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List of non-EU phytoplasmas of *Cydonia* Mill., *Fragaria* L., *Malus* Mill., *Prunus* L., *Pyrus* L., *Ribes* L., *Rubus* L. and *Vitis* L.

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Abstract

Following a request from the European Commission, the EFSA Panel on Plant Health prepared a list of non-EU phytoplasmas of *Cydonia* Mill., *Fragaria* L., *Malus* Mill., *Prunus* L., *Pyrus* L., *Ribes* L., *Rubus* L. and *Vitis* L. A systematic literature review and search of databases identified 27 phytoplasmas infecting one or more of the host genera under consideration. These phytoplasmas were assigned to three categories. The first group (a) consists of 10 non-EU phytoplasmas, known to occur only outside the EU ('*Candidatus* Phytoplasma australiense', '*Ca*. P. hispanicum', '*Ca*. P. pruni'-related strain (NAGYIII), '*Ca*. P. pyri'-related strain (PYLR) and Buckland valley grapevine yellows phytoplasma) or having only limited presence in the EU ('*Ca*. P. aurantifolia'-related strains, '*Ca*. P. fraxini', '*Ca*. P. phoenicium', '*Ca*. P. trifolii' and '*Ca*. P. ziziphi'). The second group (b) consists of three non-EU phytoplasmas, whose presence in the target plant species is not fully supported by the available literature. The third group (c) consists of 14 phytoplasmas with substantial presence in the EU (i.e. they are originally described or reported from the EU or known to occur or be widespread in some EU Member States or frequently reported in the EU). Phytoplasmas of categories (b) and (c) were excluded at this stage from further categorisation efforts. One phytoplasma from category (a) ('*Ca.* P. phoenicium') was excluded from further categorisation, as a pest risk assessment has been performed by EPPO. Comments provided by the EU Member States were integrated in the opinion. The main uncertainties of this listing concern: the geographic distribution and prevalence, the taxonomy, biology and host range. The phytoplasmas considered as non-EU and whose presence in target plant species is fully supported by literature (category (a)) are categorised by the Panel in a separate opinion.

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1. Introduction

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

1.1.1. Background

Council Directive 2000/29/EC[1] on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community establishes the present European Union plant health regime. The Directive lays down the phytosanitary provisions and the control checks to be carried out at the place of origin on plants and plant products destined for the Union or to be moved within the Union. In the Directive's 2000/29/EC annexes, the list of harmful organisms (pests) whose introduction into or spread within the Union is prohibited, is detailed together with specific requirements for import or internal movement.

Following the evaluation of the plant health regime, the new basic plant health law, Regulation (EU) 2016/2031[2] on protective measures against pests of plants, was adopted on 26 October 2016 and will apply from 14 December 2019 onwards, repealing Directive 2000/29/EC. In line with the principles of the above mentioned legislation and the follow-up work of the secondary legislation for the listing of EU regulated pests, EFSA is requested to provide pest categorisations of the harmful organisms included in the annexes of Directive 2000/29/EC, in the cases where recent pest risk assessment/pest categorisation is not available.

1.1.2. Terms of Reference

EFSA is requested, pursuant to Article 22(5.b) and Article 29(1) of Regulation (EC) No 178/2002[3], to provide scientific opinion in the field of plant health.

EFSA is requested to prepare and deliver a pest categorisation (step 1 analysis) for each of the regulated pests included in the appendices of the annex to this mandate. The methodology and template of pest categorisation have already been developed in past mandates for the organisms listed in Annex II Part A Section II of Directive 2000/29/EC. The same methodology and outcome is expected for this work as well.

The list of the harmful organisms included in the annex to this mandate comprises 133 harmful organisms or groups. A pest categorisation is expected for these 133 pests or groups and the delivery of the work would be stepwise at regular intervals through the year as detailed below. First priority covers the harmful organisms included in Appendix 1, comprising pests from Annex II Part A Section I and Annex II Part B of Directive 2000/29/EC. The delivery of all pest categorisations for the pests included in Appendix 1 is June 2018. The second priority is the pests included in Appendix 2, comprising the group of *Cicadellidae* (non-EU) known to be vector of Pierce's disease (caused by *Xylella fastidiosa*), the group of *Tephritidae* (non-EU), the group of potato viruses and virus-like organisms, the group of viruses and virus-like organisms of *Cydonia* Mill., *Fragaria* L., *Malus* Mill., *Prunus* L., *Pyrus* L., *Ribes* L., *Rubus* L. and *Vitis* L. and the group of *Margarodes* (non-EU species). The delivery of all pest categorisations for the pests included in Appendix 2 is end 2019. The pests included in Appendix 3 cover pests of Annex I part A section I and all pests categorisations should be delivered by end 2020.

For the above-mentioned groups, each covering a large number of pests, the pest categorisation will be performed for the group and not the individual harmful organisms listed under "such as" notation in the Annexes of the Directive 2000/29/EC. The criteria to be taken particularly under consideration for these cases, is the analysis of host pest combination, investigation of pathways, the damages occurring and the relevant impact.

Finally, as indicated in the text above, all references to 'non-European' should be avoided and replaced by 'non-EU' and refer to all territories with exception of the Union territories as defined in Article 1 point 3 of Regulation (EU) 2016/2031.

[1] Council Directive 2000/29/EC of 8 May 2000 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 169/1, 10.7.2000, p. 1–112.

[2] Regulation (EU) 2016/2031 of the European Parliament of the Council of 26 October 2016 on protective measures against pests of plants. OJ L 317, 23.11.2016, p. 4–104.

[3] Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety. OJ L 31/1, 1.2.2002, p. 1–24.

1.1.2.1. Terms of Reference: Appendix 1

List of harmful organisms for which a pest categorisation is requested. The list below follows the annexes of Directive 2000/29/EC.

