European Food Safety Authority

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STATEMENT OF EFSA

Statement of EFSA on host plants, entry and spread pathways and risk reduction options for *Xylella fastidiosa* Wells et al.[1]

European Food Safety Authority[2, 3]

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ABSTRACT

Following a request from the European Commission, EFSA was asked to provide urgent scientific and technical assistance on the plant pathogenic bacterium *Xylella fastidiosa*. *X. fastidiosa* was detected in olive trees in Lecce province in Apulia, Italy, in October 2013. This is the first outbreak of *X. fastidiosa* under field conditions in the European Union. EFSA reviewed the host range and vectors, the pathways for entry and spread and the risk reduction options. Known hosts include many cultivated and spontaneous plants common in Europe, however a range of European wild plant species would meet this bacterium for the first time, increasing uncertainty on the host range. All xylem-fluid feeding insects in Europe should be regarded as potential vectors of *X. fastidiosa* and identification of the vector in the Apulian outbreak is pending. The main entry pathway for *X. fastidiosa* is the movement of plants for planting. Infective vectors of *X. fastidiosa* transported on plant consignments are also of concern. The only route for natural spread of *X. fastidiosa* is by insect vectors that generally fly short distances up to 100 metres, but can be transported by wind over long distance. The movement of infected plants for planting is the most efficient way for long-distance dispersal of *X. fastidiosa*. There is no record of successful eradication of *X. fastidiosa* once established outdoors due to the broad host range of the pathogen and of its vectors. Strategies for prevention of introduction from areas where the pathogen is present and for containment of outbreak should focus on the two main pathways and be based on integrated system approach combining, when applicable, the most effective options.

KEY WORDS

Xylella fastidiosa, hosts, vectors, pathways, risk reduction options

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BACKGROUND AS PROVIDED BY THE EUROPEAN COMMISSION

Xylella fastidiosa (Wells and Raju) is a vector-transmitted bacterial plant pathogen associated with important diseases in a wide range of plants. It causes Pierce's disease in grapevine (*Vitis vinifera*), which is described as a major constrain for commercial grapevine production in parts of the USA and tropical America. Numerous species of xylem sap-sucking insects (leafhoppers/Cicadellidae) are known to be vectors of this bacterium.

Xylella fastidiosa is a regulated harmful organism in the European Union, listed in Annex I, Part A, Section I to Council Directive 2000/29/EC as a harmful organism not known to occur in any part of the Union, whose introduction into, and spread within, all Member States is banned. Non-European Cicadelidae known to be vectors of Pierce's disease, caused by *Xylella fastidiosa*, are also listed in Annex I, Part A, Section I to Council Directive 2000/29/EC.

Given the recent identification of the presence of this bacterium in Italy there are still many open issues that are currently being addressed, such as the extent of the outbreak area, the identification of insect vectors, and of the host plants providing the main source of inoculum for the further spread of the bacterium. The link between *Xylella fastidiosa* and the rapid decline symptoms observed in old olive trees also needs to be clarified.

However, there is an urgent need to put in place measures to prevent the spread of this harmful organism into other parts of the Union through the movement of relevant plants, plant parts and other products.

TERMS OF REFERENCE AS PROVIDED BY THE EUROPEAN COMMISSION

In the context of Article 31 of Regulation (EC) No 178/2002, EFSA is asked to provide urgent scientific advice to the Commission on the following:

- Preparation of a list of known host plants of *Xylella fastidiosa*.

- The identification of pathways for the introduction and spread of *Xylella fastidiosa*, including a description for each pathway of the probability of association of the bacterium with the pathway at origin, the probability of survival during transport and storage, the probability of surviving existing management procedures, and the probability of transfer of the pest to a suitable host. This analysis should take into account the pathways of spread of the bacterium via the movement of infected potential vectors.

- The identification of potential measures to prevent the introduction and spread of *Xylella fastidiosa* (risk reduction options) and the evaluation of their effectiveness.

ASSESSMENT

1. Introduction

Following a request from the European Commission, EFSA was asked to provide urgent scientific and technical assistance on the regulated harmful organism *Xylella fastidiosa* Wells et al. The request derives from the report received on 21 October 2013 by the European Commission from the Italian phytosanitaty service concerning the detection of *X. fastidiosa* in Apulia (Lecce province). The identification of *X. fastidiosa* in Italy represents the first confirmation of this pest under field conditions in the European Union.

X. fastidiosa is a bacterial plant pathogen transmitted by xylem-fluid feeding insect vectors and is associated with a number of important diseases in a wide range of plants. Most disease symptoms are associated with bacterial blockage of xylem fluid transport through the plant (water and nutrients). The symptoms of this harmful organism in susceptible host plants vary, but include marginal leaf scorching, wilting of foliage and withering of branches, dieback and stunting with eventual plant death from severe infections. The outbreak in Italy is characterised by extensive leaf scorch and dieback of olive trees (*Olea europaea*), some of which are over 100 years old, over a large area estimated in ca. 8 000 hectares.

As a regulated quarantine pest, the organism is banned from being introduced into the EU and the spread of this harmful organism in EU Member States is also prohibited. As such the activity of the Regional Plant Protection Service together with research institutions in the Apulian region of Italy are currently seeking to determine the full extent of the outbreak area and the specific role of *X. fastidiosa* in causing the olive disease, for which the etiology is still under investigation as in addition to *X. fastidiosa* also fungi and insects have been reported to be associated.

Given this background the European Commission has decided that there is an urgent need to implement measures to prevent the spread of this harmful organism to other parts of the EU and has asked EFSA to provide urgent scientific assistance to the Commission.

2. Methodology

In order to provide an urgent response to the request from the European Commission, a literature search was conducted in consultation with scientific experts. Due to the short timeframe, a systematic literature review approach could not be utilised.

For the lists of host plants of the described *X. fastidiosa* subspecies, websites and reviews dedicated to *X. fastidiosa* were consulted together with up to date scientific publications. These lists are not exhaustive because an extensive literature search or a systematic literature review were not performed due to the short timeframe. For example, for *X. fastidiosa* subspecies *fastidiosa*, the list of hosts of the Pierce' disease (PD) strain (*X. fastidiosa* subspecies *fastidiosa)* published on the website of University of Berkeley was considered and checked against the records of the Flora Europea (RBGE, online) to identify host plants present in Europe and their distribution.

The list of known vectors of *X. fastidiosa* used is the one of Redak et al. (2004), with minor taxonomic modifications. For potential vectors of *X. fastidiosa* in Europe, the presence of known vectors as well as the list of the European xylem-fluid feeding insects was drawn from the Fauna Europaea database (de Jong, 2013).

When previous risk assessments documents were considered for the identification of pathways and risk reduction options these are cited in the text.

3. Biology of the pest

3.1. Taxonomy

Xylella fastidiosa is a gammaproteobacterium in the family Xanthomonadaceae. The genus *Xylella* has only one species. *Xylella fastidiosa* was initially thought to be a virus due to its biology, but was shown to be a bacterium in the 1970s (Purcell, 2013). It was first described and named in 1987 (Wells et al., 1987). Although the sole species in the genus, bacteria named *X. fastidiosa* has substantial genotypic and phenotypic diversity. This is of fundamental importance, as genotype informs phenotype, especially with regard to host plants where an infection leads to disease. Importantly, as it will be summarised below, most host plants infected with *X. fastidiosa* do not express symptoms.

There are numerous genotyping schemes used to discriminate *X. fastidiosa*, providing resolution at different levels of genetic diversity (Almeida et al. 2008; Yuan et al. 2010). The decision on which typing protocols to be used is based on the question being asked. At the broader level of subspecies and host plant-*X. fastidiosa* genotype association, multi-locus sequence typing has been shown to be superior and the most robust approach to study the diversity of *X. fastidiosa* (Nunney et al., 2012a). This approach is based on the sequencing of fragments of seven housekeeping genes distributed throughout the genome and void of positive evolutionary selection pressure. With this now commonly used approach, individual isolates can be assigned to subspecies. Although there is infra-subspecies diversity, we will focus on the subspecies level information, supported by data provided with multi-locus sequence typing.

There are four accepted subspecies of *X. fastidiosa*. A fifth proposed subspecies which includes isolates causing disease in a tree, Chitalpa, in New Mexico USA is currently pending acceptance, partly because its phylogenetic placement is still dubious as it may fall within one of the currently accepted subspecies. There are no other records of this genotype, or reports of its occurrence. A report from Taiwan (Leu and Su, 1993; Su et al., 2012) describing a genotype of *X. fastidiosa* causing a disease in pear classifies the agent as *X. fastidiosa* based on its 16S rDNA sequence. With its biology not fully understood and with it being genetically substantially distinct from all other known *X. fastidiosa* genotypes this pathogen would certainly be assigned to a new subspecies or even to a new species; however this would require additional research.

The four currently accepted subspecies are: ssp. *fastidiosa*, ssp. *pauca*, ssp. *multiplex*, and ssp. *sandyi* (Schaad et al., 2004; Schuenzel et al., 2005). The overview below (Table 1) summarises characteristics and known geographic distribution of each subspecies. Some of the plants included in the 'important susceptible plants' list were not confirmed experimentally through infection studies as hosts for the respective subspecies but are host plants in which *X. fastidiosa* was found and identified in nature.

Table 1: Important susceptible plants and geographic distribution of subspecies of *X. fastidiosa*

Subspecies	Geographic distribution	Important susceptible plants
fastidiosa	Central and North America, Taiwan	Grapevines, citrus, coffee, almond
pauca	Brazil, Paraguay, Argentina	Citrus, coffee
multiplex	United States, Brazil	Almond, peach, plum, oak, blueberry, pecan, etc
sandyi	United States	Oleander

It is important to mention that the presence of ssp. *multiplex* in Brazil is due to an introduction associated with plums (Nunes et al., 2003; Almeida et al., 2008; Nunney et al., 2012b). In addition, the introduction of ssp. *fastidiosa* in Taiwan has led to an epidemic in grapevine in that country (Su et al., 2013). Finally, ssp. *fastidiosa* is more diverse in Central America, and it has been suggested that its presence in the United States was also the consequence of an introduction (Nunney et al., 2010). The identification of the genotype associated with the olive disease epidemic in southern Italy is pending.

Genotypic assignment to subspecies has been helpful in allowing inferences into the general biology of isolates. For example, isolates collected from symptomatic grapevines in California fall within ssp. *fastidiosa*, while those collected from almond trees fall within ssp. *fastidiosa* and *multiplex* (Almeida and Purcell, 2003). The isolates collected from almonds that belong to ssp. *fastidiosa* are capable of causing disease in grapevines and almond trees, while those belonging to ssp. *multiplex* only cause disease in almonds. However, multi-locus sequence typing also allows the grouping of genotypes that are biologically distinct within the various *X. fastidiosa* subspecies. For example, within ssp. *pauca*, there are biologically and genetically distinct genotypes that cause disease in citrus and coffee (Almeida et al., 2008). In this specific case, there is no cross-infection (Almeida et al., 2008), although the isolation of one coffee-genotype isolate from citrus has been reported (Nunney et al., 2012a); it is relevant to note that citrus and coffee often occur in sympatry and share some insect vectors, so that it is possible that this isolation was not of epidemiological relevance. Therefore, although genotypic typing allows for robust and conserved genetic and phenotypic inference, biological (e.g. experimental cross infection assays) and epidemiological (surveys that type field isolates) studies are important to determine the phenotypic characteristics of individual isolates.

Subspecies *fastidiosa* is the best characterised group and the only genetic group causing disease in grapevines in the USA (Pierce's disease) (Nunney et al., 2010). Isolates within ssp. *pauca* causing citrus variegated chlorosis in Brazil are also reasonably well characterised. Isolates from the other two subspecies (*multiplex* and *sandyi*), are however poorly characterised and their biology is not well understood.

The subspecies *multiplex* appears, so far, to have the widest host range in terms of plant species expressing disease symptoms (Nunney et al., 2013). The subspecies *multiplex* is subdivided into various subgroups, which are mostly associated with specific host plants. In other words, those within-ssp. *multiplex* genetic resolution generally supports genotype-host plant relationships (Nunney et al., 2013).

The genotype affiliation of the *X. fastidiosa* associated with the outbreak of the disease in olives in southern Italy is still pending.

3.2. A short introduction to the biology of the pathogen

X. fastidiosa is a Gram-negative, strictly aerobic, xylem-inhabiting, non-flagellated bacterial pathogen with a growth optimum of 26-28 °C. It colonises the xylem where it can move downstream, but also upstream (Almeida et al., 2001; Meng et al., 2005). Populations of *X. fastidiosa* restrict water movement in the xylem and high frequencies of blocked vessels are associated with disease symptom development (Newman et al., 2003). *X. fastidiosa* colonises many host plants that remain symptomless and serves as a source of inoculum for vectors (Hopkins and Purcell, 2002). The colonisation of different host species (by different *X. fastidiosa* genotypes) ranges from successful infections resulting in plant death within months, to persistent yet non-symptomatic infection (Purcell and Saunders, 1999). Therefore, colonisation patterns are complex and depends upon, amongst others, host plant species and genotype of the pathogen.

