SCIENTIFIC OPINION

EFSA Journal

ADOPTED: 26 November 2020

doi: 10.2903/j.efsa.2020.6355

List of non-EU phytoplasmas of tuber-forming *Solanum* spp.

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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 tuber-forming *Solanum* spp. A systematic literature review and search of databases identified 12 phytoplasmas infecting *S. tuberosum*. These phytoplasmas were assigned to three categories. The first group (a) consists of seven non-EU phytoplasmas, known to occur only outside the EU ('*Candidatus* Phytoplasma americanum', '*Ca*. P. australiense', '*Ca*. P. fragariae'-related strain (YN-169, YN-10G) and '*Ca*. P. hispanicum') or having only limited presence in the EU ('*Ca*. P. aurantifolia'–related strains, '*Ca*. P. pruni'-related strains and '*Ca*. P. trifolii'). The second group (b) consists of three phytoplasmas originally described or reported from the EU. The third group (c) consists of two phytoplasmas with substantial presence in the EU, whose presence in *S. tuberosum* is not fully supported by the available literature. Phytoplasmas of categories (b) and (c) were excluded at this stage from further categorisation efforts. Three phytoplasmas from category (a) ('*Ca*. P. australiense', '*Ca*. P. hispanicum' and '*Ca*. P. trifolii') were excluded from further categorisation, as a pest categorisation has already been performed by EFSA. Comments provided by the EU Member States were integrated in the opinion. The main uncertainties of this listing concern: the taxonomy, the geographic distribution and prevalence and host range. The following phytoplasmas considered as non-EU and whose presence in *S. tuberosum* is fully supported by literature (category (a)) are categorised by the Panel in a separate opinion: '*Ca.* P. americanum', '*Ca*. P. fragariae'-related strain (YN-169, YN-10G), '*Ca*. P. aurantifolia'–related strains and '*Ca*. P. pruni'-related strains.

Keywords: Clover yellow edge, pest risk, plant health, plant pest, potato hair sprouts, Potato purple top, quarantine

Requestor: European Commission

Question number: EFSA-Q-2020-00732

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Acknowledgements: This document was prepared in cooperation with the Istituto per la Protezione Sostenibile delle Piante, Consiglio Nazionale delle Ricerche (Italy) under the tasking grant (GP/EFSA/ALPHA/2017/02). The Panel thanks for the information provided to this scientific output: Franco Finelli (Phytosanitary Service, Italy). The Panel acknowledges Jan van der Wolf for his review of a previous draft and all European competent institutions, Member State bodies and other organisations that provided data for this scientific output.

Competing interests: In line with EFSA's policy on declarations of interest, Panel member Francesco Di Serio did not participate in the adoption of this scientific output.

Suggested citation: EFSA PLH Panel (EFSA Panel on Plant Health), Bragard C, Dehnen-Schmutz K, Gonthier P, Jaques Miret JA, Justesen AF, MacLeod A, Magnusson CS, Milonas P, Navas-Cortes JA, Parnell S, Potting R, Reignault PL, Thulke H-H, Van der Werf W, Vicent Civera A, Yuen J, Zappalà L, Bosco D, Chiumenti M, Di Serio F, Galetto L, Marzachì C, Pautasso M and Jacques M-A, 2020. Scientific Opinion on the list of non-EU phytoplasmas of tuber-forming *Solanum* spp. EFSA Journal 2020;18(12):6355, 22 pp. https://doi.org/10.2903/j.efsa.2020.6355

ISSN: 1831-4732

The EFSA Journal is a publication of the European Food Safety Authority, an agency of the European Union.

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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
Palm lethal yellowing mycoplasm
Satsuma dwarf virus
Citrus tristeza virus (non-EU isolates)
Leprosis
Little cherry pathogen (non- EU isolates)
Naturally spreading psorosis
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 tuber-forming *Solanum* spp., for which the EFSA Plant Health Panel (from now on: "the Panel") then conducted a pest categorisation in a separate opinion (EFSA PLH Panel et al., 2020b). This list is based on information collected from databases up to January 2020, as well as information received from EU Member States (MS) during the period April-June 2020.

The search conducted for this list made it clear that the only tuber-forming species of *Solanum* genus reported to be infected by phytoplasmas is *S. tuberosum*.

