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# Pest categorisation of *Xiphinema americanum* sensu lato

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## Abstract

The Panel on Plant Health performed a pest categorisation of *Xiphinema americanum* sensu lato (Nematoda: Longidoridae) for the EU. Sixty-one species in this group are recognised. They are polyphagous pests found in soil associated with a number of plant species. As a migratory ectoparasitic species, it punctures cells of plant roots. Nematodes were classified in four categories based on their distribution and ability to transmit viruses. Category I contains the seven virus vector species present outside the EU: *X. americanum* sensu stricto, *X. bricolense, X. californicum, X. inaequale, X. intermedium, X. rivesi* (non-EU populations) and *X. tarjanense*. Category II contains the 28 species not present in the EU and not known to transmit any virus. Twenty-six species are present in the EU and are not known to be virus vectors (category III). Category IV contains the species present in the EU, which is a virus vector (EU populations of *X. rivesi*). All nematodes known to be virus vectors occurring outside the EU (category I) satisfy all the criteria that are within the remit of EFSA to assess to be regarded as Union quarantine pests. This is mainly due to their association with non-EU virus isolates. Categories II and III contain species that are not reported to transmit viruses or cause economic damage to crop plants. Although uncertainty concerning their ability to transmit viruses exists, those species do not satisfy all the criteria to be regarded as Union quarantine pests. Category IV contains the EU populations of *X. rivesi.* The species is a virus vector but current EU populations of *X. rivesi* have not been reported to be associated with any of the EU viruses or their non-EU isolates under field conditions. *Xiphinema rivesi* (EU populations) is widespread in some Member States and does not satisfy all the criteria to be regarded as a Union quarantine. None of the species can be regarded as a regulated non-quarantine pest.



**Keywords:** European Union, pest risk, plant health, plant pest, quarantine, dagger nematode, virus vector

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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**

*Aleurocantus* 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

*Xiphinema americanum* sensu lato (non–EU populations) 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 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.

For the purpose of this pest categorisation, the Panel considers all species within the *Xiphinema americanum* sensu lato group, including species that are also present in the EU.

## 2. Data and methodologies

### 2.1. Data

#### 2.1.1. Literature search

A literature search on *X. americanum* sensu lato was conducted at the beginning of the categorisation in the ISI Web of Science bibliographic database, using the scientific name of the pest and the combination of scientific name of the nematode species and "virus" as search terms (details can be found in Appendix A). Relevant papers were reviewed and further references and information were obtained from experts, as well as from citations within the references.

#### 2.1.2. Database search

Pest information, on host(s) and distribution, was retrieved from the European and Mediterranean Plan Protection Organization (EPPO) Global Database (EPPO, 2017) 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 *X. americanum* sensu lato following guiding principles and steps presented in the EFSA guidance on the harmonised framework for pest risk assessment (EFSA PLH Panel, 2010) and as defined in the International Standard for Phytosanitary Measures No 11 (FAO, 2013) and No 21 (FAO, 2004).

In accordance with the guidance on a harmonised framework for pest risk assessment in the EU (EFSA PLH Panel, 2010), this work was initiated 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 regulated non-quarantine pest 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 regulated non-quarantine pest. 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 regulated non-quarantine pest 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, in agreement with EFSA guidance on a harmonised framework for pest risk assessment (EFSA PLH Panel, 2010).

**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?<br>If present, is the pest widely distributed within the EU?<br>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 regulated non-quarantine pest must be present in the risk assessment area) |

| 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 |
|---|---|---|---|
| **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).<br>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?<br><br>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?<br>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?<br><br>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 regulated non-quarantine pest 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 or No)*

Yes, the identity of the pest is established. It is a group of morphologically similar nematode species some of which are important virus vectors.

*Xiphinema americanum* sensu lato is a group of morphologically closely related nematode species in the family Longidoridae. The group comprises several species and the number of species is constantly changing; at present 61 species are recognised (EPPO, 2017). The group includes some virus-transmitting nematodes: *X. americanum* (sensu stricto), *X. bricolense*, *X. californicum*, *X. inaequale, X. intermedium*, *X. rivesi* and *X. tarjanense*. For the majority of species, little or no information on virus transmission is available.

For the purpose of this pest categorisation, the group is clustered into four categories based on their distribution (see Section 3.2) and their ability to transmit viruses (see Section 3.5).

Category I contains the non-EU species, which are known virus vectors (7 species, including non-EU populations of *X. rivesi*).

Category II contains the non-EU species, which are not known to be virus vectors (28 species).

Category III contains the species present in the EU, which are not known to be virus vectors (26 species).

Category IV contains the species present in the EU, which is a virus vector nematode species (*X. rivesi* – EU populations), but virus transmission has not been shown under field conditions in the EU.

### 3.1.2. Biology of the pest

Nematodes belonging to the *X. americanum* sensu lato group are migratory ectoparasites of plant roots. All nematode stages are found in soil but there is no specialised survival stage except in *X. pachtaicum*, which may survive under dry conditions in an anhydrobiotic state (Dalmasso, 1970). They may survive in soil at cool temperatures for several years (Bitterlin and Gonsalves, 1987) but only poorly in dry soils (Griffin and Barker, 1966). Their life cycle lasts approximately 1 year and they are assumed to reproduce parthenogenetically; males do not exist or are extremely rare. Optimum temperatures for reproduction are 20–24°C.