4. Occurrence of the pest

4.1. World

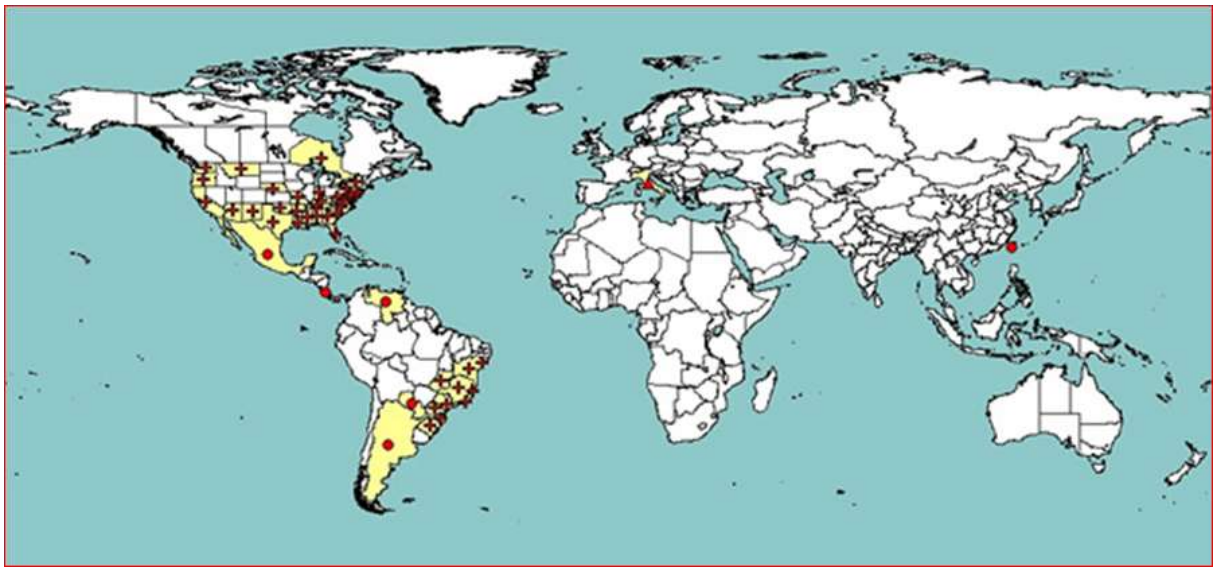

Figure 1: World distribution of *X.fastidiosa* from EPPO-PQR database (EPPO, online)

A disease caused by *X. fastidiosa* was first observed in Anaheim, Orange County, California Diseases caused by *X. fastidiosa* occur in tropical, subtropical and temperate areas of the Americas. The geographical distribution according to the EPPO-PQR database (EPPO, online) is as follows:

- **North America**: Canada (Ontario), Mexico, USA (Alabama, Arizona, Arkansas, California, Delaware, District of Columbia, Florida, Georgia, Indiana, Kentucky, Louisiana, Maryland, Mississippi, Missouri, Montana, Nebraska, New Jersey, New Mexico, New York, North Carolina, Oklahoma, Oregon, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, Washington, West Virginia);
- **Central America and Caribbean**: Costa Rica.
- **South America**: Argentina, Brazil (Bahia, Espirito Santo, Goias, Minas Gerais, Parana, Rio Grande do Sul, Rio de Janeiro, Santa Catarina, São Paulo, Sergipe), Paraguay, Venezuela;
- **Asia**: Taiwan;
- **Africa**: not reported;
- **Europe**: *X. fastidiosa* is present in Italy where the disease has been observed in Apulia (EPPO, 2013).

4.2. Occurrence in Europe

No interceptions of *X. fastidiosa* or its vectors are recorded in the Europhyt database (Europhyt, online).

The occurrence of Pierce's disease was previously reported on grapevine, in Kosovo (Berisha et al., 1998). However, this report remains dubious because of the lack of further study and of doubt about the nature of original material (EPPO RS N°98/157, 1998). In France, a blemished apricot was checked for the presence of *X. fastidiosa* by a serological assay based on immunofluorescence, in 2011. A positive reaction was recorded on one sample but all further serological and molecular tests failed to detect *X. fastidiosa* (Anses, 2012). Since then, no apricot trees have displayed any symptoms in the orchard and *X. fastidiosa* was not detected using ELISA and qPCR in scions collected from the suspected tree and kept for 2 years in a containment facility (C. Manceau, Anses, personal communication, 19th November 2013). In 2012, *X. fastidiosa* was isolated from coffee plants (*Coffea*

arabica et *C. canephora*) growing in a confined glasshouse near Tours, France. This outbreak was eradicated (EPPO RS N°2012/165).

In October 2013, the occurrence of *X. fastidiosa* was reported in Southern Italy (near Lecce, Salento peninsula, Apulia region), causing quick decline symptoms on olive trees (*Olea europea*), oleander and almond (Saponari et al. 2013). Investigations showed that symptomatic olive trees were generally affected by a complex of pests: *X. fastidiosa*, several fungal species belonging to the genus *Phaeoacremonium* and *Phaemoniella*, and *Zeuzera pyrina* (leopard moth) (Nigro et al., 2013). Investigations are ongoing to delimit the outbreak area, genetically characterise the Apulian strain of *X. fastidiosa* and conduct epidemiological investigations.

5. Host plants

5.1. Host plants of *Xylella fastidiosa*

X. fastidiosa has a very broad list of host plants including monocotyledonous and dicotyledonous species, herbaceous and arboreous plants, cultivated crops and weeds, natural vegetation, riparian and ruderal species. This is evident from the host list of Pierce's Disease strains of *X. fastidiosa* compiled by the University of California Berkeley[4]. The strain causing Pierce's Disease of grapevine is classified within the subspecies *fastidiosa* (Nunney et al., 2013). This host list (attached to this report as Appendix B) includes 132 species from 46 different families in which the pathogen was isolated by the diagnostic test indicated in the table (Appendix B). Fifty-two of these species are recorded as present in Europe in the Flora Europaea database (RBGE, online), however the actual number of species from the list that are present in Europe is higher as for some of the European species distribution data is not available in the database.

A non-exhaustive list of main host plants of the other *X. fastidiosa* subspecies restricted to the hosts where the disease has been consistently shown in the field or demonstrated in the greenhouse is presented in Table 2. The hosts of the subspecies *multiplex* include important fruit crops such as almond, peach, plum, apricot and olive, but also oak, elm, Ginkgo, sunflower etc (Anonymous, 2005; Nunney et al., 2013). The list of non-symptomatic hosts is much larger (Rodrigo Almeida, University of California Berkeley, personal communication, November 2013). The host of the subspecies *pauca* is citrus (Schaad et al., 2004). The hosts of the subspecies *sandyi* include Oleander and some ornamental species (Anonymous, 2005; Nunney et al., 2013).

[4] See http://www.cnr.berkeley.edu/xylella/control/hosts.htm

Table 2: Symptomatic host plant specialisation of *X. fastidiosa* subspecies *multiplex*, *pauca* and *sandyi*. The table only includes the hosts where disease has been consistently shown in the field or demonstrated in greenhouse tests. The list of non-symptomatic hosts is much larger.

Subspecies	Common name	Host species	Family	Reference
multiplex	Almond	*Prunus dulcis*	Rosaceae	Nunney et al. (2013)
	Brittlebush	*Encelia farinose*	Asteraceae	
	Black sage	*Salvia mellifera*	Lamiaceae	
	Olive	*Olea europaea*	Oleaceae	
	Purple leaf plum	*Prunus cerasifera*	Rosaceae	
	Plum	*Prunus domestica*	Rosaceae	
	Peach	*Prunus persica*	Rosaceae	
	Apricot	*Prunus armeniaca*	Rosaceae	
	Periwinkle	*Vinca* sp.	Apocynaceae	
	Pin oak	*Quercus palustris*	Fagaceae	
	Red oak	*Quercus rubra*	Fagaceae	
	Turkey oak	*Quercus laevis*	Fagaceae	
	Oak species	Other oak species (*n* _ 5)	Fagaceae	
	Sweetgum	*Liquidambar styraciflua*	Altingiaceae	
	Redbud	*Cercis canadensis*	Fabaceae	
		Cercis occidentalis	Fabaceae	
	American sycamore	*Platanus occidentalis*	Platanaceae	
	American elm	*Ulmus Americana*	Ulmaceae	
	Green ash	*Ulmus crassifolia*	Ulmaceae	
	Annual sunflower	*Fraxinus pennsylvanica*	Oleaceae	
	Giant ragweed	*Helianthus annuus*	Asteraceae	
	Mexican hat flower	*Ambrosia trifida*	Asteraceae	
		Ratibida columnaris	Asteraceae	
	Ginkgo	*Ginkgo biloba*	Ginkgoaceae	Anonymous (2005)
	Crape myrtle	*Lagerstroemia indica*	Lythraceae	
	Liquidambar	*Liquidambar styraciflua*	Altingiaceae	
	Western redbud	*Cercis occidentalis*	Fabaceae	
pauca	Citrus	*Citrus*	Rutaceae	Schaad et al. (2004)
sandyi	Oleander	*Nerium oleander*	Apocynaceae	Anonymous (2005); Nunney et al. (2013)
	Day Lily	*Hemerocallis*	Hemerocallidaceae	
	Jacaranda	*Jacaranda mimosifolia*	Bignoniaceae	
	Southern Magnolia	*Magnolia grandiflora*	Magnoliaceae	

5.2. Conclusions on host plants of *Xylella fastidiosa* in Europe

In conclusion, with very low uncertainty, *X. fastidiosa* has a very broad host range including many cultivated and spontaneous plants common in Europe.

There is some hosts differentiation among the four subspecies with regard to symptomatic hosts, but many plants could be infected and remain asymptomatic.

There is high uncertainty with regard to the potential host range of *X. fastidiosa* in the European flora as a range of European wild plant species have never met the bacterium and it is not known whether they would be hosts, symptomatic or asymptomatic. In addition, as discussed below (Section 6), the potential European vectors of *X. fastidiosa* include many xylem-fluid feeding insect species that are different from the American known vectors and could therefore bring the bacterium in contact with a new host range.

6. Vectors

X. fastidiosa is a xylem-limited bacterium that in nature is exclusively transmitted by xylem-fluid feeding insects.

Xylem-fluid feeding insects belong to the order Hemiptera, sub-order Cicadomorpha (de Jong, 2013). They have sucking mouthparts (mandibular and maxillary stylets) that allow them to reach the xylem of plants, from which they ingest sap. Due to the very poor nutritional value of xylem fluid, xylem-fluid feeders ingest large amounts of crude sap and produce big amounts of liquid excretions. They are generally not direct pests unless present at very high population levels.

Within Cicadomorpha, the three superfamilies, *Cercopoidea*, *Cicadoidea* and *Membracoidea* include xylem-fluid feeding groups, but, while all Cercopoidea (known as spittlebugs or froghoppers) and Cicadoidea (cicadas) are regarded as xylem-fluid feeders, only the subfamily *Cicadellinae* (known as sharpshooters) within the family *Cicadellidae* are actually xylem-fluid feeders. It should be noted that other sap-sucking insects also feed on xylem. However, only these three groups of 'specialists' in xylem-fluid feeding have been shown to be vectors of *X. fastidiosa.*

Spittlebugs, cicadas and sharpshooters are heterometabolous insects that develop through egg, five nymphal stages and adult (winged) stages. Nymphs of cicadas and of spittlebugs of the family *Cercopidae* are subterranean root feeders, nymphs of spittlebugs of the family *Aphrophoridae* and of sharpshooters develop on the parts of host plants above the ground. All adults feed and live on the aerial parts of host plants.

The transmission of *X. fastidiosa* by insects is peculiar in that it does not require a latent period yet the bacteria are persistently transmitted (Almeida et al., 2005). Vectors (both nymphs and adults) acquire the bacteria by feeding in the xylem of an infected plant and can inoculate the pathogen to healthy plants immediately after acquisition, without the need for a latent period. Bacteria are restricted to the alimentary canal and do not infect systemically the insect body. They adhere to and multiply in the pre-cibarium (part of the foregut). This implies that vectors lose the infectivity with moulting, as the foregut is of ectodermal origin and is renewed with moulting. Therefore, newly emerged adults must feed on an infected plant to become infectious and spread *X. fastidiosa*. Once infected, adult vectors can transmit during their whole lifetime, because the bacterium multiplies and persists in the vector foregut (Almeida et al., 2005). The bacterium is not transovarially transmitted to the progeny of the vector (Freitag, 1951). Winged adults, due to their high mobility, are mostly responsible of *X. fastidiosa* spread. It is important to remember that, since the bacterium is restricted to the foregut (Purcell and Finlay, 1979), the number of bacterial cells per insect is low (very few live bacterial cells in the vector's foregut are required for transmission: Hill and Purcell, 1995) and therefore a sensitive diagnostic tool, like PCR, is needed to detect the presence of *X. fastidiosa* in the vector insects (ELISA test is not sensitive enough). Importantly, even PCR (or qPCR and other related methods) have so far not been shown to provide robust results (i.e. detection of *X. fastidiosa* in vectors is possible, but challenging even in a research setting).

On one hand *X. fastidiosa* transmission is restricted to xylem-fluid feeding insects, on the other hand, insect transmission of *X. fastidiosa* is known to be poorly specific and therefore all xylem-fluid feeding insects are considered vectors, until proven otherwise (Frazier, 1944; Purcell, 1989; Almeida et al., 2005). However, transmission efficiency varies substantially depending on insect species, host plant, and *X. fastidiosa* genotype (Redak et al. 2004; Lopes et al., 2010).

6.1. Non-European vectors of *Xylella fastidiosa*

Because *X. fastidiosa* has been found and studied primarily in the Americas, and causes disease in different crops in the Nearctic and Neotropics regions, its vectors have been identified and studied in these biogeographical areas only. Known vectors of *X. fastidiosa* are listed by Redak et al. (2004).

List of *X. fastidiosa* vectors in the Americas (modified from Redak et al., 2004)

Cicadellidae, Subfamily *Cicadellinae*, Tribe Cicadellini
Amphigonalia severini (DeLong)
Bucephalogonia xantophis (Berg)
Dilobopterus costalimai Young
Draeculacephala californica D. & F.
Draeculacephala crassicornis Van Duzee
Draeculacephala minerva Ball
Draeculacephala noveboracensis (Fitch)
Ferrariana trivittata (Signoret)
Graphocephala atropunctata (Signoret)
Graphocephala confluens (Uhler)
Graphocephala cythura (Baker)
Graphocephala hieroglyphica (Say)
Graphocephala versuta (Say)
Helochara delta Oman
Macugonalia leucomelas (Walker)
Paragonia confusa Oman
Paragonia furcata Oman
Paragonia tredecimpunctata Ball
Paragonia triundata Ball
Plesiommata corniculata Young
Parathona gratiosa (Blanchard)
Sonesimia grossa (Signoret)
Xyphon flaviceps (Riley)
Xyphon fulgida Nottingham
Xyphon triguttana Nottingham

Cicadellidae, Subfamily *Cicadellinae*, Tribe Proconiini
Acrogonia citrina Marucci & Cavichioli
Acrogonia virescens (Metcalf)
Cuerna costalis (F.)
Cuerna occidentalis Oman and Beamer
Cuerna yuccae Oman and Beamer
Friscanus friscanus (Ball)
Homalodisca vitripennis (=coagulata) (Germar)
Homalodisca ignorata Melichar
Homalodisca insolita (Walker)
Homalodisca liturata Ball
Oncometopia facialis (Signoret)
Oncometopia nigricans (Walker)
Oncometopia orbona (F.)