Annex IIAI

(a) Insects, mites and nematodes, at all stages of their development

Aleurocanthus spp.
Anthonomus bisignifer (Schenkling)
Anthonomus signatus (Say)
Aschistonyx eppoi Inouye
Carposina niponensis Walsingham
Enarmonia packardi (Zeller)
Enarmonia prunivora Walsh
Grapholita inopinata Heinrich
Hishomonus phycitis
Leucaspis japonica Ckll.
Listronotus bonariensis (Kuschel)
Numonia pyrivorella (Matsumura)
Oligonychus perditus Pritchard and Baker
Pissodes spp. (non-EU)
Scirtothrips aurantii Faure
Scirtothrips citri (Moultex)
Scolytidae spp. (non-EU)
Scrobipalpopsis solanivora Povolny
Tachypterellus quadrigibbus Say
Toxoptera citricida Kirk.
Unaspis citri Comstock

(b) Bacteria

Citrus variegated chlorosis
Erwinia stewartii (Smith) Dye
Xanthomonas campestris pv. *oryzae* (Ishiyama) Dye and pv. *oryzicola* (Fang. et al.) Dye

(c) Fungi

Alternaria alternata (Fr.) Keissler (non-EU pathogenic isolates)
Anisogramma anomala (Peck) E. Müller
Apiosporina morbosa (Schwein.) v. Arx
Ceratocystis virescens (Davidson) Moreau
Cercoseptoria pini-densiflorae (Hori and Nambu) Deighton
Cercospora angolensis Carv. and Mendes
Elsinoe spp. Bitanc. and Jenk. Mendes
Fusarium oxysporum f. sp. *albedinis* (Kilian and Maire) Gordon
Guignardia piricola (Nosa) Yamamoto
Puccinia pittieriana Hennings
Stegophora ulmea (Schweinitz: Fries) Sydow & Sydow
Venturia nashicola Tanaka and Yamamoto

(d) Virus and virus-like organisms

Beet curly top virus (non-EU isolates)
Black raspberry latent virus
Blight and blight-like
Cadang-Cadang viroid
Citrus tristeza virus (non-EU isolates)
Leprosis
Little cherry pathogen (non- EU isolates)
Naturally spreading psorosis
Palm lethal yellowing mycoplasm
Satsuma dwarf virus
Tatter leaf virus
Witches' broom (MLO)

Annex IIB

(a) Insect mites and nematodes, at all stages of their development

Anthonomus grandis (Boh.)
Cephalcia lariciphila (Klug)
Dendroctonus micans Kugelan
Gilphinia hercyniae (Hartig)
Gonipterus scutellatus Gyll.
Ips amitinus Eichhof
Ips cembrae Heer
Ips duplicatus Sahlberg
Ips sexdentatus Börner
Ips typographus Heer
Sternochetus mangiferae Fabricius

(b) Bacteria

Curtobacterium flaccumfaciens pv. flaccumfaciens (Hedges) Collins and Jones

(c) Fungi

Glomerella gossypii Edgerton
Gremmeniella abietina (Lag.) Morelet
Hypoxylon mammatum (Wahl.) J. Miller

1.1.2.2. Terms of Reference: Appendix 2

List of harmful organisms for which a pest categorisation is requested per group. The list below follows the categorisation included in the annexes of Directive 2000/29/EC.

Annex IAI

(a) Insects, mites and nematodes, at all stages of their development

Group of Cicadellidae (non-EU) known to be vector of Pierce's disease (caused by *Xylella fastidiosa*), such as:

1) *Carneocephala fulgida* Nottingham
2) *Draeculacephala minerva* Ball
3) *Graphocephala atropunctata* (Signoret)

Group of Tephritidae (non-EU) such as:

1) *Anastrepha fraterculus* (Wiedemann)
2) *Anastrepha ludens* (Loew)
3) *Anastrepha obliqua* Macquart
4) *Anastrepha suspensa* (Loew)
5) *Dacus ciliatus* Loew
6) *Dacus curcurbitae* Coquillet
7) *Dacus dorsalis* Hendel
8) *Dacus tryoni* (Froggatt)
9) *Dacus tsuneonis* Miyake
10) *Dacus zonatus* Saund.
11) *Epochra canadensis* (Loew)
12) *Pardalaspis cyanescens* Bezzi
13) *Pardalaspis quinaria* Bezzi
14) *Pterandrus rosa* (Karsch)
15) *Rhacochlaena japonica* Ito
16) *Rhagoletis completa* Cresson
17) *Rhagoletis fausta* (Osten-Sacken)
18) *Rhagoletis indifferens* Curran
19) *Rhagoletis mendax* Curran
20) *Rhagoletis pomonella* Walsh
21) *Rhagoletis suavis* (Loew)

(c) Viruses and virus-like organisms

Group of potato viruses and virus-like organisms such as:

1) Andean potato latent virus
2) Andean potato mottle virus
3) Arracacha virus B, oca strain
4) Potato black ringspot virus
5) Potato virus T
6) non-EU isolates of potato viruses A, M, S, V, X and Y (including Yo, Yn and Yc) and Potato leafroll virus

Group of viruses and virus-like organisms of *Cydonia* Mill., *Fragaria* L., *Malus* Mill., *Prunus* L., *Pyrus* L., *Ribes* L., *Rubus* L. and *Vitis* L., such as:

1) Blueberry leaf mottle virus
2) Cherry rasp leaf virus (American)
3) Peach mosaic virus (American)
4) Peach phony rickettsia
5) Peach rosette mosaic virus
6) Peach rosette mycoplasm
7) Peach X-disease mycoplasm
8) Peach yellows mycoplasm
9) Plum line pattern virus (American)
10) Raspberry leaf curl virus (American)
11) Strawberry witches' broom mycoplasma
12) Non-EU viruses and virus-like organisms of *Cydonia* Mill., *Fragaria* L., *Malus* Mill., *Prunus* L., *Pyrus* L., *Ribes* L., *Rubus* L. and *Vitis* L.

Annex IIAI

(a) Insects, mites and nematodes, at all stages of their development

Group of *Margarodes* (non-EU species) such as:

1) *Margarodes vitis* (Phillipi)
2) *Margarodes vredendalensis* de Klerk
3) *Margarodes prieskaensis* Jakubski

1.1.2.3. Terms of Reference: Appendix 3

List of harmful organisms for which a pest categorisation is requested. The list below follows the annexes of Directive 2000/29/EC.

