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Pest categorisation of the non-EU phytoplasmas of tuber-forming *Solanum* spp.

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Abstract

Following a request from the European Commission, the EFSA Panel on Plant Health performed a pest categorisation of four phytoplasmas of tuber-forming *Solanum* spp. known to occur only outside the EU or having a limited presence in the EU. The only tuber-forming species of *Solanum* reported to be phytoplasma infected is *S. tuberosum*. This opinion covers '*Candidatus* Phytoplasma 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) and '*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 ('*Ca*. P. americanum', and '*Ca*. P. fragariae'-related strains) to wide ('*Ca*. P. aurantifolia'-related strains and '*Ca*. P. pruni'-related strains), thus increasing the possible entry pathways in the latter case. *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.

Keywords: *Solanum tuberosum*, pest risk, plant health, plant pest, quarantine, insect vectors

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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.

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[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 IIAI

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

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

(b) Bacteria

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

(c) Fungi

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

(d) Virus and virus-like organisms

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

Annex IIB

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

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

(b) Bacteria

Curtobacterium flaccumfaciens pv. flaccumfaciens (Hedges) Collins and Jones

(c) Fungi

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

1.1.2.2. Terms of Reference: Appendix 2

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

Annex IAI

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

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

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

Group of Tephritidae (non-EU) such as:

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

(c) Viruses and virus-like organisms

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

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

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

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

Annex IIAI

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

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

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

1.1.2.3. Terms of Reference: Appendix 3

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

Annex IAI

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

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

(b) Fungi

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

(c) Viruses and virus-like organisms

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

(d) Parasitic plants

Arceuthobium spp. (non-EU)

Annex IAII

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

Meloidogyne fallax Karssen

Popillia japonica Newman

Rhizoecus hibisci Kawai and Takagi

(b) Bacteria

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

Ralstonia solanacearum (Smith) Yabuuchi et al.

(c) Fungi

Melampsora medusae Thümen

Synchytrium endobioticum (Schilbersky) Percival

Annex I B

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

Leptinotarsa decemlineata Say

Liriomyza bryoniae (Kaltenbach)

(b) Viruses and virus-like organisms

Beet necrotic yellow vein virus

1.1.3. Interpretation of the Terms of Reference

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 fulfil 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. australiense', '*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".

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 SANTÉ) 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)	Is the pest regulated as a quarantine pest? If currently regulated as a quarantine pest, are there grounds to consider its status could be revoked?
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?	Is spread mainly via specific plants for planting, rather than via natural spread or via movement of plant products or other objects? Clearly state if plants for planting is the main pathway!
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?

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
Conclusion of pest categorisation (Section 4)	A statement as to whether (1) all criteria assessed by EFSA above for consideration as a potential quarantine pest were met and (2) if not, which one(s) were not met	A statement as to whether (1) all criteria assessed by EFSA above for consideration as potential protected zone quarantine pest were met, and (2) if not, which one(s) were not met	A statement as to whether (1) all criteria assessed by EFSA above for consideration as a potential RNQP were met, and (2) if not, which one(s) were not met

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. aurantifolia'-related strains	These phytoplasmas belong to the 16SrII ribosomal group (IRPCM, 2004). A categorisation of the '*Ca*. P. aurantifolia' 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. aurantifolia' 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. aurantifolia'-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 PHYPAA, 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 (Pacifico 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 brasiliana* 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 chinensis* (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 sinuata* 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). *Neoaliturus 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, Neoaliturus 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

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). *Scleroracus flavopictus* transmits Gentian witches' broom and Tsuwabuki witches' broom phytoplasmas, (16SrIII-B; Okuda et al., 1997)	*Sonronius binotatus, Anoscopus albifrons, 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); *Psammotettix striatus* (Kastalyeva et al., 2018)	*Orosius argentatus*, *Macrosteles cristatus*, *M. laevis* and *Alebroides nigroscutellatus* 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: Intraspecific 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)

Phytoplasma name, reference strain/related strain name	Justification
'*Ca.* P. pruni'-related strains	Mexican strains of the subgroup 16SrIII-U, consistently distinguishable from their South American counterpart based on molecular markers, may represent emerging or previously unknown North American geographic lineages of the 16SrIII-U subgroup (Perez-Lopez et al., 2017)

3.1.4. Detection and identification of the pest

Are detection and identification methods available for the pest?