The life cycle of *X. americanum* sensu lato consists of five or six tages: the egg, three or four juvenile stages and adult (male and female). Species with four juvenile stages are most often observed but some, e.g. *X. californicum*, have only three (Brown et al., 1994). Brown and Trudgill (1997) speculated that the American species have three juvenile stages (which are the only ones transmitting nepoviruses) while those from other continents have four.

All juvenile stages and adults have a stylet typical for the family Longidoridae consisting of two parts: the anterior odontostyle and a supporting structure (odontophore). *X. americanum* sensu lato have a long odontostyle (up to 150 μm) which is used for feeding on epidermal cells. During feeding, juveniles and adults may acquire and transmit viruses, that may persist for several months and up to 2 years (Bitterlin and Gonsalves, 1987).

Some species are important vectors of some American nepoviruses including *Tobacco ringspot virus* (TRSV), *Tomato ringspot virus* (ToRSV), *Peach rosette mosaic virus* (PRMV) and *Cherry rasp leaf virus* (CRLV) (genus *Chelarivirus*) (Brown et al., 1993, 1994).

### 3.1.3. Intraspecific diversity

*Xiphinema americanum* sensu lato is a complex of 61 species (EPPO, 2017). Within this group, minor differences are used to distinguish species and the number of species is constantly changing. Although within this species group, diversity may be considered high it may not be considered intraspecific diversity.

The most important characteristic is that some species are important virus vectors while others may not transmit any virus (although there is some uncertainty). There are also differences among different populations of the same nematode species in their ability to transmit viruses (Griesbach and Maggenti, 1989).

### 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. Detection follows standard protocols such as the EPPO Standard PM 7/119 for migratory nematodes larger than 1 mm. Identification is extremely difficult and can be only carried out by trained personnel using the international diagnostic protocol for regulated pests (FAO, 2016).

Nematodes can be isolated from the soil or growing media by different extraction techniques, e.g. the Flegg-modified Cobb technique, Oostenbrink elutriator or other elutriation methods (EPPO, 2013).

Identification of species in the *X. americanum* sensu lato group is based on morphological and morphometric analyses (Lamberti et al., 2000; FAO, 2016), but species differentiation is extremely difficult due to only minor differences.

Because of the difficulties to discriminate species of *X. americanum* sensu lato based on their morphology, the use of molecular approaches is recommended (Brown et al., 1995; Lamberti et al., 2000). However, at present, there is no reliable molecular test to distinguish between members of *X. americanum* sensu lato. Such molecular diagnostic method are reported in the Q-bank website (http://www.q-bank.eu/Nematodes/DefaultInfo.aspx?Page=MolecularDS), but have not been included in the relevant IPPC and EPPO diagnostic protocols yet (FAO, 2016; EPPO, 2017).

## 3.2. Pest distribution

### 3.2.1. Pest distribution outside the EU

*Xiphinema americanum* sensu lato is a complex of 61 nominal species many of which are widespread throughout the world, while some others have been reported from only certain geographic areas (Tables 2 and 3, Figures 1 and 2). Among those species, the ones known to transmit viruses of the genera *Nepovirus* and *Cheravirus* are listed in the Annex I.A.I and Table 2.

**Table 2:** Distribution of non-EU species or populations of *Xiphinema americanum* sensu lato that are vectors of economically important plant viruses (Category I) based on EPPO (2017)

| Species | Africa | North America | Central and South America | Asia | Oceania | Europe (non EU) |
|---|---|---|---|---|---|---|
| *X. americanum* sensu stricto | √ | √ | | | | |
| *X. bricolense* | | √ | | | | |
| *X. californicum* | | √ | √ | | | |
| *X. inaequale* | | | √ | √ | | |
| *X. intermedium* | | √ | | | | |
| *X. tarjanense* | | √ | | | | |
| *X. rivesi* (non-EU populations) | √* | √ | √ | √ | | √ |

*: Canary Islands.

Distribution of species of *Xiphinema americanum sensu lato* not known to transmit non-EU viruses are shown in Table 3.

**Table 3:** Distribution of non-EU species of *Xiphinema americanum* sensu lato, which are not known to be virus vectors of economically important plant viruses (Category II) according to EPPO (2017) and a literature search specified in Appendix A

| Species | Africa | North America | Central and South America | Asia | Oceania | Europe (non EU) |
|---|---|---|---|---|---|---|
| *X. bacaniboia* | | | | | √ | |
| *X. citricolum* | | √ | | | | |
| *X. floridae* | | √ | | | | |
| *X. franci* | √ | | | √ | | |
| *X. georgianum* | | √ | √ | | | |
| *X. himalayense* | | | | √ | | |
| *X. incognitum* | √ | | | √ | | |
| *X. kosaigudense* | | | | √ | | |
| *X. laevistriatum* | | √ | | | | |
| *X. lambertii* | | | | √ | | |
| *X. luci* | √ | | √ | | | |
| *X. minor* | | | | √ | | |
| *X. neoelongatum* | | | | √ | | |
| *X. occiduum* | | √ | | | | |
| *X. oxycaudatum* | √ | | √ | √ | | |
| *X. pacificum* | | √ | | | | |
| *X. pakistanense* | | | | √ | | |
| *X. paramanovi* | | | | | | √* |
| *X. parvum* | | | √ | | | |
| *X. penevi* | √ | | | | | |
| *X. peruvianum* | | | √ | | | |
| *X. pseudoguirani* | √ | | | √ | √ | |
| *X. sheri* | | √ | | √ | | |
| *X. silvaticum* | √ | | | √ | | |
| *X. tenuicutis* | | √ | | | | |
| *X. thornei* | | √ | | √ | | √* |
| *X. utahense* | | √ | | | | |
| *X. waimungui* | | | | | √ | |

*: Former Soviet Union.

