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Pest categorisation of the *Ralstonia solanacearum* species complex

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Abstract

Following a request from the European Commission, the EFSA Panel on Plant Health performed a pest categorisation of the *Ralstonia solanacearum* species complex (RSSC), a distinguishable cosmopolitan group of bacterial plant pathogens (including *R. solanacearum*, *Ralstonia pseudosolanacearum* and two subspecies of *Ralstonia syzygii*) of the family Burkholderiaceae. The RSSC causes bacterial wilt in solanaceous crops, such as potato, tomato and pepper, but can also cause wilts in other important food crops such as fruit banana, plantain banana and cassava. The pest survives in the soil, and a number of weed species can also be infected by the pest, often asymptomatically. The RSSC is regulated in Council Directive 2000/29/EC (Annex IAII) (indicated by its former name *R. solanacearum,* as delimited by Yabuuchi et al.) as a harmful organism whose introduction into the EU is banned. In addition, Council Directive 1998/57/EC (amended by Commission Directive 2006/63/CE) concerns the measures to be taken within EU Member States (MS) against the RSSC to (a) detect it and determine its distribution, (b) prevent its occurrence and spread, and (c) control it with the aim of eradication. The pest is present in several EU MS, but in all cases with a restricted distribution and under official control. New phylotypes of the RSSC could enter the EU primarily via host plants for planting (including seed tubers). The pest could establish in the EU, as climatic conditions are favourable, hosts are common and the pathogen has high adaptability. Spread is mainly via plants for planting. Substantial crop losses in the EU would occur in the presence of RSSC epidemics. The RSSC is regarded as one of the world's most important phytopathogenic bacteria due to its broad geographical distribution, large host range, aggressiveness, genetic diversity and long persistence in soil and water. The list of hosts and commodities for which the pest is regulated is incomplete due to the high diversity of hosts and the lack of knowledge of the complete host range. Moreover, the comparative epidemiology of the different pathogen species has not yet been studied. The criteria assessed by the Panel for consideration of the RSSC as potential quarantine pest are met, while, for regulated non-quarantine pests, the criterion on the widespread presence in the EU is not met.

Keywords: bacterial wilt, European Union, intraspecific diversity, pest risk, plant health, plant pest, quarantine

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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 categorizations of the harmful organisms included in the annexes of Directive 2000/29/EC, in the cases where recent pest risk assessment/ pest categorisation is not available.

1.1.2. Terms of Reference

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

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

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

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

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

[1] Council Directive 2000/29/EC of 8 May 2000 on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community. OJ L 169/1, 10.7.2000, p. 1–112.

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

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

1.1.2.1. Terms of Reference: Appendix 1

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

Annex 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

1.2. Interpretation of the Terms of Reference

Ralstonia solanacearum (Smith) Yabuuchi et al. is one of a number of pests listed in the Appendices to the Terms of Reference (ToR) to be subject to pest categorisation to determine whether it fulfils the criteria of a quarantine pest or those of a regulated non-quarantine pest (RNQP) 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 species has been regrouped recently into a complex of three species, i.e. *R. solanacearum* that coincides with phylotype II), *Ralstonia pseudosolanacearum* that coincides with phylotypes I and III and *Ralstonia syzygii* (subsp. *celebensis* and *indonesiensis*) coinciding with phylotype IV (Safni et al., 2014) (see Section 3.1.1). These species differ in their ecological features. The term *Ralstonia solanacearum* species complex, abbreviated as RSSC, will be used throughout the document unless information is provided specific for one of the genomic species.

2. Data and methodologies

2.1. Data

2.1.1. Literature search

A literature search on the RSSC was conducted at the beginning of the categorisation in the ISI Web of Science bibliographic database, using the scientific names of the pest (see Section 1.2) as search term. Relevant papers were reviewed and further references and information were obtained from experts, as well as from citations within the references and grey literature.

2.1.2. Database search

Pest information, on hosts and distribution, was retrieved from the European and Mediterranean Plant Protection Organization (EPPO) Global Database (EPPO, 2018a) and relevant publications.

Data about the import of commodity types that could potentially provide a pathway for the pest to enter the EU and about the area of hosts grown in the EU were obtained from EUROSTAT (Statistical Office of the European Communities).

The Europhyt database was consulted for pest-specific notifications on interceptions and outbreaks. Europhyt is a web-based network 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 database manages 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 MS and the phytosanitary measures taken to eradicate or avoid their spread.

2.2. Methodologies

The Panel performed the pest categorisation for the RSSC following guiding principles and steps in the International Standard for Phytosanitary Measures 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 1 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 a 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 a 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 1: 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 regulated non-quarantine pest. (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!

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
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?
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 pest is established but it is considered a species complex (Fegan and Prior, 2005; Safni et al., 2014; Prior et al., 2016).

The RSSC is a soilborne, Gram-negative, motile bacterium in the family Burkholderiaceae that causes wilting and related symptoms in over 200 plant species (Prior et al., 2016; Bergsma-Vlami et al., 2018; CABI, 2018).

Other names for this bacterium include *Bacterium solanacearum, Pseudomonas solanacearum,* and *Burkholderia solanacearum* (EPPO, 1997), but the complete list is much longer (CABI, 2018). The taxonomic situation is also complicated by reclassification of all groups of the *R. solanacearum* species complex into different species (*R. solanacearum*, *R. pseudosolanacearum* and *R. syzygii*) (Safni et al., 2014). This classification was confirmed by an independent group (Prior et al., 2016). The proposal made by Safni et al. (2014) elevated phylotypes I and III to a novel species, *R. pseudosolanacearum*; phylotype II remained in an emended *R. solanacearum* species while phylotype IV formed the subsp. *celebensis* and *indonesiensis* within the *R. syzygii* species (Table 2). *R. syzygii* subsp. *syzygii* (a pathogen of cloves, *Syzygium* spp.; Safni et al., 2018) existed prior to this reclassification and is not regulated. Given that this reclassification was performed recently, the biology and epidemiology of the different species within the RSSC still need to be explored. In addition, genetic exchange between the different phylotypes/species has been documented (Wicker et al., 2012). Therefore, for the purposes of this document, the RSSC is considered.