Yes, the non-EU phytoplasmas categorised here can be detected by molecular methods.

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. americanum'	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, *Alu*I, *Hha*I and *Mse*I (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 AMERICA: US ASIA: Bangladesh, China, India, Indonesia, Japan, Korea, Lebanon, Malaysia, Philippines, Taiwan OCEANIA: Australia, Micronesia, New Caledonia, Niue, Palau, Papua New Guinea, Solomon Islands, Tonga, Vanuatu EUROPE (NON-EU): Russia	AFRICA: Burkina Faso, Egypt, Ethiopia, Uganda (EFSA PLH Panel et al., 2020a); Malawi, Mozambique (Kumar et al., 2011); Sudan (Tahir et al., 2017) AMERICA: Brazil, Cuba, Peru (EFSA PLH Panel et al., 2020a); Mexico (Santos-Cervantes et al., 2010) 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: Wallis and Futuna Islands (Davis et al., 2005) 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'	None	None
'*Ca.* P. aurantifolia'-related strains	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* (Parrella et al., 2008), (iii) in three field-collected *Calendula arvensis* 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. 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; Staniulis et al., 2000; Samuitienė 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 (Staniulis et al., 2000) and in undefined numbers of *Gaillardia* spp., *Dictamnus albus* (Samuitienė 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[4], 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.

[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.

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

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 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 ex 0601 20 90 ex 0602 90 50 ex 0602 90 70 ex 0602 90 91 ex 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 ex 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

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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
12	Root and tubercle vegetables, other than tubers of *Solanum tuberosum* L.	0706 10 00 0706 90 10 0706 90 30 0706 90 90 ex 0709 99 90 ex 0714 10 00 ex 0714 20 10 ex 0714 20 90 ex 0714 30 00 ex 0714 40 00 ex 0714 50 00 ex 0714 90 20 ex 0714 90 90 ex 0910 11 00 ex 0910 30 00 ex 0910 99 91 ex 1212 91 80 ex 1212 94 00 ex 1212 99 95 ex 1214 90 10 ex 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
13	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 ex 0706 90 10 ex 0910 11 00 ex 0910 20 10 ex 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
14	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
15	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* (Povolný) is not known to occur, or (b) an area free from *Tecia solanivora* (Povolný), established by the national plant protection organisation in accordance with relevant International Standards for Phytosanitary Measures
16	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*

				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, in the country of origin
17	Tubers of *Solanum tuberosum* L.	0701 10 00 0701 90 10 0701 90 50 0701 90 90	Third countries where *Synchytrium endobioticum* (Schilb.) Percival is known to occur	Official statement that: 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	Third countries	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	Third countries	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

21	Tubers of *Solanum tuberosum* L., other than those for planting	0701 90 10 0701 90 50 0701 90 90	Third countries	Official statement that 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

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) Nouioui 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
21	Seeds of *Solanum tuberosum* L., other than those specified in entry 3	Official statement that: a) the seeds derive from plants complying, as applicable, with the requirements set out in points 4, 5, 6, 7, 8 and 9, and that the seeds: b) originate in areas known to be free from *Synchytrium endobioticum* (Schilb.) Percival, *Clavibacter sepedonicus* (Spieckermann and Kottho) Nouioui et al., *Ralstonia solanacearum* (Smith) Yabuuchi et al. emend. Safni et al., or comply with all of the following requirements: i) they have been produced in a site where, since the beginning of the last cycle of vegetation, no symptoms of disease caused by the Union quarantine pests referred to in point (a) have been observed; ii) they have been produced at a site where all of the following actions have been taken: — prevention of contact with and hygiene measures concerning staff and items, such as tools, machinery, vehicles, vessels and packaging material, from other sites producing solanaceous plants to prevent infection are ensured; — only water free from all Union quarantine pests referred to in this point is used

ANNEX X	**List of plants, plant products and other objects, to be introduced into, or moved within protected zones and corresponding special requirements for protected zones**			
	Plants, plant products and other objects	CN code	Special requirements for protected zones	Protected zones
6	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)
7	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)