Annex IAI

(a) Insects, mites and nematodes, at all stages of their development

Acleris spp. (non-EU)
Amauromyza maculosa (Malloch)
Anomala orientalis Waterhouse
Arrhenodes minutus Drury
Choristoneura spp. (non-EU)
Conotrachelus nenuphar (Herbst)
Dendrolimus sibiricus Tschetverikov
Diabrotica barberi Smith and Lawrence
Diabrotica undecimpunctata howardi Barber
Diabrotica undecimpunctata undecimpunctata Mannerheim
Diabrotica virgifera zeae Krysan & Smith
Diaphorina citri Kuway
Heliothis zea (Boddie)
Hirschmanniella spp., other than *Hirschmanniella gracilis* (de Man) Luc and Goodey
Liriomyza sativae Blanchard
Longidorus diadecturus Eveleigh and Allen
Monochamus spp. (non-EU)
Myndus crudus Van Duzee
Nacobbus aberrans (Thorne) Thorne and Allen
Naupactus leucoloma Boheman
Premnotrypes spp. (non-EU)
Pseudopityophthorus minutissimus (Zimmermann)
Pseudopityophthorus pruinosus (Eichhoff)
Scaphoideus luteolus (Van Duzee)
Spodoptera eridania (Cramer)
Spodoptera frugiperda (Smith)
Spodoptera litura (Fabricus)
Thrips palmi Karny
Xiphinema americanum Cobb *sensu* lato (non-EU populations)
Xiphinema californicum Lamberti and Bleve-Zacheo

(b) Fungi

Ceratocystis fagacearum (Bretz) Hunt
Chrysomyxa arctostaphyli Dietel
Cronartium spp. (non-EU)
Endocronartium spp. (non-EU)
Guignardia laricina (Saw.) Yamamoto and Ito
Gymnosporangium spp. (non-EU)
Inonotus weirii (Murril) Kotlaba and Pouzar
Melampsora farlowii (Arthur) Davis
Mycosphaerella larici-leptolepis Ito et al.
Mycosphaerella populorum G. E. Thompson
Phoma andina Turkensteen
Phyllosticta solitaria Ell. and Ev.
Septoria lycopersici Speg. var. *malagutii* Ciccarone and Boerema
Thecaphora solani Barrus
Trechispora brinkmannii (Bresad.) Rogers

(c) Viruses and virus-like organisms

Tobacco ringspot virus
Tomato ringspot virus
Bean golden mosaic virus
Cowpea mild mottle virus
Lettuce infectious yellows virus
Pepper mild tigré virus
Squash leaf curl virus
Euphorbia mosaic virus
Florida tomato virus

(d) Parasitic plants

Arceuthobium spp. (non-EU)

Annex IAII

(a) Insects, mites and nematodes, at all stages of their development

Meloidogyne fallax Karssen
Popillia japonica Newman
Rhizoecus hibisci Kawai and Takagi

(b) Bacteria

Clavibacter michiganensis (Smith) Davis et al. ssp. *sepedonicus* (Spieckermann and Kotthoff) Davis et al.
Ralstonia solanacearum (Smith) Yabuuchi et al.

(c) Fungi

Melampsora medusae Thümen
Synchytrium endobioticum (Schilbersky) Percival

Annex I B

(a) Insects, mites and nematodes, at all stages of their development

Leptinotarsa decemlineata Say
Liriomyza bryoniae (Kaltenbach)

(b) Viruses and virus-like organisms

Beet necrotic yellow vein virus

1.1.3. Interpretation of the Terms of Reference

This opinion provides a list of non-EU phytoplasmas of *Cydonia* Mill., *Fragaria* L., *Malus* Mill., *Prunus* L., *Pyrus* L., *Ribes* L., *Rubus* L. and *Vitis* L. (from now on: 'the host plants'), for which the EFSA Plant Health Panel (from now on: 'the Panel') then conducted a pest categorisation in a separate opinion (EFSA PLH Panel, 2020). This list is based on information collected from databases up to June 2018, as well as information received from EU Member States (MS) during the period February-March 2019.

Non-EU phytoplasmas of the host plants are pests listed in the Appendices to the Terms of Reference (ToR) to be subject to pest categorisation to determine whether they fulfil the criteria of quarantine pests or those of regulated non-quarantine pests for the area of the EU excluding Ceuta, Melilla and the outermost regions of MS referred to in Article 355(1) of the Treaty on the Functioning of the European Union (TFEU), other than Madeira and the Azores.

As a first step towards this goal, the Panel prepared a list of phytoplasmas infecting the host plants. In the process, three groups of phytoplasmas were distinguished:

(a) non-EU phytoplasmas with presence in the host plants fully supported by literature,
(b) non-EU phytoplasmas with presence in the host plants not fully supported by literature, and
(c) phytoplasmas (affecting the host plants) with widespread presence in the EU (known to occur in several MS, frequently reported in the EU, widespread in some MS) or originally described or reported from the EU.

A non-EU phytoplasma is defined by its geographical origin outside of the EU. Therefore, phytoplasmas not reported from the EU and occurring only outside of the EU are considered as non-EU phytoplasmas. Likewise, phytoplasmas occurring outside the EU and having only a limited presence in the EU (reported in only one or few MSs, with restricted distribution) are also considered as non-EU phytoplasmas.

This opinion provides the methodology and results for this classification, thus preparing the ground for the pest categorisation linked to the present mandate (EFSA PLH Panel, 2020). This means that the Panel then performed a pest categorisation for the non-EU phytoplasmas with confirmed ability to infect the host plants. The phytoplasmas with uncertain ability to infect the host plants and the phytoplasmas with significant presence in the EU or originally described or reported from the EU are excluded from further categorisation efforts, unless this will be requested by the risk managers in the future.

In this opinion, to capture the broadest possible range of phytoplasmas, even the poorly characterised ones for which very partial molecular or biological data are available, were considered. In particular, as in some cases there are uncertainties about the '*Ca*. P. species definition', related strains will be considered if they infect any of the host plants. Instead, phytoplasma-like diseases of unknown

aetiology or caused by viruses and formerly associated to mycoplasma-like organisms (MLO) or by other graft-transmissible bacteria are not addressed in this opinion.