Table 2: Overview of the Safni et al. (2014) revision of the *R. solanacearum* species complex, including information on the host range of the different phylotypes/species (from Wicker et al., 2012; Safni et al., 2014)

Before 2014	After the revision of Safni et al. (2014)	Main hosts
R. solanacearum phylotype I	*R. pseudosolanacearum*	*Solanum tuberosum*, *Solanum lycopersicon*, *Casuarina equisetifolia,* mulberry (*Morus* spp.)
R. solanacearum phylotype II	*R. solanacearum*	*Solanum* spp. (including *S. tuberosum* affected by the potato brown rot), *Anthurium*, *Heliconia* and *Musa* spp.
R. solanacearum phylotype III	*R. pseudosolanacearum*	*Solanum* spp. and *Nicotiana* spp.
R. solanacearum phylotype IV	*R. syzygii* subsp. *celebensis*	Banana (*Musa* spp.)
	R. syzygii subsp. *indonesiensis*	*S. tuberosum, S. lycopersicon, Capsicum annuum*, *Syzygium aromaticum*
R. syzygii	*R. syzygii* subsp. *syzygii*	Clove (*Syzygium* spp.)

3.1.2. Biology of the pest

Most of the biological and epidemiological knowledge on the RSSC has been generated for the species complex, not at the phylotype/species level. Therefore, a general presentation of the biology of the species complex is provided.

Except for the narrow-host range pathogen *R. syzygii* subsp. *syzygii*, strains of the RSSC cause bacterial wilt in solanaceous crops, such as potato and tomato, but can also cause wilts in other important food crops such as fruit banana, plantain banana, and cassava (Hayward, 1991). The pest can survive in the soil for 2–3 years, and a number of weed species can also be infected by the pest (often asymptomatically), which provides an additional way for the bacteria to survive (Moffett and Hayward, 1980; Elphinstone, 1996). In both Egypt and the Netherlands, survival (measured as colony forming units) was shown to be shorter in sandy than in clay soils (Messiha et al., 2009).

The pest can enter the plant via stem wounds, sites of secondary root emergence, and root damage (Genin and Boucher, 2002). Infection of banana plants via aerial transmission by insects has also been reported (Fegan and Prior, 2006). Once inside the plant, the bacteria move in the vascular bundles and colonise the xylem (Lowe-Power et al., 2018). The plant eventually wilts and dies, and the pest returns to the soil, where it can survive for a limited time as a saprophyte (Granada and Sequeira, 1983; van Elsas et al., 2000).

Initial symptoms on potato plants consist of wilting, with the plants initially able to recover during the night (Gutarra et al., 2017). Symptoms on tomato plants are similar. Eventually, the plants do not recover and die. Examination of the stem may reveal a brown discolouration (EPPO, 1997). Bacteria may ooze from cut surfaces of the stem, and this is also seen in potato tuber infections, which may not show external symptoms (CABI, 2018).

Movement of the pathogen can take place via irrigation water, and over longer distances via movement of infected planting material, such as seed tubers and in some cases true seed (Elphinstone et al., 1998; Hong et al., 2008; Janse, 2012; CABI, 2018). The pathogen can be dispersed by machines and equipment, as it can survive for up to 14 days on wood (di Bisceglie et al., 2005).

Movement of the bacteria via contaminated surface water has also been documented (Wenneker et al., 1999; Janse et al., 2004). Insects have been reported to vector the bacteria only between banana plants (see Section 3.4.4). Time for symptom development varies, and is favoured by high temperatures (35–37°C; EPPO, 1997) and high soil moisture, although strains with a growth optimum at lower temperatures (27°C) have been reported (Champoiseau et al., 2009; Bocsanczy et al., 2012.

3.1.3. Intraspecific diversity

Earlier subdivisions of the species have been based on differential pathogenicity to various host plants, giving rise to races (Buddenhagen et al., 1962). Moreover, the ability to metabolise different carbohydrate sources was used, which differentiates biovars (Hayward, 1964). Later on, sequence data of different genes resulted in a classification reflecting geographic origin, with four phylotypes (I–IV), from Asia, the Americas, Africa and the Indonesian archipelago (Fegan and Prior, 2005). Safni et al. (2014) transferred phylotype IV to subspecies of *R. syzygii*, and elevated phylotypes I and III to the species *R. pseudosolanacearum* (Table 2). These species, however, do not provide absolute information on pathogenicity to different host species, and thus this document will consider together all of them as a species complex, as done e.g. by Salgon et al. (2017), Van Vaerenbergh et al. (2017) and da Silva Xavier et al. (2019). The group of strains previously called phylotype IIB, sequevar 1 (PIIB-1) or race 3 biovar 2, which is responsible for potato brown rot, was introduced into the EU and is present with restricted distribution in some EU MS (see Section 3.2.2). Further division via sequence information of the endoglucanase gene into sequevars is also possible (Fegan and Prior, 2005).

3.1.4. Detection and identification of the pest

Are detection and identification methods available for the pest?

Yes, detection and identification methods are available.

A rapid presumptive test for the RSSC is bacterial streaming from the cut surface of the stem when suspended in water (Allen et al., 2001). Standardised diagnostic methods are mandated via Council Directive 98/57/EC on the control of the RSSC and Commission Directive 2006/63/EC, and are also made available by EPPO (2011, 2018b), including isolation and cultural methods, immunofluorescence tests, and a number of molecular tests. Some methods, such as a LAMP (Loop mediated isothermal amplification) assay (Kubota et al., 2008) will identify the species complex, while other methods can detect some of (Pastrik et al., 2002) or all the phylotypes/species (Cellier et al., 2017). Comparisons of the accuracy of different detection methods are available (Van Vaerenbergh et al., 2017; Okiro et al., 2019).