ANNEX XI	List of plants, plant products and other objects subject to phytosanitary certificates and those for which such certificates are not required for their introduction into the Union territory	
PART A	**List of plants, plant products and other objects, as well as the respective third countries of origin or dispatch, for which, pursuant to Article 72(1) of Regulation (EU) 2016/2031 phytosanitary certificates are required for their introduction into the Union territory**	
Plants, plant products and other objects	CN code and its respective description under Council Regulation (EEC) No 2658/87	Country of origin or dispatch
7. **Tubers of:**		
Solanum tuberosum L.	Potatoes, fresh or chilled, other than seed potatoes: **ex 0701 90 10 ex 0701 90 50 ex 0701 90 90**	Third countries other than Switzerland
8. **Seeds of:**		
Solanum tuberosum L.	Potato true seeds, for sowing: **ex 1209 91 80**	All third countries

ANNEX XIII	List of plants, plant products and other objects for which a plant passport is required for movement within the Union territory
7. Seeds *of Solanum tuberosum* L.	

ANNEX XIV	List of plants, plant products and other objects for which a plant passport with the designation 'PZ' is required for introduction into, and movement within certain protected zones
6. Tubers of *Solanum tuberosum* L., intended for planting	

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 sinuate, Cacopsylla chinensis, Circulifer haematoceps, Empoasca papaya, Euscelis incises, Macrosteles cristatus, Macrosteles laevis, Neoaliturus 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* (PHYPAA); *Ipomea batatas* (PHYP39) EPPO Unclassified: *Fabaceae* (PHYPAA); *Solanum lycopersicum* (PHYP01) *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) *Allium cepa* *Apium graveolens* *Beta vulgaris* ssp. *esculenta* *Brassica chinensis* *Brassica juncea* *Brassica oleracea* *Capsicum annuum* *Carica papaya* *Chrysanthemum morifolium* *Chrysanthemum* spp. *Cichorium intybus* *Cucumis sativus* *Cucurbita maxima* *Cucurbita pepo* *Daucus carota* *Glycine max* *Gossypium hirsutum* *Helianthus* spp. *Hibiscus rosa-sinensis* *Hibiscus trionum* *Linum usitatissimum* *Manihot esculenta* *Medicago sativa* *Nicotiana tabacum* *Passiflora edulis* *Pelargonium capitatum* *Phaseolus vulgaris* *Phoenix dactilifera* *Pisum sativum* *Rosa* spp. *Solanum lycopersicum* *Solanum melongena* *Solanum nigrum* *Trifolium repens* *Vicia faba* *Washingtonia robusta*	*Allium cepa:* VIII 14; XIA 8; XIII 6 *Apium graveolens:* VII 28; XIA 3 *Beta vulgaris*: VII 24; VIII 14; X 2, 5, 8, 33, 34; XII 1, 4, 8; XIV 2, 7, 8, 9 *Brassica* spp. and *Brassicaceae:* VIII 14; XIA 8 *Capsicum annuum:* VII 22, 68; VIII 13; XIII 6, 10 *Carica papaya:* XIA 5 *Chrysanthemum* L.: VII 25, 26, 28 *Cichorium* spp.: XIA 2; XIB *Cucurbitaceae:* VIII 15 *Daucus* L.: X 4 *Glycine max*: VG 3(3), (4); XIA 10; XIII 9 *Gossypium* spp.: X 32, 35; XII 5; XIV 9, 10 *Helianthus annuus*: VG 3(1), (2); XIA 8; XII 9,10 *Hibiscus* L.: X 14; XIV 2 *Linum usitatissimum:* VG 3 (2),(5),(6),(7),(8); XIA 10; XIII 9 *Mangifera* L.: VII 61; X 36; XIA 5; XII 4 *Manihot esculenta:* XIA 3 *Medicago sativa:* VA 3 (1), (2); XIA 8; XIII 8 *Nicotiana* L.: VII 22 *Passiflora* L.: XIA 3 *Pelargonium* L.: VII 25, 27; XIA 3 *Phaseolus vulgaris:* XIA 8; XIII 6 *Phoenix dactylifera:* X 31; XIC *Pisum sativum:* XIA 9; XIII 6 *Psidium* L.: XIA 5 *Punica granatum:* VII 62; XIA 5 *Rosa* L. and *Rosaceae*: VII 8, 9; XIA 6 *Solanum lycopersicum:* VII 22, 23, 26, 68, 69; VIII 12, 13; XIA 3, 8; XIII 6 *Solanum melongena:* VII 22, 23, 68, 69, 70; VIII 12, 13; XIA 3 *Solanum* L.: VI 16, 17; VIII 3, 4