2. Data and methodologies

2.1. Data

2.1.1. Literature search

The literature considered to generate the list of phytoplasmas infecting the host plants (see Section 1.1.3) and to fill in the extraction tables on their distribution (see Appendixes A–C and Annex A) was obtained from expert knowledge and extensive literature searches performed in Web of Science (WoS, last access June 2018). For each host plant genus, searches in WoS were performed using as keywords: phytoplasma/mycoplasma/witch/spiroplasma combined with the scientific name of the genus OR the common name(s) of the crops. Therefore, for each host plant genus, searches in WoS were performed according to the following strategy:

TS=((Phytoplasma* OR mycoplasma* OR witch* OR spiroplasma*) AND (latin name of the host genus – e.g. Vitis – OR common name in English of the crop – e.g. grapevine)

All the references were screened by title, by abstract, and, if needed, by full paper with the specific objective of selecting those providing additional information regarding distribution and host range of the phytoplasmas included in the list or not yet included.

Extensive literature searches in Google Scholar using as keyword the name of a single phytoplasma were also performed for all the phytoplasmas listed in the EPPO Global Database (EPPO GD) (EPPO, 2019), and for all '*Candidatus* Phytoplasma species' described up to 2017 (Naderali et al., 2017).

Information on phytoplasma taxonomy was gathered from either the original reference to species description or IRPCM (International Research Programme on Comparative Mycoplasmology) Phytoplasma/Spiroplasma Working Team–Phytoplasma Taxonomy Group (IRPCM, 2004).

Further references and data were obtained from experts, EU National Plant Protection Organisations and from citations within primary references.

2.1.2. Database search

Data on host(s) and distribution of the phytoplasmas were retrieved from the EPPO GD (EPPO, 2019), the Centre for Agriculture and Biosciences International Crop Protection Compendium (CABI, 2019) and relevant publications.

GenBank accessions referring to phytoplasmas were added.

2.2. Methodology

A preliminary list of phytoplasmas infecting the host plants (see Section 1.1.3) was generated by screening for phytoplasma diseases of the host plants present in the EPPO Lists A1 and A2. Further, all phytoplasma diseases listed in the EPPO GD were also screened for their association with the host plants. Then, all phytoplasmas listed in the most recent '*Ca*. P. phytoplasma' species description (Naderali et al., 2017) were screened for their association with the host plants. Finally, the relevant phytoplasmas resulting from the literature search in WoS (as previously described) were included in the list.

The collected information was used to fill an extraction table (Annex A) with data regarding the taxonomy, geographical distribution and host range of each phytoplasma and key references and sources used to obtain that information. Taxonomy, distribution and host range are reported in the table using the following scheme:

- the taxonomy was reported according to '*Ca*. P. species' description, when available. Although phytoplasmas have not yet been cultivated *in vitro*, phylogenetic analyses based on various conserved genes have shown that they represent a distinct, monophyletic clade within the class Mollicutes. Phytoplasmas are therefore accommodated within the '*Candidatus* Phytoplasma' genus. Within this genus, several subtaxa have been described to accommodate organisms sharing less than 97.5% similarity among their 16S rRNA gene sequences. Additional species are described to accommodate organisms that, despite their 16S rRNA gene sequence being > 97.5 % similar to those of other '*Ca*. Phytoplasma' species, are characterised by distinctive biological, phytopathological and genetic properties. Conversely, some organisms, despite their 16S rRNA gene sequence being < 97.5 % similar to that of any other '*Ca*. Phytoplasma' species, are not presently

described as *Candidatus* species, due to their poor overall characterisation (IRPCM, 2004). When a phytoplasma was not classified yet, information on a tentative classification was included based on the original literature source in which the pathogen was reported; to facilitate data retrieval from the literature and available databases, also the 16S rRNA group and subgroups were reported.
– data on distribution and host range of phytoplasmas were first searched in EPPO (2019) and in CABI (2019). Whenever conclusive information was not identified in the two databases or the information retrieved was at odds with expert knowledge, or in the absence of any information, extensive literature searches according to the protocol reported in Section 2.1 were performed.

Because only the non-EU phytoplasmas were subject of further categorisation efforts in the frame of the present mandate, it was decided to have consultation phases with EU MS so that they could provide additional input if necessary. The information provided by EU MS was then considered by the Panel to determine the non-EU phytoplasmas that were further categorised (Section 3.1). The phytoplasmas excluded from this group are referred to here as phytoplasmas excluded from further categorisation in the frame of the present mandate (Section 3.2).

3. Listing of phytoplasmas

3.1. Phytoplasmas considered as non-EU

The phytoplasmas considered as non-EU (Appendix A) belong to two sub-categories:

- Phytoplasmas not known to be present in the EU ('*Ca*. P. australiense', '*Ca*. P. hispanicum', '*Ca*. P. pruni'-related strain (NAGYIII), '*Ca*. P. pyri'-related strain (PYLR) and Buckland valley grapevine yellows phytoplasma)
- Phytoplasmas known to be present outside the EU and with only limited presence (i.e. reported in only one or few MSs or known to have a restricted distribution) in the EU ('*Ca*. P. aurantifolia'–related strains, '*Ca*. P. fraxini', '*Ca*. P. phoenicium', '*Ca*. P. trifolii' and '*Ca*. P. ziziphi').

These phytoplasmas are categorised in EFSA PLH Panel (2020), with the exception of '*Ca*. P. phoenicium', for which a pest risk assessment is already available (EPPO, 2017).

3.2. Phytoplasmas excluded from further categorisation in the frame of the present mandate

The phytoplasmas excluded from further categorisation in the frame of the present mandate are listed in Appendices B and C. The phytoplasmas listed in Appendix B are considered as non-EU, but their ability to infect the host plants was not conclusively supported by the available literature, and belong to two subcategories:

- Phytoplasmas not known to be present in the EU,
- Phytoplasmas known to be present outside the EU and with only limited presence (i.e. reported in only one or few MSs or known to have restricted distribution) in the EU.