Non-EU phytoplasmas of *S. tuberosum* 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 toward this goal, the Panel prepared a list of phytoplasmas infecting *S. tuberosum*. In the process, three groups of phytoplasmas were distinguished:

a) non-EU phytoplasmas with presence in *S. tuberosum* fully supported by literature,
b) phytoplasmas (affecting *S. tuberosum*) 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, and
c) phytoplasmas of category (b) but with presence in *S. tuberosum* not fully supported by the literature.

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 et al. 2020b). This means that the Panel then performed a pest categorisation for the non-EU phytoplasmas with confirmed

ability to infect *S. tuberosum*. The phytoplasmas with uncertain ability to infect *S. tuberosum* 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. As in some cases there is uncertainty about the '*Ca*. P. species definition', related strains were considered if they infect *S. tuberosum*. 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 *S. tuberosum* (see Section 1.1.3) and to fill in the extraction tables on their distribution (see Appendices A–C and Annex A) was obtained from expert knowledge and extensive literature searches performed in Web of Science (WoS, last access January 2020). The search in WoS was performed using as keywords: phytoplasma/mycoplasma/witch/spiroplasma combined with the scientific name of the genus OR the common name of the crop. Therefore, the search in WoS was performed according to the following strategy:

TOPIC:((Phytoplasma* OR mycoplasma* OR witch* OR spiroplasma*) AND (Solanum OR potato*))

All the references were screened by title, abstract and, if needed, 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.

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 *S. tuberosum* as natural host and distribution of the phytoplasmas were retrieved from the EPPO Global Database (GD) (EPPO, 2020), the Centre for Agriculture and Biosciences International (CABI) Crop Protection Compendium (CABI, 2020) and relevant publications.

GenBank accessions referring to phytoplasmas were added.

2.2. Methodology

A preliminary list of phytoplasmas infecting *S. tuberosum* (see Section 1.1.3) was generated by screening for phytoplasma diseases of the species present in the EPPO Lists A1 and A2. Further, all phytoplasma diseases listed in the EPPO GD were also screened for their association with *S. tuberosum*. 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 of each *S. tuberosum*-infecting phytoplasma and key references and sources used to obtain that information. Taxonomy and distribution are reported in the table using the following scheme:

- the taxonomy was reported according to the '*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 has not been 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 on *S. tuberosum* as natural host of phytoplasmas were first searched in EPPO (2020) and in CABI (2020). 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 Member States (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 subcategories:

- Phytoplasmas not known to be present in the EU ('*Ca*. P. americanum', '*Ca*. P. australiense', '*Ca*. P. fragariae'-related strain (YN-169, YN-10G), and '*Ca*. P. hispanicum')
- 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. pruni'-related strains and '*Ca*. P. trifolii').

These phytoplasmas are categorised in EFSA PLH Panel et al., (2020b), with the exception of '*Ca*. P. australiense', '*Ca*. P. hispanicum' and '*Ca*. P. trifolii', for which a pest categorisation is already available (EFSA PLH Panel et al., 2020a).

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. Phytoplasmas listed in Appendix B are originally described or reported from the EU. For the phytoplasmas listed in Appendix C, the ability to infect the host plants is not conclusively supported by the available literature.

3.3. Uncertainties

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

- The geographic distribution and prevalence of the phytoplasmas.
- The taxonomy and biological status of poorly characterised phytoplasmas.
- The ability to infect *S. tuberosum* 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 needed is non-EU phytoplasmas of tuber-forming *Solanum* spp. As a first step, a systematic approach identified 12 phytoplasmas reported to naturally infect *S. tuberosum* (Annex A).

Among these phytoplasmas, based on information on distribution and prevalence both inside and outside the EU, the Panel identified seven 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 et al. (2020b), with the exception of '*Ca*. P. australiense', '*Ca*. P. hispanicum' and '*Ca*. P. trifolii', for which a pest categorisation is already available (EFSA PLH Panel et al., 2020a).

The remaining five phytoplasmas (which have a substantial presence in the EU or are originally described or reported from the EU (Appendix B, three phytoplasmas), or whose ability to infect *S. tuberosum* is not fully confirmed by available literature (Appendix C, two phytoplasmas)) were not categorised within the current mandate. However, the European Commission may request EFSA to categorise some or all the phytoplasmas excluded from the present exercise.

