Pest categorisation of the non-EU phytoplasmas of tuber-forming \textit{Solanum} spp.

EFSA Panel on Plant Health (PLH),
Claude Bragard, Katharina Dehnen-Schmutz, Paolo Gonthier; Josep Anton Jaques Miret,
Annemarie Fejer Justesen, Alan MacLeod, Christer Sven Magnusson, Panagiotis Milonas,
Juan A Navas-Cortes, Stephen Parnell, Roel Potting, Philippe Lucien Reignault,
Hans-Hermann Thulke, Wopke Van der Werf, Antonio Vicent Civera, Jonathan Yuen,
Lucia Zappalà, Domenico Bosco, Michela Chiumenti, Francesco Di Serio, Luciana Galetto,
Cristina Marzachi, Marco Pautasso and Marie-Agnès Jacques

Abstract

Following a request from the European Commission, the EFSA Panel on Plant Health performed a pest categorisation of four phytoplasmas of tuber-forming \textit{Solanum} spp. known to occur only outside the EU or having a limited presence in the EU. The only tuber-forming species of \textit{Solanum} reported to be phytoplasma infected is \textit{S. tuberosum}. This opinion covers ‘\textit{Candidatus Phytoplasma americanum}’, ‘\textit{Ca. P. aurantifolia}’-related strains (GD32; St_JO_10, 14, 17; PPT-SA; Rus-343F; PPT-GTO29, -GTO30, -SINTV; Potato Huayao Survey 2; Potato hair sprouts), ‘\textit{Ca. P. fragariae}’-related strains (YN-169, YN-10G) and ‘\textit{Ca. P. pruni}’-related strains (Clover yellow edge; Potato purple top AKpot7, MT117, AKpot6; PPT-COAHP, -GTOP). Phytoplasmas can be detected by molecular methods and are efficiently transmitted by vegetative propagation. Phytoplasmas are also transmitted in a persistent and propagative manner by some insects belonging to families within Cicadomorpha, Fulgoromorpha and Sternorrhyncha (order Hemiptera). No transovarial, pollen or seed transmission has been reported. The reported natural host range of the phytoplasmas categorised here varies from restricted (‘\textit{Ca. P. americanum}’, and ‘\textit{Ca. P. fragariae}’-related strains) to wide (‘\textit{Ca. P. aurantifolia}’-related strains and ‘\textit{Ca. P. pruni}’-related strains), thus increasing the possible entry pathways in the latter case. \textit{S. tuberosum} is widely cultivated in the EU. All the categorised phytoplasmas can enter and spread through the trade of host plants for planting, and by vectors. Establishment of these phytoplasmas is not expected to be limited by EU environmental conditions. The introduction of these phytoplasmas in the EU would have an economic impact. There are measures to reduce the risk of entry, establishment, spread and impact. Uncertainties result from limited information on distribution, biology and epidemiology. All the phytoplasmas categorised here meet the criteria evaluated by EFSA to qualify as potential Union quarantine pests, and they do not meet all the criteria to qualify as potential regulated non-quarantine pests, because they do not occur or are not known to be widespread in the EU.

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Keywords: \textit{Solanum tuberosum}, pest risk, plant health, plant pest, quarantine, insect vectors

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Correspondence: alpha@efsa.europa.eu
Panel members: Claude Bragard, Katharina Dehnen-Schmutz, Francesco Di Serio, Paolo Gonthier, Marie-Agnès Jacques, Josep Anton Jaques Miret, Annemarie Fejer Justesen, Alan MacLeod, Christer Sven Magnusson, Panagiotis Milonas, Juan A Navas-Cortes, Stephen Parnell, Roel Potting, Philippe L Reignault, Hans-Hermann Thulke, Wopke Van der Werf, Antonio Vicent Civera, Jonathan Yuen and Lucia Zappalà.

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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 pest categorisation is requested. The list below follows the annexes of Directive 2000/29/EC.

Annex IIA

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

| Organism                                                   |
|------------------------------------------------------------|
| Aleurocanthus spp.                                          |
| Anthonomus bisignifer (Schenkling)                         |
| Anthonomus signatus (Say)                                  |
| Aschistonyx eppei Inouye                                    |
| Carposina niponensis Walsingham                            |
| Enarmonia packardi (Zeller)                                |
| Enarmonia prunivora Walsh                                  |
| Grapholita inopinata Heinrich                              |
| Hisphonous phycitis                                         |
| Leucaspis japonica Ckll.                                   |
| Listronotus bonariensis (Kuschel)                           |
| Numonia pyrivorella (Matsumura)                            |
| Oligonychus perditus Pritchard and Baker                   |
| Pissodes spp. (non-EU)                                     |
| Scirtothrips aurantii Faure                                |
| Scirtothrips citri (Moulletex)                              |
| Scolytidae spp. (non-EU)                                   |
| Toxoptera citricida Kirk.                                  |
| Unasps citri Comstock                                      |

(b) Bacteria

| Organism                                                   |
|------------------------------------------------------------|
| Citrus variegated chlorosis                                |
| Erwinia stewartii (Smith) Dye                              |
| Xanthomonas campestris pv. oryzae (Ishiyama)               |
| Dye and pv. oryza (Fang. et al.) Dye                       |

(c) Fungi

| Organism                                                   |
|------------------------------------------------------------|
| Alternaria alternata (Fr.) Keisser (non-EU pathogenic isolates) |
| Anisogromma anomala (Peck) E. Müller                       |
| Anisogramma morbosa (Schwein.) v. Arx                      |
| Ceratocystis virescens (Davidson) Moreau                   |
| Cercospora pini-densiflora (Hori and Nambu) Deighton      |
| Cercospora angoensis 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

| Organism                                                   |
|------------------------------------------------------------|
| 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

| Organism                                                   |
|------------------------------------------------------------|
| 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  
Hypoxylon mammatum (Wahl.) J. Miller

Gremmeniella abietina (Lag.) Morelet

1.1.2.2. Terms of Reference: Appendix 2

List of harmful organisms for which 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

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) Epocha 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 indifferentes 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)  
3) *Margarodes prieskaensis* Jakubski  
2) *Margarodes vredendalensis* de Klerk

1.1.2.3. Terms of Reference: Appendix 3

List of harmful organisms for which 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

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

(b) Fungi

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

(c) Viruses and virus-like organisms

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

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(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

Rhizoeus hibisci Kawai and Takagi

(b) Bacteria

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

Davis 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

Non-EU phytoplasmas of tuber-forming Solanum spp. are pests listed in the Appendices to the Terms of Reference (ToR) to be subject to pest categorisation to determine whether they fulfill the criteria of quarantine pests or those of regulated non-quarantine pests (RNQPs) for the area of the EU excluding Ceuta, Melilla and the outermost regions of Member States (MS) referred to in Article 355(1) of the Treaty on the Functioning of the European Union (TFEU), other than Madeira and the Azores. The EFSA Plant Health Panel (from here on: “the Panel”) decided to address the pest categorisation of this group of infectious agents in two steps: first, a list of the non-EU phytoplasmas of the host plants (EFSA PLH Panel et al., 2020b) and second, the present pest categorisation. The search conducted for this list showed that the only tuber-forming species of Solanum genus reported to be phytoplasma-infected is S. tuberosum. The process is described in EFSA PLH Panel et al., (2020b), in which a systematic approach identified 12 phytoplasmas naturally infecting S. tuberosum. 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 occurring outside the EU and having only limited presence (reported in fewer than five EU Member States (MS)) in the EU. The remaining five phytoplasmas have a substantial presence (reported in five or more EU MS) in the EU or were originally described in the EU. In addition, for two of them their presence in S. tuberosum is not fully supported by the literature, as the ability to infect S. tuberosum was inferred from detection in fewer than 10 plants. These phytoplasmas are not categorised within the current mandate. Three of the seven non-EU phytoplasmas (‘Ca. P. australiensis’, ‘Ca. P. hispanicum’, and ‘Ca. P. trifolii’) were excluded from further categorisation, as their pest categorisation has recently been performed by the Panel (EFSA PLH Panel et al., 2020a).

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 sub-taxa 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 characterized 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 characterization (IRPCM, 2004). The current opinion covers phytoplasma strains infecting S. tuberosum within their officially described ‘Ca. P. species’. For this purpose, pathogens were identified according to the list of strains/-related strains within the original ‘Ca. P. species’ description, when available. Otherwise, affiliation to a ‘Ca. P. species’-related strain was based on the identity of the 16S rRNA subgroup.

This opinion provides a pest categorisation of the four non-EU phytoplasmas with confirmed presence in tuber-forming Solanum spp., that have been listed in EFSA PLH Panel et al. (2020b), thus covering the following entities:

- ‘Ca. P. americanum’,
- ‘Ca. P. aurantifolia’-related strains (GD32; St_JO_10, 14, 17; PPT-SA; Rus-343F; PPT-GTO29, -GTO30, -SINTV; Potato Huayao Survey 2; Potato hair sprouts),
- ‘Ca. P. fragariae’-related strains (YN-169, YN-10G),
- ‘Ca. P. pruni’-related strains (Clover yellow edge; Potato purple top AKpot7, MT117, AKpot6; PPT-COAHP, -GTOP).

Viruses, virus-like diseases of unknown aetiology or diseases caused by other graft-transmissible bacteria of tuber-forming Solanum spp. are not addressed in this opinion.

2. Data and methodologies

2.1. Data

2.1.1. Literature search

A literature search on non-EU phytoplasmas infecting S. tuberosum was conducted at the beginning of the categorisation in the Web of Science (WoS) database, using the scientific name of the pests as search term. Table 1 lists the search strings used. Relevant papers were reviewed and further references and data were obtained from citations within the references.

Table 1: Topics used for Web of Science mining, and search dates.

| Phytoplasma name, reference strain/related strain name | Topic | Search date |
|------------------------------------------------------|-------|-------------|
| ‘Ca. P. americanum’                                  | TOPIC: (phytoplasma AND ((Candidatus Phytoplasma americanum) OR (American potato purple top wilt phytoplasma) OR (Potato purple-top wilt agent) OR (apical leafroll of potato) OR (blue stem of potato) OR (bunch top of potato) OR (haywire disease of potato) OR (late breaking of potato) OR (moron of potato) OR (purple dwarf of potato) OR (purple-top wilt of potato) OR (yellow top of potato) OR (fitoplasma americano))) | March 6, 2020 |
| ‘Ca. P. aurantifolia’-related strains                | TOPIC: ((phytoplasma AND ((Candidatus Phytoplasma aurantifolia) OR (GD32) OR (St_JO_1*) OR (PPT-SA) OR (Rus-343F) OR (PPT-GTO*) OR (PPT-SINTV) OR (Potato Huayao) OR (Potato hair sprouts) OR (16SrII)) | April 14, 2020 |
| ‘Ca. P. fragariae’-related strains (YN-169, YN-10G)  | TOPIC: (phytoplasma AND ((Candidatus Phytoplasma fragariae) OR (YN-169) OR (YN-10G) OR (16SrXII-I) OR (16SrXII-E))) | March 16, 2020 |
| ‘Ca. P. pruni’-related strains                       | TOPIC: (((phytoplasma AND (16SrIII)) AND ((Clover yellow edge) OR (Potato purple top) OR (16SrIII-B) OR (16SrIII-F) OR (16SrIII-M) OR (16SrIII-N) OR (16SrIII-U))) | March 16, 2020 |

Due to the little information found on ‘Ca. P. americanum’ following the WoS search, a search in Google Scholar was performed with the following search string: “Candidatus phytoplasma americanum”.

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2.1.2. Database search

Pest information, on host(s) and distribution, was retrieved from the EPPO Global Database (EPPO GD) (EPPO, 2020) and relevant publications. Data kindly provided by National Plant Protection Organisations of the EU MS were also considered.

Information on pest vectors was retrieved from the Hemiptera-Phytoplasma-Plant biological interaction database (Trivellone, 2019). Data on the EU distribution of pest vectors were retrieved from the EPPO GD (EPPO, 2020), the Fauna Europaea database (de Jong et al., 2014) and the Catalogue of Life 2020 checklist (Roskov et al., 2019). When an insect species was not listed in the EU on any of the above-mentioned databases, a further WoS search was performed using the species name as a search string. All results were individually checked.

Data about the area of *S. tuberosum* grown in the EU were obtained from EUROSTAT (Statistical Office of the European Communities).

The Europhyt and TRACES databases were consulted for pest-specific notifications on interceptions and outbreaks. Europhyt and TRACES are web-based networks run by the Directorate General for Health and Food Safety (DG SANTE) of the European Commission, and is a subproject of PHYSAN (Phyto-Sanitary Controls) specifically concerned with plant health information. The Europhyt and, since 2020, TRACES databases manage notifications of interceptions of plants or plant products that do not comply with EU legislation, as well as notifications of plant pests detected in the territory of the EU MS and the phytosanitary measures taken to eradicate or avoid their spread.

2.2. Methodologies

The Panel performed the pest categorisation for the non-EU phytoplasmas of *S. tuberosum* following guiding principles and steps presented in the EFSA guidance on quantitative pest risk assessment (EFSA PLH Panel, 2018) and in the International Standard for Phytosanitary Measures (ISPM) No 11 (FAO, 2013) and No 21 (FAO, 2004).

This work was started following an evaluation of the EU plant health regime. Therefore, to facilitate the decision-making process, in the conclusions of the pest categorisation, the Panel addresses explicitly each criterion for a Union quarantine pest and for a Union RNQP in accordance with Regulation (EU) 2016/2031 on protective measures against pests of plants, and includes additional information required in accordance with the specific terms of reference received by the European Commission. In addition, for each conclusion, the Panel provides a short description of its associated uncertainty.

Table 2 presents the Regulation (EU) 2016/2031 pest categorisation criteria on which the Panel bases its conclusions. All relevant criteria have to be met for the pest to potentially qualify either as a quarantine pest or as an RNQP. If one of the criteria is not met, the pest will not qualify. A pest that does not qualify as a quarantine pest may still qualify as an RNQP that needs to be addressed in the opinion. For the pests regulated in the protected zones only, the scope of the categorisation is the territory of the protected zone; thus, the criteria refer to the protected zone instead of the EU territory.

It should be noted that the Panel’s conclusions are formulated respecting its remit and particularly with regard to the principle of separation between risk assessment and risk management (EFSA founding regulation (EU) No 178/2002); therefore, instead of determining whether the pest is likely to have an unacceptable impact, the Panel will present a summary of the observed pest impacts. Economic impacts are expressed in terms of yield and quality losses and not in monetary terms, whereas addressing social impacts is outside the remit of the Panel.
Table 2: Pest categorisation criteria under evaluation, as defined in Regulation (EU) 2016/2031 on protective measures against pests of plants (the number of the relevant sections of the pest categorisation is shown in brackets in the first column)

| Criterion of pest categorisation | Criterion in Regulation (EU) 2016/2031 regarding Union quarantine pest | Criterion in Regulation (EU) 2016/2031 regarding protected zone quarantine pest (articles 32–35) | Criterion in Regulation (EU) 2016/2031 regarding Union regulated non-quarantine pest |
|----------------------------------|--------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| Identity of the pest (Section 3.1) | Is the identity of the pest established, or has it been shown to produce consistent symptoms and to be transmissible? | Is the identity of the pest established, or has it been shown to produce consistent symptoms and to be transmissible? | Is the identity of the pest established, or has it been shown to produce consistent symptoms and to be transmissible? |
| Absence/presence of the pest in the EU territory (Section 3.2) | Is the pest present in the EU territory? If present, is the pest widely distributed within the EU? Describe the pest distribution briefly! | Is the pest present in the EU territory? If not, it cannot be a protected zone quarantine organism | Is the pest present in the EU territory? If not, it cannot be a RNQP. (A RNQP must be present in the risk assessment area) |
| Regulatory status (Section 3.3) | If the pest is present in the EU but not widely distributed in the risk assessment area, it should be under official control or expected to be under official control in the near future | The protected zone system aligns with the pest free area system under the International Plant Protection Convention (IPPC) The pest satisfies the IPPC definition of a quarantine pest that is not present in the risk assessment area (i.e. protected zone) | |
| Pest potential for entry, establishment and spread in the EU territory (Section 3.4) | Is the pest able to enter into, become established in, and spread within, the EU territory? If yes, briefly list the pathways! | Is the pest able to enter into, become established in, and spread within, the protected zone areas? Is entry by natural spread from EU areas where the pest is present possible? | |
| Potential for consequences in the EU territory (Section 3.5) | Would the pests’ introduction have an economic or environmental impact on the EU territory? | Would the pests’ introduction have an economic or environmental impact on the protected zone areas? | Does the presence of the pest on plants for planting have an economic impact, as regards the intended use of those plants for planting? |
| Available measures (Section 3.6) | Are there measures available to prevent the entry into, establishment within or spread of the pest within the EU such that the risk becomes mitigated? | Are there measures available to prevent the entry into, establishment within or spread of the pest within the protected zone areas such that the risk becomes mitigated? Is it possible to eradicate the pest in a restricted area within 24 months (or a period longer than 24 months where the biology of the organism so justifies) after the presence of the pest was confirmed in the protected zone? | Are there measures available to prevent pest presence on plants for planting such that the risk becomes mitigated? |
The Panel will not indicate in its conclusions of the pest categorisation whether to continue the risk assessment process, but following the agreed two-step approach, will continue only if requested by the risk managers. However, during the categorisation process, experts may identify key elements and knowledge gaps that could contribute significant uncertainty to a future assessment of risk. It would be useful to identify and highlight such gaps so that potential future requests can specifically target the major elements of uncertainty, perhaps suggesting specific scenarios to examine.