3.2. Pest distribution

3.2.1. Pest distribution outside the EU

The RSSC is distributed worldwide (Figure 1). The disease is favoured by warmer climates, but strains of the pathogen adapted to cooler climates result in an even wider distribution. Historical reports of the presence of the pathogen outside of the EU have not always distinguished between different races, biovars, phylotypes or species.

In Asia, the pest is present in Bangladesh (widespread), Bhutan, China, India (widespread), Indonesia, Iran, Japan, North and South Korea, Lao, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Saudi Arabia, Singapore, Sri Lanka, Taiwan (widespread), Thailand, Turkey and Vietnam (CABI, 2018; EPPO, 2018a).

In Africa, the pest is present in Angola, Benin, Burkina Faso, Burundi, Cameroon (widespread), Congo, Congo Democratic Republic, Cote d'Ivoire, Egypt, Ethiopia, Gambia, Ghana, Kenya, Lesotho, Libya, Madagascar, Malawi (widespread), Mali (widespread), Mauritius, Morocco, Nigeria, Reunion, Rwanda, Senegal, Sierra Leone, Somalia, South Africa, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe (CABI, 2018; EPPO, 2018a).

In North and Central America, the pest is present in Belize (widespread), Costa Rica, Cuba, Dominican Republic, El Salvador, Grenada, Guadeloupe, Guatemala, Honduras, Martinique (widespread), Mexico, Nicaragua, Panama, Puerto Rico, Trinidad and Tobago (widespread) and the USA (widespread) (CABI, 2018; EPPO, 2018a).

In South America, the pest is present in Bolivia, Brazil, Chile, Colombia, Ecuador, French Guiana, Guyana, Paraguay, Peru, Suriname, Uruguay (widespread) and Venezuela (CABI, 2018; EPPO, 2018a).

In Oceania, the pest is present in Australia, Cook Islands, Fiji, French Polynesia, Guam, Micronesia, New Caledonia, New Zealand, Papua New Guinea, Samoa, Tonga and Vanuatu (CABI, 2018; EPPO, 2018a).

In non-EU Europe, the pest is present in Georgia, Moldova, Russia, Serbia and Ukraine (CABI, 2018; EPPO, 2018a).

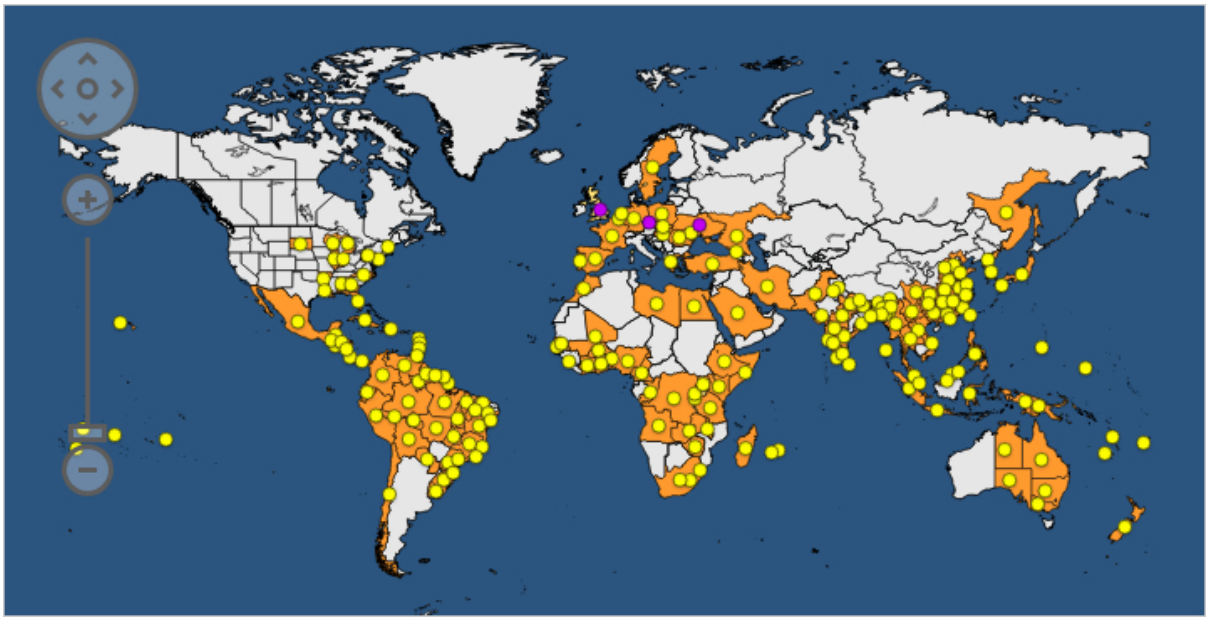

Figure 1: Global distribution map for the *Ralstonia solanacearum* species complex (from EPPO, 2018a, accessed January 2019). Yellow and orange indicate reported presence and purple stands for reported transient presence

3.2.2. Pest distribution in the EU

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

Yes, the pest is present within the EU, but with a limited distribution.

Many of the reports on the presence of the RSSC within the EU are interceptions or isolated occurrences, which are then followed by procedures for pathogen eradication and other control measures (Table 3). Standardised surveys have confirmed the absence of the pathogen in many MS. Historical reports of the presence of the pathogen in the EU have not always distinguished between different races, biovars, phylotypes or species.