The main uncertainties of this listing concern the taxonomy, geographic distribution and prevalence and the ability to infect *S. tuberosum* for some phytoplasmas.

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Abbreviations

Ca. P.	*Candidatus* Phytoplasma
CYE	Clover yellow edge
EPPO	European and Mediterranean Plant Protection Organization
GD	Global Database
IRPCM	International Research Programme on Comparative Mycoplasmology
MS	Member State
PCR	Polymerase Chain Reaction
PHS	Potato hair sprouts
PHYPAA	*Candidatus* Phytoplasma australasia
PHYPAE	*Candidatus* Phytoplasma americanum
PHYPAS	*Candidatus* Phytoplasma asteris
PHYPAU	*Candidatus* Phytoplasma australiense
PHYPFG	*Candidatus* Phytoplasma fragariae
PHYPMA	*Candidatus* Phytoplasma mali
PHYPTR	*Candidatus* Phytoplasma trifolii
PHYP07	*Candidatus* Phytoplasma hispanicum
PHYP19	Clover yellow edge phytoplasma
PHYP74	Alder yellows phytoplasma
PLH	Plant Health
PPT	Potato purple top
RFLP	Restriction Fragment Length Polymorphism
TFEU	Treaty on the Functioning of the European Union
ToR	Terms of Reference
WoS	Web of Science

Appendix A – Non-EU phytoplasmas of *Solanum tuberosum*

ID	Phytoplasma name	Related strain name[1]	Abbreviation (EPPO code)	16S rRNA	Reasoning for considering non-EU	Uncertainties	References
1	*Candidatus Phytoplasma americanum*	–	PHYPAE	XVIII	Not reported to be present in the EU	–	Species description: (Lee et al., 2006); *S. tuberosum*: (EPPO, 2020)
2	*Candidatus Phytoplasma aurantifolia*	GD32; St_JO_10, 14, 17; PPT-SA; Rus-343F; PPT-GTO29, PPT-GTO30, PPT-SINTV; Potato Huayao Survey 2; Potato hair sprouts, PHS	PHYPAA, PHYP01, PHYP39	II	Italian reports refer to few infected individuals; present in Greece, Portugal; present in EU neighbouring Countries	Cheng et al. (2019) (despite identification of the phytoplasma as belonging to 16SrII by sequencing identity, in silico RFLP, neighbour-joining phylogenetic, in the text it is named as 'Ca. P. australiense'); Omar et al. (2018), Girsova et al. (2016), Hodgetts et al. (2009), Leyva-Lopez et al. (2002) (unclear subgroup assignation); Paltrinieri and Bertaccini (2007) (12 nested PCR-positive plants over 600 asymptomatic seed potato plants in Italy, no accession numbers available); Parrella et al. (2008) (one batch of 10 *Empoasca decipiens* in Italy); Tolu et al. (2006) (3 plants from 3 species in Italy); Prota et al. (2007) (less than 20 *Myrtus communis* plants and possibly in mixed infection in Italy); Granata et al. (2006) (in two *Opuntia ficus-indica* plants in Italy); Davino et al., 2007 (in one *Matthiola incana* plant in Italy)	Species description: (White et al., 1998; IRPCM, 2004); Strain descriptions and *S. tuberosum*: 'GD32 (Cheng et al., 2019); St_JO_10, 14, 17 (Salem et al., 2019); PPT-SA (Omar et al., 2018); Rus-343F (Girsova et al., 2016); PPT-GTO29, PPT-GTO30, PPT-SINTV (Santos-Cervantes et al., 2010); Potato Huayao Survey 2 (Hodgetts et al., 2009); Potato hair sprouts, PHS (Leyva-Lopez et al., 2002) *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)