Cercopoidea, Aphrophoridae
Aphrophora angulata Ball
Aphrophora permutata (Uhler)
Philaenus leucophtalmus (L.)
Philaenus spumarius L.

Cercopoidea, Clastopteridae
Clastoptera brunnea Ball

Besides the above mentioned insects, cicadas are also xylem-fluid feeders, but their role in transmitting *X. fastidiosa* in very poorly understood. There are two reports noticing the possible role of cicadas in *X. fastidiosa* transmission (Paiao et al., 2002; Krell et al., 2007).

6.2. Potential European vectors of *Xylella fastidiosa*

With the exception of *Philaenus spumarius* (Aphrophoridae), an Old World species introduced in North America, all the American vector species are absent in Europe according to the Fauna Europaea database (de Jong, 2013). According to Janse and Obradovic (2010) only two species, *Cicadella viridis* and *Philaenus spumarius*, are possible vectors for Europe, but they did not consider all the xylem-fluid feeders, that, following Frazier (1944) and Purcell (1989) should be considered as potential vectors.

X. fastidiosa never established before in Europe and the identification of the vector(s) in the current Apulian outbreak of *X. fastidiosa* is still pending. For this statement, we have therefore considered that all xylem-fluid feeders in Europe have to be regarded as potential vectors (Frazier, 1944; Purcell, 1989).

A list of potential vectors of *X. fastidiosa* in Europe was drawn from the Fauna Europaea database (de Jong, 2013) using the following criteria: all the xylem-fluid feeding insects were included, provided that their presence was certain.

List of *X. fastidiosa* potential vectors in Europe

Cicadellidae, Subfamily Cicadellinae, tribe Cicadellini
Cicadella lasiocarpae Ossiannilsson (not reported in Italy)
Cicadella viridis (L.)
Graphocephala fennahi Young

Cicadellidae, Subfamily Cicadellinae, tribe Evacanthini
Evacanthus acuminatus (Fabricius)
Evacanthus interruptus (Linnaeus
Evacanthus rostagnoi (Picco)

Cicadellidae, Subfamily Cicadellinae, tribe Anoterostemmatini
Anoterostemma ivanoffi (Lethierry)

Cicadellidae, Subfamily Cicadellinae, tribe Errhomenini
Errhomenus brachypterus Fieber (not reported in Italy)

Cercopoidea, Aphrophoridae
Aphrophora alni (Fallen)
Aphrophora corticea (Germar)
Aphrophora major Uhler
Aphrophora pectoralis Matsumura
Aphrophora salicina (Goeze)
Aphrophora similis Lethierry (not reported in Italy)
Aphrophora willemsi Lallemand (not reported in Italy)
Lepyronia coleoptrata (Linnaeus)
Neophilaenus albipennis (Fabricius)
Neophilaenus campestris (Fallen)
Neophilaenus exclamationis (Thunberg)
Neophilaenus infumatus (Haupt)
Neophilaenus limpidus (Wagner)
Neophilaenus lineatus (Linnaeus)

Neophilaenus longiceps (Puton) (not reported in Italy)
Neophilaenus minor (Kirschbaum)
Neophilaenus modestus (Haupt) (not reported in Italy)
Neophilaenus pallidus (Haupt) (not reported in Italy
Paraphilaenus notatus (Mulsant & Rey) (not reported in Italy)
Peuceptyelus coriaceus (Fallen)
Philaenus italosignus Drosopoulos & Remane
Philaenus lukasi Drosopoulos & Asche (not reported in Italy)
Philaenus maghresignus Drosopoulos & Remane (not reported in Italy)
Philaenus signatus Melichar (not reported in Italy)
Philaenus spumarius (L.)
Philaenus tarifa Remane & Drosopoulos (not reported in Italy)
Philaenus tesselatus Melichar (not reported in Italy)

Cercopoidea, Cercopidae
Cercopis arcuata Fieber
Cercopis intermedia Kirschbaum
Cercopis sabaudiana Lallemand
Cercopis sanguinolenta (Scopoli)
Cercopis vulnerata Rossi
Haematoloma dorsata (Ahrens)
Triecphorella geniculata (Horvath) (not reported in Italy)

As stated before, cicadas are xylem-fluid feeders and also expected to be potential vectors, although their role in *X. fastidiosa* transmission is poorly understood. In Italy, about 16 species of cicadas are known, in the families *Cicadidae* and *Tibicinidae*, while about 60 species are reported in Europe, most having a very restricted area of distribution (de Jong, 2013).

Sharpshooters (Cicadellidae subfamily Cicadellinae) are by far the most important vectors of *X. fastidiosa* in the Americas and only few are present in Europe (Wilson et al., 2009). One species, *Cicadella viridis*, is widespread in Europe but only common in humid areas. On the contrary a relatively high number of spittlebug species, which are less important vectors in America, occur in Europe and some, like *Philaenus spumarius*, are very common.

It has to be noted that, while the sharpshooters in America overwinter as adult and when infected can maintain *X. fastidiosa* during winter, the European sharpshooters (Cicadellidae, Cicadellinae) and most of the European spittlebugs (Aphrophoridae, with the exception of few Cercopidae) overwinter as egg (Nickel and Remane, 2002) and therefore, if infected, cannot sustain overwintering of *X. fastidiosa*, since transovarial transmission of *X. fastidiosa* does not occur (Freitag, 1951).

6.3. Conclusions on vectors

All xylem-fluid feeding insects in Europe have to be regarded as potential vectors, including insects from the families Cicadellidae, Aphrophoridae, Cercopidae**,** Cicadidae and Tibicinidae. The identification of the vector of *X. fastidiosa* in the Apulian outbreak is pending.

7. Pathways

7.1. Entry

Recent interceptions of plants for planting and outbreaks of *X. fastidiosa* (see Sections 4.1 and 4.2) show that there is a probability of entry for *X. fastidiosa*. Several theoretical trade pathways can be identified for the entry, as well as for the spread, of *X. fastidiosa.* According to Anses (2012), the entry pathways are plants for planting of host plants of *X. fastidiosa*, citrus fruit and seeds (the latter with uncertainty). In addition detached wood, cut flowers and green ornamental foliage with branches are also discussed in the following sections.

Due to the persistence of the pathogen in the vectors, *X. fastidiosa* can be carried by infected plant material but also by infective vectors (adults and nymphs) on a consignment. The pathways of plant parts such as fruit, cut flowers, cut foliage and wood (detached branches) can be considered as minor pathways because successful establishment following entry requires transfer of the bacteria to a suitable host. Vector transmission would require the concomitant presence, in close vicinity of the infected plant part, of a vector and a susceptible host plant, but it also would require that infected plant part such as fruit, cut flower, cut branches or wood would retain their attractiveness for the insect vectors. Although the risk of such a scenario cannot be excluded, the overall probability of this transfer is rated as unlikely.

Entry of infected plant material intended for planting assures establishment. Plants for planting and infective vectors are considered as major pathways and will be further assessed in detail.

7.1.1. Minor pathways

Citrus fruit was considered by Anses (2012) as a entry pathway but no details were provided. Li et al. (2003) detected *X. fastidiosa* by PCR in fruit, as well as in germinated seedlings, from sweet orange (*Citrus sinensis*) plants infected with citrus variegated chlorosis disease. However, no further analysis were conducted and transmission by vectors from infected fruit has not been tested. The risk of table grape fruit clusters as a source of inoculum of *X. fastidiosa* has been reviewed by the Australian Quarantine and Inspection Service (AQIS, 2010) and considered not epidemiologically significant. This is because eggs of vectors (sharpshooters) are not laid on grape clusters; sharpshooter vectors are easily disturbed and unlikely to occur on harvested grape clusters as hitch-hikers and the concentration of *X. fastidiosa* in grape clusters is very low. Also grape clusters showing PD symptoms are not likely to be harvested and traded; survival of the *X. fastidiosa* is low under normal in-transit cold storage regimes and the likelihood of inoculum bearing fruit being fed upon by potential Australian insect vectors is extremely low. Similar conclusions were reached also for stone fruit (Biosecurity Australia, 2010). In fact, with regard to transfer to a suitable host, for grapes, Purcell and Saunders (1995) demonstrated that, when the blue-green sharpshooter *Graphocephala atropunctata* and the green sharpshooter *Draeculacephala minerva* were let to feed on grapevine fruit clusters from PD-infected vines, the vectors were not able to transmit *X. fastidiosa* to healthy grapevines. In addition, cold storage at 4 °C, that is common practice for transport and storage of citrus and grapes, was shown to strongly affect *X. fastidiosa* viability in grape clusters (Purcell and Saunders, 1995). Overall, the entry through this pathway is considered therefore as very unlikely with low uncertainty.

Regarding seeds as possible pathway, the only study identified was that of Li et al. (2003) who have shown the presence of *X. fastidiosa* in seeds of sweet orange (*Citrus sinensis*) and also shown that the bacteria can be transmitted from the seeds to the seedlings (Li et al, 2003) The uncertainty related to seed transmission is considered high because only one study was conducted in only one species out of the wide host range and the experiment was stopped soon after germination. The entry through this pathway is therefore considered as unlikely with high uncertainty due to lack of studies.

With regard to wood detached from the plant (for processing, not for plant propagation purposes), since xylem-fluid feeders are adapted to suck sap with negative (xylem) pressure the probability that a xylem-fluid feeding insect would transfer the bacterium from detached wood to a host plant is considered very unlikely. The vector *Homalodisca vitripennis* was shown to transmit *X. fastidiosa* to 2-year old woody tissue of live grapevines plants (Almeida and Purcell, 2003), but no data is available on transmission from detached wood, therefore the uncertainty is high. The entry through this pathway is therefore considered as very unlikely with high uncertainty.

Transport and storage of cut flowers and ornamental foliage are done at low temperatures, however not for long periods, therefore these conditions are not expected to affect *X. fastidiosa* viability. This pathway is considered having a probability of transfer to host rated as unlikely because the cut flowers or cut ornamental foliage are expected not being sufficiently attractive for xylem-fluid feeders and

their in house decorative use is not expected to favour transfer by vector to natural environments or crops. The same applies for citrus fruit with leaves. Uncertainty is high because of lack of specific studies. The entry through this pathway is therefore considered as unlikely with high uncertainty.

7.1.2. Plants for planting (excluded seeds)

Entry of the pathogen into EU territory by the movement of plants for planting is considered the most important pathway. Since *X. fastidiosa* has more than 150 hosts and many of them are imported (often as planting material) into Europe, risk of introduction of the pathogen (especially with asymptomatic plants) cannot be underestimated (Janse, 2012).

7.1.2.1. Probability of association with the pathway at origin

The pathogen has a very wide host range in many botanical families including Monocotyledonous and Dicotyledonous (Anses, 2012; see Section 5). Diseases caused by *X. fastidiosa* are reported on many crops and plants in the regions of the Americas where *X. fastidiosa* is present. The organism has been intercepted twice in France in infected coffee plants from South and Central America, indicating that entry can occur via plant propagation material even on plants which are not cultivated in the EU. Although importation of citrus and grapevine plants into the EU is currently forbidden, trade of other hosts such as ornamental plants exists with huge volumes of plant species traded and rapid transport allowing survival of pest and their vector insects (EPPO, 2012). The recent interceptions of coffee plants in France infected with *X. fastidiosa*, show that the probability of association with the plants for planting pathway can be rated as likely, with low uncertainty, however with variations due to origin, crop, type of material (certified vs. non-certified).

7.1.2.2. Probability of survival during transport and storage

When infecting plants for planting, the pathogen is transported in living plant material and is likely to survive both transport and storage particularly for potted plants which are transported at mild temperatures not expected to influence significantly the viability of the pathogen. Dormant plants of *Vitis* are conserved and transported at lower temperature, however *X. fastidiosa* can survive in grapevines dormant plant material in the vineyard and if grape plant material is cut and stored over the winter at 4 °C, following year, after rooting, it can still be infected (Rodrigo Almeida, University of California Berkeley, USA, personal communication, November 21st, 2013). Overall, the probability of the pathogen to survive transport and storage is rated as likely, with low uncertainty.

7.1.2.3. Probability of surviving existing management procedures

The pathogen is regulated in Annex IAI of Council Directive 2000/29/EC[5] meaning that its introduction into the EU on any plant species is banned, and plants would be subjected to inspection upon entering the risk assessment area. However, since *X. fastidiosa* infections often remain symptomless (e.g. Purcell and Saunders, 1999), visual inspection is not reliable in detecting infected plants. Asymptomatic or poorly symptomatic plants can escape inspection and therefore *X. fastidiosa* infection may be overlooked in a range of situations. Visual inspection of dormant materials is inappropriate to detect the pathogen. In addition, *X. fastidiosa* is listed in the EU plant health directive but no specific requirements are indicated for the plant propagation material. Since (1) the list of *X. fastidiosa* hosts is not directly addressed in the legislation, (2) there is no specific requirement indicated for plant propagation material for *X. fastidiosa* and, finally, (3) infected hosts can escape visual inspections as explained above, the probability of surviving existing management procedures is rated as very likely, with low uncertainty.

7.1.2.4. Probability of transfer to a suitable host

Upon entering the risk assessment area with infected plant material, the pathogen is already in a suitable host to be planted and grown, therefore transfer to a suitable host is immediate. The further

[5] Council Directive 2000/29/EC on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community. OJ L 169, 10.7.2000, p. l-112.

dispersal by vectors of *X. fastidiosa* from the imported infected plants to local neighbouring plants susceptible to *X. fastidiosa* is expected to occur with high efficiency because of the wide host range of the pathogen and the large number of European potential xylem-fluid feeding vectors (see Section 6.2). Many of the hosts of *X. fastidiosa* (Section 5.1) are grown in Southern Europe in commercial plantations, natural and ruderal vegetation, alleys, parks or gardens (e.g. peach, plum, almond, apricot, olive, citrus, grapes, oak, magnolia, Gingko, oleander, sunflower, alfalfa, ragweed, Bermuda grass etc.). Overall the probability of transfer of *X. fastidiosa* to a suitable host considering the plants for planting pathway is rated as very likely with low uncertainty.