Phytoplasmas listed in Appendix C belong to two sub-categories:

- Phytoplasmas originally described or reported from the EU,
- Phytoplasmas known to be present outside the EU, but with a substantial presence also in the EU (known to occur in several MSs, frequently reported in the EU, widespread in some MSs).

3.3. Uncertainties

Uncertainties potentially affecting the current list of non-EU phytoplasmas include:

- The geographic distribution and prevalence of the phytoplasmas.
- The taxonomy and biological status of poorly characterised phytoplasmas.
- The host status of particular plant genera for some phytoplasmas.

4. Conclusions

The Panel was requested by the European Commission to produce a categorisation of 133 harmful organisms or groups listed in annexes of Directive 2000/29/EC. One of the groups for which a categorisation was prepared is non-EU phytoplasmas of *Cydonia, Fragaria, Malus, Prunus, Pyrus,*

Ribes, Rubus and *Vitis.* As a first step, a systematic approach identified 27 phytoplasmas reported to naturally infect one or more of these genera (Annex A).

Among these phytoplasmas, based on information on distribution and prevalence both inside and outside the EU, the Panel identified 10 non-EU phytoplasmas, known to occur only outside the EU or having only a limited presence in the EU (Appendix A). These phytoplasmas are categorised in EFSA PLH Panel (2020), with the exception of '*Ca.* P. phoenicium', for which a pest risk assessment is already available (EPPO, 2017).

The remaining 17 phytoplasmas (non-EU phytoplasmas, known to occur only outside the EU or having only a limited presence in the EU, whose ability to infect the host species is not fully confirmed by available literature (Appendix B, 3 phytoplasmas), or which have a substantial presence in the EU or are originally described or reported from the EU (Appendix C, 14 phytoplasmas)) were not categorised within the current mandate. However, the European Commission may, at any time, request EFSA to categorise some or all the phytoplasmas excluded from the present exercise.

The main uncertainties of this listing concern the geographic distribution, taxonomy, biology and host range of some phytoplasmas.

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Abbreviations

Ca. P.	*Candidatus* Phytoplasma
CrWB	Crotalaria witches'-broom
EPPO	European and Mediterranean Plant Protection Organization
GD	Global Database

IRPCM	International Research Programme on Comparative Mycoplasmology
KAP	Knautia arvensis phyllody
MLO	mycoplasma-like organisms
MS	Member State
NAGYIII	North American Grapevine Yellows
PCR	polymerase chain reaction
PDTWII	Pear decline Taiwan II
PEY	Picris echioides yellows
PHYPAA	*Candidatus* Phytoplasma australasia
PHYPAS	*Candidatus* Phytoplasma asteris
PHYPAU	*Candidatus* Phytoplasma australiense
PHYPBR	*Candidatus* Phytoplasma brasiliense
PHYPFG	*Candidatus* Phytoplasma fragariae
PHYPFR	*Candidatus* Phytoplasma fraxini
PHYPMA	*Candidatus* Phytoplasma mali
PHYPPH	*Candidatus* Phytoplasma phoenicium
PHYPPN	*Candidatus* Phytoplasma pruni
PHYPPR	*Candidatus* Phytoplasma prunorum
PHYPPY	*Candidatus* Phytoplasma pyri
PHYPRU	*Candidatus* Phytoplasma rubi
PHYPSO	*Candidatus* Phytoplasma solani
PHYPTR	*Candidatus* Phytoplasma trifolii
PHYPUL	*Candidatus* Phytoplasma ulmi
PHYPZI	*Candidatus* Phytoplasma ziziphi
PHYP01	Tomato big bud
PHYP07	*Candidatus* Phytoplasma hispanicum
PHYP19	Clover yellow edge phytoplasma
PHYP39	Sweet potato little leaf
PHYP42	Pigeon pea witches' broom
PHYP45	Knautia phyllody phytoplasma
PHYP64	Grapevine Flavescence dorée phytoplasma
PHYP65	German flavescence dorée phytoplasma
PHYP74	Alder yellows phytoplasma
PLH	Plant Health
PYLR	Peach yellow leaf roll
RFLP	Restriction Fragment Length Polymorphism
SPLL	Sweet potato little leaf
TBB	Tomato big bud
TFEU	Treaty on the Functioning of the European Union
The host plants	*Cydonia, Fragaria, Malus, Prunus, Pyrus, Ribes, Rubus* and *Vitis*
ToR	Terms of Reference
WoS	Web of Science

Appendix A – Non-EU phytoplasmas of *Cydonia*, *Fragaria*, *Malus*, *Prunus*, *Pyrus*, *Ribes*, *Rubus* and *Vitis*

ID	Phytoplasma name	Related strain name(1)	Abbreviation (EPPO code)	16S rRNA	*Cydonia*	*Fragaria*	*Malus*	*Prunus*	*Pyrus*	*Ribes*	*Rubus*	*Vitis*	Reasoning for considering non-EU	Uncertainties	References
1	*Candidatus Phytoplasma aurantifolia*	'*Ca*. P. australasia, pear decline Taiwan II (PDTWII); Crotalaria witches'-broom phytoplasma (CrWB); sweet potato little leaf (SPLL)	PHYPAA, PHYP39	II	–	–	Yes	Yes	Yes	–	–	Yes	Only one report in *Fallopia japonica* in UK(2); Greek report of TBB (tomato big bud) (listed in EPPO) is most probably to be assigned to either '*Ca*. P. asteris' or '*Ca*. P. solani'; Italian reports refer to few infected individuals	Hashemi-Tameh et al., 2014 (4 infected *Malus* plants); Ghayeb Zamharir et al., 2017 (4 Vitis plants); Reeder et al., 2010a (only one report from UK, 4 plants detected by nested PCR (polymerase chain reaction) out of 4 tested ones); [PHYP01]: in Tomato in Greece following EPPO (Alivizatos, 1993; only EM), but Vellios and Lioliopoulou, 2007 identified only 16SrI and XII in tomato in Greece. No record of its presence in Portugal.(2) Absence of PHYPAA distribution map	Species description: (White et al., 1998; Liu et al., 2011; IRPCM, 2004) *Malus*: (Hashemi-Tameh et al., 2014); *Prunus*: (Zirak et al., 2009, 2010a,b); *Vitis*: (Constable et al., 2003; Ghayeb Zamharir et al., 2017); *Pyrus*: (Schneider and Gibb, 1997; Liu et al., 2011); *Fallopia japonica* in UK (Reeder et al., 2010a); *Solanum tuberosum* in Italy (Paltrinieri and Bertaccini, 2007); *Empoasca decipiens* in Italy (Parrella et al., 2008); *Calendula arvensis, Solanum nigrum*, and *Chenopodium* spp. In Italy (Tolu et al., 2006); *Matthiola incana* in Italy (Davino et al., 2007)
2	*Candidatus Phytoplasma australiense*	–	PHYPAU	XII-B	–	Yes	–	Yes	–	–	Yes	Yes	Not reported to be present in the EU	–	Species description: (Davis et al., 1997); *Prunus*: (Jones et al., 2005)