ID	Phytoplasma name	Related strain name[1]	Abbreviation (EPPO code)	16S rRNA	Reasoning for considering non-EU	Uncertainties	References
3	*Candidatus Phytoplasma australiense*	–	PHYPAU	XII-B	Not reported to be present in the EU	–	Species description: (Davis et al., 1997); *S. tuberosum*: (EPPO, 2020)
4	*Candidatus Phytoplasma fragariae*	YN-169, YN-10G		XII	Not reported to be present in the EU	Cheng et al., 2015 (several strains ascribed to 16SrXII-I, YN-169, but not identical to each other, plus other 16SrXII strains not assigned to any subgroup, YN-10G)	Species description: (Cheng et al., 2015); *S. tuberosum*: (Dong et al., 2011; Cheng et al., 2015)
5	*Candidatus Phytoplasma hispanicum*	–	PHYP07	XIII	Not reported to be present in the EU	Strawberry multiplier disease phytoplasma (STRAWB1) [PHYP75] is classified as RNQP (Annex IV; updated 2019). The phytoplasma is a strain of *Ca*. P. hispanicum, and the latter is not known to be present in the EU (EFSA PLH Panel et al., 2020a)	Species description: (Davis et al., 2016); *S. tuberosum*: (Santos-Cervantes et al., 2010)

ID	Phytoplasma name	Related strain name[1]	Abbreviation (EPPO code)	16S rRNA	Reasoning for considering non-EU	Uncertainties	References
6	*Candidatus Phytoplasma pruni*	Clover yellow edge, CYE (Girsova et al., 2016); Potato purple top, AKpot7, MT117, AKpot6 (Davis et al., 2013); Potato purple top, PPT-COAHP, PPT-GTOP (Santos-Cervantes et al., 2010)	PHYP19 (CYE)	III-B (CYE); III-F (AKpot7); III-M (MT117); III-N (AKpot6);III-U (PPT-COAHP, PPT-GTOP)	In the EU reported in four MSs: Czech Republic (two reports), Italy (three reports), Hungary (one report), Lithuania (four reports)	The pest was reported: in eight symptomatic *Echinacea purpurea* (Franova et al., 2013) and eight *Trifolium* spp. plants in the Czech Republic (Franova et al., 2004); in less than 50 symptomatic weed samples (*Leucanthemum vulgare*, *Taraxacum officinale* and *Crepis biennis*) (Firrao et al., 1996), in three *Prunus* spp. (cherry) plants (Paltrinieri et al., 2008) and in an undefined number (few samples) of *Asclepias physocarpa* plants (Bertaccini et al., 2006) in Italy; in an undefined number of *Cirsium arvense* and *Convolvolus arvensis* (Palermo et al., 2004) in Hungary; in two *Trifolium* spp. plants and in mixed infections (Staniulis et al., 2000), in an undefined number of *Gaillardia* sp., *Dictamnus albus* (Samuitienė et al., 2007), *Heracleum sosnowskyi*, *Dictamnus albus* (Valiunas et al., 2007), *Glycine max* and *Lupinus* spp. (Jomantiene et al., 2000), in Lithuania	Species description: (Davis et al., 2013); Strain descriptions and *S. tuberosum*: CYE (Girsova et al., 2016); AKpot7, MT117, AKpot6 (Davis et al., 2013); PPT-COAHP, PPT-GTOP (Santos-Cervantes et al., 2010); CYE in Lithuania (Staniulis et al., 2000)

ID	Phytoplasma name	Related strain name(1)	Abbreviation (EPPO code)	16S rRNA	Reasoning for considering non-EU	Uncertainties	References
7	*Candidatus Phytoplasma trifolii*	–	PHYPTR	VI-A	Reports from EU MS refer to few infected plants, ranging from 1 to 28	Reports from EU MS refer to few infected plants (Castro and Romero, 2002; Faggioli et al., 2004; Borroto Fernandez et al., 2007; Pribylova et al., 2009; Alfaro-Fernandez et al., 2017; Zambon et al., 2018); unclear subgroup assignation (Girsova et al., 2016)	Species description: (Hiruki and Wang, 2004); *S. tuberosum*: (EPPO, 2020); *Vitis* in Italy (Zambon et al., 2018); *Centaurea solstitialis* in Italy (Faggioli et al., 2004); *Amaranthus blitoides* and *Setaria adhaerens* in Spain (Alfaro-Fernandez et al., 2017); *Capsicum annuum* in Spain (Castro and Romero, 2002); *Rhododendron* spp. in Czech Republic (Pribylova et al., 2009); *Vaccinium myrtillus* in Austria (Borroto Fernandez et al., 2007)