Table 3: Distribution of the *Ralstonia solanacearum* species complex in the EU MS based on EPPO (2018b)

Country	Pest status (absence)	Pest status (presence or transience)
Austria	Absent, pest eradicated	–
Belgium	–	Present, few occurrences
Bulgaria	Absent, pest no longer present	–
Czech Republic	–	Transient, under eradication
Denmark	Absent, intercepted only	–
Estonia	Absent, confirmed by survey	–
Finland	Absent, confirmed by survey	–
France	–	Present, few occurrences
Germany	–	Present, few occurrences
Greece	–	Present, few occurrences

Country	Pest status (absence)	Pest status (presence or transience)
Hungary	–	Present, few occurrences
Italy	Absent, pest eradicated	–
Latvia	Absent, confirmed by survey	–
Lithuania	Absent, confirmed by survey	–
Malta	Absent, confirmed by survey	–
Netherlands	–	Present, restricted distribution
Poland	–	Present, few occurrences
Portugal	–	Present, few occurrences
Romania	–	Present, few occurrences
Slovak Republic	–	Present, few occurrences
Slovenia	Absent, pest eradicated	–
Spain	–	Present, few occurrences
Sweden	–	Present, few occurrences
United Kingdom	–	Transient, under eradication

3.3. Regulatory status

3.3.1. Council Directive 2000/29/EC

The RSSC is listed in Council Directive 2000/29/EC as *R. solanacearum* (Smith) Yabuuchi et al. The different species (see Section 3.1.1) within the species complex are not mentioned in the Council Directive. Details are presented in Tables 4 and 5.

In addition, Council Directive 1998/57/EC (amended by Commission Directive 2006/63/CE) concerns the measures to be taken within EU MS against *R. solanacearum* to (a) detect it and determine its distribution, (b) prevent its occurrence and spread, and (c) to control it with the aim of eradication.

Table 4: The *Ralstonia solanacearum* species complex in Council Directive 2000/29/EC

Annex I, Part A	Harmful organisms whose introduction into, and spread within, all Member States shall be banned
Section II	Harmful organisms known to occur in the Community and relevant for the entire Community
(b)	Bacteria
	Species
2.	*Ralstonia solanacearum* (Smith) Yabuuchi et al.

3.3.2. Legislation addressing hosts of the *Ralstonia solanacearum* species complex

Table 5: Regulated hosts and commodities that may involve the *Ralstonia solanacearum* species complex in Annexes III, IV and V of Council Directive 2000/29/EC

Annex III, Part A	**Plants, plant products and other objects the introduction of which shall be prohibited in all Member States**	
	Description	Country of origin
9.	Plants of [...] *Rosa* L., intended for planting, other than dormant plants free from leaves, flowers and fruit	Non-European countries
10.	Tubers of *Solanum tuberosum* L., seed potatoes	Third countries other than Switzerland
11.	Plants of stolon- or tuber-forming species of *Solanum* L. or their hybrids, intended for planting, other than those tubers of *Solanum tuberosum* L. as specified under Annex III A (10)	Third countries

13.	Plants of Solanaceae intended for planting, other than seeds and those items covered by Annex III A (10), (11) or (12)	Third countries, other than European and Mediterranean countries
14.	Soil and growing medium as such, which consists in whole or in part of soil or solid organic substances such as parts of plants, humus including peat or bark, other than that composed entirely of peat	Turkey, Belarus, Moldavia, Russia, Ukraine and third countries not belonging to continental Europe, other than the following: Egypt, Israel, Libya, Morocco, Tunisia
Annex IV, Part A	**Special requirements which shall be laid down by all Member States for the introduction and movement of plants, plant products and other objects into and within all Member States**	
Section I	**Plants, plant products and other objects originating outside the Community**	
	Plants, plant products and other objects	Special requirements
25.7.	Plants of *Capsicum annuum* L., *Solanum lycopersicum* L., *Musa* L., *Nicotiana* L. and *Solanum melongena* L., intended for planting other than seeds, originating in countries where *Ralstonia solanacearum* (Smith) Yabuuchi et al. is known to occur	Without prejudice to the provisions applicable to the plants listed in Annex III(A)(11) and (13), and Annex IV(A)(I)(25.5) and (25.6), where appropriate, official statement that: (a) the plants originate in areas which have been found free from *Ralstonia solanacearum* (Smith) Yabuuchi et al., or (b) no symptoms of *Ralstonia solanacearum* (Smith) Yabuuchi et al. have been observed on the plants at the place of production since the beginning of the last complete cycle of vegetation.
34.	Soil and growing medium, attached to or associated with plants, consisting in whole or in part of soil or solid organic substances such as parts of plants, humus including peat or bark or consisting in part of any solid inorganic substance, intended to sustain the vitality of the plants, originating in: — Turkey, — Belarus, Georgia, Moldova, Russia, Ukraine, — non-European countries, other than Algeria, Egypt, Israel, Libya, Morocco, Tunisia	Official statement that: (a) the growing medium, at the time of planting, was: — either free from soil, and organic matter, or — found free from insects and harmful nematodes and subjected to appropriate examination or heat treatment or fumigation to ensure that it was free from other harmful organisms, or — subjected to appropriate heat treatment or fumigation to ensure freedom from harmful organisms, and (b) since planting: — either appropriate measures have been taken to ensure that the growing medium has been maintained free from harmful organisms, or — within two weeks prior to dispatch, the plants were shaken free from the medium leaving the minimum amount necessary to sustain vitality during transport, and, if replanted, the growing medium used for that purpose meets the requirements laid down in (a).
Section II	**Plants, plant products and other objects originating in the Community**	
	Plants, plant products and other objects	Special requirements