3. Pest categorisation

3.1. Identity and biology of the pest

3.1.1. Identity and taxonomy

| Is the identity of the pest established, or has it been shown to produce consistent symptoms and to be transmissible? | Yes, the identity of the non-EU phytoplasmas of *S. tuberosum* is clear. |

Phytoplasmas are bacteria accommodated within the ‘Candidatus Phytoplasma’ genus. Within this genus, several species have been described based on their 16S rRNA gene sequences. Within a species, strains officially included in the species description share a common signature at this locus. For each species, a reference strain is described, and its 16S rRNA sequence determined. As it was done in the pest categorisation of non-EU phytoplasmas of fruit trees (EFSA PLH Panel et al., 2020a), strains with minimal differences in the 16S rRNA gene (≥ 97.5% identity) are considered as related strains. In the presence of minimal differences of the 16S rRNA gene, if the two phytoplasmas are transmitted by different vectors, have a different natural plant host (or, at least, their behaviour is significantly different in the same plant host), and there is evidence of significant molecular diversity (achieved by either hybridisation to cloned DNA probes, serological reaction or polymerase chain reaction (PCR)-based assay), the description of a new species is recommended (IRPCM, 2004). The current opinion covers pathogens at the strain level, infecting *S. tuberosum* within their officially described ‘Ca. P. species’. When available, the names of the disease caused by these pathogens that are reported in Table 3 were retrieved from EPPO GD (EPPO, 2020).

Key information on the identity of the phytoplasmas categorised in the present opinion is reported in Table 3.
### Table 3: Justification for establishing identity of the phytoplasmas categorised here

| Phytoplasma name, reference strain/related strain name | Justification |
|--------------------------------------------------------|---------------|
| 'Ca. P. americanum'                                    | On the basis of unique 16S rRNA gene sequences and biological properties, the phytoplasma associated with American potato purple top wilt (APPTW) belongs to the 'Ca. P. americanum' species (16SrXVIII), with the isolate APPTW12-NE as the reference strain (Lee et al., 2006). The pathogen first associated with a severe disease of potato chips was identified as a phytoplasma (Secor et al., 2006), which was subsequently named 'Ca. P. americanum' (Lee et al., 2006). The phytoplasma is the causal agent of Potato purple-top wilt, apical leafroll of potato, blue stem of potato, bunch top of potato, haywire disease of potato, late breaking of potato, moron of potato, purple dwarf of potato, purple-top wilt of potato and yellow top of potato. The phytoplasma is listed as PHYPAE in the EPPO GD (EPPO, 2020). |
| 'Ca. P. australasiae'-related strains                  | These phytoplasmas belong to the 16SrII ribosomal group (IRPCM, 2004). A categorisation of the 'Ca. P. australasiae' reference strain is already available (EFSA PLH Panel et al., 2017), under the name Witches' broom disease of lime phytoplasma. That disease has only been reported in Citrus spp. (Zreik et al., 1995). Phytoplasmas of the 16Sr-II group have a diverse ecology, as they have been identified in association with diseases in various cultivated plants widespread in different geographical areas. Phytoplasma strains of the 16SrII group are classified into 23 subgroups. Until sufficient molecular and ecological evidence is obtained, all phytoplasmas belonging to this group are considered as relatives of 'Ca. P. australasiae' or 'Ca. P. australasiae' (Siampour et al., 2019), although the latter species has not been further supported (IRPCM, 2004). Phytoplasma infecting S. tuberosum are categorised here, and they include 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). In many reports, identification of the 16SrII subgroup is missing. These pests were included in the pest categorisation. In the absence of clear taxonomic assignment, all 'Ca. P. australasiae'-related strains, 'Ca. P. australasiae' and 16SrII phytoplasma isolates are categorised here, in agreement with the corresponding search string detailed in Section 2.1.1. 'Ca. P. australasiae', Sweet potato little leaf phytoplasma and Tomato big bud phytoplasma are listed as PHYPA, PHYP39 and PHYP01 in EPPO GD (EPPO, 2020). |
| 'Ca. P. fragariae'-related strains (YN-169, YN-10G)   | These phytoplasmas belong to the 16SrXII ribosomal group, and are considered as 'Ca. P. fragariae'-related strains (Cheng et al., 2015). In particular, several strains were detected in symptomatic potatoes from Yunnan and Inner Mongolia, and they were assigned based on restriction site analysis to the 16SrXII-I subgroup (11 strains) and to a potential new subgroup (13 strains), with YN-169 and YN-10G as reference strains, respectively (Cheng et al., 2015). The EU origin of 'Ca. P. fragariae' reference strain is established (Valiunas et al., 2006). It should be mentioned that the 16SrXII-I subgroup was originally first described by Quaglino et al. (2009), and representative isolate sequence was EU010008. According to the US National Center for Biotechnology Information (NCBI), the EU010008 sequence was found in grapevine in Italy (Pacifo et al., 2009), and consequently included in the 'Ca. P. solani' species description (16SrXII-A Quaglino et al., 2013). The 11 Chinese potato isolates show less than 97.5% homology with EU010008 on the 16SrDNA gene sequence, and therefore, they are assigned to 16SrXII-I (Cheng et al., 2015) and categorised here as 'Ca. P. fragariae'—related strains. Indeed the reference accession numbers of Chinese potato isolates are filed as 'Ca. P. fragariae' (SOURCE; ORGANISM) in NCBI. |
| 'Ca. P. pruni'-related strains                        | Several strains related to the 'Ca. P. pruni' species (16SrIII-A, Davis et al., 2013) are known to infect S. tuberosum. These are Clover yellow edge (CYE), belonging to the 16SrIII-B subgroup (Girsova et al., 2016), the North American Potato purple top (AKpot7, MT117, AKpot6), belonging to 16SrIII-F, -M, -N (Davis et al., 2013), and the Mexican Potato purple top (PPT-COAHP, PPT-GTOP), belonging to the 16SrIII-U subgroup (Santos-Cervantes et al., 2010). Assignment of the Mexican Potato purple top isolates to 16SrIII-U subgroup is uncertain as available 16S rRNA gene sequences are of insufficient length for definitive classification (Perez-Lopez et al., 2017). The Clover yellow edge phytoplasma is listed as [PHYP19] in EPPO GD (EPPO, 2020). |
3.1.2. Biology of the pest

All the phytoplasmas considered in the present pest categorisation are efficiently transmitted by grafting of infected scions on healthy plants, seed potatoes and by phloem feeding insect vectors. Phytoplasmas are transmitted by some insects in the order Hemiptera. However, vector species are restricted to only a few families within Cicadomorpha (Cicadellidae), Fulgoromorpha (Cixiidae) and Sternorrhyncha (Psyllidae) (Weintraub and Beanland, 2006)). Within a family, some species are known to be phytoplasma vectors, while others are not. Transmission is persistent and propagative (i.e. once infected, insects remain infective for life). No transovarial transmission has been reported for the phytoplasmas categorised here.

The phytoplasma transmission process consists of:

i) acquisition of the pathogen during feeding on an infected plant,
ii) a latent period in the insect, during which the phytoplasma crosses the midgut barrier, multiplies within the insect body and colonises its salivary glands and
iii) inoculation of the bacterium during feeding on a healthy plant.

Details on the symptoms on the host plants, incubation period and epidemiology are listed in Table 4. Symptoms on other plants are listed in Appendix A. The known vector species are listed in Table 5. A plant is generally infected by a single phytoplasma strain/species, and insect vectors can acquire this phytoplasma and transmit it to other plants of the same species or other susceptible species. Therefore, the epidemiological cycle is simple, since a single phytoplasma is often transmitted among susceptible plants of one or more botanical species. It appears that vectors can act in closed or open epidemiological cycles. A closed cycle is represented by a phytoplasma that circulates between the main, if not exclusive, host plant and the main, if not exclusive, vector species (Bosco and D’Amelio, 2010). No pollen and seed transmissions have been reported for the phytoplasmas considered in this opinion.

For this pest categorisation, two vector categories were identified (Trivellone, 2019):

1) An insect species is considered a competent vector if the phytoplasma capability to overcome the barriers of gut and salivary glands has been proven using classical acquisition/inoculation experiments in the laboratory, or inoculation trials with caged infected specimens collected from the field.
2) An insect species is considered a potential vector if the phytoplasma has been detected in the insect body using standard molecular methods, or inoculated to artificial medium under laboratory conditions. The status as a potential vector does not prove the ability to transmit the phytoplasma from plant to plant.

When neither competent nor potential vectors are reported, uncertainty exists (Table 5), as vector transmission is presumed although vectors are not identified.
Table 4: Symptoms on *Solanum tuberosum*, incubation period and epidemiological details of the diseases caused by the phytoplasmas categorised here. For symptoms on other plants, see Appendix A

| Phytoplasma name, reference strain/related strain name | Symptoms | Incubation period | Epidemiology |
|--------------------------------------------------------|----------|-------------------|--------------|
| *Ca. P. americanum* | Foliar symptoms include leaf curl, stunting, chlorosis, slight purple coloration of new growth, swollen nodes, proliferated axillary buds and aerial tubers. Seed potatoes from affected plants produce hair sprouts. Tuber symptoms include mild vascular discoloration and brown flecking of medullary rays (Secor et al., 2006). Storage tubers from affected plants either do not sprout or produce spindle or hair sprouts (Lee et al., 2006). Although ‘Ca. P. americanum’ was the primary pathogen associated with zebra chips (ZC) in Nebraska, it has never been consistently associated with ZC in Texas, and in this area, the disease was associated with ‘Ca. Liberibacter solanacearum’ and ‘Ca. L. psyllaurous’ (Wen et al., 2009). The detection of ‘Ca. L. solanacearum’ from potato plants showing haywire disease symptoms indicates that this bacterium might also be associated with this disease (Wen et al., 2009) | No information was found | No information was found |
| *Ca. P. aurantifolia*-related strains | Symptoms include: proliferation, upright growth, purpling of apical leaves, shortened and thick-ended stolons, stolons with multiple tubers, and formation of aerial tubers (Cheng et al., 2019), yellowing of upper leaflets, apical leafroll, axillary buds (Santos-Cervantes et al., 2010), stunting and little leaf (Hodgetts et al., 2009), sprouting of extremely weak stems deficient in chlorophyll that gives them the appearance of white threads (Leyva-Lopez et al., 2002; Santos-Cervantes et al., 2010) | Following inoculation with 5–7 field collected and putatively infected Austroagallia sinuata individuals, Zinnia elegans plants showed typical symptoms after 8–10 weeks (Hemmati and Nikooei, 2019a) | No information was found |
| *Ca. P. fragariae*-related strains (YN-169, YN-10G) | Symptoms include: rosette, upright growth, upward rolling of leaves, yellowing and purpling of new leaves, shortened and thickened internodes, and formation of aerial, malformed, and chain tubers (Cheng et al., 2015) | No information was found | No information was found |
Phytoplasma name, reference strain/related strain name | Symptoms | Incubation period | Epidemiology
---|---|---|---
'Ca. P. pruni'-related strains | Symptoms include: leaf redness and purple discoloration of apical leaves (Girsova et al., 2016) or yellowing of upper leaflets, apical leafroll, axillary buds, and the formation of aerial tubers (Santos-Cervantes et al., 2010) | No information was found | During a disease outbreak on Corylus avellana in Oregon (US), removal of symptomatic and adjacent plants eliminated the disease from the orchard, while failure to remove shrubs adjacent to infected ones resulted in the eventual spread throughout about 4 ha of a 20 ha orchard (Postman et al., 2001). Vernonia brasiliiana is reported as a probable reservoir and possible inoculum source of 16SrIII-B phytoplasmas (Fugita et al., 2017). Some infected tubers may show normal sprouting and can be an important spreading factor of phytoplasma diseases in potato growing areas (Santos-Cervantes et al., 2010)

### Table 5: Competent and potential insect vector species of the non-EU phytoplasmas of *Solanum tuberosum* with the associated uncertainty

| Phytoplasma name, reference strain/related strain name | Competent vectors | Potential vectors | Uncertainties |
|---|---|---|---|
| 'Ca. P. americanum' | None reported | None reported | Unknown vectors |
| 'Ca. P. aurantifolia'-related strains | Orosius albicinctus, O. argentatus, O. cellulose, O. lotophagorum, O. orientalis, Empoasca papaya, Cacopsylla chinenisis (EFSA PLH Panel et al., 2020a). Orosius albicinctus also transmits the pest to Petunia violacea potted plants (Hemmati et al., 2019b). Field-collected O. argentatus and Austroagallia torrida fed on field-collected symptomatic lucerne plants transmit the phytoplasmas associated with Australian lucerne yellows and Tomato big bud under controlled conditions (Pilkington et al., 2004). Austroagallia sinata transmits the pest from infected Aerva javanica to healthy periwinkle plants and to Zinnia elegans under experimental conditions (Hemmati and Nikooei, 2019a; Hemmati et al., 2019a). Nealocturus fenestratus transmits the pest from infected Picris hieracioides to healthy periwinkle plants and to healthy *P. hieracioides* seedlings (Mitrovic et al., 2012). Circulifer haematoceps leafhopper transmits the pest (16SrII-D) from affected sesame to healthy sesame and periwinkle plants (Salehi et al., 2017) | Amrasca bigutula, Circulifer spp., Empoasca decipiens, Empoasca spp., Hishimonus phycitis, Nealocturus haematoceps, and Nisia spp., Orosius spp. (EFSA PLH Panel et al., 2020a). Platymetopius shirazicus, Agallia ribauti, Psammotettix alienus (Zamharir et al., 2019); Euscelis incisus (Jakovljević et al., 2020); Dictyophara europaea (Mitrovic et al., 2012); Austroagallia avicula (Khan et al., 2003); Diaphorina citri (Siampour et al., 2006) | None |
Taking into account the reasoning of Section 3.1.1., intraspecific diversity is addressed up to the related strain level. For all the pests categorised here, sequevars (groups of strains characterised by a specific DNA sequence for one or several genes) are listed in Table 6.

### Table 6: Intraspécific variation of the phytoplasmas categorised here

| Phytoplasma name, reference strain/related strain name | Competent vectors | Potential vectors | Uncertainties |
|-------------------------------------------------------|-------------------|------------------|---------------|
| 'Ca. P. fragariae'–related strains (YN-169, YN-10G)   | None reported     | None reported    | Unknown vectors |
| 'Ca. P. pruni'–related strains                       | Euscelis incisus, both naturally and laboratory infected (after an acquisition period of 48 h on symptomatic Cirsium arvense and a latent period of 28 days), transmitted the disease with more than 80% transmission efficiencies to exposed C. arvense and periwinkle plants (Jakovljevic et al., 2015). Sclerorus flavopictus transmits Gentian witches’ broom and Tsuwabuki witches’ broom phytoplasmas, (16SrIII-B; Okuda et al., 1997) | Sonronius binotatus, Anosocus albidrons, Philaenus spumarius (Girsova et al., 2016); Anaceratagallia ribauti (Ivanauskas et al., 2014); Reptalus panzeri (Palermo et al., 2004); Jassargus obtusivalvis and Lygus rugulipennis (Orsagova et al., 2011); Psammetettix striatus (Kastalyeva et al., 2018) | Orosius argenteus, Macrosteles cristiatus, M. laevis and Alebroides nigrocutellatus transmitted putative 16SrIII-B phytoplasmas, whose identification was not confirmed by molecular tools (Trivellone, 2019) |

### 3.1.3. Intraspecific diversity

Taking into account the reasoning of Section 3.1.1., intraspecific diversity is addressed up to the related strain level. For all the pests categorised here, sequevars (groups of strains characterised by a specific DNA sequence for one or several genes) are listed in Table 6.