Overall the probability of entry through the pathway of plants for plantings is rated as likely with low uncertainty.

7.1.3. Infective vectors of *Xylella fastidiosa* as pathway

The assessment of the probability of introduction of exotic *X. fastidiosa* vector species is outside the scope of this statement and of this section. In this section, only the probability of entry of *X. fastidiosa* with infective vectors on plant consignments is considered. Due to the persistence of the bacterium in vector adults, *X. fastidiosa* can be easily carried on a consignment of plants for planting as well as on other plant materials such as cut flowers and cut green ornamental foliage. If those plants are infected, offspring from hatched eggs will acquire the pathogen and become infective and will contribute to further dissemination.

7.1.3.1. Probability of association with the pathway at origin

There is no data in the Europhyt database (Europhyt, online) on interceptions of the *X. fastidiosa* vector. The vectors as listed in Section 6.1 may be carried with the plants as eggs, nymphs or adults. The probability of association of an infective vector with the consignment at the origin would be medium to high from non-certified outdoors crops and negligible to low for certified production under screenhouse. The high likelihood includes the consideration on the high number of vectors or potential vectors, the high number of host plant species and the high prevalence of the pathogen in areas of its current distribution. Application of insecticides before shipment may reduce this likelihood (see Section 9.2.3.6). Uncertainty of the assessment is high due to lack of data on frequency of xylem-fluid feeding insects in traded consignments.

7.1.3.2. Probability of survival during transport and storage

We could not find specific studies determining survival of *X. fastidiosa* vectors or more generally, xylem-fluid feeding insects during transport and storage of plant consignments. However, the survival of the glassy-winged sharpshooter, *H. vitripennis*, was studied under constant temperatures and feeding conditions for up to 3 weeks. This study showed that continuous exposure to either low (<5 °C) or high (>30 °C) temperatures are detrimental for adult survival and that low temperatures (threshold lies between 7.8 and 13.2 °C) caused early mortality because of inhibition of feeding activity (Son et al., 2009). Without food, only with water, adults could survive 16 days at 13 °C, whereas, when provided with a citrus plant to feed, ca. 75 % of the adults survived 3 weeks at temperatures between 13 °C and 24 °C. Assuming these data can be extrapolated to other species, the probability of survival of nymphs or adults during transport and storage is low at low temperatures and for long periods e.g. with consignments of dormant plants, whereas is high with consignments of potted plants with leaves that are transported and stored at milder temperatures, provided that these plants are not sprayed with insecticides. Uncertainty is medium due to lack of data for the various vector species.

7.1.3.3. Probability of surviving existing management procedures

Xylem-fluid feeding vectors, sharpshooters and spittlebugs, can be detected by visual inspection, therefore culling and visual selection measures during preparation of consignments of plants for planting are likely to detect an infestation. The same applies for phytosanitary inspection. The

probability of surviving/escaping existing management procedures is low to moderate depending on the sampling procedure. Uncertainty is low.

7.1.3.4. Probability of transfer to a suitable host

The vector species are mobile xylem-fluid feeders with a wide host range. Therefore, the probability of transfer to a suitable host is rated as likely with low uncertainty.

Overall the probability of entry through the pathway of infective vectors of *X. fastidiosa* transported on plant consignments is rated as negligible to likely, depending on type and treatment of the consignment, with high uncertainty due to lack of specific data.

7.1.4. Conclusions on entry pathways

The main entry pathway for *X. fastidiosa* is the trade and movement of plants for planting (excluded seeds). The pathway of infective vectors of *X. fastidiosa* transported on plant consignments is also of concern. Fruit and wood (not for plant propagation purposes) are considered as minor pathways with negligible likelihood of entry, whereas seeds, cut flowers and ornamental foliage are minor pathways with low likelihood of entry. Uncertainty is low for the plants for planting pathway and high for the others.

8. Spread

8.1. Spread by natural means

The only route of natural spread of *X. fastidiosa* is by insect vectors, mainly sharpshooters and froghoppers or spittlebugs Transmission is very rapid because there is no latency period for transmission. There is no trans-stadial or transovarial transmission of the bacterium. The pathogen persists and multiplies in the foregut of the adult vectors that can remain infective throughout their lifespan (Almeida et al., 2005). The potential vector species in the EU are listed in Section 6.2.

Dispersal seems to be primarily limited by the short range leafhoppers generally fly that is about 100 m for *H. vitripennis* (Blackmer et al., 2004) with a similar range reported for other leafhopper species, e.g. *Scaphoideus titanus* (Lessio and Alma, 2004). In addition, leafhoppers can be transported by wind over long distances, for example the aster leafhopper is carried from the Gulf Coast states of Texas, Louisiana, Arkansas, and Oklahoma to Ohio, Wisconsin, and the Northern Great Plains (Hoy et al., 1992) and thus wind contributes to long distance dissemination. Sharpshooters and spittlebugs are much larger compared to the aster leafhopper and therefore wind transportation could be less efficient.

8.2. Spread by human assistance

Infected nursery trees are an efficient way of long-distance dispersal because vegetative propagation through grafting is widely used for most long-lived perennial *X. fastidiosa* hosts; transportation of live plant tissue is a common practice in the various agricultural industries affected by this pathogen, eventually increasing its geographic distribution (Almeida et al., in press). As described by Almeida et al. (in press), transmission by infected plant material was probably the main mode of spread of the CVC disease within Brazil to areas far from the initial foci in São Paulo state. Two factors are considered to have been important in this initial spreading: (1) the long incubation period required for symptom expression, and (2) the fact that the bacterium can be transmitted from plant material taken from infected but yet asymptomatic plants used for grafting. Since the production of healthy nursery trees under vector-proof screen houses became mandatory, the tree-to-tree transmission of *X. fastidiosa* by vectors is the major, if not only, form of bacterial spread in São Paulo state (Almeida et al., in press).

8.3. Conclusions on spread

The only route for natural spread of *X. fastidiosa* is by insect vectors that generally fly short distances up to 100 metres, but can be transported by wind over long distance.

The movement of infected plants for planting is the most efficient way for long-distance dispersal of *X. fastidiosa*.

9. Risk reduction options

The identified risk reduction options are rated for their effectiveness, technical feasibility and uncertainty as described in the tables of Appendix A. First, in Section 8.1, the current phytosanitary measures related to *X. fastidiosa*, its vectors and host plants in the EU are presented and discussed. Then, in Section 8.2 risk reduction options to reduce the probability of entry, establishment and spread of *X. fastidiosa* are systematically identified and evaluated for the main pathway of plants for planting.

It is recommended that the evaluation of risk reduction options is further assessed once a complete pest risk assessment for *X. fastidiosa* is available for the EU and more knowledge has been acquired on the Apulian outbreak of *X. fastidiosa*.

9.1. Review of current measures in Europe

9.1.1. In the EPPO region

X. fastidiosa is included in EPPO A1 List of pests recommended for regulation as quarantine pests. *Homalodisca vitripennis*, *Xyphon fulgida* (= *Carneocephala fulgida*), *Draeculacephala minerva*, and *Graphocephala atropunctata* which are considered to be important vectors of Pierce's disease are also listed in the A1 List.

9.1.2. In the European Union

Xylella fastidiosa (Well and Raju) is listed in Annex I Part A Section I of the Council Directive 2000/29/EC as a harmful organism not known to occur in any part of the community and relevant for the entire community, whose introduction into, and spread within, all Member States shall be banned. However no specific requirements are defined in the directive for plants, plant parts or plant products of host plants of *X. fastidiosa*. In addition, a disease caused on citrus by *X. fastidiosa*, the Citrus variegated chlorosis, is listed in Annex II Part A Section I of the Council Directive 2000/29/EC as a harmful organism whose introduction into, and spread within, all Member States shall be banned if it is present on plants of *Citrus* L., *Fortunella* Swingle, *Poncirus* Raf., and their hybrids, other than fruit and seeds.

Following the rules cited above, *X. fastidiosa* should be absent from host plants exported to the European Union and the phytosanitary certificate issued by the exporting country should be delivered in compliance with this requirement. However, in the absence of specific requirements in Annex IV A this requirement may be difficult to implement in practice by the exporting countries. Import inspections are carried out upon entering the European Union from Third Countries, however, hosts may be symptomless and therefore *X. fastidiosa* infection may be overlooked.

With regards to the vectors of *X. fastidiosa*, Annex I Part A Section I makes the provisions that Cicadellidae (non-European), known to be vector of Pierce's disease (caused by *X. fastidiosa*), such as *Xyphon fulgida* (named in the Council Directive as *Carneocephala fulgida*), *Draeculacephala minerva* and *Graphocephala atropunctata*) are harmful organism not known to occur in any part of the community and relevant for the entire community, and whose introduction into, and spread within, all Member States shall be banned. No specific requirements are defined in the directive for plants, plant parts or plant products of host plants of these Cicadellidae.

The vectors of *X. fastidiosa* listed in Annex IAI cover the Cicadellidae (non-European) known to be vector of Pierce's disease (caused by *X. fastidiosa*) but Cercopoidea vectors are not covered.

Among the cultivated host plants of *X. fastidiosa*, the Council Directive 2000/29/EC states that:

- the introduction of plants of *Citrus* L., *Fortunella* Swingle, *Poncirus* Raf. and their hybrids, other than fruit and seeds, originating in Third Countries, is prohibited (Annex III part A, item 16);
- the introduction of plants of *Vitis* L., other than fruit, originating in Third Countries other than Switzerland, is prohibited according to Annex III part A item 15.
- the introduction into the EU of plants intended for planting for *Prunus* L., originating from Non European Countries is forbidden, with the exception of dormant *Prunus* plants (free from leaves, flowers and fruit) from Mediterranean countries, Australia, New Zealand, Canada and the continental states of the USA (Annex III part A item 9 and item 18).

In the case of the genus *Prunus*, that includes major hosts of the pathogen, according to the Annex IIIA 18, dormant plants for planting may be introduced from the continental states of the USA where the pathogen is known to occur and therefore introduction of *X. fastidiosa* through this pathway cannot be excluded.

For internal trade within the common market area of the European Union, plants and plant products that are listed in Annex V part A Section I of the Council Directive 2000/29/EC should be accompanied by a plant passport issued following plant health inspection(s). In addition, specific requirements may be requested for the internal EU trade when plants of plant products are destined for a protected zone (pest free area) within the EU or in case of emergency measures following an outbreak of a new pest. The list of plants and plant products accompanied by plant passport only covers partially the full list of hosts of *X. fastidiosa*.

In addition, Member States may, in so far as there is no risk of spread of harmful organisms, exempt small producers whose entire production and sale of relevant plants, plant products and other objects are intended for final usage by persons on the local market and who are not professionally involved in plant production (local movement) from official registration. Local movement of plants, plant products and other objects originating from such producers may be exempted from the official inspections and plant passport requirements (see Article 6 of the Council Directive 2000/29/EC). In case of outbreaks of *X. fastidiosa*, considering the very wide host range, the exemption from official inspections and plant passport requirements for the local movement of plants, plant products and other objects originating from small producers could result in an additional pathway for spread of the pathogen.

9.2. Identification and evaluation of risk reduction options to reduce the probability of entry and spread for the pathway plants for planting

In Sections 9.2.1, 9.2.2 and 9.2.3 below, the identified risk reduction options are valid for both preventing the entry of *X. fastidiosa* into the EU from Third Countries and preventing its spread from the area of an outbreak into other areas in the EU.

9.2.1. Options ensuring that the area, place or site of production at the place of origin, remains free from *Xylella fastidiosa*

9.2.1.1. Limiting import to plants for planting originating in pest-free areas

ISPM 4 (FAO, 1995) describes the components to consider when establishing and delimiting pest free areas. A 'pest free area' is 'an area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained'. It can be an entire country, an uninfested part of a country in which a limited infested area is present, or an uninfested part of a country within a largely infested area.

Pest freedom of the area must be supported by general surveillance, delimiting surveys to demarcate the area and detection surveys to demonstrate the absence in the area and its buffer zone (EFSA Panel on Plant Health, 2012). When the pest free area is within a country where an infested area is present,

measures must be in place to prevent the movement of infested material into the pest free area and to prevent natural spread of the pest into the area. Surveys for *X. fastidiosa* should include inspection and testing of crops as well as of natural, riparial or ruderal vegetation, owing to the very wide host range. Survey observations should always be confirmed by appropriate diagnostic methods, due to the presence of asymptomatic infections, the possible similarity with symptoms of other diseases as well as the partially different host range for the various subspecies or strains of *X. fastidiosa.* Aerial photos and crop maps may offer a tool for survey of large surfaces and first identification of diseased crops. Appropriate sampling techniques need to be applied for more efficient surveillance. Variability in host susceptibility and symptoms expression should also be taken into account in the inspection and monitoring programmes.

When the import of plants for planting of hosts of *X. fastidiosa* is restricted to material originating in pest free areas, the probability of introduction of *X. fastidiosa* into the risk assessment area is reduced. The effectiveness depends on the frequency and the confidence level of detection surveys to confirm absence of *X. fastidiosa* in the pest free area and the buffer zone, and the intensity of phytosanitary measures to prevent entry of infected plant material into the pest free area. The design and frequency of surveys to confirm absence of *X. fastidiosa* in the area and the buffer zone should take into account the presence of unmanaged host plants in private gardens and uncultivated areas and the possible presence of latently infected plants, in order to accomplish the required confidence level of the surveys.

The effectiveness is assessed as high. The establishment and maintenance of a pest free area for *X. fastidiosa* is technically feasible, but surveys with adequate attention to the distribution of managed and unmanaged host plants in the pest free area should be performed when designating the pest free area and its buffer zone. The technical feasibility is assessed as high. The uncertainty of these ratings is low.

9.2.1.2. Limiting import to host plants for planting originating in pest-free production places or pest-free production sites

ISPM 10 makes provisions that:

A pest free place of production is a place of production in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained for a defined period.

A pest free production site is a defined portion of a place of production in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained for a defined period and that is managed as a separate unit in the same way as a pest free place of production**.**

ISPM 10 (FAO, 1999) indicates that depending on the pest concerned, local circumstances and the acceptable level of risk for the importing country, an adequate level of security may be achieved by different intensities of measures, ranging from a simple growing-season inspection in the year of export to a complex system of surveys and supporting procedures maintained over several years.