18.2	Tubers of *Solanum tuberosum* L., intended for planting, other than tubers of those varieties officially accepted in one or more Member States pursuant to Council Directive 70/457/EEC of 29 September 1970 on the common catalogue of varieties of agricultural plant species (1)	Without prejudice to the special requirements applicable to the tubers listed in Annex IV(A)(II) (18.1), official statement that the tubers: — belong to advanced selections such a statement being indicated in an appropriate way on the document accompanying the relevant tubers, — have been produced within the Community, and — have been derived in direct line from material which has been maintained under appropriate conditions and has been subjected within the Community to official quarantine testing in accordance with appropriate methods and has been found, in these tests, free from harmful organisms.
18.3	Plants of stolon or tuber-forming species of *Solanum* L., or their hybrids, intended for planting, other than those tubers of *Solanum tuberosum* L. specified in Annex IV(A)(II) (18.1) or (18.2), and other than culture maintenance material being stored in gene banks or genetic stock collections	(a) The plants shall have been held under quarantine conditions and shall have been found free of any harmful organisms in quarantine testing; (b) the quarantine testing referred to in (a) shall: (aa) be supervised by the official plant protection organisation of the Member State concerned and executed by scientifically trained staff of that organisation or of any officially approved body; (bb) be executed at a site provided with appropriate facilities sufficient to contain harmful organisms and maintain the material including indicator plants in such a way as to eliminate any risk of spreading harmful organisms; (cc) be executed on each unit of the material, — 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 harmful organisms, — by testing, in accordance with appropriate methods to be submitted to the Committee referred to in Article 18: — in the case of all potato material at least for — Andean potato latent virus, — Arracacha virus B. oca strain, — Potato black ringspot virus, — Potato spindle tuber viroid, — Potato virus T, — Andean potato mottle virus, — common potato viruses A, M, S, V, X and Y (including Y^{o}, Y^{n} and Y^{c}) and Potato leaf roll virus, — *Clavibacter michiganensis* ssp. *sepedonicus* (Spieckermann and Kotthoff) Davis et al., — *Ralstonia solanacearum* (Smith) Yabuuchi et al., — in the case of true seed potato of least for the viruses and viroid listed above; (dd) by appropriate testing on any other symptom observed in the visual examination in order to identify the harmful organisms having caused such symptoms;

		(c) any material, which has not been found free, under the testing specified under (b) from harmful organisms as specified under (b) shall be immediately destroyed or subjected to procedures which eliminate the harmful organism(s); (d) each organisation or research body holding this material shall inform their official Member State plant protection service of the material held.
18.4	Plants of stolon, or tuber-forming species of *Solanum* L., or their hybrids, intended for planting, being stored in gene banks or genetic stock collections	Each organisation or research body holding such material shall inform their official Member State plant protection service of the material held.
18.5	Tubers of *Solanum tuberosum* L., other than those mentioned in Annex IV(A)(II) (18.1), (18.1.1), (18.2), (18.3) or (18.4)	There shall be evidence by a registration number put on the packaging, or in the case of loose-loaded potatoes transported in bulk, on the vehicle transporting the potatoes, that the potatoes have been grown by an officially registered producer, or originate from officially registered collective storage or dispatching centres located in the area of production, indicating that the tubers are free from *Ralstonia solanacearum* (Smith) Yabuuchi et al. and that (a) the Union provisions to combat *Synchytrium endobioticum* (Schilbersky) Percival, [. . .] are complied with.
18.7.	Plants of *Capsicum annuum* L., *Solanum lycopersicum* L., *Musa* L., *Nicotiana* L., and *Solanum melongena* L., intended for planting, other than seeds	Without prejudice to the requirements applicable to the plants listed in Annex IV(A)(II)(18.6) where appropriate, official statement that: (a) the plants originate in areas which have been found free from *Ralstonia solanacearum* (Smith) Yabuuchi et al., or (b) no symptoms of *Ralstonia solanacearum* (Smith) Yabuuchi et al. have been observed on the plants at the place of production since the beginning of the last complete cycle of vegetation.

Annex V	**Plants, plant products and other objects which must be subject to a plant health inspection (at the place of production if originating in the Community, before being moved within the Community—in the country of origin or the consignor country, if originating outside the Community) before being permitted to enter the Community**
Part A	**Plants, plant products and other objects originating in the Community**
Section I	**Plants, plant products and other objects which are potential carriers of harmful organisms of relevance for the entire Community and which must be accompanied by a plant passport**
1.3.	Plants of stolon- or tuber-forming species of *Solanum* L. or their hybrids, intended for planting.
2.1.	Plants intended for planting, other than seeds, of the genera [. . .] *Pelargonium* l'Hérit. ex Ait. [. . .] intended for planting, and other than bulbs, corms, rhizomes, seeds and tubers
2.2.	Plants of Solanaceae, other than those referred to in point 1.3 intended for planting, other than seeds.
2.3.	Plants of [. . .] Musaceae, [. . .], rooted or with growing medium attached or associated.
Part B	**Plants, plant products and other objects originating in territories, other than those territories referred to in Part A**
Section I	**Plants, plant products and other objects which are potential carriers of harmful organisms of relevance for the entire Community**
4.	Tubers of *Solanum tuberosum* L.
7.	(a) Soil and growing medium as such, which consists in whole or in part of soil or solid organic substances such as parts of plants, humus including peat or bark, other than that composed entirely of peat. (b) Soil and growing medium, attached to or associated with plants, consisting in whole or

	in part of material specified in (a) or consisting in part of any solid inorganic substance, intended to sustain the vitality of the plants, originating in: —Turkey, — Belarus, Moldova, Russia, Ukraine, — non-European countries, other than Algeria, Egypt, Israel, Libya, Morocco, Tunisia.

3.4. Entry, establishment and spread in the EU

3.4.1. Host range

The RSSC has a wide host range and the list of recognised hosts is still growing (Genin and Denny, 2012; Weibel et al., 2016; Lopes and Rossato, 2018), e.g. blueberry (*Vaccinium corymbosum*) (Norman et al., 2018). It is thus likely that the host range is not yet fully known. Host ranges of the species within the RSSC are generally broad and often overlap, but not completely (Champoiseau et al., 2009; Wicker et al., 2012; Safni et al., 2014) (see Section 3.1.1).