### Table 6: Intraspécific variation of the phytoplasmas categorised here

| Phytoplasma name, reference strain/related strain name | Justification |
|-------------------------------------------------------|---------------|
| 'Ca. P. americanum’                                   | Four strains, APPTW1-TX, APPTW2-TX, APPTW9-NE and APPTW12-NE were designated as subgroup 16SrXVIII-A; three strains, APPTW 1883 #6-TX, APPTW10-NE and APPTW13-NE were designated as subgroup 16SrXVIII-B (Lee et al., 2006) |
| 'Ca. P. aurantifolia’–related strains                 | The 16SrII phytoplasma group includes several strains with a worldwide distribution. Twenty-three 16SrII subgroups have been described (Siampour et al., 2019). Phytoplasmas of 16SrII could be resolved into at least three main phylogenetic lineages: one lineage comprises phytoplasmas of the subgroups 16SrII-A and II-D, another includes strains of subgroups 16SrII-B and II-C and the third lineage comprises phytoplasmas belonging to 16SrII-E (Siampour et al., 2019). Polyclonal antibodies against the full-length recombinant Imp protein recognise subgroup B and C isolates from different hosts, confirming phylogenetic clustering based on 16S rDNA and imp genes (Siampour et al., 2013). Infections of different 16SrII strains are often reported from the same host species (e.g. Omar et al., 2020) |
| 'Ca. P. fragariae’–related strains (YN-169, YN-10G)   | The sequence similarities between the ‘Ca. P. fragariae’ reference strain and the 16SrXII-I or the unclassified Chinese potato isolates ranged from 98.0 to 99.1 and from 98.1 to 98.9, respectively (Cheng et al., 2015) |
3.1.4. Detection and identification of the pest

For all the categorised phytoplasmas, molecular detection methods are available. Phytoplasmas are routinely detected by polymerase chain reaction (PCR) assays. Universal and specific primers are available and nested PCR protocols have been developed to overcome low pathogen titre in certain hosts and/or in the case of asymptomatic infection (reviewed in Palmano et al., 2015). Several robust diagnostic protocols have also become available based on real-time PCR and loop-mediated isothermal amplification (LAMP) approaches. A locked nucleic acid (LNA) probe-based real-time PCR procedure for a universal detection of all the phytoplasma groups reported in potatoes (‘Ca. P. americanum’, ‘Ca. P. asteris’, ‘Ca. P. aurantifolia’-related strains, ‘Ca. P. australiense’, ‘Ca. P. mali’, ‘Ca. P. pruni’-related strains, ‘Ca. P. solani’ and an unclassified 16SrV strain) has been developed (Palmano et al., 2015). Its high sensitivity and reliability make it suitable for testing in post-entry potato quarantine, initiation of potato nuclear stocks and potato certification (Palmano et al., 2015). Identification of phytoplasmas is routinely achieved by sequencing of a specific 16S rRNA fragment followed by virtual restriction fragment length polymorphism (RFLP) analyses according to an available online tool (Zhao et al., 2009; iPhyClassifier, 2020). Phytoplasma-specific symptoms may indicate phytoplasma infection, but cannot be used to identify the infecting ‘Ca. P. species’.

In Table 7, the detection and identification methods for each categorised phytoplasma are summarised together with the associated uncertainty.

Table 7: Available detection and identification methods of the phytoplasmas categorised here

| Phytoplasma name, reference strain/related strain name | Available detection and identification methods | Uncertainties |
|--------------------------------------------------------|-------------------------------------------------|---------------|
| ‘Ca. P. pruni’-related strains                         | LNA probe-based real-time PCR procedure (Palmano et al., 2015) | None reported |
| ‘Ca. P. aurantifolia’-related strains                  | A quantitative (real-time) polymerase chain reaction (qPCR, Taqman chemistry) to assay and quantify the distribution pattern of ‘Ca. P. aurantifolia’ in tissues of Mexican lime plants was designed on the 16Sr RNA gene (Mazraie et al., 2019). Pest and plant (sesame) specific reagents with different fluorescent dyes were used for simultaneous multiple detection and quantification of 16SrII and 16SrIX phytoplasmas in sesame plant and insect vector samples (Ikten et al., 2016). A rapid real-time group-specific LAMP assay was developed to detect 16SrII phytoplasmas (Bekele et al., 2011) | Specificity of ribosomal primers and probes was not assessed on the different 16SrII strains (Ikten et al., 2016; Mazraie et al., 2019). LAMP primers designed on secY gene properly recognised 16SrII-B and-D strains, but specificity on other 16SrII subgroups was not tested (Bekele et al., 2011) |
| ‘Ca. P. fragariae’-related strains (YN-169, YN-10G)    | The pest can be detected by conventional nested PCR, and distinguished from ‘Ca. P. solani’, ‘Ca. P. australiense’ and ‘Ca. P. fragariae’ by successive multilocus sequence polymorphism analyses with three restriction sites, AluI, HhaI and MseI (Cheng et al., 2015) | None reported |
| ‘Ca. P. pruni’-related strains                         | LNA probe-based real-time PCR procedure (Palmano et al., 2015) | None reported |
3.2. Pest distribution

3.2.1. Pest distribution outside the EU

The distribution outside the EU of the phytoplasmas categorised here is reported in Table 8, based on data from the EPPO GD (EPPO, 2020) and/or the CABI Crop Protection Compendium (CPC) (CABI, 2020), and, when not available in these sources, from extensive literature searches.

The available distribution maps from the EPPO GD (EPPO, 2020) for ‘Ca. P. americanum’ (PHYPAE), and for two related strains of ‘Ca. P. aurantifolia’ (Sweet potato little leaf (PHYP39), and Tomato big bud (PHYP01) phytoplasmas) are provided in Appendix B.

Table 8: Distribution outside the EU of the phytoplasmas categorised here

| Phytoplasma name, reference strain/related strain name | Distribution based on the EPPO GD and/or CABI CPC | Additional information |
|--------------------------------------------------------|--------------------------------------------------|------------------------|
| ‘Ca. P. americanum’ | AMERICA: Canada, Mexico, US | – |
| | OCEANIA: Australia | | |
| ‘Ca. P. aurantifolia’-related strains | AFRICA: South Africa, Tanzania | AFRICA: Burkina Faso, Egypt, Ethiopia, Uganda (EFSA PLH Panel et al., 2020a); Malawi, Mozambique (Kumar et al., 2011); Sudan (Tahir et al., 2017) |
| | AMERICA: US | AMERICA: Brazil, Cuba, Peru (EFSA PLH Panel et al., 2020a); Mexico (Santos-Cervantes et al., 2010) |
| | ASIA: Bangladesh, China, India, Indonesia, Japan, Korea, Lebanon, Malaysia, Philippines, Taiwan | ASIA: Israel, Myanmar, Pakistan, Saudi Arabia, Turkey (EFSA PLH Panel et al., 2020a); Jordan (Salem et al., 2019); Iran (Salehi et al., 2017); Iraq (Al-Kuwaiti et al., 2019); Oman (Al-Subhi et al., 2018) |
| | OCEANIA: Australia, Micronesia, New Caledonia, Niue, Palau, Papua New Guinea, Solomon Islands, Tonga, Vanuatu | OCEANIA: Wallis and Futuna Islands (Davis et al., 2005) |
| | EUROPE (NON-EU): Russia | EUROPE (non-EU): Serbia (Mitrovic et al., 2012); UK (EFSA PLH Panel et al., 2020a) |
| ‘Ca. P. fragariae’-related strains (YN-169, YN-10G) | – | ASIA: China (Cheng et al., 2015) |
| ‘Ca. P. pruni’-related strains | – | AMERICA: Argentina (Galdeano et al., 2013); Brazil (Banzato and Bedendo, 2017); Costa Rica (Villalobos et al., 2019); Mexico (Tapia-Tussell et al., 2010); US (Postman et al., 2001; Davis et al., 2013) |
| | | ASIA: Japan (Okuda et al., 1997) |
| | | EUROPE (NON EU): Russia (Girsova et al., 2016; Kastalyeva et al., 2018); Serbia (Jakovljevic et al., 2015; Starovic et al., 2012; Pavlovic et al., 2012; Rancic et al., 2005) |

3.2.2. Pest distribution in the EU

Is the pest present in the EU? If present, is the pest widely distributed within the EU?

Yes, ‘Ca. P. aurantifolia’-related strains, and ‘Ca. P. pruni’-related strains are reported to be present in the EU, but none of them is reported to be widely distributed.

No, ‘Ca. P. americanum’ (reference strain), and the two ‘Ca. P. fragariae’-related strains (YN-169, YN-10G) are not known to be present in the EU.

Two of the phytoplasmas categorised here were reported in the EU (Table 9), where they can be considered to have a restricted distribution, as all of them were reported only in few plants, in up to
four EU MS. Reports of ‘Ca. P. aurantifolia’-related strains in the EPPO GD (EPPO, 2020) are presented with ‘no details’.

### Table 9: EU distribution of the non-EU phytoplasmas categorised here

| Phytoplasma name, reference strain/related strain name | EU MS from which the pest is reported | Uncertainties |
|--------------------------------------------------------|---------------------------------------|---------------|
| ‘Ca. P. americanum’                                     | Greece, Portugal (EPPO GD [PHYP01]: Present, no details), Italy (Granata et al., 2006; Tolu et al., 2006; Paltrinieri and Bertaccini, 2007; Prota et al., 2007; Parrella et al., 2008) | Reports from the EPPO GD (EPPO, 2020) in Greece and Portugal have no further details. The pest was reported in Italy: (i) in few batches of symptomless potato plantlets obtained from two lots of seeds from different undescribed Italian locations and from unknown origins (Paltrinieri and Bertaccini, 2007), (ii) in one batch (10 insects) out of 3 of field-collected Empoasca decipiens plants, one Solanum nigrum plant and one Chenopodium species (Tolu et al., 2006), (iv) in not specified number among 18 phytoplasma-infected Myrtus communis plants and possibly in mixed infection according to RFLP analysis (Prota et al., 2007), (v) in two field collected Opuntia ficus-indica plants based on ribosomal gene sequencing (Granata et al., 2006) |
| ‘Ca. P. aurantifolia’-related strains                  | None                                  | None |
| ‘Ca. P. fragariae’-related strains (YN-169, YN-10G)   | None                                  | None |
| ‘Ca. P. pruni’-related strains                         | Czech Republic (Franova et al., 2004, 2013), Hungary (Palermo et al., 2004); Italy (Firrao et al., 1996; Bertaccini et al., 2006; Paltrinieri et al., 2008); Lithuania (Jomantiene et al., 2000; Stanulis et al., 2000; Samuitiene et al., 2007; Valiunas et al., 2007) | 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 (belonging to Leucanthemum vulgare, Taraxacum officinale and Crepis biennis species) (Firrao et al., 1996), in three Prunus spp. (cherry) plants (Paltrinieri et al., 2008) and in an undefined number (presumably few samples) of Asclepias physocarpa plants (Bertaccini et al., 2006) in Italy; in an undefined number of Cirsium arvense and Convolvulus arvensis (Palermo et al., 2004) in Hungary; in mixed infection in two naturally infected Trifolium repens plants (Stanulis et al., 2000) and in undefined numbers of Gaillardia spp., Dictamnus albus (Samuitiene et al., 2007; Valiunas et al., 2007), Heracleum sosnowskyi (Valiunas et al., 2007), Glycine max and Lupinus spp. (Jomantiene et al., 2000) plants in Lithuania |

### 3.3. Regulatory status

#### 3.3.1. Commission Implementing Regulation 2019/2072

Non-EU phytoplasmas of tuber-forming Solanum spp. are listed in Annex II of Commission Implementing Regulation (EU) 2019/2072, and of Regulation (EU) 2016/2031 of the European Parliament, under the generic definition ‘Potato viruses, viroids and phytoplasmas’. Details are presented in Table 10.

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4 Commission Implementing Regulation (EU) 2019/2072 of 28 November 2019 establishing uniform conditions for the implementation of Regulation (EU) 2016/2031 of the European Parliament and the Council, as regards protective measures against pests of plants, and repealing Commission Regulation (EC) No 690/2008 and amending Commission Implementing Regulation (EU) 2018/2019. OJ L 319, 10.12.2019, p. 1-279.
3.3.2. Legislation addressing the hosts of the tuber-forming *Solanum* species

Hosts and commodities that may involve the phytoplasmas categorised here are regulated in Commission Implementing Regulation (EU) 2019/2072, and reported in Table 11.

### Table 10: Non-EU phytoplasmas of tuber-forming *Solanum* spp. in Commission Implementing Regulation (EU) 2019/2072

| Annex II | List of Union quarantine pests and their respective codes |
|----------|----------------------------------------------------------|
| Part A   | Pests not known to occur in the Union territory          |
|          | Quarantine pests and their codes assigned by EPPO       |
|          | F. Viruses, viroids and phytoplasmas                    |
|          | 8. Potato viruses, viroids and phytoplasmas              |

### Table 11: Regulations applying to tuber-forming *Solanum* species hosts and commodities that may involve the phytoplasmas categorised in the present opinion in Annexes VI, VII, VII, X, XI, XIII and XIV of Commission Implementing Regulation (EU) 2019/2072 (below)

| Annex VI | List of plants, plant products and other objects whose introduction into the Union from certain third countries is prohibited |
|----------|-------------------------------------------------------------------------------------------------------------------|
| Description | CN Code | Third country, group of third countries or specific area of third country                                      |
| 15 Tubers of *Solanum tuberosum* L., seed potatoes | 0701 10 00 | Third countries other than Switzerland                                                                           |
| 16 Plants for planting of stolon- or tuber-forming species of *Solanum* L. or their hybrids, other than those tubers of *Solanum tuberosum* L. as specified in entry 15 | ex 0601 10 90 0601 20 90 0602 90 50 0602 90 70 0602 90 91 0602 90 99 | Third countries other than Switzerland                                                                           |
| 17 Tubers of species of *Solanum* L., and their hybrids, other than those specified in entries 15 and 16 | ex 0601 10 90 0601 20 90 0701 90 10 0701 90 50 0701 90 90 | Third countries other than:                                                                 |
|          |          | a) Algeria, Egypt, Israel, Libya, Morocco, Syria, Switzerland, Tunisia and Turkey or                             |
|          |          | b) those which fulfil the following provisions:                                                                 |
|          |          | i) they are one of following: Albania, Andorra, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Canary Islands, Faeroe Islands, Georgia, Iceland, Liechtenstein, Moldova, Monaco, Montenegro, North Macedonia, Norway, Russia (only the following parts: Central Federal District (Tsentralny federalny okrug), Northwestern Federal District (Severo-Zapadny federalny okrug), Southern Federal District (Yuzhny federalny okrug), North Caucasian Federal District (Severo-Kavkazsky federalny okrug) and Volga Federal District (Privolzhsky federalny okrug)), San Marino, Serbia, and Ukraine and                                           |
|          |          | ii) — they are either recognised as being free from *Clavibacter sepedonicus* (Spieckermann and Kottho) Nouioui et al., in accordance with the procedure referred to in Article 107 of Regulation (EU) No 2016/2031, or — their legislation, is recognised as equivalent to the Union rules concerning protection against *Clavibacter sepedonicus* (Spieckermann and Kottho) Nouioui et al. in accordance with the procedure referred to in Article 107 of Regulation (EU) No 2016/2031 have been complied with |
### Annex VII