ID	Phytoplasma name	Related strain name[1]	Abbreviation (EPPO code)	16S rRNA	*Cydonia*	*Fragaria*	*Malus*	*Prunus*	*Pyrus*	*Ribes*	*Rubus*	*Vitis*	Reasoning for considering non-EU	Uncertainties	References
3	*Candidatus Phytoplasma fraxini*	–	PHYPFR	VII-A	–	Yes	–	Yes	–	–	–	Yes	Only two reports in Italy	Zambon et al., 2018 (9 plants detected in Italy by nested PCR out of 161 tested ones); Bruni et al., 2005 (*Hypericum perforatum* in Italy: it is not known on how many plants the phytoplasma was identified)	Species description: (Griffiths et al., 1999); *Fragaria*: (Fernandez et al., 2013); *Prunus*: (Zunnoon-Khan et al., 2010); *Vitis*: (Gajardo et al., 2009; Ghayeb Zamharir et al., 2017; Zambon et al., 2018); Italy: (Bruni et al., 2005; Zambon et al., 2018)
4	*Candidatus Phytoplasma hispanicum*	–	PHYP07	XIII	–	Yes	–	–	–	–	–	–	Not reported to be present in the EU	–	Species description: (Davis et al., 2016); *Fragaria*: (Jomantiene et al., 1998; Fernandez et al., 2015)
5	*Candidatus Phytoplasma phoenicium*	–	PHYPPH	IX-B, D, F, G[2]	–	–	–	Yes	–	–	–	Yes	Only one report in Italy	Ghayeb Zamharir et al., 2017 (3 *Vitis* plants with probable mixed infections)	Species description: (Verdin et al., 2003; EPPO, 2017); *Vitis*: (Ghayeb Zamharir et al., 2017); *Prunus* in Italy: (Nigro et al., 2020)
6	*Candidatus Phytoplasma pruni*	North American Grapevine Yellows - NAGYIII	–	III	–	–	–	–	–	–	–	Yes	Not reported to be present in the EU	–	Species description: (Davis et al., 2015)
7	*Candidatus Phytoplasma pyri*	Peach yellow leafroll	–	X	–	–	–	Yes	–	–	–	–	Not reported to be present in the EU	–	Species description: (Morton et al., 2003; Seemüller and Schneider, 2004); *Prunus*: (Marcone et al., 2014)

ID	Phytoplasma name	Related strain name(1)	Abbreviation (EPPO code)	16S rRNA	*Cydonia*	*Fragaria*	*Malus*	*Prunus*	*Pyrus*	*Ribes*	*Rubus*	*Vitis*	Reasoning for considering non-EU	Uncertainties	References
8	*Candidatus Phytoplasma trifolii*	–	PHYPTR	VI-A	–	Yes	–	Yes	–	–	–	Yes	Reports from the EU MS refer to few infected plants	[PHYPTR]: Pribylova et al., 2009; Borroto Fernandez et al., 2007 (Reports from the EU MS refer to few infected plants, ranging from 1 to 28); Zirak et al., 2010b (only in one *Prunus* plant out of 91 tested plants)	Species description and *Fragaria*: (Hiruki and Wang, 2004); *Prunus*: (Zirak et al., 2010b); Czech Republik: (Pribylova et al., 2009); Austria: (Borroto Fernandez et al., 2007)
9	*Candidatus Phytoplasma ziziphi*	–	PHYPZI	V-B	–	–	Yes	Yes	–	–	–	–	One report from Italy is related to mixed infections with '*Ca*. P. solani' and '*Ca*. P. asteris' and the other one has no further characterization beside PCR and RFLP (restriction fragment length polymorphism) analyses	Paltrinieri et al., 2006 (*Prunus* in Italy: only a Congress abstracts, no further details); Pasquini et al., 2000 (*Olea europea* in Italy: phytoplasma detected based only on PCR and RFLP analyses of ribosomal operon)	Species description: (Jung et al., 2003); *Malus*: (Li et al., 2014); *Prunus*: (Zhu et al., 1998; Wang et al., 2014, 2018); *Prunus* in Italy: (Paltrinieri et al., 2006); *Olea europea* in Italy: (Pasquini et al., 2000)
10	*Unclassified*	Buckland valley grapevine yellows phytoplasma	–	XXIII	–	–	–	–	–	–	–	Yes	Not reported to be present in the EU	–	Species description: (Constable et al., 2002)

(1): Reference isolate of '*Candidatus* Phytoplasma species' is indicated by '–'.
(2): Information provided by MS during commenting phase.