Phytoplasma name, reference strain/ related strain name	Other hosts	Regulation addressing other hosts
		Trifolium L.: XIA 8 *Vicia faba:* XIA 9; XIII 6 *Washingtonia* Raf.: X 30, 31; XIV 4
'*Ca.* P. fragariae'-related strains	None reported	–
'*Ca.* P. pruni'-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)	*Brassica rapa:* X 4; XIA 10; XIII 9 *Convolvulus* L.: XIA 3 *Glycine max:* VG 3(3), (4); XIA 10; XIII 9 *Manihot esculenta:* XIA 3 *Medicago sativa:* VA 3 (1), (2); XIA 8; XIII 8 *Momordica* L.: VII 71; XIA 5 *Prunus* L.: VI 8, 9; VII 42, 43, 45, 47, 61, 62, 63, 98, 99, 100, 101; X 11; XIA 3, 5, 8, 11; XIII 4, 10, 11; XIV 2, 11 *Pyrus* L.: VI 8, 9; VII 42, 43, 45, 63, 64, 65, 98, 99; IX 1; X 9; XIA 5, 12; XII 3, 8; XIV 3, 5 *Solanum lycopersicum:* VII 22, 23, 26, 68, 69; VIII 12, 13; XIA 3, 8; XIII 6 *Solanum melongena:* VII 22, 23, 68, 69, 70; VIII 12, 13; XIA 3 *Trifolium* L.: XIA 8 *Vicia faba:* XIA 9; XIII 6

3.4.2. Entry

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)

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 or tuber-forming species of *Solanum* L. 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.

'*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.

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).

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.

- entry pathway involving infectious vectors: the pathway is open for '*Ca*. P. aurantifolia'-related strains and '*Ca.* P. pruni'-related strains due to the unregulated status of their competent vectors. This pathway is possibly open for '*Ca.* P. americanum' and '*Ca.* P. fragariae'-related strains because of the possible existence of unknown competent vectors.

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. aurantifolia'-related strains	*Orosius albicinctus* *Orosius argentatus* *Orosius cellulosa* *Orosius lotophagorum* *Orosius orientalis* *Empoasca papayae* *Cacopsylla chinensis* *Austroagallia sinuata* *Neoaliturus fenestratus* *Circulifer haematoceps*	*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, Slovacchia, 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	*Austroagallia sinuata*: Spain (Llacer and Medina, 1988); France (Ribaut, 1935)
***Ca.* P. fragariae'-related strains (YN-169, YN-10G)**	None reported	–	–	–
'*Ca.* P. pruni'-related strains	*Euscelis incisus* *Scleroracus flavopictus* *Orosius argentatus* *Macrosteles cristatus* *Macrosteles laevis* *Alebroides nigroscutellatus*	–	*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	–

Phytoplasma name, reference strain/related strain name	Competent vector	EU distribution (EPPO GD)	EU distribution (Fauna Europaea)	EU distribution (WoS search)
			Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Netherlands, Poland, Romania, Slovakia, Sweden, UK	

3.5. Impacts

Would the pests' introduction have an economic or environmental impact on the EU territory?

Yes, the introduction in the EU of the phytoplasmas categorised here would have an economic impact.

RNQPs: Does the presence of the pest on plants for planting have an economic impact, as regards the intended use of those plants for planting?[5]

Yes, the pest presence would have an economic impact on the intended use of plants for planting.

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

5 See Section 2.1 on what falls outside EFSA's remit.

Phytoplasma name, reference strain/related strain name	Impacts
	et al., 2009). Chips and fries processed from infected tubers often develop brown discoloration, greatly reducing their marketability (Lee et al., 2009). Storage tubers from affected plants do not sprout, or the sprouting is of extremely weak stems deficient in chlorophyll giving the appearance of white threads (Santos-Cervantes et al., 2010). The symptoms of PPT disease resemble those of zebra chip, a disorder of potato recently found to be associated with '*Ca*. L. solanacearum' in New Zealand and the US (Santos-Cervantes et al., 2010). An incidence of about 50% has been observed in tomato fields in the Yucatan Peninsula, Mexico (Tapia-Tussell et al., 2010). The phytoplasma is tuber transmissible, and approximately 35% of plants produced from infected tubers developed symptoms (Lee et al., 2009)

3.6. Availability and limits of mitigation measures

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?