**List of plants, plant products and other objects, originating from third countries and the corresponding special requirements for their introduction into the Union territory**

| Plants, plant products and other objects | CN codes | Origin | Special requirements |
|-----------------------------------------|----------|--------|----------------------|
| Root and tubercle vegetables, other than tubers of *Solanum tuberosum* L. | 0706 10 00 0706 90 10 0706 90 30 0706 90 90 0709 99 90 0714 10 00 0714 20 10 0714 20 90 0714 30 00 0714 40 00 0714 50 00 0714 90 20 0714 90 90 0910 11 00 0910 30 00 0910 99 91 1212 91 80 1212 94 00 1212 99 95 1214 90 10 1214 90 90 | Third countries other than Switzerland | Official statement that the consignment or lot does not contain more than 1% by net weight of soil and growing medium |
| Bulbs, corms, rhizomes and tubers, intended for planting, other than tubers of *Solanum tuberosum* | 0601 10 10 0601 10 20 0601 10 30 0601 10 40 0601 10 90 0601 20 10 0601 20 30 0601 20 90 0706 90 10 0910 11 00 0910 20 10 0910 30 00 | Third countries other than Switzerland | Official statement that the consignment or lot does not contain more than 1% by net weight of soil and growing medium |
| Tubers of *Solanum tuberosum* L. | 0701 10 00 0701 90 10 0701 90 50 0701 90 90 | Third countries other than Switzerland | Official statement that the consignment or lot does not contain more than 1% by net weight of soil and growing medium |
| Tubers of *Solanum tuberosum* L. | 0701 10 00 0701 90 10 0701 90 50 0701 90 90 | Third countries | Official statement that the tubers originate in: (a) a country where *Tecia solanivora* (Povolny) is not known to occur, or (b) an area free from *Tecia solanivora* (Povolny), established by the national plant protection organisation in accordance with relevant International Standards for Phytosanitary Measures |
| Tubers of *Solanum tuberosum* L. | 0701 10 00 0701 90 10 0701 90 50 0701 90 90 | Third countries | Official statement that: a) the tubers originate in countries known to be free from *Clavibacter sepedonicus* (Spieckermann and Kottho) Nouioui et al.; or b) provisions recognised as equivalent to the provisions of Union law on combating *Clavibacter* |
|   | Tubers of *Solanum tuberosum* L. | Third countries where *Synchytrium endobioticum* (Schilb.) Percival is known to occur | Official statement that: |
|---|---------------------------------|-------------------------------------------------------------------------------------|--------------------------|
| 17|                                 | 0701 10 00 0701 90 10 0701 90 50 0701 90 90                                      | a) the tubers originate in areas known to be free from *Synchytrium endobioticum* (Schilb.) Percival (all races other than Race 1, the common European race), and no symptoms of *Synchytrium endobioticum* (Schilb.) Percival have been observed either at the place of production or in its immediate vicinity for an adequate period, or |
|   |                                 |                                                                                     | b) provisions recognised as equivalent to the provisions of Union law on combating *Synchytrium endobioticum* (Schilb.) Percival in accordance with the procedure referred to in Article 107 of Regulation (EU) No 2016/2031 have been complied with in the country of origin |
| 18| Tubers of *Solanum tuberosum* L., for planting | 0701 10 00                                                                 | Official statement that the tubers originate from a site known to be free from *Globodera rostochiensis* (Wollenweber) Behrens and *Globodera pallida* (Stone) Behrens |
| 19| Tubers of *Solanum tuberosum* L., for planting | 0701 10 00                                                                 | Official statement that: |
|   |                                 |                                                                                     | a) the tubers originate in areas in which *Ralstonia solanacearum* (Smith) Yabuuchi et al. emend. Safni et al., *Ralstonia pseudosolanacearum* Safni et al., *Ralstonia syzygii* subsp. *celebensis* Safni et al. and *Ralstonia syzygii* subsp. *indonesiensis* Safni et al. are known not to occur; or |
|   |                                 |                                                                                     | b) in areas where *Ralstonia solanacearum* (Smith) Yabuuchi et al. emend. Safni et al., *Ralstonia pseudosolanacearum* Safni et al., *Ralstonia syzygii* subsp. *celebensis* Safni et al. or *Ralstonia syzygii* subsp. *indonesiensis* Safni et al. is known to occur, the tubers originate from a place of production found free from *Ralstonia solanacearum* (Smith) Yabuuchi et al. emend. Safni et al., *Ralstonia pseudosolanacearum* Safni et al., *Ralstonia syzygii* subsp. *celebensis* Safni et al. and *Ralstonia syzygii* subsp. *indonesiensis* Safni et al. or |
considered to be free thereof, as a consequence of measures taken to eradicate *Ralstonia solanacearum* (Smith) Yabuuchi et al. emend. Safni et al., *Ralstonia pseudosolanacearum* Safni et al., *Ralstonia syzygii* subsp. *celebensis* Safni et al. and *Ralstonia syzygii* subsp. *indonesiensis* Safni et al. and set out in accordance with the procedure referred to in Article 107 of Regulation (EU) No 2016/2031.

| 20 | Tubers of *Solanum tuberosum* L., for planting | 0701 10 00 | Third countries |
|----|-----------------------------------------------|----------|-----------------|
|    | Official statement that:                      |          |                 |
|    | a) either the tubers originate in areas where *Meloidogyne chitwoodi* Golden et al. (all populations) and *Meloidogyne fallax* Karssen are known not to occur, or |
|    | b) in areas where *Meloidogyne chitwoodi* Golden et al. and *Meloidogyne fallax* Karssen are known to occur: |
|    | i) the tubers originate from a place of production which has been found free from *Meloidogyne chitwoodi* Golden et al., and *Meloidogyne fallax* Karssen based on an annual survey of host crops by visual inspection of host plants at appropriate times and by visual inspection both externally and by cutting of tubers after harvest from potato crops grown at the place of production, or |
|    | ii) the tubers after harvest have been randomly sampled and, either checked for the presence of symptoms after an appropriate method to induce symptoms, or laboratory tested, as well as inspected visually both externally and by cutting the tubers, at appropriate times and in all cases at the time of closing of the packages or containers before marketing according to the provisions on closing under Directive 66/403/EEC and no symptoms of *Meloidogyne chitwoodi* Golden et al. and *Meloidogyne fallax* Karssen have been found. |
### Annex VIII

**List of plants, plant products and other objects, originating in the Union territory and the corresponding special requirements for their movement within the Union territory**

| Plants, plant products and other objects | Requirements |
|-----------------------------------------|--------------|
| 3 Plants for planting of stolon, or tuber-forming species of *Solanum* L., or their hybrids, being stored in gene banks or genetic stock collections | Official statement that the plants shall have been held under quarantine conditions and shall have been found free from any Union quarantine pests by laboratory testing. Each organisation or research body holding such material shall inform the competent authority of the material held. |
| 4 Plants for planting of stolon or tuber-forming species of *Solanum* L., or their hybrids, other than those tubers of *Solanum tuberosum* L. specified in entries 5, 6, 7, 8, or 9 and other than culture maintenance material being stored in gene banks or genetic stock collections, and other than seeds of *Solanum tuberosum* L. specified in entry 21 | Official statement that the plants shall have been held under quarantine conditions and shall have been found free from any Union quarantine pests by laboratory testing. The laboratory testing shall: |
|   |   |
|   | a) be supervised by the competent authority concerned and executed by scientifically trained staff of that authority or of any officially approved body; |
|   | b) be executed at a site provided with appropriate facilities sufficient to contain Union quarantine pests and maintain the material including indicator plants in such a way as to eliminate any risk of spreading Union quarantine pests; |
|   | c) be executed on each unit of the material: |
|   | i) by visual examination at regular intervals during the full length of at least one vegetative cycle, having regard to the type of material and its stage of development during the testing programme, for symptoms caused by any Union quarantine pests, |
|   | ii) by laboratory testing, in the case of all potato material at least for: |
|   |   | — Andean potato latent virus, |
|   |   | — Andean potato mottle virus, |
|   |   | — Arracacha virus B. oca strain, |
|   |   | — Potato black ringspot virus, |
|   |   | — Potato virus T, |
|   |   | — non-European isolates of potato viruses A, M, S, V, X and Y (including Y o, Y n and Y c) and Potato leaf roll virus (including Y o), |
|   |   | — *Clavibacter sepedonicus* (Spieckermann and Kottho) Nouiou et al., |
|   |   | — *Ralstonia solanacearum* (Smith) Yabuuchi et al. emend. Safni et al.; *Ralstonia pseudosolanacearum* Safni et al., *Ralstonia syzygii* subsp. *celebensis* Safni et al. and *Ralstonia syzygii* subsp. *indonesiensis* Safni et al. |
|   |   | iii) in the case of seeds of *Solanum tuberosum* L., other than those specified in point 21, at least for the viruses and viroids listed above, with the exception of Andean potato mottle virus and non-European isolates of potato viruses A, M, S, V, X and Y (including Y o, Y n and Y c) and Potato leafroll virus; |
d) include appropriate testing on any other symptom observed in the visual examination in order to identify the Union quarantine pests having caused such symptoms.

5 Tubers of *Solanum tuberosum* L., for planting

Official statement that the provisions of Union law to combat *Synchytrium endobioticum* (Schilb.) Percival have been complied with

6 Tubers of *Solanum tuberosum* L., for planting

Official statement that:

a) the tubers originate in an area known to be free from *Clavibacter sepedonicus* (Spieckermann and Kottho) Nouioui et al., or
b) the provisions of Union law to combat *Clavibacter sepedonicus* (Spieckermann and Kottho) Nouioui et al. have been complied with

7 Tubers of *Solanum tuberosum* L., for planting

Official statement that the tubers originate:

a) in areas where *Ralstonia solanacearum* (Smith) Yabuuchi et al. emend. Safni et al. is known not to occur; or
b) in a place of production found free from *Ralstonia solanacearum* (Smith) Yabuuchi et al. emend. Safni et al., or considered to be free thereof, as a consequence of the implementation of an appropriate procedure aiming at eradicating *Ralstonia solanacearum* (Smith) Yabuuchi et al. emend. Safni et al.

8 Tubers of *Solanum tuberosum* L., for planting

Official statement that the tubers originate:

a) in areas where *Meloidogyne chitwoodi* Golden et al. and *Meloidogyne fallax* Karssen are known not to occur; or
b) in areas where *Meloidogyne chitwoodi* Golden et al. and *Meloidogyne fallax* Karssen are known to occur and:
   i) the tubers originate in a place of production which has been found free from *Meloidogyne chitwoodi* Golden et al. and *Meloidogyne fallax* Karssen based on an annual survey of host crops by visual inspection of host plants at appropriate times and by visual inspection both externally and by cutting of tubers after harvest from potato crops grown at the place of production,
   or
   ii) the tubers have been randomly sampled after harvest and checked for the presence of symptoms, after having applied an appropriate method to induce symptoms or laboratory tested, as well as inspected visually both externally and by cutting tubers, at appropriate times to detect the presence of those pests and in all cases at the time of closing of the packages, or containers before movement, and found free from symptoms of *Meloidogyne chitwoodi* Golden et al. and *Meloidogyne fallax* Karssen

9 Tubers of *Solanum tuberosum* L., for planting, other than those to be planted in accordance with point (b) of Article 4(4) of Directive 2007/33/EC

Official statement that the provisions of Union law to combat *Globodera pallida* (Stone) Behrens and *Globodera rostochiensis* (Wollenweber) Behrens are complied with

10 Tubers of *Solanum tuberosum* L., for planting, other than tubers of those varieties officially accepted in one or more Member States pursuant to Directive 2002/53/EC

Official statement that the tubers:

a) belong to advanced selections, and
b) have been produced within the Union, and
c) have been derived in direct line from material which has been maintained under appropriate conditions and has been subjected within the Union to official quarantine testing and has been found, in these tests, free from Union quarantine pests

11 Tubers of *Solanum tuberosum* L., other than those mentioned in entries 3, 4, 5, 6, 7, 8, 9, or 10

There shall be a registration number on the packaging, or in the case of loose-loaded tubers transported in bulk, on the accompanying documents, demonstrating that the tubers have been grown by an officially registered producer, or originate from officially registered collective storage or dispatching centres located in the area of production, and indicating that:
a) the tubers are free from *Ralstonia solanacearum* (Smith) Yabuuchi et al. emend. Safni et al.

and

b) the provisions of Union law to combat *Synchytrium endobioticum* (Schilb.) Percival,

and

where appropriate, *Clavibacter sepedonicus* (Spieckermann and Kottho) Nouioui et al.,

and

*Globodera pallida* (Stone) Behrens and *Globodera rostochiensis* (Wollenweber) Behrens are complied with

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### ANNEX X

| Plants, plant products and other objects | CN code | Special requirements for protected zones | Protected zones |
|-----------------------------------------|---------|-----------------------------------------|-----------------|
| tubers of *Solanum tuberosum* L., for planting | 0701 10 00 | Official statement that the tubers: (a) were grown in an area where Beet necrotic yellow vein virus ("BNYVV") is known not to occur; or (b) were grown on land, or in growing media consisting of soil that is known to be free from BNYVV, or officially tested by appropriate methods and found free from BNYVV; or (c) have been washed free from soil | a) France (Brittany) b) Finland c) Ireland d) Portugal (Azores) e) United Kingdom (Northern Ireland) |
| tubers of *Solanum tuberosum* L., other than those mentioned in point 6 of this Annex | ex 0701 90 10, ex 0701 90 50, ex 0701 90 90 | (a) The consignment or the lot shall not contain more than 1% by weight of soil; or (b) official statement that the tubers are intended for processing at premises with officially approved waste disposal facilities which ensures that there is no risk of spreading of BNYVV | a) France (Brittany) b) Finland c) Ireland d) Portugal (Azores) e) United Kingdom (Northern Ireland) |
3.3.3. Legislation addressing vectors of the non-EU phytoplasmas categorised here (Commission Implementing Regulation 2019/2072)

The insects identified as competent vectors (Alebroides nigroscutellatus, Austroagallia sinuata, Cacopsylla chinensis, Circulifer haematoceps, Empoasca papaya, Euscelis incises, Macrosteles cristatus, Macrosteles laevis, Nealalturus fenestratus, Orosius albicinctus, Orosius argentatus, Orosius cellulose, Orosius lotophagorum, Orosius orientalis, Scleroracus flavopictus) of the phytoplasmas categorised here are not mentioned in the Commission Implementing Regulation (EU) 2019/2072. The EU distribution of these vectors is provided in Section 3.4.4.