Appendix B – Phytoplasmas of *Cydonia*, *Fragaria*, *Malus*, *Prunus*, *Pyrus*, *Ribes*, *Rubus* and *Vitis* excluded from further categorisation as their presence in the species is not fully supported by available literature

ID	Phytoplasma name	Related strain name(1)	Abbreviation (EPPO code)	16S rRNA	*Cydonia*	*Fragaria*	*Malus*	*Prunus*	*Pyrus*	*Ribes*	*Rubus*	*Vitis*	Reasoning for considering non-EU	Uncertainties	References
11	*Candidatus Phytoplasma brasiliense*	–	PHYPBR	XV-A	–	–	–	Yes	–	–	–	–	Not reported to be present in the EU. Excluded from further categorisation as its presence in *Prunus* is not fully supported by available literature	Balakishiyeva et al., 2011 (only in 1 *Prunus* plant)	Species description: (Montano et al., 2001); *Prunus*: (Balakishiyeva et al., 2011)
12	*Candidatus Phytoplasma pruni*	Clover yellow edge, CYE (CYE-C; CYE-L)	PHYP19	III-B	–	Yes	–	–	–	–	–	–	In the EU reported only in two clover plants and in mixed infections. Excluded from further categorisation as its presence in *Fragaria* is not fully supported by available literature	Staniulis et al., 2000 (Only in two clover plants and in mixed infections); Jomantiene et al., 2002 (Reported in *Fragaria* in a unique report of a maximum of 5 tested symptomatic plants	Species description: (Davis et al., 2013); *Fragaria*: (Jomantiene et al., 2002); in clover and Lithuania (Staniulis et al., 2000)
13	Unclassified	Pigeon pea witches' broom	PHYP42	IX-A	–	–	–	–	–	–	–	Yes	Not reported to be present in the EU. Excluded from further categorisation as its presence in *Vitis* is not fully supported by available literature	Ertunc et al., 2015 (Reported on 1 *Vitis* plant out of 289 tested plants)	Species description: (Ertunc et al., 2015)

(1): Reference isolate of '*Candidatus* Phytoplasma species' is indicated by '–'.

Appendix C – Phytoplasmas of *Cydonia*, *Fragaria*, *Malus*, *Prunus*, *Pyrus*, *Ribes*, *Rubus* and *Vitis* excluded from further categorisation

ID	Phytoplasma name	Related strain name[1]	Abbreviation (EPPO code)	16S rRNA	EU MS in which the pathogen has been reported	Non-EU European and neighbouring countries	*Cydonia*	*Fragaria*	*Malus*	*Prunus*	*Pyrus*	*Ribes*	*Rubus*	*Vitis*	Reasoning for considering as EU	Uncertainties	References
14	*Candidatus Phytoplasma asteris*	–	PHYPAS	I	Germany, Hungary, Italy (Present widespread); Czech Republic, Spain (Present, restricted distribution); France, Romania (Present, no details); Belgium[2]; UK[2]	Russia (Present, restricted distribution; Belarus (Present, no details)	–	Yes	Yes[2]	Yes	Yes	–	Yes	Yes	Reported in the EU (several MS)	–	Species description, *Fragaria*, *Prunus*, *Pyrus*, *Vitis*: (Lee et al., 2004a) and *Rubus* (Reeder et al., 2010b); Lithuania (Valiunas et al., 2007); UK (Jones and Arocha, 2006; Reeder and Arocha, 2008; Nisbet et al., 2014), Slovenia: (Mehle et al., 2018; Radisek et al., 2009)
15	*Candidatus Phytoplasma fragariae*	–	PHYPFG	XII-E	Slovenia (EPPO report 2018/085); UK (2015/031); Belgium[2]		–	Yes	–	–	–	–	–	–	Originally described in the EU	–	Species description: (Valiunas et al., 2006)
16	*Candidatus Phytoplasma mali*	–	PHYPMA	X	Czech Republic, Germany, Hungary, Italy, Slovakia, Slovenia (Present widespread); Austria, Belgium, Bulgaria, Croatia, Finland, France, Greece (Present, restricted distribution); Poland, Romania (Present, no details); Netherlands (Present, few occurrences)	Switzerland (Present widespread); Norway (Present, restricted distribution); Albania, Bosnia and Herzegovina, Moldova, Turkey, Ukraine (Present, no details)	–	–	Yes	Yes	Yes	–	–	–	Reported in the EU (several MS)	–	Species description: (Seemüller and Schneider, 2004)

ID	Phytoplasma name	Related strain name[1]	Abbreviation (EPPO code)	16S rRNA	EU MS in which the pathogen has been reported	Non-EU European and neighbouring countries	*Cydonia*	*Fragaria*	*Malus*	*Prunus*	*Pyrus*	*Ribes*	*Rubus*	*Vitis*	Reasoning for considering as EU	Uncertainties	References
17	*Candidatus Phytoplasma pruni*	–	PHYPPN	III-A	Croatia, Italy, Lithuania, Poland, UK	Serbia	–	–	Yes	Yes	Yes	–	Yes	Yes	Reported in the EU (several MS)	PYLR is listed among synonyms of *Ca. P. pruni* in EPPO (2019), but following Seemüller and Schneider, 2004; and Morton et al., 2003, it is listed here as *Ca. P. pyri*-related strain	Species description: (Davis et al., 2013); *Pyrus* in Croatia: (Jezic et al., 2016); *Pyrus* in Italy: (Lee et al., 1995); *Rubus* in UK: (Davies, 2000); *Rubus* in Poland: (Cieslinska, 2011); *Vitis* in Croatia: (Jezic et al., 2013); *Prunus* in Lithuania: (Valiunas et al., 2009); *Prunus* in Italy: (Lee et al., 1995); *Celtis australis* in Italy: (Bertaccini et al., 1996); *Cirsium* in Serbia: (Jakovljevic et al., 2015); *Delphinium* in UK (Harju et al., 2008)[2]
18	*Candidatus Phytoplasma prunorum*	–	PHYPPR	X	Slovenia (Present, widespread); Austria, Bulgaria, Croatia, Czech Republic, France, Germany, Greece, Hungary, Italy, Poland, Romania, Spain, (Present, restricted distribution); Belgium, Slovakia (Present, few details)	Albania, Bosnia and Herzegovina, Switzerland, Turkey, UK (Present, restricted distribution); Belarus, Serbia (Present, no details); Azerbaijan (Present, few details)	–	–	–	Yes	–	–	–	–	Reported in the EU (several MS)	–	Species description: (Seemüller and Schneider, 2004)