Yes, measures are already in place (see section 3.3) and potential additional measures for further regulating the identified pathways to limit entry, establishment, spread or impacts are listed in 3.6.1.

RNQPs: Are there measures available to prevent pest presence on plants for planting such that the risk becomes mitigated?

Yes, measures are already in place (see section 3.3) and potential additional measures for further regulating the identified pathways to limit entry, establishment, spread or impacts are listed in 3.6.1.

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,

Information sheet title (with hyperlink to information sheet if available)	Control measure summary	Risk component (entry/establishment/spread/impact)	Agents
	Insect-proof greenhouses to isolate plants for planting from vectors		and possibly for all the others
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 Removal of pruning material to reduce pathogen inoculum source and to avoid vector egg hatching	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 Roguing of infested plants to reduce pathogen inoculum source. Pruning of symptomatic parts to reduce pathogen inoculum source in the case of woody hosts	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 Hot treatment of propagation material to reduce/eliminate pathogen load and, possibly, vector egg viability Heat treatment has been shown to reduce phytoplasma inoculum on woody host	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

3.6.1.2. Additional supporting measures

Potential additional supporting measures are listed in Table 17.

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

3.6.1.3. 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).

3.6.1.4. 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:

- Lack of epidemiological information (competent vectors, host range, biological details);
- Geographic distribution of the phytoplasmas both in and outside the EU;
- Volume of imported plants for planting of the unregulated hosts.

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

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	
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		

4.3. '*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	

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
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		

4.4. '*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

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
	enter the EU territory, they could become established and spread, due to the presence of known competent vectors in the EU		
Potential for consequences in the EU territory (Section 3.5)	The introduction and spread of '*Ca*. P. pruni'-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. pruni'-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. pruni'-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. pruni'-related strains meet all the criteria evaluated by EFSA to qualify as a potential Union quarantine pest	'*Ca*. P. pruni'-related strains are non-EU phytoplasmas and thus do not meet all the EFSA criteria to qualify as a potential Union RNQP	
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		

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Abbreviations

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

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)	The entry of a pest resulting in its establishment (FAO, 2017)
Measures	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 fasciation, 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*: fasciation (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 no 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 mascatense*: 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* ssp. 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. *yrus* spp. *Rosa* spp. *Sesamum indicum* *Solanum* [Cyphomandra] *betaceum* *Solanum lycopersicum* *Stylosanthes* spp. *Trifolium repens* *Vicia faba* *Vitis* spp. *Zinnia elegans*
'*Ca.* P. pruni'-related strains	*Arnica 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 (Samuitienė 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 brasiliana*: 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.