The concept of a pest free place of production can be applied to any premises or collection of fields operated as a single production unit. The producer applies the required measures to the entire place of production.

Where a defined portion of a place of production can be managed as a separate unit within a place of production, it may be possible to maintain that site pest free. In such circumstances, the place of production is considered to contain a pest free production site.

In order to comply with this phytosanitary measure the pest should comply with certain characteristics such as:

- the natural spread of the pest (or its vectors, if appropriate) is slow and over short distances;
- the possibilities for artificial spread of the pest are limited;
- the pest has a limited host range;
- the pest has a relatively low probability of survival from previous seasons;
- the pest has a moderate or low rate of reproduction;
- sufficiently sensitive methods for detection of the pest are available, either by visual inspection or by tests applied in the field or in the laboratory, at the appropriate season;
- as far as possible, factors in the biology of the pest (e.g. latency) and in the management of the place of production do not interfere with detection.

In the case of *X. fastidiosa* infections, the pathogen and its vectors (and its potential vectors in Europe) have a wide host range and would not comply with the characteristics above. The effectiveness of designation and maintenance of pest free production places or pest free production sites with respect to *X. fastidiosa* within an infested areas is assessed would be high but its feasibility is low, because of the very wide host range (see Section 5), the large numbers of xylem-fluid feeding vector species (see Section 6) that can spread naturally up to 100 m and at longer distances by wind (see Section 7) and the possible presence of asymptomatic infections. Uncertainty is low. Feasibility may be increased in case of system approach where this option is integrated with other risk reduction options such as growing plants under exclusion (screenhouses).

9.2.2. Options preventing or reducing *Xylella fastidiosa* infestation in the crop at the place of origin

9.2.2.1. Treatment of the crop, field or place of production in order to reduce pest prevalence

Control of the disease

There is no effective control method currently available to eliminate the pathogen *X. fastidiosa* from infected plants, however there are some examples where symptom reduction was obtained: N-Acetylcysteine, an analogue of cysteine used in medicine as mucolyitic agent, was recently shown to induce a significant symptom remission and a reduced bacterial growth rate of *X. fastidiosa* in CVC-diseased sweet orange potted plants when supplied in hydroponics, fertirrigation solutions or adsorbed to organic fertiliser (Muranaka et al., 2013); inoculation in greenhouse and in vineyards with naturally occurring strains of *X. fastidiosa* that were weakly virulent or avirulent to grapevine showed some reduction in symptoms development in *Vitis vinifera* (Hopkins, 2005); pruning of sweet orange trees was reported in Brazil having an effect on the reduction of symptoms of citrus variegated chlorosis (CVC) (Amaral et al., 1994). In general, Hopkins and Purcell (2002) state that the cultural practices that maintain the grapevine in a healthy, actively growing condition can help reduce the severity of symptoms of PD.

Control of the vector to reduce the prevalence of *X. fastidiosa* in the crop

X. fastidiosa is transmitted by many different hopper species (Section 6), so the epidemiology of the different epidemics can be different, even for the same disease in different areas. For example the Pierce's Disease spread in central-northern California is due to primary infections, whereas in southern California secondary spread by the vector *H. vitripennis* is very important.

When primary infections (incoming infected insect vector from outside the crop) are prevalent or exclusive (such as in central-northern California), insecticide applications are less effective: the vectors live outside the crop and visit the crop over a long period, transmitting the pathogen even with

a very short feeding (Almeida et al., 2005). When secondary infections are important (within the crop, as for the vector *H. vitripennis* in Southern California), insecticide applications can be more effective because they target the vector population that live in the crop and can successfully reduce the vector population (Almeida et al., 2005; Bosco, in press). Sharpshooters and spittlebugs are susceptible to a number of insecticides (Prabhaker et al., 2006 a and b) and particularly to neonicotinoids that have also been reported to reduce the incidence of *X. fastidiosa* diseases (Krewer et al., 1998; Bethke et al., 2001). Sharpshooters and spittlebugs are unlikely to develop resistance to insecticides because they only have one or two generations per year and they are not very prolific.

A successful biocontrol of *H. vitripennis* has been achieved in French Polynesia with the introduction of the egg parasitoid *Gonatocerus ashmeadi* (Grandgirard et al., 2008); however, with *X. fastidiosa* absent from French Polynesia it is not possible to know whether the biocontrol of the vector would also result in a significant reduction of the spread of *X. fastidiosa*.

In conclusion it is difficult to control the spread of *X. fastidiosa* diseases in cultivated fields or orchards by spraying insecticides against the vectors, unless the epidemiology is very clear and the secondary spread within the crop is of major importance (as in Southern California). Therefore, the effectiveness of *X. fastidiosa* vectors control in fields or orchards production can be from low to moderate depending on the vector(s) and on the epidemiology of the disease. The vectors and the epidemiology of the *X. fastidiosa* outbreak in olive trees in Italy are not yet known.

The effectiveness of vector(s) control in nurseries of plant propagation material can be increased if the crop is grown under screenhouse or greenhouse (see Section 9.2.2.3).

9.2.2.2. Resistant or less susceptible varieties

Rashed et al. (2013) studied the relative susceptibility of *Vitis vinifera* cultivars to *X. fastidiosa* and indicated that within *V. vinifera* the degree of cultivar resistance and tolerance varies over time. Research is ongoing to develop genetically modified varieties with resistance to *X. fastidiosa* (De Paoli et al., 2007), The effectiveness of resistant or tolerant varieties is high, but, considering the very wide host range of *X. fastidiosa* and the time needed to breed and introduce new resistant varieties, the feasibility is rated as low.

9.2.2.3. Growing plants under exclusion conditions (glasshouse, screen, isolation)

Plants for planting can be grown in screenhouse or greenhouse nurseries that effectively can exclude insects. One example is the control of the Citrus variegation clorosis (CVC), a citrus disease caused by *X. fastidiosa* in Brazil where a major contribution came from growing all the citrus nursery plant production system (rootstock, budwood and plants, including mother plants) under screenhouse (Carvalho et al., 2002). Screen barriers have also been shown to reduce the movement of *X. fastidiosa* vectors into vineyards or plant nurseries (Blua and Redak, 2003; Almeida et al., 2005). To prevent virus and phytoplasma infections in the propagated material, mother plant vineyards can be grown under a cover of an insect-proof tunnel with double room entrance (Mannini, 2007).

The effectiveness of this option is assessed as high, provided that the planting material introduced in the screen house is free of *X. fastidiosa*. Technical feasibility is high, because it is a common practice already implemented in Mediterranean countries for control of viral diseases in citrus nurseries as well as for other tree crops, including grapevines. The uncertainty is low.

9.2.2.4. Harvesting of plants at a certain stage of maturity or during a specified time of year

Not applicable.

9.2.2.5. Certification scheme

Certification schemes have been developed worldwide for citrus plants for planting (e.g. Von Broembsen and Lee, 1988; Passos et al., 2000; Vidalakis et al., 2010: Australian Citrus Propagation Association Inc., undated) as well as for other fruit tree crops. After the CVC outbreak of 1987, a

voluntary certification scheme of the Sao Paulo State in Brazil has been implemented for the production of citrus budwood and nursery trees free of graft and vector-transmissible diseases, including CVC (Carvalho et al., 2002). It is now a common practice that all the citrus nursery plant production system (rootstock, budwood and plant) are under screenhouse, including the mother plants. Moreover, there is a restriction of citrus vegetative material from the others Brazilian States that do not have a certification program in run. Every lot (2000 plants) of citrus nursery plants commercialised must be tested against *X. fastidiosa* and other diseases and pests by sampling the plants into the lot and mixing the material.

In general, certification schemes for plants for planting free of *X. fastidiosa* can have high effectiveness and feasibility, with low uncertainty.

9.2.3. Options for consignments

9.2.3.1. Prohibition

Prohibition of import of plants for planting of host plant species of *X. fastidiosa* from the areas of its current distribution would prevent the entry of *X. fastidiosa* into the risk assessment area along this pathway, which is considered the most important one. The effectiveness is assessed as very high, however feasibility is limited by the very broad host range of *X. fastidiosa*. Uncertainty is high due to the lack of extensive studies on the host range of some subspecies/strains of *X. fastidiosa*, as well as owing to the possibility of changes in the host range of a specific strain of *X. fastidiosa* due to mutations/recombination or to the finding of new vector-host combinations in new areas (Almeida, 2008).

This measure is partially applied in the Directive 2000/29/EC, by the prohibition of import of citrus and grapevines plants and by the partial prohibition of *Prunus* plants (see Section 8.1.1.2).

9.2.3.2. Prohibition of parts of the host or of specific genotypes of the host

All parts of host plants for planting may carry *X. fastidiosa*, therefore this risk reduction option is not applicable to the pathway of plants for planting.

With regard to the xylem-fluid feeding vectors infected with *X. fastidiosa* that could be carried as 'hitchhikers' on healthy plants, the import of dormant plants without leaves could represent a risk reduction option only for insects overwintering as eggs (as there is no transovarial transmission), as it seems the case for most of the European potential vectors, but not for some of the American vectors overwintering as adults.

9.2.3.3. Pest freedom of consignments: inspection or testing

The effectiveness of visual inspection of consignments of plants for planting to reduce the probability of entry is assessed as low because of the possibility of asymptomatic infections. In addition plants for planting of fruit trees can also be imported as dormant plants without leaves, thus making visual inspection unreliable. The effectiveness of testing is assessed as moderate, however if there is a low incidence of plants infected by *X. fastidiosa* within a consignment, sample size can affect the probability to include such plants in the sample.

The technical feasibility is assessed as moderate because of the difficulty of representative sampling, inspecting and testing consignments of plants, when plants are not tested individually and subjected to post-quarantine containment. The uncertainty on these ratings is medium.

This option would be instead relevant and could have a higher effectiveness and feasibility for detection of the infective insect vectors, that can be carried on the plants in the consignment.

9.2.3.4. Pre- or post-entry quarantine system

Pre- or post-entry quarantine systems may be developed for small consignments in commercial trade of plants for planting. Post-entry quarantine is normally applied for import of nursery stock in EU Member States (Commission Directive 2008/61/EC[6]), as well as in other countries (e.g. Vidalakis et al., 2010). The effectiveness of pre- and post-entry quarantine systems depends on the level of containment established by the quarantine facilities, the quarantine period, and the methods and intensity of inspection and testing during the quarantine period. When very high standards for containment by the quarantine facilities are applied, the effectiveness is assessed as high. The technical feasibility is very high, but for low frequency import of small consignments only. This risk reduction option is currently implemented in the EU according to Council Directive 2008/61/EC and it can be effectively applied to prevent *X. fastidiosa* introduction as shown by the findings on coffee plants in France (see Section 4.2). The uncertainty on these ratings is low.

9.2.3.5. Preparation of the consignment

Culling and visual selection measures during preparation of consignments of plants for planting are unlikely to detect *X. fastidiosa* infected units particularly in presence of asymptomatic infections and/or when dealing with dormant plants without leaves. The effectiveness is low although the technical feasibility is high. The uncertainty is low. This option is instead relevant and can have a higher effectiveness for the infective insect vectors that can be carried on the plants in the consignment.

9.2.3.6. Specified treatment of the consignment/reducing pest prevalence in the consignment

Heat therapy using hot water has long been recognised as a practical and effective means of freeing from *X. fastidiosa* infected grape (*Vitis vinifera*) plants for planting (Goheen et al., 1973). Recently Sanderlin and Melanson (2008) showed that hot water treatment of 46 °C for 30 min on scion wood of Pecan (*Carya illinoinensis*) prior to grafting was effective in near complete elimination of *X. fastidiosa* from bacterial leaf scorch diseased scion wood. Heat therapy is already applied in grapevine nurseries in Italy for control of 'flavescence dorée' and 'bois noir' diseases caused by phytoplasmas (Mannini, 2007; Mannini and Marzachì, 2007). The effectiveness and feasibility of heat therapy of dormant plant propagation material are high, with low uncertainty.

With regard to insecticide treatments, sharpshooters and spittlebugs are susceptible to a number of insecticides and particularly to neonicotinoids (Krewer et al., 1998; Bethke et al., 2001; Prabhaker et al., 2006a, b).

9.2.3.7. Restriction on end use, distribution and periods of entry

Such restrictions are not applicable to plants for planting to prevent entry and spread of *X. fastidiosa*. The host plants may carry the pathogen all year round, the end use is planting, and the distribution is to areas with host plants.

9.3. Systematic identification and evaluation of options to reduce the probability of establishment

9.3.1. Surveillance

Surveys for *X. fastidiosa* should include inspection and testing of crops as well as of natural, riparial or ruderal vegetation, owing to the very wide host range. Survey observations should always be confirmed by appropriate diagnostic methods, due to the presence of asymptomatic infections, the possible similarity with symptoms of other diseases as well as the partially different host range for the various subspecies or strains of *X. fastidiosa*. Aerial photos and crop maps may offer a tool for

[6] COMMISSION DIRECTIVE 2008/61/EC of 17 June 2008 establishing the conditions under which certain harmful organisms, plants, plant products and other objects listed in Annexes I to V to Council Directive 2000/29/EC may be introduced into or moved within the Community or certain protected zones thereof, for trial or scientific purposes and for work on varietal selections. OJ L 158, 18.6.2008, p. 41-55.

surveying large surfaces and first identification of diseased crops. Appropriate sampling techniques need to be applied for more efficient surveillance. Variability in host susceptibility and symptoms expression should also be taken into account in the inspection and monitoring programs, to ensure consideration of asymptomatic hosts.

A clear definition of the frequency and sampling of the visual inspections can result in early detection of the infection and should be enforced in nurseries located close to infested areas. Nursery surveys should be based on sampling and testing of plants as well as on monitoring the presence of potential vectors of *X. fastidiosa*. Systematic testing of nursery plants for freedom from *X. fastidiosa* by PCR testing and/or ELISA tests could detect infections at early stage.

9.3.2. Eradication

There is no record of successful eradication of *X. fastidiosa* once established outdoors. Due to the very wide host range, the pathogen may persist on natural or ruderal vegetation or in other asymptomatic cultivated hosts. Vector species are generally polyphagous, therefore insecticide treatment on a specific host crop will not eliminate the infective vector(s) from several other (wild) hosts in the environment, thus increasing the difficulties for eradication.

