression and spatial interpolation.</p>	Lessio et al., 2014
Retrieved from the article in Fig. 9 [of the paper]. One can estimate a 2-year lag phase.						Field surveys and modelling of FDp dynamics in Piedmont, Italy (field scale).	Lessio et al., 2015
	The vector <i>S. titanus</i> randomly chooses a direction for short flights.	<p>Overall, from 2012, at least 50% of newly symptomatic plants were found within 3 m of plants already symptomatic.</p> <p>The likelihood that newly symptomatic plants occurred nearby already-symptomatic plants increased year after year to 90% of occurrences within 3 m.</p>				<p>Italy (Piedmont)</p> <p>Field surveys from 2011 to 2015.</p> <p>Space-time point pattern analysis of FDp epidemic in a grapevine field: FDp natural spread.</p>	Maggi et al., 2017
		<p><i>S. titanus</i>:</p> <p>Most adults were captured within 40–50 m of untreated</p>				<p>Field experiment in northeastern Italy.</p> <p>Yellow sticky traps.</p>	Mori et al., 2014

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		vineyard, even if some individuals were captured at 80–100 m.				Data analysed with SADIE (spatial analysis by distance indices) red–blue methodology to detect spatial patterns.	
						Relationship of newly affected and total affected, and number of healthy and recovered plants (1998–2003; Fig. 1 [of the paper]).	Morone et al., 2007
		50 of the 211 <i>S. titanus</i> nymphs collected were able to develop to the adult stage. Males were 1.4 times more abundant than female specimens (i.e. 58% male, 42% female).				Laboratory experiment.	Oggier et al., 2023
						FDp: expansion from 60 ha in 1991 to 20,000 ha in 1993.	Pueyo et al., 2008
		<i>S. titanus</i> spread at a maximum distance of 600 m from the nursery of scion mother plants where it was first recorded. Authors mentioned that a particular wind situation might have enhanced leafhopper dispersal, in the absence of natural				Field surveys in central-eastern Italy. 10-year survey coordinated by the Regional Plant Protection Service. Yellow sticky traps. Taylor’s power law and distance-weighted least-	Riolo et al., 2014

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		barriers (hedges and wood).				squares contour maps used to determine the leafhopper distribution within vine fields.	
	The levels of <i>S. titanus</i> populations in the wild vegetation compartment were higher than inside the corresponding vineyard. A higher proportion of FDP-infected leafhoppers was recorded in the wild compartment compared with those from the vineyard, confirming the important role of outside FDP sources in the epidemiology of the disease.					Field monitoring activities in 2015 by yellow sticky traps at seven sites in the Piedmont region (northwestern Italy). The inspected sites included cultivated <i>V. vinifera</i> and alternative FDP host plants (e.g. abandoned <i>V. vinifera</i> , rootstocks of <i>V. riparia</i> and <i>Vitis</i> spp., and <i>Clematis vitalba</i>).	Ripamonti et al., 2020a
The highest fitness of <i>S. titanus</i> was observed on Barbera compared with Brachetto and Moscato grapevine cultivars, in terms of:						Lab and semi-field experiments to assess the fitness of <i>S. titanus</i> on three grapevine cultivars.	Ripamonti et al., 2022a
- higher nymph and adult survival rates;							
- faster nymph development;							
- higher number of eggs laid by females.							
Consistently with the studies on feeding behaviour, Barbera is the most suitable host for <i>S. titanus</i> . This may partly explain the							

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high susceptibility of this variety to FDp.							
	<p>The high level of genetic variability of FDp and the co-occurrence of many FDp genotypes inside and outside the vineyards, confirm the importance of wild or abandoned <i>Vitis</i> plants and associated <i>S. titanus</i> insects in the epidemiology of the disease. The large overlap of FDp genotypes in the two environments was confirmed at the single-site level in six out of seven sites. Such genetic diversity suggests the hypothesis of 'primary infection' by incoming vectors from outside the vineyard.</p>					Field experiment, Piedmont Region, Italy.	Rossi et al., 2019
<p><i>Scaphoideus titanus</i> transmits FDp to grapevine after acquisition on infected grape and a latency period of 3–4 weeks.</p>							Schvester et al., 1961
<p>In the area where <i>S. titanus</i> is currently present, the further increase of gas emission will reduce female fecundity and bring the egg-hatching forward.</p>					<p>Distribution of <i>S. titanus</i>: Populations will move northwards and to higher altitudes if gas emissions increase. Population range will not significantly change if gas emissions decrease.</p>	<p>Simulations based on two models representing reduction and increase of global-warming gases, respectively. Simulations aimed at inferring the impact of these</p>	Sneiders et al., 2019

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<p>A second generation/year would be possible if gas emissions increase.</p>						<p>two climatic scenarios on life cycle, distribution and number of generation/years of <i>S. titanus</i> in Swiss vineyards in the future (the years 2050 and 2070).</p>	
		<p>'Vineyards in Slovenia's border are situated near the ones in southern Styria. Passive spread by north-westerly winds along the valley of the Mur river is assumed to be the origin of the vector in southern Styria. This is supported by the fact that hundreds of specimens of <i>S. titanus</i> were caught in yellow sticky traps at observation plots close to the river 'Mur', while further inland the abundance of the vector is lower. Monitoring data showed that the vector is also able to fly to vineyards which are several km away from infested sites. Likewise, on the basis of the spatial distribution of FDP-affected plots in Catalonia (Spain), Torres et al. (2003) suggested that the Tramontana wind – a dry cool northerly wind in the Mediterranean –</p>				<p>To estimate the risk to Austrian viticulture a pest risk analysis was conducted, following the EPPO decision support scheme.</p>	<p>Steffek et al. 2007</p>

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		helped <i>S. titanus</i> to spread from infested zones to healthy plots.'				
		<p><i>S. titanus</i>:</p> <p>Spread distance of at least 75 m.</p> <p>Adults migrate into the peripheral parts of vineyards at the end of the season.</p>		<p>Rate of the migrating population: 0–7.1%</p> <p>4% of a given <i>S. titanus</i> population migrated with a high population density.</p>	<p>Field experiment in Austria.</p> <p>Modelling study, natural spread.</p> <p>Trap plants and yellow sticky traps.</p>	<p>Strauss et al., 2014</p>