3.4. Entry, establishment and spread in the EU

3.4.1. Host range

The reported natural host range of the phytoplasmas categorised here varies from restricted ('Ca. P. americanum' and 'Ca. P. fragariae'-related strains) to wide ('Ca. P. aurantifolia'-related strains' and 'Ca. P. pruni'-related strains). For the latter pests, Table 12 and Appendix C integrate data from the list of non-EU phytoplasmas infecting S. tuberosum (EFSA PLH Panel et al., 2020b) with additional information on their natural hosts. The ability of 'Ca. P. americanum' to infect Fragaria x ananassa is uncertain because it was only reported in a single report of a single infected plant (Nikolaeva et al., 2020). Table 12 only lists other hosts listed by EPPO and other hosts that are regulated, while Appendix C lists regulated and unregulated other hosts. However, in all cases, there is uncertainty about the possible existence of additional natural hosts not reported so far.
### Table 12: Natural hosts other than *Solanum tuberosum* from EPPO and regulated other natural hosts from a WoS search of the phytoplasmas categorised in the present opinion, together with the regulatory status (Commission Implementing Regulation (EU) 2019/2072 Commission Implementing Regulation (EU) 2019/2072). A comprehensive list of other natural hosts is provided in Appendix C

| Phytoplasma name, reference strain/related strain name | Other hosts | Regulation addressing other hosts |
|--------------------------------------------------------|-------------|----------------------------------|
| *‘Ca. P. americanum’* | *Fragaria x ananassa* (Nikolaeva et al., 2020) | *Fragaria* L.: VI 9; VII 45, 49, 50; VIII 14; XIA 5 |
| **‘Ca. P. aurantifolia’-related strains** | EPPO Major: *Arachis hypogaea* (PHYPA); *Ipomea batatas* (PHYP39) | *Allium cepa*: VIII 14; XIA 8; XIII 6 |
| | EPPO Unclassified: *Fabaceae* (PHYPA); *Solanum lycopersicum* (PHYP01) | *Apium graveolens*: VII 28; XIA 3 |
| | *Mangifera indica* (Rao et al., 2020b); *Psidium guajava* (Rao et al., 2020b); *Punica granatum* (Rao et al., 2020b); Listed in EFSA PLH Panel et al. (2020a) | *Beta vulgaris*: VII 24; VIII 14; X 2, 5; 8, 33, 34; XII 1, 4, 8; XIV 2, 7, 8, 9 |
| | *Capsicum annuum* | *Brassica* spp. and *Brassicaceae*: VIII 14; XIA 8 |
| | *Carica papaya*: VII 22, 68; VIII 13; XIII 6, 10 | *Capsicum annuum*: VII 22; XIA 5 |
| | *Chrysanthemum* L.: VII 25, 26, 28 | *Chrysanthemeum* L.: VII 25, 26, 28 |
| | *Cichorium intybus*: XIA 2; XIB | *Cichorium* spp.: XIA 2; XIB |
| | *Cucurbita pepo* | *Cucurbitaceae*: VIII 15 |
| | *Daucus carota* | *Daucus* L.: X 4 |
| | *Glycine max* | *Glycine max*: VG 3(3), (4); XIA 10; XIII 9 |
| | *Gossypium hirsutum* | *Gossypium* spp.: X 32, 35; XII 5; XIV 9, 10 |
| | *Helianthus annuus*: VG 3(1), (2); XIA 8; XII 9,10 | *Helianthus annuus*: VG 3(1), (2); XIA 8; XII 9,10 |
| | *Hibiscus L.:* X 14; XII 2 | *Hibiscus L.:* X 14; XII 2 |
| | *Linum usitatissimum* | *Linum usitatissimum*: VG 3(2), (5), (6), (7), (8); XIA 10; XIII 9 |
| | *Manihot esculenta* | *Mangifera L.:* VII 61; X 36; XIA 5; XII 4 |
| | *Medicago sativa* | *Manihot esculenta*: XIA 3 |
| | *Nicotiana tabacum* | *Medicago sativa*: VA 3(1), (2); XIA 8; XIII 8 |
| | *Passiflora edulis* | *Nicotiana* L.: VII 22 |
| | *Pelargonium capitatum* | *Passiflora* L.: XIA 3 |
| | *Phaseolus vulgaris* | *Pelargonium* L.: VII 25, 27; XIA 3 |
| | *Phoenix dactylifera* | *Phaseolus vulgaris*: XIA 8; XIII 6 |
| | *Pisum sativum* | *Phoenix dactylifera*: X 31; XIC |
| | *Rosa spp.* | *Pisum sativum*: XIA 9; XIII 6 |
| | *Solanum lycopersicum* | *Psidium L.:* XIA 5 |
| | *Solanum melongena* | *Punica granatum*: VII 62; XIA 5 |
| | *Solanum nigrum* | *Rosa L. and Rosaceae*: VII 8, 9; XIA 6 |
| | *Tritolium repens* | *Solanum lycopersicum*: VII 22, 23, 26, 68, 69; VIII 12, 13; XIA 3, 8; XII 6 |
| | *Vicia faba* | *Solanum melongena*: VII 22, 23, 68, 69, 70; VIII 12, 13; XIA 3 |
| | *Washingtonia robusta* | *Solanum L.:* VI 16, 17; VIII 3, 4 |
3.4.2. Entry

As of September 2020, there were no records of interception of non-EU phytoplasmas of *S. tuberosum* plants in the Europhyt and TRACE databases.

The entry pathways in the EU for the categorised phytoplasmas are potato plants for planting (i.e. seed potatoes), ware potatoes (tubers intended for consumption or processing), plants for planting of other natural hosts and viruliferous vectors. Table 13 reports a summary of the major potential entry pathways of the categorised phytoplasmas.

All categorised phytoplasmas are transmitted by vegetative propagation material, hence seed potatoes and more generally, plants for planting, are considered the most important pathway for entry. Tubers of *S. tuberosum* and seed potatoes as well as plants for planting of other natural hosts or their hybrids are regulated in Annex VI points 15 and 16 of Commission Implementing Regulation 2019/2072. These articles specify that import of such plant material is not allowed from third countries other than Switzerland.

Entry of ware potatoes is regulated by the current EU legislation in Annex VII 17 (Table 11). If the categorised phytoplasmas were present in the countries from which import of ware potatoes is permitted, they could potentially enter the EU via the ware potato pathway. As long as ware potatoes are used for their intended use (i.e. consumption or processing), this pathway is considered of minor importance, as phloem feeding vectors of phytoplasmas are not known to feed on tubers.

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| Phytoplasma name, reference strain/related strain name | Other hosts | Regulation addressing other hosts |
|--------------------------------------------------------|------------|----------------------------------|
| 'Ca. P. fragariae' related strains                     |            |                                  |
| *Brassica rapa* (Banzato and Bedendo, 2017)            |            |                                  |
| *Convolvulus arvensis* (Palermo et al., 2004)          |            |                                  |
| *Glycine max*                                          |            |                                  |
| *Lupinus* spp. (Jomantiene et al., 2000)               |            |                                  |
| *Manihot esculenta* (Flores et al., 2013)              |            |                                  |
| *Medicago sativa* (Starovic et al., 2012)              |            |                                  |
| *Momordica charantia* (Alves et al., 2017)             |            |                                  |
| *Prunus* spp. (Paltrinieri et al., 2008)               |            |                                  |
| *Pyrus* spp. (Duduk et al., 2008)                      |            |                                  |
| *Solanum lycopersicum* (Tapia-Tussell et al., 2010; Galdeano et al., 2013) | | |
| *Solanum melongena* (Mello et al., 2011)               |            |                                  |
| *Trifolium* spp (Franova et al., 2004)                 |            |                                  |
| *Vicia faba* (Girsova et al., 2017)                    |            |                                  |

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**Is the pest able to enter into the EU territory?**

**Yes.** Phytoplasmas may enter into the EU with infected plants for planting (i.e. seed potatoes) of the host plants and in some cases plants for planting of other natural hosts, and/or vectors. An additional minor pathway is represented by ware potatoes (i.e. tubers intended for consumption or processing).
‘Ca. P. americanum’, ‘Ca. P. aurantifolia’-related strains and ‘Ca. P. pruni’-related strains have other natural hosts which may provide additional entry pathways. Other natural hosts and their associated legislation are detailed in Table 12. Unregulated hosts can be considered a possibly open pathway (see Table 13 for a definition).

All phytoplasmas categorised here can also be transmitted by vectors (Table 5). Viruliferous vectors may thus represent a further entry pathway. Information on vector transmission is lacking for two of the categorised phytoplasmas (‘Ca. P. americanum’ and ‘Ca. P. fragariae’-related strains (YN-169, YN-10G)). The risk of introducing insects that have not yet been reported as competent vectors for these pathogens increases the uncertainty on the entry pathways.

For two of the phytoplasmas categorised here (‘Ca. P. aurantifolia’-related strains and ‘Ca. P. pruni’-related strains), vector species have been reported, and these are not regulated, thus providing additional entry pathways.

The import of Solanum plants for planting and seed potatoes is banned by existing legislation, with the exception of material produced in Switzerland. The phytoplasmas categorised here are not reported in Switzerland. The plant for planting pathway for the host plants is considered closed for all the phytoplasmas under categorisation; therefore, it will not be further analysed in Table 13.

The analysis of entry pathways is affected by uncertainties due to existence of other natural hosts, and/or unreported competent vectors, and geographical distribution of the non-EU phytoplasmas. Based on the above data and considerations, the entry pathways of the phytoplasmas categorised here are summarised as follows:

- **entry pathway involving other hosts**: this pathway is partially regulated for other hosts of: ‘Ca. P. aurantifolia’-related strains and ‘Ca. P. pruni’-related strains because of the existence of a wide range of unregulated hosts. It is possibly open for ‘Ca. P. americanum’ and ‘Ca. P. fragariae’-related strains because of the possible existence of unknown unregulated natural hosts.

### Table 13: Major potential entry pathways for the non-EU phytoplasmas categorised here

| Phytoplasma name, reference strain/related strain name | Plants for planting of other hosts(1) | Competent vectors(1) | Uncertainties |
|------------------------------------------------------|---------------------------------------|----------------------|--------------|
| ‘Ca. P. americanum’                                  | Pathway possibly open: other natural hosts may exist | Pathway possibly open: unknown vectors may exist | – Existence of unreported vectors  
– Existence of other unreported natural hosts |
| ‘Ca. P. aurantifolia’-related strains                | Pathway partially regulated: existence of a wide range of unregulated hosts | Pathway open | – Geographical distribution of competent vectors  
– Existence of unreported vectors  
– Existence of other natural hosts |
| ‘Ca. P. fragariae’-related strains                   | Pathway possibly open: other natural hosts may exist | Pathway possibly open: unknown vectors may exist | – Existence of unreported vectors  
– Existence of other unreported natural hosts |
| ‘Ca. P. pruni’-related strains                       | Pathway partially regulated: existence of a wide range of unregulated hosts | Pathway open | – Geographical distribution of competent vectors  
– Existence of unreported vectors  
– Existence of other natural hosts |

(1): **Pathway open**: only applicable if the pathway exists, open means that there is no regulation that prevents entry via this pathway.  
**Pathway possibly open**: the existence of the pathway, which is not closed by current legislation, is not supported by direct evidence regarding the biology of that phytoplasma. However, based on the lack of knowledge on other unknown competent vectors and natural hosts, the existence of the pathway cannot be excluded.  
**Pathway partially regulated**: the legislation does not cover all the possible paths (e.g. regulations exist for some hosts, but not for others; a ban exists for some third countries but not for all).

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3.4.3. Establishment

Are the pests able to become established in the EU territory?

Yes, the host plants of the phytoplasmas under categorisation are widespread in the EU and climatic conditions are not limiting for phytoplasma development as long as they are suitable for host growth. The presence in the EU of vectors for some phytoplasmas may facilitate their establishment (see Table 15 for the EU distribution of competent vectors).

3.4.3.1. EU distribution of main host plants

Potato is widely grown in the EU, as reported e.g. in the pest categorisation of non-EU viruses and viroids of potato (EFSA PLH Panel et al., 2020c).

3.4.3.2. Climatic conditions affecting establishment

Phytoplasma multiplication rates may be influenced in opposite ways by temperature in vectors and plants (EFSA PLH Panel et al., 2020a). It is expected that the phytoplasmas categorised here would be able to establish wherever their host plants are grown, unless the absence of vectors prevents their establishment. The Panel therefore considers that climatic conditions will not impair the ability of the phytoplasmas addressed here to establish in the EU.

3.4.4. Spread

Is the pest able to spread within the EU territory following establishment? How?

Yes, all the categorised phytoplasmas can spread through the trade of host plants for planting (i.e. seed potatoes), and by vectors, whenever these are present in the EU.

RNQPs: Is spread mainly via specific plants for planting, rather than via natural spread or via movement of plant products or other objects?

Yes, all the categorised phytoplasmas are spread mainly by the movement of infected plants for planting.

3.4.4.1. Vectors and their distribution in the EU

The geographic distribution in the EU of competent vectors of the non-EU phytoplasmas categorised here is reported in Table 14. Some of the competent vectors of 'Ca. P. aurantifolia'-related strains and of 'Ca. P. pruni'-related strains are described and known to be present in the EU, according to the EPPO GD (EPPO, 2020), Fauna Europaea, Catalogue of Life and a WoS literature search. No competent vectors are known for 'Ca. P. americanum'- and 'Ca. P. fragariae'-related strains.

The possible unreported presence in the EU of known competent vectors of the phytoplasmas categorised here and the possibility that European phloem feeder insects may act as vectors of newly introduced phytoplasmas are sources of uncertainty in predicting the spread of non-EU phytoplasmas.
Table 14: EU distribution of competent vectors of the non-EU phytoplasmas categorised here. No information was found in the Catalogue of Life.

| Phytoplasma name, reference strain/related strain name | Competent vector | EU distribution (EPPO GD) | EU distribution (Fauna Europaea) | EU distribution (WoS search) |
|--------------------------------------------------------|------------------|--------------------------|----------------------------------|------------------------------|
| 'Ca. P. americanum'                                    | None reported    |                          |                                  |                             |
| 'Ca. P. aaurantifolia'-related strains                 | Orosius albicinctus |                          | Circulifer haematoceps: Finland, France, Germany, Greece, Italy, Poland, Portugal, Spain | Orosius orientalis: Greece, Portugal, Spain; Austroagallia sinuata: Austria, Belgium, Bulgaria, Greece, Hungary, Italy, Portugal, Romania, Spain, Slovakch, UK Neoaliturus fenestratus: Austria, Belgium, Bulgaria, Czech Republic, Denmark, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Netherlands, Portugal, Romania, Slovakia, Spain Circulifer haematoceps: France, Greece, Hungary, Italy, Romania, Slovakia, Spain | Neoaliturus fenestratus: Greece, Portugal, Spain; Austroagallia sinuata: Austria, Belgium, Bulgaria, Greece, Hungary, Italy, Portugal, Romania, Spain, Slovakch, UK |
| Ca. P. fragariae'-related strains (YN-169, YN-10G)     | None reported    |                          |                                  |                             |
| 'Ca. P. pruni'-related strains                         | Euscelis incisus  |                          | Euscelis incisus: Austria, Belgium, Bulgaria, Czech Republic, Denmark, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, UK Macrosteles cristatus: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Italy, Latvia, Lithuania, Netherlands, Poland, Romania, Slovakia, Sweden, UK Macrosteles laevis: Austria, Belgium, Bulgaria, Czech |                             |
3.5. Impacts

Reported impacts caused by the phytoplasmas categorised here are reported in Table 15. These phytoplasmas cause damage to *S. tuberosum* in countries with environmental conditions similar to those present in the EU. They can be spread by infected plants for planting; therefore, introduction of these pests in the EU is likely to impact the production of *S. tuberosum*. Given that ‘*Ca. P. aurantifolia*’- and ‘*Ca. P. pruni*’-related strains also affect economically important crops beside *S. tuberosum*, their introduction in the EU may cause a broader damage.

**Table 15:** Impacts caused by the non-EU phytoplasmas categorised here

| Phytoplasma name, reference strain/related strain name | Impacts |
|--------------------------------------------------------|---------|
| ‘*Ca. P. americanum*’ | In 2004 and 2005, an outbreak of a new disease of potato occurred in Texas and Nebraska, US, which caused darkening of potato chips (potato crisps) produced from infected tubers. The defect consists of patchy brown discoloration of chips and can be a cause for rejection of contracted potatoes by the processor (Secor et al., 2006). This chip defect resulted in a considerable economic loss in the local potato industry. Cultivars susceptible to the disease include Atlantic, Snowden and FL1833 (Lee et al., 2006) |
| ‘*Ca. P. aurantifolia*’-related strains | Large-scale survey of diseased potato plants that exhibited phytoplasma symptoms in Russia (2006–2012) showed that incidence of phytoplasma belonging to 16SrII group was 1.2% of the infected samples (Girsova et al., 2016). Tubers from infected plants have reduced marketability (Santos-Cervantes et al., 2010) |
| ‘*Ca. P. fragariae*’-related strains (YN-169, YN-10G) | In the infested Yunnan and Inner Mongolia areas, the two phytoplasma strains represented 17% and 21% of the 63 tested symptomatic potato plants (Cheng et al., 2015) |
| ‘*Ca. P. pruni*’-related strains | Potato purple top (PPT) is a devastating disease that occurs in Canada, Mexico, Russia, US and elsewhere causing great economic loss to the potato industry through substantially reduced tuber yield and quality. In Russia, 25% of more than 1000 symptomatic potato plants tested positive for the presence of the pest in commercial fields (Girsova et al., 2016). PPT symptoms were observed in potato fields in Montana, US, where over 50% of plants exhibited symptoms (Lee et al., 2006) |

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5 See Section 2.1 on what falls outside EFSA’s remit.
3.6. Availability and limits of mitigation measures

Phytosanitary measures are currently applied to tuber-forming Solanum spp. (see Section 3.3). Potential additional measures to mitigate the risk of entry of the phytoplasmas categorised here may include:

– extension of phytosanitary measures to specifically include hosts other than to tuber-forming Solanum spp. for the phytoplasmas categorised here, that may be introduced as plants for planting;
– banning import of host plants for planting from the third countries where the phytoplasmas categorised here are reported;
– extension of certification schemes, testing requirements and phytosanitary certificates to natural hosts other than tuber-forming Solanum spp., for the phytoplasmas categorised here, that may be introduced as plants for planting.