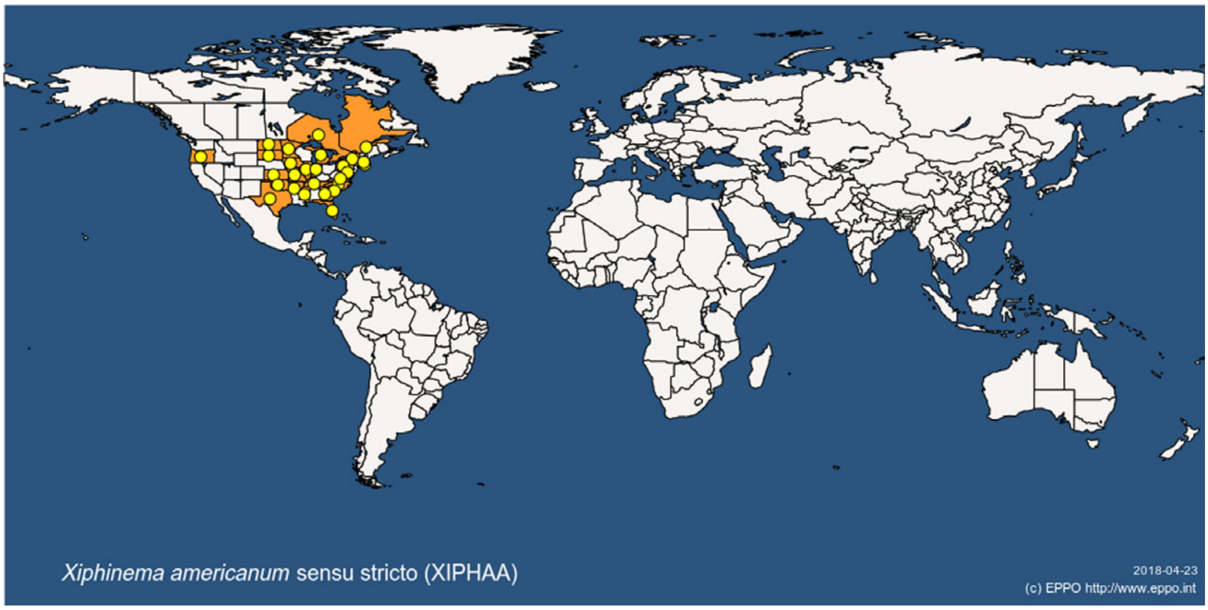


**Figure 1:** Global distribution map for *X. americanum* sensu stricto (extracted from the EPPO Global Database accessed on 23.4.2018)