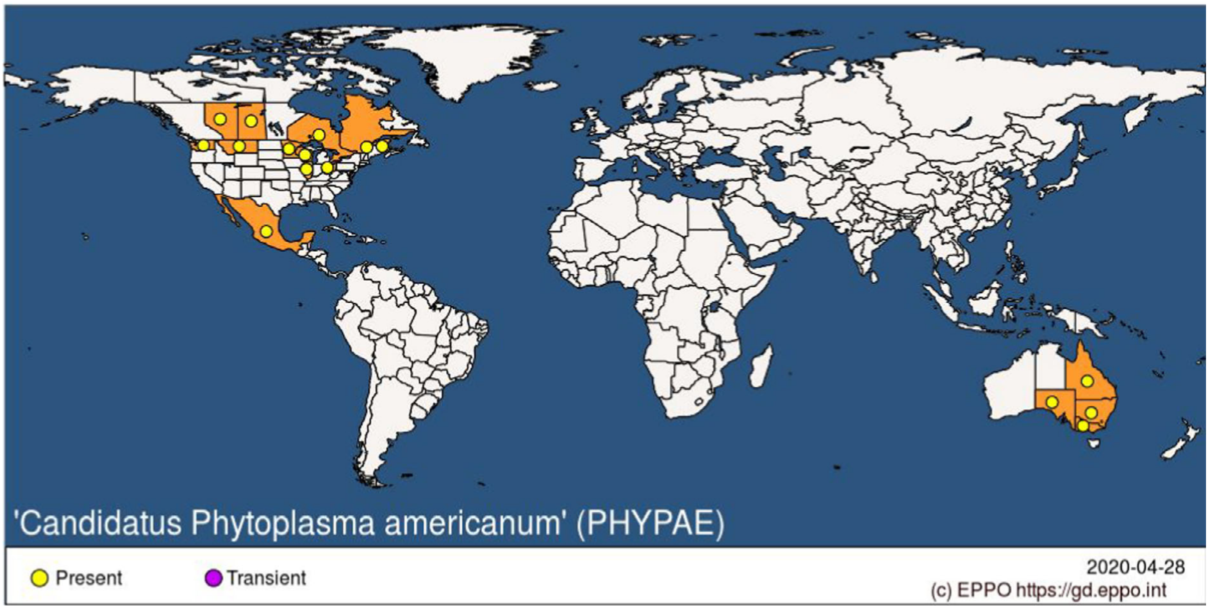

Figure B.1: EPPO distribution map for '*Candidatus* Phytoplasma americanum' (PHYPAE)

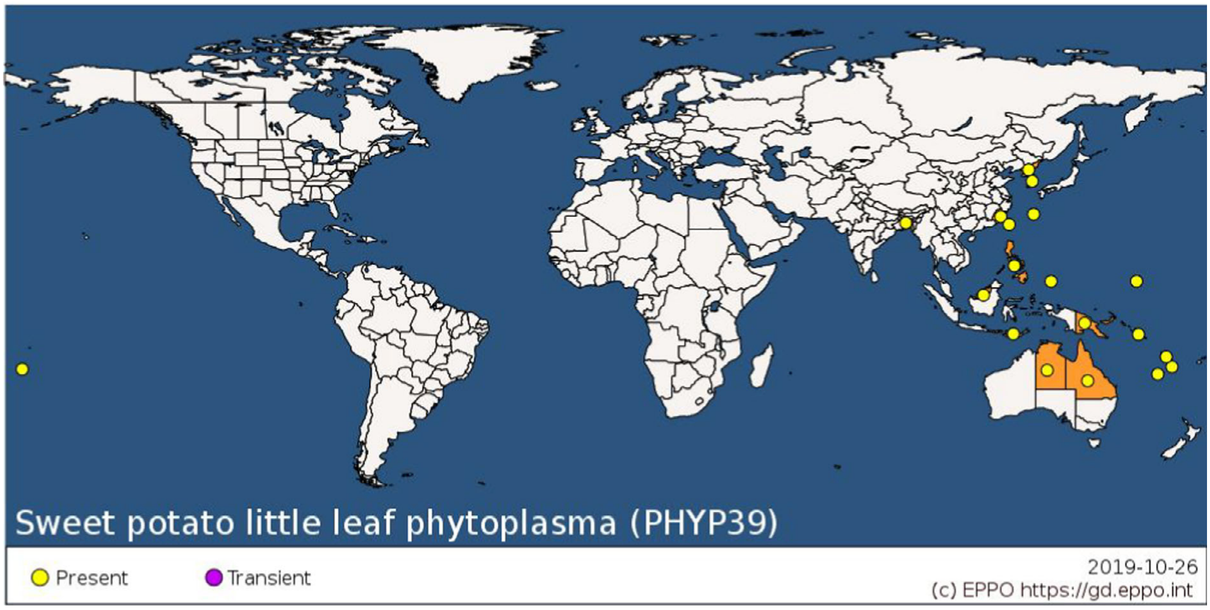

Figure B.2: EPPO distribution map for Sweet potato little leaf (PHYP39), related strain of '*Candidatus* Phytoplasma aurantifolia'