9.3.3. Containment

Due to the very wide host and vector range, containment of *X. fastidiosa* in an outbreak area should be conducted with a system approach combining different options both in nurseries and outside nurseries.

To be effective, containment should include removal of infected plants to reduce the inoculum, management of the vectors and prevention of movement outside the outbreak area of plant hosts infected with *X. fastidiosa*. Options preventing or reducing *X. fastidiosa* infestation in the crop at the place of origin (Section 9.2.2.1) and options on consignment should be both applied (Section 9.2.2.2). Roguing of infected plants (Sisteron and Stenger, 2013) can contribute to reduce the inoculum pressure and the spread of the pathogen. Strategies for treatment of the vectors should be implemented particularly for plants for planting.

9.4. Conclusions on risk reduction options

There is no record of successful eradication of *X. fastidiosa* once established outdoors due the broad host range of the pathogen and its vectors. Strategies for prevention of introduction from areas where the pathogen is present and for containment of outbreak should focus on the two main pathways (plants for planting and infective insects in plant consignments) and be based on integrated system approach, combining, when applicable, the most effective options (e.g. pest free areas; surveillance; certification, screenhouse production, control of vectors and testing for plant propagation material; preparation, treatment and inspection of consignments for the pathway of the infective vectors in plant consignments).

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

X. fastidiosa has a very broad host range, including many cultivated and spontaneous plants common in Europe. There is some hosts differentiation among the accepted four subspecies of *X. fastidiosa* with regard to symptomatic hosts, but many plants could be infected and remain asymptomatic. There is however high uncertainty with regard to the potential host range of *X. fastidiosa* in the European flora as a range of European wild plant species have never met the bacterium and it is not known whether they would be hosts, symptomatic or asymptomatic. In addition, the potential European vectors of *X. fastidiosa* include many xylem-fluid feeding insect species that are different from the American known vectors and could therefore bring the bacterium in contact with a new host range.

All xylem-fluid feeding insects in Europe have to be regarded as potential vectors of *X. fastidiosa,* including insects from the families Cicadellidae, Aphrophoridae, Cercopidae, Cicadidae and Tibicinidae. The identification of the vector of *X. fastidiosa* in the Apulian outbreak is pending.

The main entry pathway for *X. fastidiosa* is the trade and movement of plants for planting (excluding seeds). The pathway of infective vectors of *X. fastidiosa* transported on plant consignments is also of concern. Fruit and wood (not for plant propagation purposes) are considered as minor pathways with negligible likelihood of entry, whereas seeds, cut flowers and ornamental foliage are minor pathways with low likelihood of entry. Uncertainty is low for the plants for planting pathway and high for the others.

The only route for natural spread of *X. fastidiosa* is by insect vectors that generally fly short distances up to 100 metres, but can be transported by wind over long distance. The movement of infected plants for planting is the most efficient way for long-distance dispersal of *X. fastidiosa*.

There is no record of successful eradication of *X. fastidiosa* once established outdoors due the broad host range of the pathogen and of its vectors. Strategies for prevention of introduction from areas where the pathogen is present and for containment of outbreak should focus on the two main pathways (plants for planting and infective insects in plant consignments) and be based on integrated system approach, combining, when applicable, the most effective options (e.g. pest free areas; surveillance; certification, screen house production, control of vectors and testing for plant propagation material; preparation, treatment and inspection of consignments for the pathway of the infective vectors in plant consignments).

RECOMMENDATIONS

As this statement was prepared without the possibility, due to time constraints, of applying a systematic literature review approach and also at a time when the investigations on the Apulian outbreak of *X. fastidiosa* are still ongoing, it is recommended that host range, vectors, pathways and risk reduction options are further assessed, once a complete pest risk assessment for *X. fastidiosa* is conducted for the EU, and once more knowledge has been acquired on the Apulian outbreak of *X. fastidiosa.*

DOCUMENTATION PROVIDED TO EFSA

1. Request to provide urgent scientific and technical assistance on the regulated harmful organism *Xylella fastidiosa* (Well and Raju). SANCO.E2/GC/svi(2013) 3679110, 11 November 2013. Submitted by the European Commission, DG SANCO (Directorate-General for Health and Consumers).

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APPENDIX A. RATING DESCRIPTORS

1. Rating of probability of entry

Rating for entry	Descriptors
Very unlikely	The likelihood of entry would be very low because the pest: • is not, or is only very rarely, associated with the pathway at the origin, and/or • may not survive during transport or storage, and/or • cannot survive the current pest management procedures existing in the risk assessment area, and/or • may not transfer to a suitable host in the risk assessment area.
Unlikely	The likelihood of entry would be low because the pest: • is rarely associated with the pathway at the origin, and/or • survives at a very low rate during transport or storage, and/or • is strongly limited by the current pest management procedures existing in the risk assessment area, and/or • has considerable limitations for transfer to a suitable host in the risk assessment area.
Moderately likely	The likelihood of entry would be moderate because the pest: • is frequently associated with the pathway at the origin, and/or • survives at a low rate during transport or storage, and/or • is affected by the current pest management procedures existing in the risk assessment area, and/or • has some limitations for transfer to a suitable host in the risk assessment area.
Likely	The likelihood of entry would be high because the pest: • is regularly associated with the pathway at the origin, and/or • mostly survives during transport or storage; and/or • is partially affected by the current pest management procedures existing in the risk assessment area, and/or • has very few limitations for transfer to a suitable host in the risk assessment area.
Very likely	The likelihood of entry would be very high because the pest: • is usually associated with the pathway at the origin, and/or • survives during transport or storage; and/or • is not affected by the current pest management procedures existing in the risk assessment area, and/or • has no limitations for transfer to a suitable host in the risk assessment area.

2. Rating of the effectiveness of risk reduction options

Rating	Descriptors
Negligible	The risk reduction option has no practical effect in reducing the probability of entry or establishment or spread, or the potential consequences.
Low	The risk reduction option reduces, to a limited extent, the probability of entry or establishment or spread, or the potential consequences.
Moderate	The risk reduction option reduces, to a substantial extent, the probability of entry or establishment or spread, or the potential consequences.
High	The risk reduction option reduces the probability of entry or establishment or spread, or the potential consequences, by a major extent.
Very high	The risk reduction option essentially eliminates the probability of entry or establishment or spread, or any potential consequences.

3. Rating of the technical feasibility of risk reduction options

Rating	Descriptors
Negligible	The risk reduction option is not in use in the risk assessment area, and the many technical difficulties involved (e.g. changing or abandoning the current practices, implement new practices and or measures) make their implementation in practice impossible.
Low	The risk reduction option is not in use in the risk assessment area, but the many technical difficulties involved (e.g. changing or abandoning the current practices, implement new practices and or measures) make its implementation in practice very difficult or nearly impossible.
Moderate	The risk reduction option is not in use in the risk assessment area, but it can be implemented (e.g. changing or abandoning the current practices, implement new practices and or measures) with some technical difficulties.
High	The risk reduction option is not in use in the risk assessment area, but it can be implemented in practice (e.g. changing or abandoning the current practices, implement new practices and or measures) with limited technical difficulties.
Very high	The risk reduction option is already in use in the risk assessment area or can be easily implemented with no technical difficulties.

4. Ratings used for describing the level of uncertainty

Rating	Descriptors
Low	No or little information or no or few data are missing, incomplete, inconsistent or conflicting. No subjective judgement is introduced. No unpublished data are used.
Medium	Some information is missing or some data are missing, incomplete, inconsistent or conflicting. Subjective judgement is introduced with supporting evidence. Unpublished data are sometimes used.
High	Most information is missing or most data are missing, incomplete, inconsistent or conflicting. Subjective judgement may be introduced without supporting evidence. Unpublished data are frequently used.

APPENDIX B. PLANT HOST STATUS FOR PIERCE'S DISEASE STRAINS OF *XYLELLA FASTIDIOSA*

(Available online: http://www.cnr.berkeley.edu/xylella/control/hosts.htm)

Scientific Name	Family	Common Name	Field Isolated[b]	GH Isolated[c]	Systemic[d]	Technique[e]	Vector Host[f]	Reference	Presence in Europe according to Flora Europaea[(g)]
Acacia longifolia	Leguminosae	golden wattle	Y			vector		Freitag (1951)	[?Ga Hs It Lu]
Acer macrophyllum	Aceraceae	big leaf maple	Y (medium)	Y (medium)	Y?	culture		Purcell and Saunders (1999)	
Acer negundo	Aceraceae	box elder		Y (low-med)		culture		Purcell and Saunders (1999)	[Au Bu Cz Ga Ge He Hs Hu Rs(C,W)]
Aesculus californica	Hippocastanaceae	California buckeye	Y (medium)	Y (low)		culture		Purcell and Saunders (1999)	
Aesculus californica	Hippocastanaceae	California buckeye		N		vector		Freitag (1951)	
Alnus rhombifolia	Betulaceae	white alder	N	Y (low)	N	culture		Purcell and Saunders (1999)	
Ampelopsis arborea	Vitaceae	peppervine	Y			ELISA/cult./DIF		Hopkins and Adlerz (1988)	
Amsinckia douglasiana	Boraginaceae	buckthorn weed		Y		vector		Freitag (1951)	
Artemisia douglasiana	Compositae	mugwort		Y (low-med)		culture	BGSS	Purcell and Saunders (1999)	Al Au Be Br Bu Co Cz Da Fe Ga Ge Gr He Ho Hs Hu It Ju Lu No Po Rm Rs(N,B,C,W,K,E) Su [Hb]
Artemisia douglasiana	Compositae	mugwort	Y	Y		vector	BGSS	Freitag (1951)	Al Au Be Br Bu Co Cz Da Fe Ga Ge Gr He Ho Hs Hu It Ju Lu No Po Rm Rs(N,B,C,W,K,E) Su [Hb]

Scientific Name	Family	Common Name	Field Isolated[b]	GH Isolated[c]	Systemic[d]	Technique[e]	Vector Host[f]	Reference	Presence in Europe according to Flora Europaea[(g)]
Artemisia douglasiana	Compositae	mugwort		Y (medium)	N	ELISA/culture	BGSS	Hill and Purcell (1995)	Al Au Be Br Bu Co Cz Da Fe Ga Ge Gr He Ho Hs Hu It Ju Lu No Po Rm Rs(N,B,C,W,K,E) Su [Hb]
Avena fatua	Gramineae	wild oat		Y		vectors		Freitag (1951)	Al Au Az Be Bl Br Bu Co ?Cr Cz Da Fe Ga Ge ?Gr Hb He Ho Hs Hu It Ju Lu No Po Rm Rs(N,B,C,W,K,E) Sa Si Su Tu
Avena fatua	Gramineae	wild oat	Y			vectors		Freitag (1951)	Al Au Az Be Bl Br Bu Co ?Cr Cz Da Fe Ga Ge ?Gr Hb He Ho Hs Hu It Ju Lu No Po Rm Rs(N,B,C,W,K,E) Sa Si Su Tu
Baccharis pilularis	Compositae	coyote brush	N	Y (low-med)	N	culture		Purcell and Saunders (1999)	
Baccharis pilularis	Compositae	coyote brush	Y			vectors		Freitag (1951)	
Baccharis salicifolia	Compositae	mule fat		Y (medium)	N	culture	BGSS/ GWSS	Purcell and Saunders (1999)	
Bidens pilosa var. pilosa	Compositae	beggar-ticks		N		vectors		Freitag (1951)	[Az Cz Hs Lu]
Bromus catharticus	Gramineae	rescue grass		Y		vectors		Freitag (1951)	[Az Ga Lu Rs(C,W,E)]
Bromus rigidus	Gramineae	ripgut grass	Y	Y		vectors		Freitag (1951)	
Bromus sp.	Gramineae	Russian brome grass		Y		vectors		Freitag (1951)	
Callicarpa americana	Lamiaceae	American beautyberry	Y			ELISA/culture		Hopkins and Adlerz (1988)	

Scientific Name	Family	Common Name	Field Isolated[b]	GH Isolated[c]	Systemic[d]	Technique[e]	Vector Host[f]	Reference	Presence in Europe according to Flora Europaea[(g)]
Callistephus chinensis	Compositae	China aster		Y		vectors		Freitag (1951)	
Canna sp.	Cannaceae	Canna		Y		vectors		Freitag (1951)	
Chenopodium ambrosioides	Chenopodiaceae	Mexican tea		N		culture	BGSS	Purcell and Saunders (1999)	[Al Au Az Be Bl Co Cr Ga Ge Gr Hs Hu It Ju Lu Po Rm Rs(W) Sa Si]
Chenopodium ambrosioides	Chenopodiaceae	Mexican tea	Y	Y		vectors	BGSS	Freitag (1951)	[Al Au Az Be Bl Co Cr Ga Ge Gr Hs Hu It Ju Lu Po Rm Rs(W) Sa Si]
Citrus limon	Rutaceae	lemon 'Meyer'		N		vectors	GWSS	Freitag (1951)	
Citrus reticulata	Rutaceae	tangerine		N		vectors	GWSS	Freitag (1951)	
Citrus sinensis	Rutaceae	sweet orange	Y (low)			culture		Hopkins Î91b	
Claytonia perfoliata	Portulacaceae	miner's lettuce		Y		ELISA		Raju et al. (1983)	[Be Br Cz Da Ga Ge Ho Lu Su]
Conium maculatum	Umbelliferae	poison hemlock		Y		culture		Purcell and Saunders (1999)	Al Au Az Be Bl Br Bu Co Cr Cz Da Fe Ga Ge Gr Hb He Ho Hs Hu It Ju Lu No Po Rm Rs(N,B,C,W,K,E) Sa Si Su Tu
Coprosma baueri	Rubiaceae	Coprosma		Y		vectors		Freitag (1951)	
Cotoneaster francheti	Rosaceae	Cotoneaster		N		vectors		Freitag (1951)	
Cotoneaster rotundifolia	Rosaceae	cotoneaster		Y		vectors		Freitag (1951)	
Cynodon dactylon	Gramineae	Bermuda grass	Y	Y		vectors	RHSS/ GSS	Freitag (1951)	Al Au Az Bl Br Bu Co Cr Cz Ga Gr He Ho Hs Hu It Ju Lu Rm Rs(C,W,K,E) Sa Si Tu [Ge]