3.6.1. Identification of additional measures

Phytosanitary measures are currently applied to tuber-forming Solanum spp. (see Section 3.3). Potential additional measures to mitigate the risk of entry of the phytoplasmas categorised here may include:

– extension of phytosanitary measures to specifically include hosts other than to tuber-forming Solanum spp. for the phytoplasmas categorised here, that may be introduced as plants for planting;
– banning import of host plants for planting from the third countries where the phytoplasmas categorised here are reported;
– extension of certification schemes, testing requirements and phytosanitary certificates to natural hosts other than tuber-forming Solanum spp., for the phytoplasmas categorised here, that may be introduced as plants for planting.

3.6.1.1. Additional control measures

Potential additional control measures are listed in Table 16.

**Table 16:** Selected control measures (a full list is available in EFSA PLH Panel et al., 2018) for pest entry/establishment/spread/impact in relation to currently unregulated hosts and pathways. Control measures are measures that have a direct effect on pest abundance.

| Information sheet title (with hyperlink to information sheet if available) | Control measure summary | Risk component (entry/establishment/spread/impact) | Agents |
|---|---|---|---|
| Growing plants in isolation | Description of possible exclusion conditions that could be implemented to isolate the crop from pests and if applicable relevant vectors. E.g. a dedicated structure such as glass or plastic greenhouses | Spread | Competent vector present in the EU: 'Ca. P. aurantifolia' and 'Ca. P. pruni'-related strains, |
3.6.1.2. Additional supporting measures

Potential additional supporting measures are listed in Table 17.

| Information sheet title (with hyperlink to information sheet if available) | Control measure summary | Risk component (entry/establishment/spread/impact) | Agents |
|---|---|---|---|
| Waste management | Treatment of the waste (deep burial, composting, incineration, chipping, production of bio-energy, …) in authorised facilities and official restriction on the movement of waste | Establishment and spread | All phytoplasmas categorised here |
| Roguing and pruning | Roguing is defined as the removal of infested plants and/or uninfested host plants in a delimited area, whereas pruning is defined as the removal of infested plant parts only, without affecting the viability of the plant | Establishment and spread | All phytoplasmas categorised here |
| Heat and cold treatments | Controlled temperature treatments aimed to kill or inactivate pests without causing any unacceptable prejudice to the treated material itself. The measures addressed in this information sheet are: autoclaving; steam; hot water; hot air; cold treatment | Entry, establishment and spread | All phytoplasmas categorised here |
| Chemical treatments on crops including reproductive material | Insecticide treatments of crops in the presence of the vector and according to its biology, to reduce risk of infection | Establishment and spread | Competent vector present in the EU: ‘Ca. P. aurantifolia’ and ‘Ca. P. pruni’–related strains |
| Post-entry quarantine and other restrictions of movement in the importing country | This information sheet covers post-entry quarantine of relevant commodities; temporal, spatial and end-use restrictions in the importing country for import of relevant commodities; Prohibition of import of relevant commodities into the domestic country Relevant commodities are plants, plant parts and other materials that may carry pests, either as infection, infestation or contamination Identifying phytoplasma-infected plants limits the risks of entry, establishment and spread in the EU | Entry, establishment and spread | All phytoplasmas categorised here |
3.6.3. Biological or technical factors limiting the effectiveness of measures to prevent the entry, establishment and spread of the pest

- The asymptomatic phase of phytoplasma infection hampers visual detection;
- There is a wide host range for some phytoplasmas (‘Ca. P. aurantifolia’-related strains, ‘Ca. P. pruni’-related strains);
- There is a wide range of competent vectors for ‘Ca. P. aurantifolia’-related strains;
- There is a lack of information on competent vectors for some phytoplasmas (‘Ca. P. americanum’, and ‘Ca. P. fragariae’-related strains).

3.6.4. Biological or technical factors limiting the ability to prevent the presence of the pest on plants for planting

- Symptoms on tubers may not be visible or they may be misleading

3.7. Uncertainty

For each phytoplasma, the specific uncertainties are reported in the conclusion tables below. Uncertainties affecting all the phytoplasmas characterised here are:

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**Table 17:** Selected supporting measures (a full list is available in EFSA PLH Panel et al., 2018) in relation to currently unregulated hosts and pathways. Supporting measures are organisational measures or procedures supporting the choice of appropriate risk reduction options that do not directly affect pest abundance.

| Information sheet title (with hyperlink to information sheet if available) | Supporting measure summary | Risk component (entry/establishment/spread/impact) | Agents |
|---|---|---|---|
| **Inspection and trapping** | Inspection is defined as the official visual examination of plants, plant products or other regulated articles to determine if pests are present or to determine compliance with phytosanitary regulations (ISPM 5) The effectiveness of inspection and subsequent sampling to detect pests may be enhanced by including trapping and luring techniques As phytoplasma symptoms are usually specific, visual inspection of entry plant material may reduce the risk of entry of infected and symptomatic plants | Entry | All phytoplasmas categorised here |
| **Laboratory testing** | Examination, other than visual, to determine if pests are present using official diagnostic protocols. Diagnostic protocols describe the minimum requirements for reliable diagnosis of regulated pests As universal phytoplasma primers are available, molecular detection of the pathogens according to a sampling strategy may identify the phytoplasmas independently of the presence of symptoms in the host | Entry | All phytoplasmas categorised here |
| **Delimitation of Buffer zones** | ISPM 5 defines a buffer zone as ‘an area surrounding or adjacent to an area officially delimited for phytosanitary purposes in order to minimise the probability of spread of the target pest into or out of the delimited area, and subject to phytosanitary or other control measures, if appropriate’ (ISPM 5). The objectives for delimiting a buffer zone can be to prevent spread from the outbreak area and to maintain a pest free production place, site or area If the presence of the pathogen is restricted, a buffer zone (based on the flight capability of the vector) may help reduce the risk of contamination of infected entry material | Spread | All phytoplasmas categorised here |
4. Conclusions

The Panel conclusions on this pest categorisation of non-EU phytoplasmas of tuber-forming Solanum spp. are:

- All the phytoplasmas categorised here meet all the criteria evaluated by EFSA to qualify as potential Union quarantine pests.
- All the phytoplasmas categorised here do not meet some of the criteria evaluated by EFSA to qualify as potential RNQPs because they are non-EU phytoplasmas.

These conclusions are associated with uncertainties for phytoplasmas for which information on geographic distribution, biology and epidemiology is limited. As a consequence, the categorisation presented here might change for some phytoplasmas as new data become available. However, the following general conclusions can be drawn:

- The identity of all the phytoplasmas categorised here is established and diagnostic tools are available.
- All these phytoplasmas could enter the EU, especially by movement of infected plants for planting. Were this to happen, they could become established, spread and lead to impacts on S. tuberosum, but often also on other hosts.
- For all the phytoplasmas categorised here, phytosanitary measures are available to reduce the likelihood of entry, establishment and spread in the EU.

The Panel’s conclusions on the pest categorisation criteria defined in Regulation (EU) 2016/2031 on protective measures against pests of plants (the number of the relevant sections of the pest categorisation is shown in brackets in the first column) are reported for each of the phytoplasmas categorised here in Tables 18-21.

4.1. ‘Candidatus Phytoplasma americanum’

Table 18: The Panel’s conclusions on the pest categorisation criteria defined in Regulation (EU) 2016/2031 on protective measures against pests of plants (the number of the relevant sections of the pest categorisation is shown in brackets in the first column) for ‘Candidatus Phytoplasma americanum’

| Criterion of pest categorisation | Panel’s conclusions against criterion in Regulation (EU) 2016/2031 regarding Union quarantine pest | Panel’s conclusions against criterion in Regulation (EU) 2016/2031 regarding Union regulated non-quarantine pest | Key uncertainties |
|----------------------------------|------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|-------------------|
| Identity of the pest (Section 3.1) | The identity of ‘Ca. P. americanum’ is established and diagnostic tools are available                   | The identity of ‘Ca. P. americanum’ is established and diagnostic techniques are available                        | None              |
| Absence/presence of the pest in the EU territory (Section 3.2) | ‘Ca. P. americanum’ is not known to be present in the EU                                                  | ‘Ca. P. americanum’ is not known to be present in the EU                                                      | None              |
| Regulatory status (Section 3.3)  | ‘Ca. P. americanum’ can be considered as regulated in Commission Implementing Regulation (EU) 2019/2072 in ANNEX IIA, F 8 under the term ‘Potato viruses, viroids and phytoplasmas’ | ‘Ca. P. americanum’ can be considered as regulated in Commission Implementing Regulation (EU) 2019/2072 in ANNEX IIA, F 8 under the term ‘Potato viruses, viroids and phytoplasmas’ | ‘Ca. P. americanum’ is not explicitly mentioned in Commission Implementing Regulation (EU) 2019/2072 |
4.2. *Candidatus Phytoplasma aurantifolia*-related strains

Table 19: The Panel’s conclusions on the pest categorisation criteria defined in Regulation (EU) 2016/2031 on protective measures against pests of plants (the number of the relevant sections of the pest categorisation is shown in brackets in the first column) for *Candidatus Phytoplasma aurantifolia*-related strains (GD32; St_JO_10, 14, 17; PPT-SA; Rus-343F; PPT-GTO29, -GTO30, -SINTV; Potato Huayao Survey 2; Potato hair sprouts)

| Criterion of pest categorisation | Panel’s conclusions against criterion in Regulation (EU) 2016/2031 regarding Union quarantine pest | Panel’s conclusions against criterion in Regulation (EU) 2016/2031 regarding Union regulated non-quarantine pest | Key uncertainties |
|----------------------------------|---------------------------------------------------|-------------------------------------------------|------------------|
| Pest potential for entry, establishment and spread in the EU territory (Section 3.4) | ‘Ca. P. americanum’ is able to enter in the EU. The plant for planting pathway for the host plants is considered closed. Other potential pathways (other hosts and vectors) are possibly open. If ‘Ca. P. americanum’ is able to enter the EU, it could become established and spread | Plants for planting are the main means of spread for ‘Ca. P. americanum’ | The susceptibility of Fragaria needs to be confirmed The host range is not fully known Competent vectors are not reported The potential vector ability of EU phloem feeder insects is uncertain |
| Potential for consequences in the EU territory (Section 3.5) | The introduction and spread of ‘Ca. P. americanum’ would have a negative impact on S. tuberosum industry | The presence of ‘Ca. P. americanum’ on plants for planting would have a negative impact on their intended use | Impacts on Fragaria industry needs to be confirmed |
| Available measures (Section 3.6) | Phytosanitary measures are available to reduce the likelihood of establishment and spread of ‘Ca. P. americanum’ in the EU | Certification of plants for planting material for susceptible hosts is by far the most efficient control measure | None |
| Conclusion on pest categorisation (Section 4) | ‘Ca. P. americanum’ meets all the criteria evaluated by EFSA to qualify as a potential Union quarantine pest | ‘Ca. P. americanum’ is a non-EU phytoplasma and thus does not meet all the EFSA criteria to qualify as a potential Union RNQP | None |
| Aspects of assessment to focus on/scenarios to address in future if appropriate | The main knowledge gaps are listed in this table Given the limited information available, the development of a full PRA would not allow solving the uncertainties of the present categorisation until more data become available | |

4.2. *Candidatus Phytoplasma aurantifolia*-related strains

Table 19: The Panel’s conclusions on the pest categorisation criteria defined in Regulation (EU) 2016/2031 on protective measures against pests of plants (the number of the relevant sections of the pest categorisation is shown in brackets in the first column) for *Candidatus Phytoplasma aurantifolia*-related strains (GD32; St_JO_10, 14, 17; PPT-SA; Rus-343F; PPT-GTO29, -GTO30, -SINTV; Potato Huayao Survey 2; Potato hair sprouts)

| Criterion of pest categorisation | Panel’s conclusions against criterion in Regulation (EU) 2016/2031 regarding Union quarantine pest | Panel’s conclusions against criterion in Regulation (EU) 2016/2031 regarding Union regulated non-quarantine pest | Key uncertainties |
|----------------------------------|---------------------------------------------------|-------------------------------------------------|------------------|
| Identity of the pest (Section 3.1) | The identity of ‘Ca. P. aurantifolia’-related strains is established and diagnostic tools are available | The identity of ‘Ca. P. aurantifolia’-related strains is established and diagnostic techniques are available | None |
| Absence/presence of the pest in the | ‘Ca. P. aurantifolia’-related strains have been reported in | ‘Ca. P. aurantifolia’-related strains ‘are known to be | Reports from the EPPO GD in Greece and |
| Criterion of pest categorisation | Panel’s conclusions against criterion in Regulation (EU) 2016/2031 regarding Union quarantine pest | Panel’s conclusions against criterion in Regulation (EU) 2016/2031 regarding Union regulated non-quarantine pest | Key uncertainties |
|---------------------------------|------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|------------------|
| EU territory (Section 3.2)      | the EU. Reports from EU MS (Greece, Italy, Portugal) refer to few infected plants. 'Ca. P. aurantifolia'-related strains are not considered to be widely present in the EU | present in the EU, but only from some MS with a restricted distribution | Portugal have no further details. Reports from two EU MS refer to few infected plants (Italy) |
| Regulatory status (Section 3.3) | 'Ca. P. aurantifolia'-related strains can be considered as regulated in Commission Implementing Regulation (EU) 2019/2072 in ANNEX IIA, F 8 under the term 'Potato viruses, viroids and phytoplasmas' | 'Ca. P. aurantifolia'-related strains can be considered as regulated in Commission Implementing Regulation (EU) 2019/2072 in ANNEX IIA, F 8 under the term 'Potato viruses, viroids and phytoplasmas' | 'Ca. P. aurantifolia'-related strains are not explicitly mentioned in Commission Implementing Regulation (EU) 2019/2072 |
| Pest potential for entry, establishment and spread in the EU territory (Section 3.4) | 'Ca. P. aurantifolia'-related strains are able to enter in the EU. The plant for planting pathway for the host plants is considered closed. The plant pathways (other hosts) are partially regulated by existing legislation. The vector pathway is open. If 'Ca. P. aurantifolia'-related strains were to enter the EU territory, they could become established and spread, due to the presence of known competent vectors in the EU | Plants for planting are the main means of spread for 'Ca. P. aurantifolia'-related strains | The host range is not fully known. The potential vector ability of EU phloem feeder insects is uncertain |
| Potential for consequences in the EU territory (Section 3.5) | The introduction and spread of 'Ca. P. aurantifolia'-related strains would have a negative impact on S. tuberosum industry, as well as other crops (see Section 3.4.1) | The presence of 'Ca. P. aurantifolia'-related strains on plants for planting would have a negative impact on their intended use | None |
| Available measures (Section 3.6) | Phytosanitary measures are available to reduce the likelihood of entry and spread of 'Ca. P. aurantifolia'-related strains in the EU | Certification of plants for planting material for susceptible host is by far the most efficient control measure | None |
| Conclusion on pest categorisation (Section 4) | 'Ca. P. aurantifolia'-related strains meet all the criteria evaluated by EFSA to qualify as a potential Union quarantine pest | 'Ca. P. aurantifolia'-related strains are non-EU phytoplasmas and thus do not meet all the EFSA criteria to qualify as a potential Union RNQP | None |
| Aspects of assessment to focus on/scenarios to address in future if appropriate | The main knowledge gaps are listed in this table | Given the limited information available, the development of a full PRA would not allow solving the uncertainties of the present categorisation until more data become available | None |
4.3. ‘Candidatus Phytoplasma fragariae’-related strains