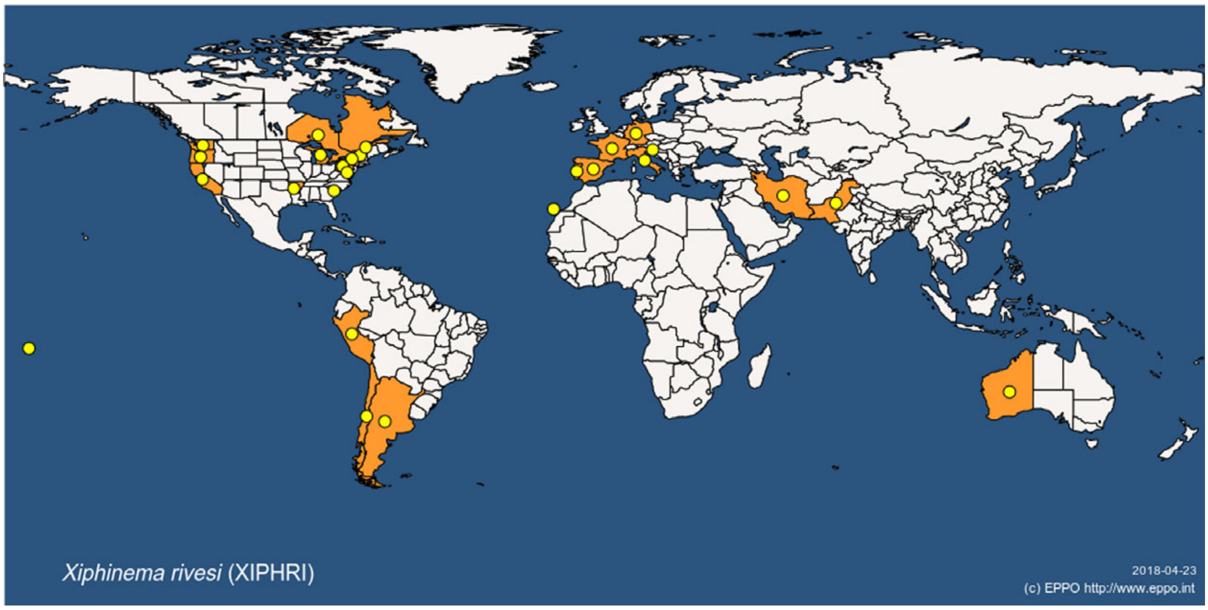


**Figure 2:** Global distribution map for *X. rivesi* (extracted from the EPPO Global Database accessed on 23.4.2018)

### 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,** 27 nematode species of *X. americanum sensu lato* have been reported from the EU. Twenty-six species are not reported as virus vectors. Only *X. rivesi* (all populations) has been shown to transmit TRSV, ToRSV, PRMV and CRLV; this nematode species has a wide distribution.

As shown below, 27 nematode species of *X. americanum sensu lato* have been reported from the EU (Tables 4 and 5). Twenty-six species are not reported as virus vectors (Category III). Some of them have only been reported from the EU. In case the species occur in other regions of the world as well, this is indicated in the footnotes of Table 4. *X. rivesi*, the only virus vector present in the EU (Category IV) has a worldwide distribution and is therefore also listed in Table 2.

**Table 4:** EU distribution of species belonging to *Xiphinema americanum* sensu lato which are not known to be virus vectors (Category III) according to EPPO (2017). In the footnotes, the distribution of the species outside the EU is indicated

| Species | MS | Source |
|---|---|---|
| *Xiphinema astaregiense* | Spain | Archidona-Yuste et al. (2016) |
| *X. brevicolle*[(a),(b),(c),(d)] | Bulgaria, Portugal, Germany, Poland, Slovakia | Szczygiel (1974); Lamberti and Bleve-Zacheo (1979); Brown and Taylor (1987); Gutiérrez-Gutiérrez et al. (2016) |
| *X. browni* | Czech Republic, Slovakia | Lazarova et al. (2016) |
| *X. brevisicum* | Portugal | Lamberti et al. (1994) |
| *X. diffusum*[(a),(b),(c),(d),(e)] | Portugal | Lamberti et al. (2000) |
| *X. duriense* | Spain, Portugal | Lamberti et al. (2002); Gutierrez-Gutierrez et al. (2012); Archidona-Yuste et al. (2016); Gutiérrez-Gutiérrez et al. (2016) |
| *X. exile* | Portugal | Roca et al. (1988); Gutiérrez-Gutiérrez et al. (2016) |
| *X. fortuitum* | Italy | Roca et al. (1987); Lamberti et al. (2000) |
| *X. incertum*[(d)] | Bulgaria, Croatia, Spain | Lamberti et al. (1983); Peneva and Choleva (1992); Lamberti et al. (2002); Gutierrez-Gutierrez et al. (2012) |
| *X. lafoense* | Portugal | Roca et al. (1987); Gutiérrez-Gutiérrez et al. (2016) |
| *X. longistilum* | Portugal | Lamberti et al. (1994, 2000); Gutiérrez-Gutiérrez et al. (2016) |
| *X. madeirense* | Portugal | Brown et al. (1992); Lamberti et al. (1994); Gutiérrez-Gutiérrez et al. (2016) |
| *X. mesostilum* | Portugal | Lamberti et al. (1994); Gutiérrez-Gutiérrez et al. (2016) |
| *X. microstilum* | Portugal | Lamberti et al. (1994); Gutiérrez-Gutiérrez et al. (2016) |
| *X. opisthohysterum*[(d)] | Spain, Portugal; | Sturhan (1983); Gutierrez-Gutierrez et al. (2012); Gutiérrez-Gutiérrez et al. (2016) |
| *X. pachtaicum*[(a),(b),(c),(d)] | Bulgaria, Spain, Germany, Portugal, Hungary, England | Lamberti et al. (1983); Barsi and Lamberti (2002); Gutierrez-Gutierrez et al. (2012); Sturhan (2014); Palomares Rius et al. (2015); Lazarova et al. (2016) |
| *X. pachydermum* | Portugal | Sturhan (1983); Lamberti et al. (2000); Gutiérrez-Gutiérrez et al. (2016) |
| *X. parabrevicolle* | Italy | Gutierrez-Gutierrez et al. (2012) |
| *X. parapachydermum* | Spain | Gutierrez-Gutierrez et al. (2012); Archidona-Yuste et al. (2016) |
| *X. parasimile*[(d)] | Bulgaria, Romania | Bonta (Groza) et al. (2012); Lazarova et al. (2016) |
| *X. paratenuicutis* | Spain | Gutierrez-Gutierrez et al. (2012) |
| *X. plesiopachtaicum* | Spain | Archidona-Yuste et al. (2016) |
| *X. santos*[(a)] | Spain, Portugal | Lamberti et al. (1993, 2000); Gutierrez-Gutierrez et al. (2012) |
| *X. simile*[(a),(d)] | Bulgaria; Slovakia, Czech Republic; Crete, Romania | Lamberti et al. (1983, 2000); Bonta (Groza) et al. (2012); Lazarova et al. (2016) |
| *X. taylori*[(c),(d)] | Slovakia; Germany, Romania, Italy | Lamberti et al. (1993); Roca and Lamberti (1994); Lišková et al. (1995); Lamberti et al. (2000); Lišková et al. (2007); Bonta (Groza) et al. (2012); Sturhan (2014); Barsalote et al. (2017) |
| *X. vallense* | Spain | Archidona-Yuste et al. (2016) |

None of the species is reported from Oceania.
(a): Present also in Africa.
(b): Present also in Central and South America.
(c): Present also in Asia.
(d): Present also in Europe (non-EU).
(e): Present also in North America.