Scientific Name	Family	Common Name	Field Isolated[b]	GH Isolated[c]	Systemic[d]	Technique[e]	Vector Host[f]	Reference	Presence in Europe according to Flora Europaea[(g)]
Cynodon dactylon	Gramineae	Bermuda grass*		N		ELISA/culture	RHSS/ GSS	Hill and Purcell (1995)	Al Au Az Bl Br Bu Co Cr Cz Ga Gr He Ho Hs Hu It Ju Lu Rm Rs(C,W,K,E) Sa Si Tu [Ge]
Cyperus eragrostis	Cyperaceae	purple nutsedge		Y		culture	RHSS/ GSS	Purcell and Saunders (1999)	[Az Ga Hs Lu]
Cyperus esculentus	Cyperaceae	yellow nutsedge		Y		vectors		Freitag (1951)	Al Az Bu Co Ga Gr It Lu Si [Au Bl *Cr *Hs Rs(W)]
Cytisus scoparius	Leguminosae	Scotch broom	Y	Y (med-high)		vectors		Freitag (1951)	Au Be Br Co Cz Da Ga Ge Hb He Ho Hs Hu It Ju Lu No Po Rm Rs(B,C,W) Sa Si Su [Az]
Daucus carota var. sativa	Umbelliferae	short white carrot		Y		vectors		Freitag (1951)	Al Au Az Be Bl Br Bu Co Cr Cz Da Ga Ge Gr Hb He Ho Hs Hu It Ju Lu No Po Rm Rs(B,C,W,K,E) Sa Si Su Tu [Fe Rs(N)]
Digitaria sanguinalis	Gramineae	hairy crabgrass	Y			vectors		Freitag (1951)	Al Az Bl Bu Co Cr Ga Gr Hs Hu It Ju Lu Rm Rs(W,K,E) Sa Si [Au Be Cz Ge He Ho Po Rs(B,C) Su]
Digitaria sanguinalis	Gramineae	hairy crabgrass		Y		vectors		Freitag (1951)	Al Az Bl Bu Co Cr Ga Gr Hs Hu It Ju Lu Rm Rs(W,K,E) Sa Si [Au Be Cz Ge He Ho Po Rs(B,C) Su]
Duranta repens	Verbenaceae	pigeon-berry	Y			vectors		Freitag (1951)	
Echinochloa crus-galli	Gramineae	water grass		Y (medium)	N	ELISA/culture	RHSS/ GSS	Hill and Purcell (1995)	Al Az Bl Bu Co Cr Ga Gr Hs It Ju Lu Rm

Scientific Name	Family	Common Name	Field Isolated[b]	GH Isolated[c]	Systemic[d]	Technique[e]	Vector Host[f]	Reference	Presence in Europe according to Flora Europaea[(g)]
									Rs(W,K,E) Sa Si Tu [Au Be Cz Da Ge He Ho Hu Po Rs(B,C)]
Echinochloa crus-galli	Gramineae	water grass	Y	Y		vectors	GSS	Freitag (1951)	Al Az Bl Bu Co Cr Ga Gr Hs It Ju Lu Rm Rs(W,K,E) Sa Si Tu [Au Be Cz Da Ge He Ho Hu Po Rs(B,C)]
Epilobium californicum	Onagraceae	willow-herb		Y		vectors		Freitag (1951)	
Epilobium paniculatum	Onagraceae	panicled willow-herb		Y		vectors		Freitag (1951)	
Eragrostis diffusa	Gramineae	diffuse love grass		Y		vectors		Freitag (1951)	
Erodium cicutarium	Geraniaceae	red stem filaree		Y		vectors		Freitag (1951)	Al Au Az Be Bl Br Bu Co Cr Cz Da Fe Ga Ge Gr Hb He Ho Hs Hu It Ju Lu No Po Rm Rs(N,B,C,W,K,E) Sa Si Su Tu
Escallonia montevidensis	Escalloniaceae	Escallonia	Y			vectors		Freitag (1951)	
Eugenia myrtifolia		Aust. brush-cherry	Y	Y		vectors	BGSS	Freitag (1951)	
Fragaria californica	Rosaceae	wild strawberry		Y		ELISA		Raju et al. (1983)	
Franseria acanthicarpa		annual bur-sage		Y		vectors		Freitag (1951)	
Fraxinus dipetala	Oleaceae	California ash	Y			vectors		Freitag (1951)	
Fraxinus latifolia	Oleaceae	Oregon ash	N	Y (low)		culture		Purcell and Saunders (1999)	
Fuchsia magellanica	Onagraceae	Fuchsia	Y			vectors		Freitag (1951)	[Az Br Hb]

Scientific Name	Family	Common Name	Field Isolated[b]	GH Isolated[c]	Systemic[d]	Technique[e]	Vector Host[f]	Reference	Presence in Europe according to Flora Europaea[(g)]
Genista monspessulana	Leguminosae	French broom	Y	Y (med-high)		culture		Purcell and Saunders (1999)	
Hedera helix	Araliaceae	English ivy		Y (low-med)		culture		P + S '99	Al Au Az Be Bl Br Bu Co Cr Cz Da Ga Ge Gr Hb He Ho Hs Hu It Ju Lu No Po Rm Rs(B,C,W,K) Sa Si Su Tu
Hedera helix	Araliaceae	English ivy		Y		vectors		Freitag (1951)	Al Au Az Be Bl Br Bu Co Cr Cz Da Ga Ge Gr Hb He Ho Hs Hu It Ju Lu No Po Rm Rs(B,C,W,K) Sa Si Su Tu
Helianthus sp.	Compositae	wild sunflower		N		vectors	GWSS	Freitag (1951)	
Heteromeles arbutifolia	Rosaceae	toyon		Y		vectors		Freitag (1951)	
Hordeum murinum	Gramineae	common foxtail		Y		vectors		Freitag (1951)	Al Au Az Be Bl Br Bu Co Cr Cz Ga Ge Gr He Ho Hs Hu It Ju Lu Po Rm Rs(W,K,E) Sa Si Tu [Da Hb No Su]
Hordeum vulgare	Gramineae	barley		Y		vectors		Freitag (1951)	
Hydrangea paniculata	Hydrangeaceae	Hydrangea	Y			vectors		Freitag (1951)	
Juglans californica	Juglandaceae	Calif. black walnut	N		N	culture		Purcell and Saunders (1999)	

Scientific Name	Family	Common Name	Field Isolated[b]	GH Isolated[c]	Systemic[d]	Technique[e]	Vector Host[f]	Reference	Presence in Europe according to Flora Europaea[(g)]
Lactuca serriola	Compositae	prickly lettuce		Y		vectors		Freitag (1951)	Al Au Az Be Bl Br Bu Co Cr Cz Da Ga Ge Gr He Ho Hs Hu It Ju Lu Po Rm Rs(B,C,W,K,E) Sa Si Su Tu
Lathyrus cicera	Leguminosae	Lathyrus		Y		vectors		Freitag (1951)	Al Bl Bu Co Cr Ga Gr He Hs It Ju Lu Rm Rs(K,E) Sa Si Tu [Au]
Lathyrus clymenium	Leguminosae	Lathyrus		Y		vectors		Freitag (1951)	
Lathyrus sativa	Leguminosae	grass pea		Y		vectors		Freitag (1951)	
Lolium multiflorum	Gramineae	Italian ryegrass	Y	Y		vectors	GSS/R HSS	Freitag (1951)	Al Az Bl Bu Co Cr Ga Gr Hs It Ju Lu Rm Sa Si Tu [Au Be Br Cz Da Fe Ge Hb He Ho Hu No Po Rs(C,W,K) Su]
Lolium temulentum	Gramineae	darnel		Y		vectors		Freitag (1951)	
Lonicera japonica	Caprifoliaceae	Japanese honeysuckle		Y		vectors		Freitag (1951)	[Az Br Ga Ge He Hs It]
Majorana hortensis	Labiatae	sweet majoram	Y			vectors		Freitag (1951)	
Malus sylvestris	Rosaceae	apple		N		vectors		Freitag (1951)	Al Au Be Br Bu Co Cz Da Fe Ga Ge Gr Hb He Ho Hs Hu It Ju Lu No Po Rm Rs(B,C,W,K,E) Si Su Tu
Malva parvifolia		cheeseweed		N		vectors	GWSS	Freitag (1951)	
Matricaria suaveolens	Compositae	pineapple weed		N		vectors		Freitag (1951)	
Medicago hispida	Leguminosae	bur clover	Y			vectors		Freitag (1951)	

Scientific Name	Family	Common Name	Field Isolated[b]	GH Isolated[c]	Systemic[d]	Technique[e]	Vector Host[f]	Reference	Presence in Europe according to Flora Europaea[(g)]
Melilotus alba	Leguminosae	white meliot		Y		vectors	BGSS	Freitag (1951)	Al Au Bu Cz *Da *Fe Ga Ge Gr He *Ho Hs Hu It Ju Lu *No Po Rm *Rs(N) *Rs(B,C,W,K,E) *Su Tu [Be Br]
Melilotus indica	Leguminosae	hubam clover		Y		vectors		Freitag (1951)	Al *Az Bl Co Cr Ga Gr Hs It Ju Lu Sa Si Tu [Au Be Br Cz Ge He Ho]
Melilotus officinalis	Leguminosae	yellow sweet clover		Y		vectors		Freitag (1951)	Al Au *Be Bl Bu Cz Ga Ge Gr He *Ho Hs Hu It Ju Po Rm *Rs(N) *Rs(B,C,W,K,E) Sa Tu [Br Da Fe Hb No Su]
Melilotus sp.	Leguminosae	sweet clover	Y			vectors		Freitag (1951)	
Melissa offcinalis	Labiatae	garden balm	Y			vectors		Freitag (1951)	?Al Bl Bu Co Cr Ga Gr Hs It Ju Rm Sa Si [Au Az Be Br Cz Da Ge Hb He Lu Po Rs(W,K,E) Su ?Tu]
Mentha sp.	Labiatae	mint		Y		vectors		Freitag (1951)	
Mimulus aurantiacus	Phrymaceae	bush monkeyflower		N		vectors		Freitag (1951)	
Oeanthe sarmetosa		water parsley		Y		vectors		Freitag (1951)	
Oenothera hookeri	Onagraceae	evening primrose		Y		vectors		Freitag (1951)	
Parthenocissus quinquefolia	Vitaceae	Virginia creeper	Y			ELISA/cult./DIF		Hopkins and Adlerz (1988)	[Au Br Ge He Ho]
Parthenocissus tricuspidata	Vitaceae	Boston ivy	Y	Y		vectors		Freitag (1951)	[Ju]
Paspalum dilatatum	Gramineae	Dallisgrass	Y	Y		vectors	GSS/RHSS	Freitag (1951)	[Az Ga Hs It Lu]

Scientific Name	Family	Common Name	Field Isolated[b]	GH Isolated[c]	Systemic[d]	Technique[e]	Vector Host[f]	Reference	Presence in Europe according to Flora Europaea[(g)]
Pelargonium hortorum	Geraniaceae	fish geranium		Y		vectors		Freitag (1951)	
Pennisetum clandestimun	Gramineae	Kikuyugrass		Y		vectors		Freitag (1951)	
Phalaris minor	Gramineae	Mediter. canary grass		Y		vectors		Freitag (1951)	?Al Az Bl Co Cr Ga Gr Hs It Ju Lu Sa Si Tu [Rs(K)]
Phalaris paradoxa	Gramineae	gnawed canary grass		Y		vectors		Freitag (1951)	Al Bl Cr Ga Gr Hs It Ju Lu Tu
Philadelphus lewisii	Hydrangeaceae	syringa		N		vectors		Freitag (1951)	
Phleum pratense	Gramineae	Timothy grass		Y		vectors		Freitag (1951)	Al Au Az Be Br Bu Co Cz Da Fa Fe Ga Ge Gr Hb He Ho Hs Hu Is It Ju Lu No Po Rm Rs(N,B,C,W,K,E) Sa Si Su Tu
Pittosporum crassifolium	Pittosporaceae	karo		Y		vectors		Freitag (1951)	
Plantago lanceolata	Plantaginaceae	English plantain		N		vectors		Freitag (1951)	Al Au Az Be Bl Br Bu Co Cr Cz Da Fa Fe Ga Ge Gr Hb He Ho Hs Hu Is It Ju Lu No Po Rm Rs(N,B,C,W,K,E) Sa Si Su Tu
Platanus occidentalis	Platanaceae	sycamore	Y			culture	BGSS	Hopkins and Adlerz (1988)	
Poa annua	Gramineae	annual bluegrass	Y	Y		vectors		Freitag (1951)	Al Au Az Be Bl Br Bu Co Cr Cz Da Fa Fe Ga Ge Gr Hb He Ho Hs Hu Is It Ju Lu No Po Rm Rs(N,B,C,W,K,E) Sa Si Su Tu
Polygonum convolvulus	Polygonaceae	black bindweed		Y		vectors		Freitag (1951)	

Scientific Name	Family	Common Name	Field Isolated[b]	GH Isolated[c]	Systemic[d]	Technique[e]	Vector Host[f]	Reference	Presence in Europe according to Flora Europaea[(g)]
Polygonum persicaria	Polygonaceae	ladys thumb	Y	Y		vectors		Freitag (1951)	Al Au Az Be Bl Br Bu Co Cz Da Fa Fe Ga Ge Gr Hb He Ho Hs Hu Is It Ju Lu No Po Rm Rs(N,B,C,W,K,E) Sa Si Su Tu
Populus fremontii	Salicaceae	Fremont cottonwood	N	Y (low-med)		culture		Purcell and Saunders (1999)	
Prunus demissa	Rosaceae	western chokecherry		N		vectors		Freitag (1951)	
Prunus mume	Rosaceae	Japanese apricot		N		vectors		Freitag (1951)	
Prunus sp.	Rosaceae	wild plum	Y (low-med)			culture		Purcell and Saunders (1999)	
Pyracantha augustifolia	Rosaceae	firethorn		N		vectors		Freitag (1951)	
Quercus agrifolia	Fagaceae	coast live oak	Y	Y (low-med)	Y?	culture		Purcell and Saunders (1999)	
Quercus lobata	Fagaceae	valley oak	Y (low)	Y (low-med)		culture		Purcell and Saunders (1999)	
Reseda odorata	Resedaceae	common migonette		Y		vectors		Freitag (1951)	[Au Bl Cz Ga Hs It Rm]
Rheum rhaponticum	Polygonaceae	rhubarb		Y		vectors		Freitag (1951)	*Bu No
Rosa californica	Rosaceae	California wild rose	Y			culture		Purcell and Saunders (1999)	
Rosa californica	Rosaceae	California wild rose	Y			vectors		Freitag (1951)	
Rosmarinus officinalis		rosemary	Y			vectors		Freitag (1951)	Bl Co *Cr Ga Gr Hs It Ju Lu Sa Si [Al Az Bu