The main cultivated hosts of the RSSC within the EU are *Solanum tuberosum* (potato) and *Solanum lycopersicum* (tomato) (CABI, 2018). CABI (2018) lists *Solanum phureja* as a separate host species but this is actually considered to be a cultivar group within *S. tuberosum* (Huamán and Spooner, 2002). Other cultivated hosts include *Arachis hypogaea* (groundnut), *Musa* spp. (banana and plantain) and *Zingiber officinale* (ginger). Cotton, cucurbits (cucumber, melon, pumpkins, etc.), eggplant, pepper and tobacco are also host crops (CABI, 2018).

Various weeds (e.g. *Chenopodium* spp., *Galinsoga parviflora* and *Urtica dioica*), ornamental plants (e.g. *Anthurium* spp., *Pelargonium* spp. and *Rosa* spp.) and some tree species (e.g. *Eucalyptus* spp., *Olea europaea* (Poussier et al., 1999; Xu et al., 2009; Tebaldi et al., 2014) and *Tectona grandis*) are also hosts for the RSSC (Norman and Yuen, 1999; Norman et al., 2009; CABI, 2018). *Solanum dulcamara* is an epidemiologically important weed host in Europe (Champoiseau et al., 2009).

A comprehensive host list is provided by CABI (2018), but it does not identify the pathogen at the phylotype or species level. Historical reports of the hosts of the pathogen have indeed not always distinguished between different races, biovars, phylotypes or species. The hosts ranked as main by CABI (2018) are shown in Table 6.

Table 6: Main hosts of the *R. solanacearum* species complex (CABI, 2018)

Host name	Host family
Annona cherimola (cherimoya)	Annonaceae
Casuarina spp.	Casuarinaceae
Heliconia	Heliconiaceae
Musa spp. (banana)	Musaceae
Musa x *paradisiaca* (plantain)	Musaceae
Nicotiana tabacum (tobacco)	Solanaceae
Solanum lycopersicum (tomato)	Solanaceae
Solanum melongena (aubergine)	Solanaceae
Solanum tuberosum (potato)	Solanaceae
Tectona grandis (teak)	Lamiaceae
Zingiber officinale (ginger)	Zingiberaceae

The hosts and commodities for which the pest is regulated are not comprehensive of the host range due to the high diversity of hosts and the lack of knowledge of the complete host range.

Is the pest able to enter into the EU territory? If yes, identify and list the pathways!

Yes, mainly by the movement of infected planting material, such as seed tubers.

3.4.2. Entry

The primary route by which the RSSC can enter the EU is via infected planting material, such as potato tubers and ornamental plants (Janse et al., 2004; Norman et al., 2009). Entry via true seed is also possible but risks for seed infection and transmission from seed to seedling are limited (CABI,

2018). The pathogen can survive in soil, either in association with plant debris or as a free-living saprophyte (Felix et al., 2012). Given the overlap in the host range for the different phylotypes/species within the species complex (Table 2), there is a general overlap in the pathways of entry for the different phylotypes/species. Thus, also given the lack of information regarding the phylotype/species in earlier epidemiological studies, pathways of entry are considered for the species complex.

The following potential pathways of entry of the RSSC into the EU territory are regulated by the current EU legislation (see Section 3.3):

- Tubers of *S. tuberosum* (seed potatoes),
- Stolon- or tuber-forming plants for planting of *Solanum* spp., or their hybrids, other than *S. tuberosum* seed tubers,
- Plants for planting of the family Solanaceae, other than *S. tuberosum* seed tubers and stolon- or tuber-forming *Solanum* species, originating in third countries, other than European non-EU28 countries and Mediterranean countries,
- Plants for planting of *Capsicum annuum*, *S. lycopersicum, Musa, Nicotiana* and *Solanum melongena*, other than seeds, originating in third countries where *R. solanacearum* is known to occur,
- Soil and growing media attached to or associated with plants originating in Turkey, Belarus, Georgia, Moldova, Russia, Ukraine and non-European countries, other than Algeria, Egypt, Israel, Libya, Morocco and Tunisia
- Soil and growing media not attached to or associated with plants originating in Turkey, Belarus, Moldavia, Russia, Ukraine and third countries not belonging to continental Europe other than Egypt, Israel, Libya, Morocco and Tunisia.

The following potential pathways of entry of the RSSC into the EU are currently not regulated:

- Infected host plant debris in soil adhering to agricultural machinery and implements, footwear and vehicles originating in infested third countries.
- Infected true seed of groundnut (*Arachis*), tomato (*S. lycopersicum*) and eggplant (*S. melongena*).
- Commodities of hosts that are not regulated (e.g. *Rosa* plants for planting, as the legislation does not cover dormant plants without leaves) (see Section 3.3.2).

There is limited information on factors affecting survival of the RSSC on true seed, which increases the uncertainty associated with this pathway. Only some of the hosts are considered in the legislation – there are many more hosts, but studies demonstrating the role of these hosts in pathogen movement are generally lacking (see Section 3.4.1).

As of November 2018, there were 18 records of interception of the RSSC in the Europhyt database. Up to now, with two exceptions, interceptions of the pathogen have not distinguished between different races, biovars, phylotypes or species. Nine interceptions were reported in 2018, all on *S. tuberosum* – four of these interceptions were on intra-EU trade (from Spain to Portugal, from the Czech Republic to Slovakia, from Greece to Poland, and from the Netherlands to the UK) and five interceptions originated in Egypt (to the Czech Republic (two), to Italy, Poland and Romania). Six interceptions were reported in 2017 (four on *S. tuberosum* and two on *Rosa* spp.) – five of these interceptions were made on intra-EU trade (from Spain to Portugal, from the Netherlands to Portugal, from Germany to the Netherlands, from Germany to Poland and from the Netherlands to Poland) and one interception originated from Egypt (to Poland). Previously, three interceptions were reported in 2015, all on *S. tuberosum* – one of these interceptions originated in Uganda (to the UK) and two originated in Egypt (both to Greece).