Among species belonging to *X. americanum* sensu lato group that are identified as virus vectors, only *X. rivesi* has been reported from several locations in the EU (Table 5). Although the populations of *X. rivesi* present in the EU can transmit ToRSV and TRSV under experimental conditions (Širca et al., 2007), their presence in the EU has never been associated with the respective viral diseases under field conditions.

**Table 5:** Current distribution of *X. rivesi* in the 28 EU Member States based on the EPPO Global Database and additional references

| Country | EPPO Global Database<br>Last update:<br>Date accessed: 23. 03. 2018 | Other sources |
|---|---|---|
| **Bulgaria** | Not reported | Lamberti et al. (2000); Bello et al. (2005); Gutierrez-Gutierrez et al. (2011) |
| **France** | Present, no details | Bello et al. (2005); Gutierrez-Gutierrez et al. (2011) |
| **Germany** | Present, no details | Sturhan (2014) |
| **Italy** | Present, widespread | Lazarova et al. (2016) |
| **Portugal** | Present, widespread | Lamberti et al. (1994, 2000); Gutiérrez-Gutiérrez et al. (2016) |
| **Slovenia** | Present, restricted distribution | Urek et al. (2005); Širca et al. (2007); Peneva et al. (2012) |
| **Spain** | Present, widespread | Lamberti et al. (2000); Bello et al. (2005); Gutierrez-Gutierrez et al. (2011) |

## 3.3. Regulatory status

### 3.3.1. Council Directive 2000/29/EC

*X. americanum* sensu lato is listed in Council Directive 2000/29/EC. Details are presented in Tables 6 and 7.

**Table 6:** *Xiphinema americanum* sensu lato 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 I** | **Harmful organisms not known to occur in any part of the community and relevant for the entire community** |
| (a) | Insects, mites and nematodes, at all stages of their development |
| | Species |
| 26. | *Xiphinema americanum* Cobb *sensu lato* (non-European populations) |

### 3.3.2. Legislation addressing the hosts of *Xiphinema americanum* sensu lato

**Table 7:** Regulated hosts and commodities that may involve *Xiphinema americanum* sensu lato 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<br>in all Member States** | |
|---|---|---|
| | Description | Country of origin |
| **Annex IV, Part A** | **Special requirements which must 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** | |
| | Plants, plant products and other objects | Special requirements |
| **31.** | Plants of Pelargonium L'Herit. ex Ait., intended for planting, other than seeds, originating in countries where Tomato ringspot virus is known to occur: | Without prejudice to the requirements applicable to the plants listed in Annex IV(A)(I)(27.1 and) (27.2), |

| | | |
|---|---|---|
| | (a) where *Xiphinema americanum* Cobb *sensu lato* (non-European populations) or other vectors of Tomato ringspot virus are not known to occur | official statement that the plants:<br>(a) are directly derived from places of production known to be free from Tomato ringspot virus; or<br>(b) are of no more than fourth generation stock, derived from mother plants found to be free from Tomato ringspot virus under an official approved system of virological testing. |
| | (b) where *Xiphinema americanum* Cobb *sensu lato* (non-European populations) or other vectors of Tomato ringspot virus are known to occur | official statement that the plants:<br>(a) are directly derived from places of production known to be free from Tomato ringspot virus in the soil or plants; or<br>(b) are of no more than second generation stock, derived from mother plants found to be free from Tomato ringspot virus under an officially approved system of virological testing. |

### 3.3.3. Legislation addressing the organisms vectored by *Xiphinema americanum* sensu lato (Directive 2000/29/EC)

Four plant viruses belonging to two plant virus genera, *Cheravirus* and *Nepovirus*, are vectored by *X. americanum* sensu lato:

- CRLV is listed in Annex I, AI, position (d) 5b.
- CRLV is also listed in Annex IV, AI:
  - 22.1 – Plants of *Malus* Mill., intended for planting, other than seeds, originating in countries where the relevant harmful organisms are known to occur on *Malus* Mill.
  - 23.2 – Plants of *Prunus* L., intended for planting (b) other than seeds, originating in countries where the relevant harmful organisms are known to occur
  - 24 – Plants of *Rubus* L., intended for planting (b) other than seeds, originating in countries where the relevant harmful organisms are known to occur
- PRMV is listed in Annex I, AI, position (d) 5e
- TRSV is listed in Annex I, AI, position (d) 3.
- ToRSV is listed in Annex I, AI, position (d) 4.

## 3.4. Entry, establishment and spread in the EU

### 3.4.1. Host range

*X. americanum* sensu lato are free-living ectoparasitic nematodes and have been found associated with a wide range of herbaceous and woody host plants. They are able to parasitise essentially all plants but economically important are only the plant species which are host plants to the viruses (EPPO, 2017).