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

Appendix B – Phytoplasmas of *Solanum tuberosum* excluded from further categorisation as they have substantial presence in the EU or are originally described or reported from the EU

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	Reasoning for not considering as non-EU	Uncertainties	References
8	*Candidatus Phytoplasma asteris*	–	PHYPAS	I	Germany, Hungary, Italy (Present widespread); Czech Republic, Spain (Present, restricted distribution); Belgium Denmark, France, Romania (Present, no details); Lithuania; Slovenia(2)	Russia (Present, restricted distribution; Belarus (Present, no details); UK(2)	Reported in the EU (several MS)	–	Species description: (Lee et al., 2004a); *S. tuberosum*: (Lee et al., 2006; Arocha et al., 2007; Fahmeed et al., 2009; Hodgetts et al., 2009; Dong et al., 2011; Hosseini et al., 2011; Longoria-Espinoza et al., 2013; Tiwari et al., 2013; Girsova et al., 2016; Castillo Carrillo et al., 2018); *S. tuberosum* in Italy: (Paltrinieri and Bertaccini, 2007); *S. tuberosum* in Lithuania (Urbonaite et al., 2016); UK (Jones and Arocha, 2006; Reeder and Arocha, 2008; Nisbet et al., 2014), Slovenia: (Radisek et al., 2009; Romanazzi et al., 2009; Mehle et al., 2018)
9	*Candidatus Phytoplasma fragariae*	–	PHYPFG	XII-E	Slovenia (EPPO report 2018/085); Belgium(2)	UK (EPPO report 2015/031)	Originally described in the EU	-	Species description: (Valiunas et al., 2006)

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	Reasoning for not considering as non-EU	Uncertainties	References
10	*Candidatus Phytoplasma solani*	–	PHPSO	XII-A	Italy (Present, widespread); Bulgaria, Croatia, France, Germany, Greece, Hungary, Slovakia, Slovenia, Spain, (Present, restricted distribution); Austria, Czech Republic, Poland (Present, few occurrences); Romania; Belgium(2); Portugal(2)	Macedonia, Montenegro (Present, widespread); Russia, Serbia, Switzerland, Turkey (Present, restricted distribution); Albania, Armenia, Azerbaijan, Bosnia and Herzegovina, Georgia, Ukraine (Present, no details)	Originally described in the EU (several MS)	–	Species description: (Quaglino et al., 2013); *S. tuberosum*: (EPPO, 2020); *S. tuberosum* in Romania: (Lindner et al., 2011)

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

Appendix C – Phytoplasmas of *Solanum tuberosum* 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	EU MS in which the pathogen has been reported	Non-EU European and neighbouring countries	Reasoning for not considering as non-EU	Uncertainties	References
11	*Candidatus Phytoplasma mali*	–	PHYPMA	X	Czech Republic, Germany, Hungary, Italy, Slovakia, Slovenia (Present widespread); Austria, Belgium, Bulgaria, Croatia, Finland, France, Greece, Spain (Present, restricted distribution); Poland, Romania (Present, no details); Lithuania, Netherlands (Present, few occurrences)	Switzerland (Present widespread); Belarus, Norway, Serbia (Present, restricted distribution); Albania, Bosnia and Herzegovina, Moldova, Russia, Turkey, Ukraine (Present, no details)	Originally described in the EU (several MS)	Only one nested PCR positive plant from 600 seed potato asymptomatic plants, probably in mixed infections and no accession number of the isolate available (Paltrinieri and Bertaccini, 2007)	Species description: (Seemuller and Schneider, 2004); *S. tuberosum* in Italy: (Paltrinieri and Bertaccini, 2007)
12	*Unclassified*	Potato Colombia M/V	PHYP74	V-C	France	–	Reported in the EU	Only one report from 8 potato plants, 4 in mixed infections with *Ca*. P. solani; no accession number of the isolate available; taxonomic status uncertain within the 16SrV-C subgroup (Mejia et al., 2011)	Species description: (Lee et al., 2004b); Strain description and *S. tuberosum*: (Mejia et al., 2011); *Alnus* in France: (Arnaud et al., 2007)

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

Annex A – List of phytoplasmas considered in the opinion

See Excel file in Supplementary Information online.