ID	Phytoplasma name	Related strain name[1]	Abbreviation (EPPO code)	16S rRNA	EU MS in which the pathogen has been reported	Non-EU European and neighbouring countries	*Cydonia*	*Fragaria*	*Malus*	*Prunus*	*Pyrus*	*Ribes*	*Rubus*	*Vitis*	Reasoning for considering as EU	Uncertainties	References
19	*Candidatus Phytoplasma pyri*	–	PHYPPY	X	Italy, Netherlands (Present widespread); Belgium, Bulgaria, Croatia, Czech Republic, France, Germany, Greece, Poland, Slovakia, Slovenia (Present, restricted distribution); Hungary (Present, no details); Austria, Portugal, Spain (Present, few occurrences)	Switzerland (Present widespread); Norway, Serbia, Turkey (Present, restricted distribution); Albania, Bosnia and Herzegovina, Moldova (Present, no details)	Yes	–	–	Yes	Yes	–	–	–	Reported in the EU (several MS)	–	Species description: (Seemüller and Schneider, 2004); *Prunus*: (Sabate et al., 2014)
20	*Candidatus Phytoplasma rubi*	–	PHYPRU	V-E	Denmark, Germany, Italy, Netherlands (Present widespread); Bulgaria, Portugal, Slovakia (Present, no details); UK (Present widespread); Belgium[2]; Czech Republic[2]	Russia (Present, restricted distribution); Norway, Central Russia, Switzerland (Present, no details)	–	–	–	–	–	–	Yes	–	Reported in the EU (several MS)	–	Species description: (Malembic-Maher et al., 2011)

ID	Phytoplasma name	Related strain name[1]	Abbreviation (EPPO code)	16S rRNA	EU MS in which the pathogen has been reported	Non-EU European and neighbouring countries	*Cydonia*	*Fragaria*	*Malus*	*Prunus*	*Pyrus*	*Ribes*	*Rubus*	*Vitis*	Reasoning for considering as EU	Uncertainties	References
21	*Candidatus Phytoplasma solani*	–	PHYPSO	XII-A	Bulgaria, Croatia, France, Germany, Greece, Hungary, Italy, Slovakia, Slovenia, Spain, (Present, restricted distribution); Italy (Present, no details); Austria, Czech Republic, Poland (Present, few occurrences); UK (Transient, under eradication); Belgium (Absent, eradicated)[2]; Portugal (Present, restricted distribution)[2]	Macedonia, Montenegro (Present, widespread); Russia, Serbia, Switzerland, Turkey (Present, restricted distribution); Albania, Armenia, Azerbaijan, Bosnia and Herzegovina, Georgia, Ukraine (Present, no details)	–	Yes	Yes	Yes	–	–	Yes	Yes	Reported in the EU (several MS)	–	Species description: (Quaglino et al., 2013); *Malus*: (Duduk et al., 2010); *Prunus*: (Avramov et al., 2011)
22	*Candidatus Phytoplasma ulmi*	–	PHYPUL	V-A	Croatia (Present, widespread), France, Italy, Slovenia (Present, restricted distribution), Belgium (Present, under eradication)[2], Czech Republic, Germany (Present, few occurrences), Poland (Transient, under eradication); UK (Absent, eradicated)[2]	Serbia (Present, few occurrences)	–	–	–	–	–	–	–	Yes	Reported in the EU (several MS), but not in target species. Reported only once in *Vitis* (and in 1 plant)	Zambon et al., 2018 (Detected in one *Vitis* out of 161 tested ones in Italy)	Species description: (Lee et al., 2004b); *Vitis*: (Zambon et al., 2018)

ID	Phytoplasma name	Related strain name(1)	Abbreviation (EPPO code)	16S rRNA	EU MS in which the pathogen has been reported	Non-EU European and neighbouring countries	*Cydonia*	*Fragaria*	*Malus*	*Prunus*	*Pyrus*	*Ribes*	*Rubus*	*Vitis*	Reasoning for considering as EU	Uncertainties	References
23	*Unclassified*	Grapevine Flavescence dorée phytoplasma	PHYP64	V	Croatia, France, Hungary, Italy, Portugal, Slovenia (Present, restricted distribution); Austria, Spain (Present, few occurrences); Belgium (Absent, no pest record)(2)	Serbia, Switzerland (Present, restricted distribution)	–	–	–	–	–	–	–	Yes	Reported in the EU (several MS)	–	Species description: (EFSA PLH Panel, 2014); (Lee et al., 2004b)-
24	*Unclassified*	German flavescence dorée phytoplasma	PHYP65	V	Germany	–	–	–	–	–	–	–	–	Yes	Originally described in the EU	–	Species description and *Vitis*: (Angelini et al., 2001)
25	*Unclassified*	Alder yellows phytoplasma	PHYP74	V-C	France	–	–	–	–	–	–	–	–	Yes	Originally reported in the EU	–	Species description: (Lee et al., 2004b); *Vitis* (experimental transmission to): (Maixner et al., 2000); *Alnus* in France: (Arnaud et al., 2007)
26	*Unclassified*	*Knautia phyllody phytoplasma, KAP*	PHYP45	IX-C	Italy	–	–	–	–	Yes	Yes	–	–	–	Originally reported in the EU	–	Species description : (Marcone et al., 2001); *Knautia arvensis* in Italy: (Marcone et al., 1997); *Pyrus*: (Sharbatkhari et al., 2008); *Prunus*: (Salehi et al., 2006);
27	*Unclassified*	Picris echioides yellows, PEY		IX-C	Italy	–	–	–	–	–	–	–	–	Yes	Originally reported in the EU	Salehi et al., 2016 (8 plants)	Species description and *Argyranthemum* in Italy: (Ferretti et al., 2015); *Vitis*: (Salehi et al., 2016); *Picris echioides* in Italy: (Marcone et al., 1997)

(1): Reference isolate of '*Candidatus* Phytoplasma species' is indicated by '–'.
(2): Information provided by MS during commenting phase.

Annex A – List of phytoplasmas considered in the opinion

See excel file in Supplementary Information online.