The transmission of viruses is the major damage caused by certain species of *X. americanum* sensu lato. For the list of viruses which are vectored by *X. americanum* sensu lato, see Table 8. Important host plants of these viruses are, among others, apple, plum, grapevine, cherry and peach (Taylor and Brown, 1997).

### 3.4.2. Entry

*Is the pest able to enter into the EU territory? (Yes or No) If yes, identify and list the pathways!*

**Yes**, soil and growing media, soil and growing media attached to planting material and soil and growing media attached to machinery and packaging material.

Species of *X. americanum* sensu lato are ectoparasitic pests and do not invade plant tissue. They are only found in soil or growing media. The following pathways have been identified:

- Soil and growing media as such from areas where the nematode occurs. This pathway is closed because of Annex III, Part A, No. 14 of EU 2000/29.

- Soil and growing media attached to plants (hosts or non-host plants) from areas where the nematode occurs. This pathway is not closed as plants may be imported with soil or growing media attached to sustain their live.
- Soil and growing media attached to (agricultural) machinery, tools, packaging materials. This pathway is not considered an important pathway for entry because the volume of trade of used machinery is considered low. Furthermore, soil adhering to agricultural machinery during transport (if relevant) may dry and subsequently lead to decreased viability of the pest.

Until 15.3.2018, there were 67 records of interceptions of *X. americanum* sensu lato and sensu stricto in the Europhyt database.

### 3.4.3. Establishment

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

**Yes**, the pest is able to establish in the EU territory. Some species are already present in the EU.

#### 3.4.3.1. EU distribution of main host plants

The nematode species within this group have a wide host range and are associated with several herbaceous and woody host plants. Important host plants such as apple, plum, grapevine, cherry and peach are present throughout the EU (see Appendix B).

#### 3.4.3.2. Climatic conditions affecting establishment

Twenty-seven species of the *X. americanum* sensu lato group are already present in the EU (see Table 4). Other *X. americanum* group species, most importantly those transmitting viruses (Category I, see Table 2) are present mainly in North, Central and South America where climatic conditions (warm temperate) similar to those in the EU can be found. The climate in many parts of the EU is therefore considered suitable for pest establishment.

### 3.4.4. Spread

#### 3.4.4.1. Vectors and their distribution in the EU (if applicable)

*Is the pest able to spread within the EU territory following establishment? (Yes or No) How?*

**Yes**, soil and growing media either alone, attached to planting material or attached to machinery and packaging material.

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

**No**, the pest is not mainly spread with specific plants for planting. It can however be spread in soil attached to plants for planting and other objects or soil as such.

Species of the *X. americanum* group are migratory ectoparasites found in the soil. Movement in soil is restricted to short (< 1 m) distances (EPPO GD 26.10.2017). The pest never invades plant tissue (except by puncturing root plant cells with its stylet). Spread may therefore mainly occur with moist soil or growing media (soil as such or soil attached to plants, machinery, tools, shoes, animals, packaging material) or run-off water but not by plants without soil. Soil attached to agricultural machinery, tools, etc., may contribute to spread, but this may be mostly relevant for within field spread or spread to adjacent fields.

*X. americanum* sensu lato includes some virus transmitting (CRLV, PRMV, ToRSV and TRSV) nematodes (see Table 8) and their spread may also lead to spread of those viruses.

According to EPPO PQR, TRSV and ToRSV are present in some EU MS, but the exact distribution of those viruses is not known. CRLV and PRMV are not known to be present in the EU according to EPPO PQR. Viruliferous nematodes may be a pathway not only for the entrance of CLRV and PRMV in the EU, but also for the entry of additional isolates or spread in new areas of both TRSV and ToRSV.

## 3.5. Impacts

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

**Yes,** *Xiphinema americanum sensu lato* can cause damage to certain host plants but data on the extent of such damage are missing. In addition to causing direct damage, certain species of this nematode group are capable of transmitting certain economically important plant viruses such as TRSV, ToRSV, PRMV and CRLV.

*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**, if the pest is present in soil associated with plants for planting of important host plants such as grapes, apples and plums, those plants may not be marketed as plants for planting anymore.

Nematode species from the group known as *X. americanum* sensu lato can cause damage to a wide range of wild and cultivated plants with direct feeding on the roots, causing bent or swollen root tips (EPPO GD, 26.10.2017). Above ground symptoms are unclear and are most often similar to those resulting from water and nutrient deficiencies and are shown as stunted plant growth and patchy fields (Heve et al., 2015). Direct damage can occur only in the case of high population densities. Besides causing direct damage to plants, certain species of *X. americanum* sensu lato can also transmit some economically important plant viruses such as TRSV, ToRSV, PRMV and CRLV (Brown et al., 1993). However, not all species from this group of nematodes have been reported to transmit viruses. According to Taylor and Brown (1997) the following species are considered as virus-vectors: *X. americanum* sensu stricto*, X. bricolense, X. californicum, X. intermedium, X. rivesi* and *X. tarjanense* (Table 8)*.* Verma et al. (2003) reported that also *X. inequale* may transmit ToRSV showing that more nematode species of the group may be virus-vectors. This indicates that viruses can also be transmitted by nematode species from the *X. americanum* group which are currently not recognised as virus vectors.