Table 20: The Panel’s conclusions on the pest categorisation criteria defined in Regulation (EU) 2016/2031 on protective measures against pests of plants (the number of the relevant sections of the pest categorisation is shown in brackets in the first column) for ‘Candidatus Phytoplasma fragariae’-related strains (YN-169, YN-10G)

| Criterion of pest categorisation | Panel’s conclusions against criterion in Regulation (EU) 2016/2031 regarding Union quarantine pest | Panel’s conclusions against criterion in Regulation (EU) 2016/2031 regarding Union regulated non-quarantine pest | Key uncertainties |
|----------------------------------|---------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|------------------|
| **Identity of the pest (Section 3.1)** | The identity of ‘Ca. P. fragariae’-related strains is established and diagnostic tools are available | The identity of ‘Ca. P. fragariae’-related strains is established and diagnostic techniques are available | None |
| **Absence/presence of the pest in the EU territory (Section 3.2)** | ‘Ca. P. fragariae’-related strains are not known to be present in the EU | ‘Ca. P. fragariae’-related strains are not known to be present in the EU | None |
| **Regulatory status (Section 3.3)** | ‘Ca. P. fragariae’-related strains can be considered as regulated in Commission Implementing Regulation (EU) 2019/2072 in ANNEX IIA, F 8 under the term ‘Potato viruses, viroids and phytoplasmas’ | ‘Ca. P. fragariae’-related strains can be considered as regulated in Commission Implementing Regulation (EU) 2019/2072 in ANNEX IIA, F 8 under the term ‘Potato viruses, viroids and phytoplasmas’ | ‘Ca. P. fragariae’-related strains are not explicitly mentioned in Commission Implementing Regulation (EU) 2019/2072 |
| **Pest potential for entry, establishment and spread in the EU territory (Section 3.4)** | ‘Ca. P. fragariae’-related strains are able to enter in the EU The plant for planting pathway for the host plants is considered closed. Other potential pathways (other hosts and vectors) are possibly open. If ‘Ca. P. fragariae’-related strains are able to enter the EU, they could become established and spread | Plants for planting are the main means of spread for ‘Ca. P. fragariae’-related strains | The host range is not fully known Competent vectors are not reported The potential vector ability of EU phloem feeder insects is uncertain |
| **Potential for consequences in the EU territory (Section 3.5)** | The introduction and spread of ‘Ca. P. fragariae’-related strains would have a negative impact on S. tuberosum industry | The presence of ‘Ca. P. fragariae’-related strains on plants for planting would have a negative impact on their intended use | None |
| **Available measures (Section 3.6)** | Phytosanitary measures are available to reduce the likelihood of establishment and spread of ‘Ca. P. fragariae’-related strains in the EU | Certification of plants for planting material for susceptible hosts is by far the most efficient control measure | None |
| **Conclusion on pest categorisation (Section 4)** | ‘Ca. P. fragariae’-related strains meet all the criteria evaluated by EFSA to qualify as a potential Union quarantine pest | ‘Ca. P. fragariae’-related strains are non-EU phytoplasmas and thus do not meet all the EFSA criteria to qualify as a potential Union RNQP | }
4.4. ‘Candidatus Phytoplasma pruni’-related strains

Table 21: The Panel’s conclusions on the pest categorisation criteria defined in Regulation (EU) 2016/2031 on protective measures against pests of plants (the number of the relevant sections of the pest categorisation is shown in brackets in the first column) for ‘Candidatus Phytoplasma pruni’-related strains (Clover yellow edge; Potato purple top AKpot7, MT117, AKpot6; PPT-COAHP, -GTOP)

| Criterion of pest categorisation | Panel’s conclusions against criterion in Regulation (EU) 2016/2031 regarding Union quarantine pest | Panel’s conclusions against criterion in Regulation (EU) 2016/2031 regarding Union regulated non-quarantine pest | Key uncertainties |
|----------------------------------|--------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|------------------|
| Identity of the pest (Section 3.1) | The identity of ‘Ca. P. pruni’-related strains is established and diagnostic tools are available | The identity of ‘Ca. P. pruni’-related strains is established and diagnostic techniques are available | None |
| Absence/presence of the pest in the EU territory (Section 3.2) | ‘Ca. P. pruni’-related strains have been reported in the EU. Reports from EU MS (Lithuania, Czech Republic, Italy, Hungary) refer to few infected plants. ‘Ca. P. pruni’-related strains are not considered to be widely present in the EU | ‘Ca. P. pruni’-related strains are known to be present in the EU, but only from some MS with a restricted distribution | Reports from four EU MS refer to few infected plants |
| Regulatory status (Section 3.3) | ‘Ca. P. pruni’-related strains can be considered as regulated in Commission Implementing Regulation (EU) 2019/2072 in ANNEX IIA, F 8 under the term ‘Potato viruses, viroids and phytoplasmas’ | ‘Ca. P. pruni’-related strains can be considered as regulated in Commission Implementing Regulation (EU) 2019/2072 in ANNEX IIA, F 8 under the term ‘Potato viruses, viroids and phytoplasmas’ | ‘Ca. P. pruni’-related strains are not explicitly mentioned in Commission Implementing Regulation (EU) 2019/2072 |
| Pest potential for entry, establishment and spread in the EU territory (Section 3.4) | ‘Ca. P. pruni’-related strains are able to enter in the EU. The plant for planting pathway for the host plants is considered closed. The plant pathways (other hosts) are partially regulated by existing legislation. The vector pathway is open. If ‘Ca. P. pruni’-related strains were to | Plants for planting are the main means of spread for ‘Ca. P. pruni’-related strains | The host range is not fully known. The potential vector ability of EU phloem feeder insects is uncertain |
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**Abbreviations**

| Abbreviation | Description |
|--------------|-------------|
| Ca. P.       | *Candidatus* Phytoplasma |
| CABI         | Centre for Agriculture and Bioscience International |
| CPC          | Crop Protection Compendium |
| EPPO         | European and Mediterranean Plant Protection Organization |
| FAO          | Food and Agriculture Organization |
| GD           | Global Database |
| IPPC         | International Plant Protection Convention |
| IRPCM        | International Research Programme on Comparative Mycoplasmology |
| ISPM         | International Standards for Phytosanitary Measures |
| LAMP         | Loop mediated isothermal amplification |
| LNA          | Locked nucleic acid |
| MLO          | Mycoplasma-like organism |
| MS           | Member State |
| NCBi         | National Center for Biotechnology Information |
| PCR          | Polymerase Chain Reaction |
| PHYPAA       | ‘*Candidatus Phytoplasma australasiae’* |
| PHYPAE       | ‘*Candidatus Phytoplasma americanum’* |
| PHYP01       | Tomato big bud |
| PHYP39       | Sweet potato little leaf |
| PLH          | Plant Health |
| PZ           | Protected Zone |
| RFLP         | Restriction Fragment Length Polymorphism |
| RNQP         | Regulated Non-Quarantine Pest |
| RRO          | Risk reduction option |
| TFEU         | Treaty on the Functioning of the European Union |
| ToR          | Terms of Reference |
| WoS          | Web of Science |
| ZC           | Zebra Chips |

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**Glossary**

**Containment (of a pest)** Application of phytosanitary measures in and around an infested area to prevent spread of a pest (FAO, 1995, 2017)

**Control (of a pest)** Suppression, containment or eradication of a pest population (FAO, 1995, 2017)

**Entry (of a pest)** Movement of a pest into an area where it is not yet present, or present but not widely distributed and being officially controlled (FAO, 2017)

**Eradication (of a pest)** Application of phytosanitary measures to eliminate a pest from an area (FAO, 2017)

**Establishment (of a pest)** Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO, 2017)

**Impact (of a pest)** The impact of the pest on the crop output and quality and on the environment in the occupied spatial units

**Introduction (of a pest) Measures** The entry of a pest resulting in its establishment (FAO, 2017)

**Control (of a pest) is defined in ISPM 5 (FAO 2017) as ‘Suppression, containment or eradication of a pest population’ (FAO, 1995). Control measures are measures that have a direct effect on pest abundance. Supporting measures are organisational measures or procedures supporting the choice of appropriate Risk Reduction Options that do not directly affect pest abundance**

**Pathway** Any means that allows the entry or spread of a pest (FAO, 2017)

**Phytosanitary measures** Any legislation, regulation or official procedure having the purpose to prevent the introduction or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests (FAO, 2017)

**Protected zones (PZ)** A Protected zone is an area recognised at EU level to be free from a harmful organism, which is established in one or more other parts of the Union

**Quarantine pest** A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled (FAO, 2017)

**Regulated non-quarantine pest** A non-quarantine pest whose presence in plants for planting affects the intended use of those plants with an economically unacceptable impact and which is therefore regulated within the territory of the importing contracting party (FAO, 2017)

**Risk reduction option (RRO)** A measure acting on pest introduction and/or pest spread and/or the magnitude of the biological impact of the pest should the pest be present. An RRO may become a phytosanitary measure, action or procedure according to the decision of the risk manager

**Spread (of a pest)** Expansion of the geographical distribution of a pest within an area (FAO 2017)
Appendix A – Symptoms on plants other than *Solanum tuberosum*

Table A.1 provides a synopsis of symptoms caused by the phytoplasmas categorised here on plants other than *S. tuberosum*.

**Table A.1: Summary of symptoms of the categorised non-EU phytoplasmas on plants other than *Solanum tuberosum***

| Phytoplasma name, reference strain/related strain name | Symptoms on plants other than *Solanum tuberosum* |
|--------------------------------------------------------|---------------------------------------------------|
| *'Ca. P. americanum'*                                   | *Fragaria x ananassa*: stunting and unseasonal reddening and distortion of leaves (Nikolaeva et al., 2020)* |
| *'Ca. P. aurantifolia' - related strains*               | *Acacia mangium*: leaf yellowing (Rao et al., 2020a)* |
|                                                       | *Aerva javanica*: witches' broom, little leaf and leaf roll (Hemmati et al., 2019a)* |
|                                                       | *Andrographis paniculata*: virescence, proliferation and witches' broom along with little leaf and stunted growth (Saeed et al., 2015)* |
|                                                       | *Artemisia sieberi*: witches' broom (Hemmati and Nikooei, 2019c)* |
|                                                       | *Bituminaria bituminosa*: stunted growth with small leaves, shortened internodes and bushy growth (Aryamanesh et al., 2011)* |
|                                                       | *Carthamus tinctorius*: extensive fascination, formation of bushy growth, phyllody and shortened of internodes (Mahmoudi et al., 2019)* |
|                                                       | *Cosmos bipinnatus*: phyllody, virescence, little leaf and stunting (Nikooei et al., 2017)* |
|                                                       | *Crassula argentea*: fascination (Dewir et al., 2016)* |
|                                                       | *Echinacea pallida*: virescence, phyllody and chlorotic leaves (Pearce et al., 2011)* |
|                                                       | *Echinacea purpurea*: floral virescence, phyllody and witches' broom (Tseng et al., 2012)* |
|                                                       | *Eclipta prostrata*: phyllody and witches' broom (Chen et al., 2020)* |
|                                                       | *Elettaria cardamomum*: excessive shoot proliferation with reduced panicle with or small-sized degenerated cardamom capsules (Mishra et al., 2019)* |
|                                                       | *Helichrysum bracteatum*: phyllody and witches' broom (Ashwathappa et al., 2019)* |
|                                                       | *Lens culinaris*: floral malformation, chlorosis of old leaves, little leaf, virescence, extensive proliferation of branches, lack of apical leaves, thick and distorted youngest leaves (Akhtar et al., 2016)* |
|                                                       | *Litchi chinensis*: little leaf, leaf yellows and malformation symptoms (Rao et al., 2020b)* |
|                                                       | *Mangifera indica*: little leaf, leaf yellows and malformation symptoms (Rao et al., 2020b)* |
|                                                       | *Medicago arborea*: witches' broom, an asymmetric chlorotic and bushy zone in the crown comprising smaller yellow-green leaves and short internodes (Yang et al., 2013)* |
|                                                       | *Pedalium murex*: stunted growth, reduced leaf size, shortened internodes and phyllody (Babu et al., 2015)* |
|                                                       | *Peganum harmala*: witches' broom, little leaves, flattened stem and twisting the shoots (Hemmati and Nikooei, 2019b)* |
|                                                       | *Petunia violacea*: phyllody, virescence, witches' broom, little leaf and yellowing (Hemmati et al., 2019b)* |
|                                                       | *Pistacia vera*: witches' broom, yellowing and leaf malformation symptoms (Khodaygan et al., 2014)* |
|                                                       | *Polygala matucana*: small leaves, bushy growth, phyllody (Livingston et al., 2006)* |
|                                                       | *Psidium guajava*: little leaf, leaf yellows and malformation symptoms (Rao et al., 2020b)* |
|                                                       | *Punica granatum*: little leaf, leaf yellows and malformation symptoms (Rao et al., 2020b)* |
|                                                       | *Raphanus sativus*: phyllody (Win and Jung, 2012)* |
|                                                       | *Spermacoce exilis*: phyllody and elongated pedicels (Li and Chen, 2018)* |
|                                                       | *Simmondsia chinensis*: witches' broom and little leaves (Omar et al., 2017)* |
|                                                       | *Solanum melongena*: phyllody, little leaves and witches' broom (Omar et al., 2020)* |
|                                                       | Details on symptoms on the following species are listed in EFSA PLH Panel et al. (2020a)* |
|                                                       | *Allium cepa* |
|                                                       | *Amaranthus spp.* |
|                                                       | *Apium graveolens* |
|                                                       | *Beta vulgaris spp.* Esculenta |
|                                                       | *Brassica chinensis* |
|                                                       | *Brassica juncea* |
|                                                       | *Brassica oleracea* |
|                                                       | *Calendula officinalis* |
### Phytoplasma name, reference strain/related strain name

| Symptoms on plants other than *Solanum tuberosum* |
|-----------------------------------------------|
| Callistephus chinensis                        |
| Capsicum annuum                               |
| Capsicum spp.                                 |
| Cardaria draba                                |
| Carica papaya                                 |
| Celosia argentea                              |
| Cicer arietinum                               |
| Cichorium intybus                             |
| Codiaeum variegatum                           |
| Corchorus olitorius                           |
| Conocarpus erectus                            |
| Crotalaria aegyptiaca                         |
| Crotalaria juncea                             |
| Daucus carota                                 |
| Dendrocalamus strictus                        |
| Fallopia japonica                             |
| Fragaria spp.                                 |
| Gerbera jamesonii                             |
| Glycine max                                   |
| Gypsophila paniculata                         |
| Helianthus spp.                               |
| Hibiscus rosa-sinensis                        |
| Jasminum sambac                               |
| Lactuca sativa                                |
| Linum usitatissimum                           |
| Malvaviscus arborus                           |
| Manihot esculenta                              |
| Manilkara zapota                              |
| Matthiola incana                              |
| Medicago sativa                               |
| Mirabilis jalapa                              |
| Parthenium hysterophorus                      |
| Passiflora edulis                              |
| Petroselinum crispum                          |
| Phaseolus vulgaris                            |
| Praxelis clematidea                            |
| Prosopis farcta                               |
| Prunus spp.                                   |
| prunus spp.                                   |
| Rosa spp.                                     |
| Sesamum indicum                               |
| Solanum [Cyphomandra] betaceum                |
| Solanum lycopersicum                          |
| Stylis sandwicensis                            |
| Vicia faba                                    |
| Vitis spp.                                    |
| Zinnia elegans                                |

### ‘Ca. P. pruni’-related strains

- *Arminia montana*: virescence, flower malformation (Pavlovic et al., 2012)
- *Asclepias physocarpa*: severe stunting, associated with rosette-like symptoms, leaf and vein yellowing (Bertaccini et al., 2006)
- *Bougainvillea spectabilis*: foliar chlorosis, shoot proliferation, leaf and bract deformations and decline (Silva et al., 2015)
- *Catharanthus roseus*: yellowing, dwarfing, little leaf and axillary proliferation, virescence, floral abortion and malformation, stalk elongation, big bud and phyllody (Villalobos et al., 2019)
- *Cirsium arvense*: multiple inflorescence or absence of flowering, shortened internodes, plant desiccation (Jakovljevic et al., 2015)
### Phytoplasma name, reference strain/related strain name

| Symptoms on plants other than *Solanum tuberosum* |
|--------------------------------------------------|
| *Cirsium arvense* and *Convolvulus arvensis*: yellows, multiple inflorescence and stunting (Palermo et al., 2004) |
| *Corylus avellana*: slightly chlorotic with reduced leaf size, reduced internode length, insignificant nut production and dieback of small branches (Postman et al., 2001) |
| *Dictamnus albus* and *Gaillardia* spp.: general yellowing and stunting, proliferation of shoots, phyllody, virescence and reduced size of flowers and reddening of leaves (Samuitiene et al., 2007) |
| *Echinacea purpurea*: flower abnormalities, purplish reddening of leaves and severely infected plants neither produced seeds nor survived (Franova et al., 2013) |
| *Glycine max*: normal growth habit but with veinal necrosis (Jomantiene et al., 2000) |
| *Heracleum sosnowskyi*: yellows disease symptoms (Valiunas et al., 2007) |
| *Leonurus sibiricus*: small, shrivelled and mildly chlorotic leaves (Flores and Bedendo, 2013) |
| *Lupinus* spp.: stunting, abnormally small leaves and witches' broom (Jomantiene et al., 2000) |
| *Manihot esculenta*: witches' broom, general stunt, leaves with chlorosis, deformation and reduced size (Flores et al., 2013) |
| *Medicago sativa*: stunting, proliferation and phyllody associated with leaf yellowing and reddening (Starovic et al., 2012) |
| *Melia azedarach*: yellowing, little leaves, witches' broom and decline (Duarte et al., 2009) |
| *Prunus* spp.: leaves of smaller size, with chlorosis, reddening, curling aspect and premature fall, young branches also show some lack of lignifications (Paltrinieri et al., 2008) |
| *Pyrus* spp.: witches' broom and reduced growth (Duduk et al., 2008) |
| *Solanum lycopersicum*: leaf yellowing and curling, little leaf and severe stunting (Tapia-Tussell et al., 2010) |
| *Solanum melongena*: foliar chlorosis, shoot proliferation, shortened internodes, stunting, enlarged calyces (giant calyx), small flowers and fruit of reduced size (Mello et al., 2011) |
| *Trifolium* spp.: phyllody associated with yellowing/reddening, dwarf growth habit without floral abnormalities (Franova et al., 2004), leaf discoloration and virescence (Girsova et al., 2017) |
| *Vernonia brasiliiana*: intensive shoot proliferation, mild leaf chlorosis and deformed leaves (Fugita et al., 2017) |
Appendix B – Distribution maps

The available distribution maps of the non-EU phytoplasmas infecting tuber-forming *Solanum* spp. (Source: EPPO, 2020) are provided in Figures B.1–B.3.