3.4.3. Establishment

Is the pest able to become established in the EU territory?

Yes, hosts are widespread and climatic conditions are favourable, particularly to strains adapted to cool temperatures even in northern MS. Strains adapted to warmer temperatures have also been isolated within the EU (EPPO, 2018b).

3.4.3.1. EU distribution of main host plants

One of the main cultivated hosts of *R. solanacearum* is potato, which is grown throughout the EU (Table 7). Tomato, peppers, aubergines and olive are also widely cultivated in the risk assessment area.

Table 7: Area (in 1,000 ha) cultivated with *Solanum tuberosum* in the 28 EU Member States between 2013 and 2017 (Source: Eurostat, accessed September 2018)

Countries	2013	2014	2015	2016	2017
European Union	1,741	1,663	1,656	1,688	1,740
Austria	21	21	20	21	23
Belgium	75	80	79	89	90
Bulgaria	13	10	11	8	13
Croatia	10	10	10	10	10
Cyprus	5	5	5	5	5
Czech Republic	23	24	23	23	23
Denmark	40	20	42	46	50
Estonia	5	4	4	4	3
Finland	22	22	22	22	21
France	161	168	167	179	192
Germany	243	245	237	243	251
Greece	25	24	21	18	11
Hungary	21	21	19	16	16
Ireland	11	9	9	9	9
Italy	50	52	50	48	49
Latvia	12	11	10	11	22
Lithuania	28	27	23	22	19
Luxembourg	1	1	1	1	1
Malta	1	1	1	1	1
Netherlands	156	156	156	156	161
Poland	337	267	293	301	321
Portugal	27	27	25	23	24
Romania	208	203	196	186	172
Slovakia	9	9	8	8	7
Slovenia	3	4	3	3	3
Spain	72	76	72	72	74
Sweden	24	24	23	24	25
United Kingdom	139	141	129	139	145

3.4.3.2. Climatic conditions affecting establishment

The RSSC can cause disease in a wide variety of climatic conditions (Cruz et al., 2012). It was initially considered a pathogen that needed warmer conditions, but it can establish in cooler climates such as the Netherlands and Sweden (Janse, 1996; Persson, 1998) due to strains adapted to those climates. Thus, while the pest has not been reported from some EU MS (Table 3), it has been found in MS with climate similar to the one found in MS without reports.

3.4.4. Spread

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

Yes, the pest would be able to spread, mainly by movement of infected plant material.

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

Yes, spread is mainly via plants for planting.

Natural dispersal of the RSSC is usually limited to short distances and, in particular phylotype IIB (race 3), is linked to the use of contaminated surface water for irrigation (Janse, 2012). Contamination of surface water is linked to the presence of RSSC-infected *Solanum dulcamara* plants growing along water courses.

Movement of infected planting material (seed tubers and ornamental plants) is the main human-mediated source for movement of the pathogen (Breukers et al., 2006). This is the case for all phylotypes/species. Disease spread could also occur by movement of infected soil and growing media (see Section 3.4.2), again for all phylotypes/species.

Insects (*Cosmopolites sordidus* (Coleoptera, Dryophthoridae), the banana weevil, which in the EU is reported from Madeira (Fauna Europaea, accessed December 2018), and other *Musa*-associated insects) have been reported to vector the bacteria causing blood disease of banana (Safni et al., 2018).

3.5. Impacts

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

Yes, the pest introduction would have an economic impact, e.g. on potato and tomato production.

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?[4]

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

The RSSC is regarded as one of the world's most important phytopathogenic bacteria due to its broad geographical distribution, large host range, aggressiveness, genome plasticity and long persistence in soil and water (Genin, 2010). Race 3 biovar 2 is listed as a Select Agent plant pathogen under the USA Agricultural Bioterrorism Act of 2002 (Champoiseau, 2008).

Substantial losses in EU potato and tomato production would occur in the presence of RSSC epidemics. Historically, heavy losses were reported from potato in Portugal (Cruz et al., 2012), and potato yield losses of 90 or even 100% have been reported in Bangladesh and China (Jiang et al., 2017; Karim et al., 2018). Infected tubers cannot be sold, and infected seed lots would be destroyed or sterilised, greatly reducing their value (Breukers et al., 2007).

There have been several recent outbreaks of the RSSC in various EU MS (Bulgaria, France, Germany, Italy, Netherlands, Poland, Portugal, Spain) in 2017 (10) and 2018 (20), mostly on *S. tuberosum* (14), *Rosa* spp. (10) and *S. lycopersicon* (6), but also on *S. melongena* (1) (some outbreaks were reported without a host; Europhyt database, as of December 2018).

Given the widespread cultivation of potato, and the ability of the RSSC to infect host crops in a wide variety of climatic conditions, the losses due to this disease would be extremely high if the pathogen were to become widespread within the EU. This is likely to be the case for all phylotypes/species.

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 to prevent entry, establishment and spread are available (see Sections 3.3 and 3.6).

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

Yes, measures to prevent pest presence on plants for planting are available.

3.6.1. Identification of additional measures

Phytosanitary measures are currently applied to tubers and planting material of *S. tuberosum* (see Section 3.3).

Additional measures for surveillance and control are documented in Council Directive 98/57/EC, amended by Commission Directive 2006/63/EC.

[4] See Section 2.1 on what falls outside EFSA's remit.

3.6.1.1. Additional control measures

Potential additional control measures are listed in Table 8.