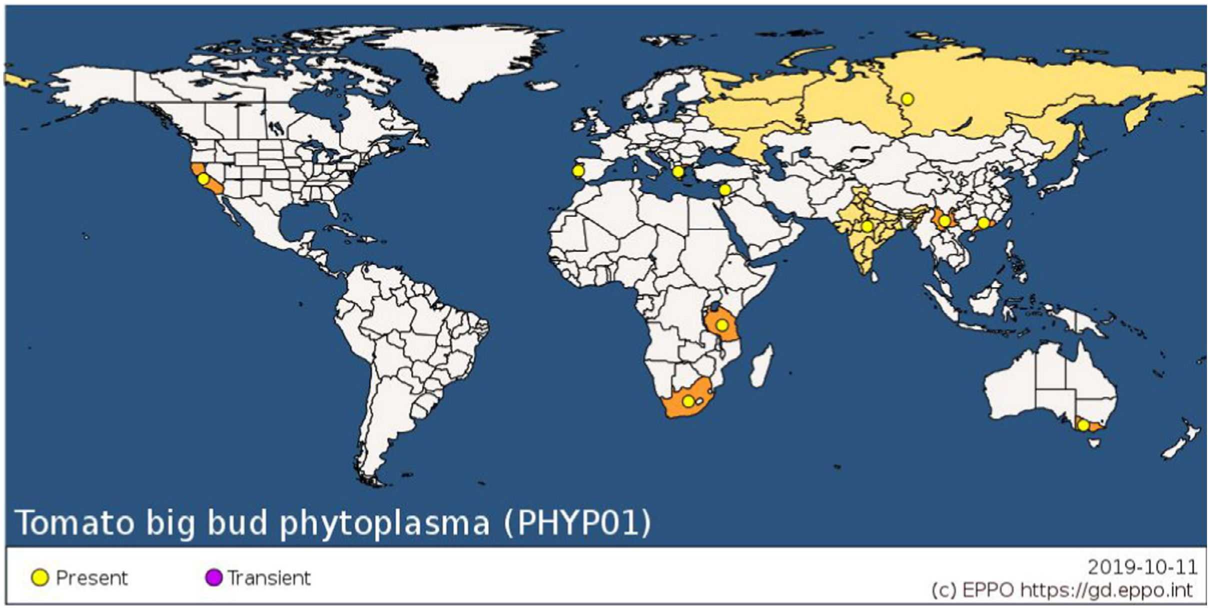

Figure B.3: EPPO distribution map for Tomato big bud (PHYP01), related strain of '*Candidatus* Phytoplasma aurantifolia'

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 stapeliiformis* (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* *Aeschynomene americana* *Aeschynomene 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 christata* *Cenchrus 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 aestuans* *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* *Erimophyla* 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* *Malvaviscus 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* *Pisum sativum* *Plantago lanceolata* *Podocarpus macrophyllus* *Polygala paniculata* *Praxelis clematidea* *Prosopis farcta* *Rhynchosia minima* *Rosa* spp. *Rynchosia minima* *Saccharum officinarum* *Sarcochilus hartmanii* x *Sarcochilus falcatus* *Sarcochilus hartmanii* *Scaevola taccada* *Senna obtusifolia* *Sesamum indicum* *Sesuvium portulacastrum* *Sida cordifolia* *Solanum lycopersicum* *Solanum melongena*

Phytoplasma name, reference strain/related strain name	Other natural hosts
	Solanum nigrum *Spinacia olearia* *Stylosanthes* spp. *Tephrosia purpurea* *Tridax procumbens* *Trifolium repens* *Vicia faba* *Vigna lanceolata* *Vigna luteola* *Vigna radiata* *Vigna trilobata* *Vigna unguiculata* *Washingtonia robusta* *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) *Bougainvillea spectabilis* (Silva et al., 2015) *Brassica rapa* (Banzato and Bedendo, 2017) *Catharanthus roseus* (Villalobos et al., 2019) *Cirsium arvense* and *Convolvulus arvensis* (Palermo et al., 2004) *Cirsium vulgare, Carduus acanthoides, Lathyrus tuberosus, Lathyrus aphaca* (Jakovljevic et al., 2015) *Corylus avellana* (Postman et al., 2001) *Echinacea purpurea* (Franova et al., 2013) *Gaillardia* spp. and *Dictamnus albus* (Samuitienė et al., 2007) *Gentiana* spp., *Farfugium japonicum* (Okuda et al., 1997) *Glycine max, Lupinus* spp. (Jomantiene et al., 2000) *Heracleum sosnowskyi* (Valiunas et al., 2007) *Leonurus sibiricus* (Flores and Bedendo, 2013) *Leucanthemum vulgare, Taraxacum officinale, Crepis biennis* (Firrao et al., 1996) *Manihot esculenta* (Flores et al., 2013) *Medicago sativa* (Starovic et al., 2012) *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) *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) *Solanum melongena* (Mello et al., 2011) *Trifolium* spp. (Franova et al., 2004) *Vernonia brasiliana* (Fugita et al., 2017)