**Figure B.1:** EPPO distribution map for *'Candidatus Phytoplasma americanum'* (PHYPAE)

**Figure B.2:** EPPO distribution map for Sweet potato little leaf (PHYP39), related strain of *'Candidatus Phytoplasma aurantifolia'*
Figure B.3: EPPO distribution map for Tomato big bud (PHYP01), related strain of 'Candidatus Phytoplasma aurantifolia'
Appendix C – List of other natural hosts

Table C.1 provides a list of natural hosts other than the target host plants for the phytoplasmas categorised here.

Table C.1: List of other natural hosts for the phytoplasmas categorised here

| Phytoplasma name, reference strain/related strain name | Other natural hosts |
|--------------------------------------------------------|---------------------|
| ‘Ca. P. americanum’                                     | Fragaria x ananassa (Nikolaeva et al., 2020) |
| ‘Ca. P. aurantifolia’-related strains                  | Acacia mangium (Rao et al., 2020a) |
|                                                       | Acacia saligna, Allocasuarina fraseriana (Saqib et al., 2007) |
|                                                       | Aerva javanica (Hemmati et al., 2019a) |
|                                                       | Andrographis paniculata (Saeed et al., 2015) |
|                                                       | Artemisia sieberi (Hemmati and Nikooei, 2019c) |
|                                                       | Bituminaria bituminosa (Aryamanesh et al., 2011) |
|                                                       | Carthamus tinctorius (Mahmoudi et al., 2019) |
|                                                       | Cosmos bipinnatus (Nikooei et al., 2017) |
|                                                       | Crassula argentea (Dewir et al., 2016) |
|                                                       | Dendrocalamus strictus (Yadav et al., 2016) |
|                                                       | Echinacea pallida (Pearce et al., 2011) |
|                                                       | Eclipta prostrata (Chen et al., 2020) |
|                                                       | Elettaria cardamomum (Mishra et al., 2019) |
|                                                       | Echinacea purpurea (Tseng et al., 2012) |
|                                                       | Enicostemma axillare (Abirami et al., 2012) |
|                                                       | Euphorbia coerulescens, Orbea gigantea, Senecio stapeliformis (Omar et al., 2014) |
|                                                       | Fallopia japonica (Reeder et al., 2010) |
|                                                       | Helichrysum bracteatum (Ashwathappa et al., 2019) |
|                                                       | Lens culinaris (Akhtar et al., 2016) |
|                                                       | Litchi chinensis (Rao et al., 2020b) |
|                                                       | Mangifera indica (Rao et al., 2020b) |
|                                                       | Medicago arborea (Yang et al., 2013) |
|                                                       | Myrtus communis (Prota et al., 2007) |
|                                                       | Pedalium murex (Babu et al., 2015) |
|                                                       | Peganum harmala (Hemmati and Nikooei, 2019b) |
|                                                       | Petunia violacea (Hemmati et al., 2019b) |
|                                                       | Pistacia vera (Khodaygan et al., 2014) |
|                                                       | Polygala mascatense (Livingston et al, 2006) |
|                                                       | Psidium guajava (Rao et al., 2020b) |
|                                                       | Punica granatum (Rao et al., 2020b) |
|                                                       | Raphanus sativus (Win and Jung, 2012) |
|                                                       | Spermacoce exilis (Li and Chen, 2018) |
|                                                       | Simmondsia chinensis (Omar et al., 2017) |
|                                                       | Tabebuia pentaphylla (Mafia et al., 2008) |
|                                                       | Stachytarpheta jamaicensis (Pramesh et al., 2020) |
|                                                       | Vigna mungo (Win and Jung, 2012) |
|                                                       | Listed in EFSA PLH Panel et al. (2020a) |
|                                                       | Acacia salicina |
|                                                       | Achyranthes aspera |
|                                                       | Adenium obesum |
|                                                       | Aescynomene americana |
|                                                       | Aescynomene indica |
|                                                       | Allium cepa |
|                                                       | Alternanthera ficoidea |
|                                                       | Alysicarpus rugosus |
|                                                       | Alysicarpus vaginalis |
|                                                       | Amaranthus spp. |
|                                                       | Apium graveolens |
|                                                       | Arachis hypogaea |
|                                                       | Arachis pintoii |

Listed in EFSA PLH Panel et al. (2020a)

Acacia salicina
Achyranthes aspera
Adenium obesum
Aescynomene americana
Aescynomene indica
Allium cepa
Alternanthera ficoidea
Alysicarpus rugosus
Alysicarpus vaginalis
Amaranthus spp.
Apium graveolens
Arachis hypogaea
Arachis pintoii
| Phytoplasma name, reference strain/related strain name | Other natural hosts |
|------------------------------------------------------|---------------------|
| Araujia sericifera                                   | Beta vulgaris ssp. esculenta |
|                                                      | Boeharvia spp.       |
|                                                      | Bougainvillea glabra  |
|                                                      | Brassica chinensis    |
|                                                      | Brassica juncea       |
|                                                      | Brassica oleracea     |
|                                                      | Brugmansia candida    |
|                                                      | Cajanus cajan         |
|                                                      | Cajanus marmoratus    |
|                                                      | Calendula arvensis    |
|                                                      | Calendula officinalis |
|                                                      | Callistephus chinensis|
|                                                      | Callitris baileyi     |
|                                                      | Canavalia spp.        |
|                                                      | Capsicum annuum       |
|                                                      | Cardaria draba        |
|                                                      | Carica papaya         |
|                                                      | Catharanthus roseus   |
|                                                      | Celosia argentea      |
|                                                      | Celosia cristata      |
|                                                      | Conchrys ciliaris     |
|                                                      | Centrosema pascuorum  |
|                                                      | Chenopodium carinatum |
|                                                      | Chenopodium spp.      |
|                                                      | Chrysanthemum morifolium|
|                                                      | Chrysanthemum spp.    |
|                                                      | Cicer arietinum       |
|                                                      | Cichorium intybus     |
|                                                      | Cinnamomum cassia     |
|                                                      | Cleome viscosa        |
|                                                      | Codiaeum variegatum   |
|                                                      | Conocarpus erectus    |
|                                                      | Conyza spp.           |
|                                                      | Corchorus aenuans     |
|                                                      | Corchorus olitorius   |
|                                                      | Crotalaria spp.       |
|                                                      | Cucumis sativus       |
|                                                      | Cucurbita maxima      |
|                                                      | Cucurbita pepo        |
|                                                      | Cyanthillium cinereum |
|                                                      | Cynodon dactylon      |
|                                                      | Datura stramonium     |
|                                                      | Daucus carota         |
|                                                      | Desmodium triflorum   |
|                                                      | Emilia sonchifolia    |
|                                                      | Eragrostis falcata    |
|                                                      | Eriachne obtusa       |
|                                                      | Erimphylia spp.       |
|                                                      | Eruca sativa          |
|                                                      | Erysimum cheiri       |
|                                                      | Euphorbia millii      |
|                                                      | Foeniculum vulgare    |
|                                                      | Gerbera jamesonii     |
|                                                      | Glycine max           |
|                                                      | Gomphocarpus physocarpus|
|                                                      | Gossypium hirsutum    |
|                                                      | Guizotia abyssinica   |
|                                                      | Gypsophila paniculata |
| Phytoplasma name, reference strain/related strain name | Other natural hosts |
|------------------------------------------------------|---------------------|
| Helianthus spp.                                      | Hibiscus rosa-sinensis |
|                                                      | Hibiscus trionum     |
|                                                      | Indigofera colutea   |
|                                                      | Indigofera hirsuta   |
|                                                      | Indigofera linifolia |
|                                                      | Ipomea spp.          |
|                                                      | Ipomoea aquatica     |
|                                                      | Ipomea batatas       |
|                                                      | Jacksonia scoparia    |
|                                                      | Jasminum sambac      |
|                                                      | Lactuca sativa       |
|                                                      | Linum usitatissimum  |
|                                                      | Macroptilium atropurpureum |
|                                                      | Macroptilium lathyroides |
|                                                      | Malaviscus arborus   |
|                                                      | Manihot esculenta    |
|                                                      | Manilkara zapota     |
|                                                      | Matthiola incana     |
|                                                      | Medicago polymorpha  |
|                                                      | Medicago sativa      |
|                                                      | Melaleuca citrine    |
|                                                      | Mirabilis jalapa     |
|                                                      | Mitracarpus hirtus    |
|                                                      | Mucuna pruriens      |
|                                                      | Nicotiana tabacum    |
|                                                      | Opuntia spp.         |
|                                                      | Pachyrhizus erosus   |
|                                                      | Parthenium hysterophorus |
|                                                      | Passiflora edulis    |
|                                                      | Pelargonium capitatum|
|                                                      | Petroselinum crispum |
|                                                      | Phaseolus vulgaris   |
|                                                      | Phlox spp.           |
|                                                      | Phoenix dactilifera  |
|                                                      | Phyllanthus amarus   |
|                                                      | Physalis ixocarpa    |
|                                                      | Physalis minima      |
|                                                      | Picris hieracioides  |
|                                                      | Pilotus distans      |
|                                                      | Pismum sativum       |
|                                                      | Plantago lanceolata  |
|                                                      | Podocarpus macrophyllus |
|                                                      | Polyaula paniculata  |
|                                                      | Praxelis clematidea  |
|                                                      | Prosopis farcta      |
|                                                      | Rhynchosia minima    |
|                                                      | Rosa spp.            |
|                                                      | Rynchosia minima     |
|                                                      | Saccharum officinarum|
|                                                      | Sarcocilus hartmanii x Sarcocilus falcatus |
|                                                      | Sarcocilus hartmanii |
|                                                      | Scaevola taccada     |
|                                                      | Senna obtusifolia    |
|                                                      | Sesamum indicum      |
|                                                      | Sesuvium portulacastrum |
|                                                      | Sida cordifolia      |
|                                                      | Solanum lycopersicum |
|                                                      | Solanum melongena    |
| Phytoplasm name, reference strain/related strain name | Other natural hosts |
|-----------------------------------------------------|---------------------|
| **Solanum nigrum** | Solanum nigrum  
| Spinacia oleraria | Spinacia oleraria  
| *Stylosanthes* spp. | *Stylosanthes* spp.  
| *Tephrosia* purpurea | *Tephrosia* purpurea  
| *Tridax* procumbens | *Tridax* procumbens  
| *Trifolium* repens | *Trifolium* repens  
| *Vicia* faba | *Vicia* faba  
| *Vigna* lanceolata | *Vigna* lanceolata  
| *Vigna* luteola | *Vigna* luteola  
| *Vigna* radiata | *Vigna* radiata  
| *Vigna* trilobata | *Vigna* trilobata  
| *Vigna* unguiculata | *Vigna* unguiculata  
| *Washingtonia* robusta | *Washingtonia* robusta  
| *Zinnia* elegans | *Zinnia* elegans  
| **‘Ca. P. fragariae’-related strains** | None reported  
| **‘Ca. P. pruni’-related strains** | Arnica montana (Pavlovic et al., 2012)  
| Asclepias physocarpa (Bertaccini et al., 2006) | Asclepias physocarpa (Bertaccini et al., 2006)  
| Bougainvillea spectabilis (Silva et al., 2015) | Bougainvillea spectabilis (Silva et al., 2015)  
| Brassica rapa (Banzato and Bedendo, 2017) | Brassica rapa (Banzato and Bedendo, 2017)  
| Catharanthus roseus (Villalobos et al., 2019) | Catharanthus roseus (Villalobos et al., 2019)  
| *Cirsium* arvense and Convolvulus arvensis (Palermo et al., 2004) | *Cirsium* arvense and Convolvulus arvensis (Palermo et al., 2004)  
| *Cirsium* vulgare, Carduus acanthoides, Lathyrus tuberosus, Lathyrus aphaca (Jakovljevic et al., 2015) | *Cirsium* vulgare, Carduus acanthoides, Lathyrus tuberosus, Lathyrus aphaca (Jakovljevic et al., 2015)  
| *Corylus* avellana (Postman et al., 2001) | *Corylus* avellana (Postman et al., 2001)  
| *Echinacea* purpurea (Franova et al., 2013) | *Echinacea* purpurea (Franova et al., 2013)  
| Gaillardia spp. and Dictamnus albus (Samuitiene et al., 2007) | Gaillardia spp. and Dictamnus albus (Samuitiene et al., 2007)  
| Gentiana spp., Furfugium japonicum (Okuda et al., 1997) | Gentiana spp., Furfugium japonicum (Okuda et al., 1997)  
| Glycine max, Lupinus spp. (Jomantienë et al., 2000) | Glycine max, Lupinus spp. (Jomantienë et al., 2000)  
| *Heracleum* sosnowskyi (Valiunas et al., 2007) | *Heracleum* sosnowskyi (Valiunas et al., 2007)  
| *Leonurus* sibiricus (Flores and Bedendo, 2013) | *Leonurus* sibiricus (Flores and Bedendo, 2013)  
| *Leucanthemum* vulgare, Taraxacum officinale, Crepis biennis (Firrao et al., 1996) | *Leucanthemum* vulgare, Taraxacum officinale, Crepis biennis (Firrao et al., 1996)  
| Manihot esculenta (Flores et al., 2013) | Manihot esculenta (Flores et al., 2013)  
| *Medicago* sativa (Starovic et al., 2012) | *Medicago* sativa (Starovic et al., 2012)  
| Melia azedarach, Solanum lycopersicum, Caesalpinia gilliesii, Catharanthus roseus (Galdeano et al., 2013) | Melia azedarach, Solanum lycopersicum, Caesalpinia gilliesii, Catharanthus roseus (Galdeano et al., 2013)  
| Melilotus album, Vicia villosa, Lotus corniculatus, Medicago lupulina, Melilotus officinalis, Vicia faba (Girsova et al., 2017) | Melilotus album, Vicia villosa, Lotus corniculatus, Medicago lupulina, Melilotus officinalis, Vicia faba (Girsova et al., 2017)  
| Momordica charantia (Alves et al., 2017) | Momordica charantia (Alves et al., 2017)  
| Prunus spp. (Paltrinieri et al., 2008) | Prunus spp. (Paltrinieri et al., 2008)  
| Pyrus spp. (Duduk et al., 2008) | Pyrus spp. (Duduk et al., 2008)  
| Solanum lycopersicum (Tapia-Tussell et al., 2010) | Solanum lycopersicum (Tapia-Tussell et al., 2010)  
| Solanum melongena (Mello et al., 2011) | Solanum melongena (Mello et al., 2011)  
| *Trifolium* spp. (Franova et al., 2004) | *Trifolium* spp. (Franova et al., 2004)  
| *Vernonia* brasiliensis (Fugita et al., 2017) | *Vernonia* brasiliensis (Fugita et al., 2017)  
| Vernonia brasiliensis (Fugita et al., 2017) | Vernonia brasiliensis (Fugita et al., 2017)  
| Vernonia brasiliensis (Fugita et al., 2017) | Vernonia brasiliensis (Fugita et al., 2017)  
| Vernonia brasiliensis (Fugita et al., 2017) |