Table 8: Selected control measures (a full list is available in EFSA PLH Panel, 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)
Soil treatment	Treatments (e.g. fertiliser amendments, sometimes combined with soil solarisation) for reducing inoculum in the soil have been shown to be effective in reducing pest populations (Gorissen et al., 2004; Messiha et al., 2009)	Impact

3.6.1.2. Biological or technical factors limiting the effectiveness of measures to prevent the entry, establishment and spread of the pest

- The host range is very wide (CABI, 2018) and new hosts are often reported (Lopes et al., 2015; Lopes and Rossato, 2018).
- Infected hosts can remain asymptomatic, particularly under temperate climatic conditions (Breukers et al., 2006).
- The pathogen is soilborne and can spread in irrigation and surface water (Champoiseau et al., 2009).
- Successful eradication from EU MS has been achieved (Persson, 1998), but not in all cases (Janse, 1996).

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

- Latent infection has been documented on various hosts (Swanson et al., 2005; CABI, 2018).
- Host resistance is limited and the pathogen has a high genetic and phenotypic diversity (Champoiseau et al., 2009).

3.7. Uncertainty

Movement of the pathogen via vegetative planting material, such as potato tubers, is well known, but the extent to which it is seed transmitted and the impacts due to seed transmission are less clear (see Section 3.4.2).

Studies demonstrating the role of unregulated hosts in pathogen movement are generally lacking (see Section 3.4.2).

Isolated reports exist, but the effects of temperature and relative humidity on survival of the RSSC on true seed is not well documented.

There is uncertainty about the distribution, host specificity, epidemiology and biology of the different species within the RSSC: host ranges are broad and often overlap.

The host range is not fully known.

4. Conclusions

The RSSC meets the criteria assessed by EFSA for consideration as a potential quarantine pest (Table 9).

Table 9: 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)

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 *R. solanacearum* as a species complex is clear	The identity of *R. solanacearum* as a species complex is clear	*R. solanacearum* was reclassified into different species matching more or less previously defined phylotypes (Safni et al., 2014) but there is a lack of information on the distribution, host range and epidemiology of the different species. Moreover, many researchers are still using the term *R. solanacearum* as a species complex
Absence/presence of the pest in the EU territory (Section 3.2)	The RSSC is reported to be present in several EU MS, but in all cases with a restricted distribution and under official control	The RSSC is reported to be present in several EU MS, but in all cases with a restricted distribution and under official control	None
Regulatory status (Section 3.3)	*R. solanacearum* is regulated by Council Directive 2000/29/EC (Annex IAII) as a harmful organism whose introduction into, and spread within, all Member States shall be banned. In addition, Council Directive 1998/57/EC (amended by Commission Directive 2006/63/CE) concerns the measures to be taken within EU MS against *R. solanacearum* to (a) detect it and determine its distribution, (b) prevent its occurrence and spread, and (c) to control it with the aim of eradication	*R. solanacearum* is regulated by Council Directive 2000/29/EC (Annex IAII) as a harmful organism whose introduction into, and spread within, all Member States shall be banned. In addition, Council Directive 1998/57/EC (amended by Commission Directive 2006/63/CE) concerns the measures to be taken within EU MS against *R. solanacearum* to (a) detect it and determine its distribution, (b) prevent its occurrence and spread, and (c) to control it with the aim of eradication	None
Pest potential for entry, establishment and spread in the EU territory (Section 3.4)	Entry: the pest could enter the EU via host plants for planting (including seed tubers and true seed). Establishment: hosts are common and climatic conditions are favourable in the risk assessment area. Spread: the pest could spread following establishment by movement of plants for planting (including seed tubers), as well as locally by natural spread	Spread is mainly via plants for planting	There is uncertainty about the role of true seed transmission for entry and spread. The role of unregulated hosts in pathogen movement is often not studied

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
Potential for consequences in the EU territory (Section 3.5)	The pest introduction would have economic impacts on several crops	The pest presence would have an economic impact on the intended use of plants for planting	None
Available measures (Section 3.6)	Measures to prevent entry, establishment and spread, and to limit impacts, are available	Measures to prevent pest presence on plants for planting are available	None
Conclusion on pest categorisation (Section 4)	The criteria assessed by the Panel for consideration of the RSSC as potential quarantine pest are met. The pest is present in several EU MS, but in all cases with a restricted distribution and under official control	The criterion on the widespread presence in the EU is not met	
Aspects of assessment to focus on/scenarios to address in future if appropriate	The main knowledge gap concerns the host range, which is not fully known. Moreover, the comparative epidemiology of the different phylotypes / species has not really been studied		

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Glossary

Containment (of a pest)	Application of phytosanitary measures in and around an infested area to prevent spread of a pest (FAO, 1995, 2017)
Control (of a pest)	Suppression, containment or eradication of a pest population (FAO, 1995, 2017)
Entry (of a pest)	Movement of a pest into an area where it is not yet present, or present but not widely distributed and being officially controlled (FAO, 2017)
Eradication (of a pest)	Application of phytosanitary measures to eliminate a pest from an area (FAO, 2017)
Establishment (of a pest)	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO, 2017)
Impact (of a pest)	The impact of the pest on the crop output and quality and on the environment in the occupied spatial units
Introduction (of a pest)	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 RNQPs (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)
RNQP	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. A 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)

Abbreviations

DG SANTÉ	Directorate General for Health and Food Safety
EPPO	European and Mediterranean Plant Protection Organization
FAO	Food and Agriculture Organization
IPPC	International Plant Protection Convention
ISPM	International Standards for Phytosanitary Measures
LAMP	Loop mediated isothermal amplification
MS	Member State
PLH	EFSA Panel on Plant Health
PHYSAN	Phyto-Sanitary Controls
PZ	Protected Zone
RNQP	Regulated non-quarantine pest
RSSC	*Ralstonia solanacearum* species complex
TFEU	Treaty on the Functioning of the European Union
ToR	Terms of Reference