**Table 8:** List of nematode species from the *Xiphinema americanum* sensu lato group known to be vectors of some economically important plant viruses (Taylor and Brown, 1997; Verma et al., 2003)

| Vector nematode | CRLV[(a)] | PRMV[(b)] | TRSV[(c)] | ToRSV[(d)] |
|---|---|---|---|---|
| ***X. americanum* sensu lato** | + | + | + | + |
| ***X. americanum* sensu stricto** | + | | + | + |
| ***X. bricolense*** | | | | + |
| ***X. californicum*** | + | | + | + |
| ***X. inaequale*** | | | | + |
| ***X. intermedium*** | | | + | + |
| ***X. rivesi*** | + | + | + | + |
| ***X. tarjanense*** | | | + | + |

(a): *Cherry rasp leaf virus.*
(b): *Peach rosette mosaic virus.*
(c): *Tobacco ringspot virus.*
(d): *Tomato ringspot virus*.

## 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**, prohibition of import of soil and growing media and plants for planting or machinery with soil attached from areas where nematodes known to transmit non-EU viruses are present would prevent their introduction into and spread within the PRA area.

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

| |
|---|
| *RNQPs: Are there measures available to prevent pest presence on plants for planting such that the risk becomes mitigated?*<br>The nematodes do not invade plants (ectoparasites), therefore plants for planting are not the main pathway. Measures are therefore not considered. |

### 3.6.1. Phytosanitary measures

The following phytosanitary measures are considered:

- Prohibition of import from areas where both, non-EU viruses and their vector nematodes are known to be present,
- Phytosanitary certificate for which a general plant health inspection must be done prior to export, which is generally based on sampling,
- Pest-free production site, inspection and testing, and soil treatment

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

- Sampling and testing procedures – a very high accuracy is required for the purpose of issuing a phytosanitary certificate; detection of nematodes in soil depends on spatial and seasonal nematode distribution, sampling intensity, sampling depth and sample volume.
- Correct identification of the pest is required for the implementation of appropriate measures to prevent its introduction and spread. Species identification of *X. americanum sensu lato* is based on a detailed morphological observations and morphometric measurements of individual species, and is a challenge even for experienced, well-trained staff due to general similarity of these nematodes (Taylor and Brown, 1997). Currently, no appropriate routine molecular tools for the identification of *X. americanum sensu lato* is available, therefore the whole diagnostic procedure is based on morphological identification (FAO, 2016; EPPO, 2017).

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

- Sampling and testing procedures – a very high accuracy is required for the purpose of issuing a phytosanitary certificate; detection of nematodes in soil depends on spatial and seasonal nematode distribution, sampling intensity, sampling depth and sample volume.
- Removal of soil from plants for planting or other objects may not be feasible and therefore not fully effective.

### 3.6.2. Pest control methods

- The use of certified or tested plants for planting, grown under conditions that assure corresponding plant health helps to reduce the risk of introducing and spreading of non-EU viruses: TRSV, ToRSV, PRMV and CRLV and their vector nematodes (*X. americanum* sensu lato). Only planting material originating from areas where these viruses and their vector nematodes have not been reported, and where surveillance is carried out to confirm the absence of the pest (Pest Free Area, Pest Free Production Site) could be declared as pest free material and could be therefore used in the EU.
- Disinfection of soil by physical (heat, steam) or chemical (nematicides) measures – the efficacy of these measures is limited (it is considered that the efficacy never reaches 100%) and the nematodes that remain in soil can still transmit viruses to the roots of the host plants.

## 3.7. Uncertainty

- Uncertainty exists about the number and identity of species within the *X. americanum* sensu lato group.
- Uncertainty exists about the species of the *X. americanum* sensu lato group that transmit plant viruses.
- The distribution of viruses transmitted by *X. americanum* sensu lato group and their vectors in countries of origin and in the EU is not exactly known.

- Specificity of virus transmission has been reported but is unclear whether non EU viruses and virus strains can be transmitted by *X. americanum* sensu lato group species present in the EU. It is also not clear if non-EU populations of the nematodes are efficient vectors of the respective viruses already present in the EU.
- Efficiency of virus transmission under field conditions has not been studied in detail. The nematodes move only over short distances and within field spread is expected to be limited and may require several years. Uncertainty exists about population build-up (one generation per year) which may affect virus spread. Although *Xiphinema* species are known to retain viruses for long periods (transmission after 9 months has been experimentally proven), uncertainty on virus persistence exists.
- The extent of direct damage caused by the nematode is not known. *Xiphinema* species are able to damage root systems (galling and stunting) leading to considerable crop losses (Taylor, 1978). Although there is some uncertainty on the extent of damage caused, this may not influence the assessment as the main damage is the transmission of viruses. Direct damage may be similar to direct damage caused by indigenous (European) *Xiphinema* species.

# 4. Conclusions

Four categories of species within the *Xiphinema americanum* sensu lato were considered for the purpose of this pest categorisation. The main damage caused by nematodes in this group is the transmission of plant viruses.

Category I contains the non-EU species, which are known virus vectors: *X. americanum* sensu stricto*, X. bricolense, X. californicum, X. inaequale, X. intermedium, X. rivesi* (non-EU populations) *and X. tarjanense* (Table 2). Those species satisfy all the criteria that are within the remit of EFSA to assess to be regarded as Union quarantine pests (Table 9).