Scientific Name	Family	Common Name	Field Isolated[b]	GH Isolated[c]	Systemic[d]	Technique[e]	Vector Host[f]	Reference	Presence in Europe according to Flora Europaea[(g)]
									He Rs(K)]
Rubus discolor	Rosaceae	Himalayan blackberry		Y (medium)	Y	ELISA/culture	BGSS	Hill and Purcell (1995)	Au Be Bu Cz Ga Ge He Ho Hu It Ju Lu Rm Tu [Br Da]
Rubus discolor	Rosaceae	Himalayan blackberry		Y		ELISA	BGSS	Raju et al. (1983)	
Rubus sp.	Rosaceae	blackberry	Y			culture	BGSS	Hopkins and Adlerz (1988)	
Rubus ursinus	Rosaceae	California blackberry	Y	Y (medium)		culture	BGSS	Purcell and Saunders (1999)	
Rubus ursinus	Rosaceae	California blackberry	Y	Y		vectors	BGSS	Freitag (1951)	
Rumex crispus	Polygonaceae	curly dock	Y	Y		vectors		Freitag (1951)	Al Au Be Bl Br Bu Co Cz Da Fa Fe Ga Ge Gr Hb He Ho Hs Hu It Ju Lu No Po Rm Rs(N,B,C,W,K,E) Sa Si Su Tu [Az Is]
Salix laevigata	Salicaceae	red willow	N	Y (low-med)	N	culture		Purcell and Saunders (1999)	
Salix lasiolepis	Salicaceae	arroyo willow	N	Y (low-med)	N	culture		Purcell and Saunders (1999)	
Sambucus canadensis	Caprifoliaceae	American elder	Y			ELISA/cult./DIF	BGSS?	Hopkins and Adlerz (1988)	
Sambucus mexicana	Caprifoliaceae	blue elderberry	Y	Y		vectors	BGSS	Freitag (1951)	
Sambucus mexicana	Caprifoliaceae	blue elderberry	Y (medium)	Y (medium)	Y?	culture	BGSS	Purcell and Saunders (1999)	
Setaria lutescens	Gramineae	yellow bristle grass		Y		vectors		Freitag (1951)	

Scientific Name	Family	Common Name	Field Isolated[b]	GH Isolated[c]	Systemic[d]	Technique[e]	Vector Host[f]	Reference	Presence in Europe according to Flora Europaea[(g)]
Sonchus asper	Compositae	prickly sowthistle		Y		vectors		Freitag (1951)	Al Au Az Be Bl Br Bu Co Cr Cz Da Fe Ga Ge Gr Hb He Ho Hs Hu It Ju Lu No Po Rm Rs(N,B,C,W,K,E) Sa Si Su Tu
Sorghum halepense	Gramineae	Johnson grass		Y		vectors		Freitag (1951)	[Al Az Bl Bu Co *Cr Cz Ga *Gr He Hs Hu It Ju Lu Rm Rs(W,K) Sa Si *Tu]
Sorghum vulgare	Gramineae	Sudangrass		Y		vectors		Freitag (1951)	
Symphoricarpos albus	Caprifoliaceae	snowberry	Y			culture		Purcell and Saunders (1999)	
Symphoricarpos albus	Caprifoliaceae	snowberry		Y		vectors	BGSS	Freitag (1951)	
Syringa vulgaris	Oleaceae	lilac		Y		vectors		Freitag (1951)	Al Bu Gr Ju Rm [Au Be Br Cz Ga Ge Hb He Hu It Rs(K)]
Toxicodendron diversilobum	Anacardiaceae	poison oak	Y (low-med)	Y		culture		Purcell and Saunders (1999)	
Toxicodendron diversilobum	Anacardiaceae	poison oak	Y			vectors		Freitag (1951)	
Trifolium fragarium	Leguminosae	strawberry clover		Y		vectors		Freitag (1951)	
Trifolium hybridum	Leguminosae	Aliske clover		Y		vectors		Freitag (1951)	*Au Bu Cr *Cz Ga Gr *He Hs *Hu It Ju *Rm *Rs(W,K) *Rs(E) Tu [Be Br Da Fe Ge Hb Ho No Po Rs(N,B,C) Su]

Scientific Name	Family	Common Name	Field Isolated[b]	GH Isolated[c]	Systemic[d]	Technique[e]	Vector Host[f]	Reference	Presence in Europe according to Flora Europaea[(g)]
Trifolium incarnatum	Leguminosae	crimson clover		Y		vectors		Freitag (1951)	Al Au Be Br Bu Co Cr Cz Da Fe Ga Ge Gr He Ho Hs Hu It Ju Lu No Po Rm Rs(W,K,E) Sa Si Su Tu
Trifolium pratense	Leguminosae	red clover		Y		vectors		Freitag (1951)	Al Au Az Be Br Bu Co Cz Da Fe Ga Ge Gr Hb He Ho Hs Hu It Ju Lu No Po Rm Rs(N,B,C,W,K,E) Sa Si Su Tu [Fa Is]
Trifolium repens	Leguminosae	white clover		Y		vectors	BGSS	Freitag (1951)	Al Au Az Be Bl Br Bu Co Cr Cz Da Fa Fe Ga Ge Gr Hb He Ho Hs Hu Is It Ju Lu No Po Rm Rs(N,B,C,W,K,E) Sa Si Su Tu
Trifolium repens var. latum	Leguminosae	Ladino clover	Y	Y		vectors	BGSS	Freitag (1951)	
Umbellularia californica		California bay or laurel	Y	Y (low)	N	culture		Purcell and Saunders (1999)	
Uritca dioica ssp.gracilis	Urticaceae	stinging nettle	Y	Y		vectors	BGSS	Freitag (1951)	
Urtica dioica ssp.gracilis	Urticaceae	stinging nettle		Y (low)	N	culture	BGSS	Purcell and Saunders (1999)	
Veronica sp.	Scrophulariaceae	speedwell	Y			vectors		Freitag (1951)	
Vicia monathus	Apocynaceae	vetch		Y		vectors		Freitag (1951)	
Vinca major	Apocynaceae	greater periwinkle	Y	Y (high)		culture	BGSS	Purcell and Saunders (1999)	Ga Hs It Ju Si [Au Br Bu Co Cr Gr Hb He Lu Rs(W,K)]
Vinca major	Apocynaceae	greater periwinkle		Y		vectors	BGSS	Freitag (1951)	

Scientific Name	Family	Common Name	Field Isolated[b]	GH Isolated[c]	Systemic[d]	Technique[e]	Vector Host[f]	Reference	Presence in Europe according to Flora Europaea[(g)]
Vinca minor	Apocynaceae	periwinkle		Y		ELISA	BGSS	Raju et al. (1983)	
Vitis californica	Vitaceae	Calif. wild grape	Y			vectors	BGSS	Freitag (1951)	
Vitis rupestris	Vitaceae	St. George	Y			culture	BGSS	Purcell and Saunders (1999)	
Vitis vinifera	Vitaceae	grape 'Pinot Noir'		Y (high)	Y	ELISA/culture	BGSS	Hill and Purcell (1995)	Al Au Bu Co Cz Ga Ge Gr He Hu It Ju Rm Rs(W,K) Sa Si Tu [Az Be Bl Cr Hs Lu Po Rs(E)]
Vulpia myuros var. hirsuta	Gramineae	foxtail fescue		Y		vectors		Freitag (1951)	
Xanthium strumarium	Compositae	cocklebur		Y		vectors	BGSS	Freitag (1951)	Al Au Az Bl Bu Co Cr Cz Ga Ge Gr He Hs Hu It Ju Lu Po Rm Rs(B,C,W,K,E) Sa Si Tu

a: The list includes plants from which *X. fastidiosa* has been recovered using a variety of detection methods.

b: *X. fastidiosa* was isolated from field-collected material after mechanical (needle) inoculation

c: *X. fastidiosa* was isolated from greenhouse-grown material after vector inoculation or needle inoculation. Greenhouse conditions can result in populations of bacteria that are several times higher than for the same plant species in the field.
Populations of *X. fastidiosa* are expressed as:
High = 10 million to one billion live cells per gram of plant material
Medium = 100,000 to 9 million live cells per gram of plant material
Low = less than 100,000 live cells per gram of plant material

d: 'Y' means *X. fastidiosa* was recovered from tissues beyond the inoculation point. 'N' means that the bacteria was not recovered. The bacteria moves from cell to cell in the xylem of the plant. A question mark (?) indicates that *X. fastidiosa* was detected at a long distance from the inoculation site but this may have been due to the xylem vessels in the plant being very long.

e: The method used to detect *X. fastidiosa* from plant material.
Vector = Infective insects were caged on plants, removed, and non-infective insects were placed on the same plants for varying intervals of days to weeks. The new insects were then moved to healthy grape or alfalfa test plants. If the test plants became diseased (PD in grapes, alfalfa dwarf in alfalfa), the original plant exposed to infective vectors was presumed to harbor the 'virus.' These experiments were done by Julius Freitag in the 1940s, when the cause of PD was assumed to be a virus.
Culture = Assays based on the growth of *X. fastidiosa* from finely ground plant samples plated onto semi-selective microbiological media and incubated. The number of live bacteria in the sample can be determined from the number of colonies that grow on the plate. The advantages of culture-based assays are that they quantitatively detect live cells, are fairly sensitive (down to thousands of *X. fastidiosa* per gram) and highly reliable if the cultured bacteria are further confirmed as *X. fastidiosa* by other means. Disadvantages are that the method requires at least a

week to complete, other bacteria and fungi in plant samples can completely obscure the results, and certain plants (black walnut and coffeeberry, for example) contain substances which inhibit growth of *X. fastidiosa* on the Petri dish.
DIF = **D**irect **I**mmuno**F**luorescence uses antibodies against *X. fastidiosa* to bind a fluorescent indicator dye to *X. fastidiosa* cells so they can be seen using a microscope that has ultravolet light illumination.
PCR = **P**olymerase **C**hain **R**eaction amplifies a *Xylella*-specific piece of DNA millions of times. The amplified DNA is visible as bands on a gel after separation in an electric field. PCR is becoming more widely used to detect *X. fastidiosa.* It has the advantage that it is the most sensitive method for detecting *X. fastidiosa* (to below 100 cells per sample), and can be used even for frozen or preserved samples. PCR also is unlikely to give false positives or be affected by the presence of other microorganisms. PCR can also be used to quickly distinguish some strains of *X. fastidiosa.* Disadvantages are that it is generally not quantitative, it is still not widely available in diagnostic labs, and cannot distinguish DNA from living vs. dead bacteria. Some naturally-occurring chemicals in plants can inhibit PCR, resulting in negative test results even though *X. fastidiosa* is present in the plant.
Budding = *X. fastidiosa* was transmitted when budwood from an infected plant was grafted onto a previously healthy plant. This older method depends on accurate identification of the disease in the indicator (recipient) plants. Successful grafting requires the inclusion of live xylem ('wood') with the scion grafted onto the indicator plant.

f: Indicates which important sharpshooter species (for California viticulture) feed or lay eggs on the plant. Blanks indicate no data available or that the plant is not a host.
BGSS = **B**lue-**G**reen **S**harp**s**hooter (*Graphocephala atropunctata*).
GSS = **G**reen **S**harp**s**hooter (*Draeculacepahala minerva*).
GWSS = **G**lassy-**W**inged **S**harp**s**hooter (*Homalodisca coagulata*).
RHSS = **R**ed-**H**eaded **S**harp**s**hooter (*Carneocephala fulgida*).

g: Flora europaea: […]: not native; *:Status doubtful, possibly native; ?:Occurrence doubtful; Al: Albania, Au: Austria with Liechtenstein; Az: Azores; Be: Belgium, Bl: Baleary Islands; Br: Britain, including Orkney, Zetland and Isle of Man; excluding Channel Islands and Northern Ireland; Bu: Bulgaria; Co: Corsica; Cr: Crete *(Creta)* with Karpathos, Kasos and Gavdhos; Cz: Czechoslovakia; Da: Denmark; Fa: Faroe Islands; Fe: Finland *(Fennia)*, including (Åland Islands); Ga: France *(Gallia)* with the Channel Islands and Monaco excluding Corse; Ge: Germany; Gr: Greece, excluding those islands included under Kriti Crete and those which are outside Europe as defined for *Flora Europaea*; Hb: Ireland (*Hibernia*); both the Republic of Ireland and Northern Ireland; He: Switzerland (*Helvetia*); Ho: Netherlands (*Hollandia*); Hs: Spain (*Hispania*) with Gibraltar and Andora, excluding the Baleary Islands; Hu: Hungary; Is: Iceland (*Islandia*); It: Italy, including the Arcipelago Toscano; excluding Sardegna and Sicilia; Ju: Jugoslavia; Lu: Portugal (*Lusitania*); No: Norway; Po: Poland; Rm: Romania; Rs: Territories of the former U.S.S.R; Sa: Sardegna; Sb: Svalbard, comprising Spitsbergen, Björnöya (Bear Island) and Jan Mayen; Si: Sicilia, with Pantelleria, Isole Pelagie, Isole Lipari and Ustica, also the Malta archipelago; Su: Sweden (*Suecia*), including Öland and Gotland; Tu: Turkey (European part), including Gökçeada (Imroz)

A blank cell indicates the data was not available.

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ABBREVIATIONS

CLS Coffee leaf scorch

CVC Citrus variegation chlorosis

EFSA European Food Safety Authority

EPPO European and Mediterranean Plant Protection Organisation

FAO Food and Agriculture Organisation

IPPC International Plant Protection Convention

ISPM International Standard for Phytosanitary Measures

OLS Oleander leaf scorch

PD Pierce's Disease of Grapevine