Category II contains the non-EU species, which are not known to be virus vectors (28 species): *X. bacaniboia, X. citricolum, X. floridae, X. franci, X. georgianum, X. himalayense, X. incognitum, X. kosaigudense, X. laevistriatum, X. lambertii, X. luci, X. minor, X. neoelongatum, X. occiduum, X. oxycaudatum, X. pacificum, X. pakistanense, X. paramanovi, X. parvum, X. penevi, X. peruvianum, X. pseudoguirani, X. sheri, X. silvaticum, X. tenuicutis, X. thornei, X. utahense,* and *X. waimungui* (Table 3). Those species do not satisfy all the criteria specifically the criterion of causing a significant impact to be regarded as Union quarantine pests. Uncertainty exists whether species in this category can transmit viruses once compatible viruses were introduced into the EU (Table 10).

Category III contains the species present in the EU, which are not known to be virus vectors (26 species): *Xiphinema astaregiense, X. brevicolle, X. brevisicum, X. browni, X. diffusum, X. duriense, X. exile, X. fortuitum, X. incertum, X. lafoense, X. longistilum, X. madeirense, X. mesostilum, X. microstilum, X. opisthohysterum, X. pachtaicum, X. pachydermum, X. parabrevicolle, X. parapachydermum, X. parasimile, X. paratenuicutis, X. plesiopachtaicum, X. santos, X. simile, X. taylori* and *X. vallense* (Table 4). Those species do not satisfy the criteria of being absent from the EU and causing significant impact to be regarded as Union quarantine pests. Uncertainty exists on the vector status of these species (Table 11).

Category IV contains the species *X. rivesi* (EU populations), which is present in the EU and able to transmit viruses under experimental conditions (Table 5). However, the species is not associated with EU viruses under field conditions and non-EU viruses or strains are not present under field conditions in the EU. The introduction of new plant viruses or strains into the EU would have major consequences as *X. rivesi* is an efficient virus vector of TRSV, ToRSV, PRMV and CRLV. *X. rivesi* does not satisfy the criterion of being absent from the EU to be regarded as a Union quarantine pest (Table 12).

The nematodes do not invade plants (ectoparasites); therefore, none of the 61 species satisfies the criteria that are within the remit of EFSA to assess to be regarded as regulated non-quarantine pests as plants for planting are not the main pathway.

**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) for category I (*X. americanum* sensu *stricto, X. bricolense, X. californicum, X. inaequale, X. intermedium, X. rivesi (non-EU populations) and X. tarjanense*) that are vectors of plant viruses

| 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)** | Yes the identities of *X. americanum* sensu stricto, *X. bricolense, X. californicum, X. inaequale, X. intermedium, X. rivesi (non-EU populations) and X. tarjanense* are established | Yes the identities of *X. americanum* sensu stricto*, X. bricolense, X. californicum, X. inaequale, X. intermedium, X. rivesi (non-EU populations) and X. tarjanense* are established | Identification is only possible for experienced nematologists. Molecular methods are not available for routine diagnostics. The distinction of EU-populations of *X. rivesi* from non-EU-populations is not possible |
| **Absence/ presence of the pest in the EU territory (Section 3.2)** | No, the pests are not known to be present in the EU | No, the pests are not known to be present in the EU | No systematic surveillance in all MSs |
| **Regulatory status (Section 3.3)** | Nematodes belonging to the *X. americanum* sensu lato group are currently regulated by Council Directive 2000/29/EC as harmful organisms whose introduction into, and spread within, all member states shall be banned | Nematodes belonging to the *X. americanum* sensu lato group are currently regulated by Council Directive 2000/29/EC as harmful organisms whose introduction into, and spread within, all member states shall be banned | |
| **Pest potential for entry, establishment and spread in the EU territory (Section 3.4)** | *X. americanum* sensu stricto, *X. bricolense, X. californicum, X. inaequale, X. intermedium, X. rivesi (non-EU populations) and X. tarjanense* are able to enter and spread with soil, soil attached to plants for planting or to machinery, tools etc | *X. americanum* sensu stricto, *X. bricolense, X. californicum, X. inaequale, X. intermedium, X. rivesi (non-EU populations) and X. tarjanense* are able to enter and spread with soil attached to plants but plants for planting are not the main pathway | No uncertainties |
| **Potential for consequences in the EU territory (Section 3.5)** | *X. americanum* sensu stricto, *X. bricolense, X. californicum, X. inaequale, X. intermedium, X. rivesi (non-EU populations) and X. tarjanense* are vectors of important plant viruses. Introduction of the nematodes may also lead to the introduction of viruses or new strains not present in the EU. Economic impacts are expected | The presence of the pest on plants for planting would have an economic impact | Introduction of the nematodes may also lead to the introduction of viruses which may also be vectored by nematode species already present in the EU (e.g., *X. rivesi* EU populations) |
| **Available measures (Section 3.6)** | Measures are available to inhibit entry via traded commodities (e.g. prohibition on the importation of soil and the introduction of plants for planting with soil or growing media attached) | Pest-free area and pest free places/ sites of production reduce the risk of the pest being present in soil attached to plants for planting | No uncertainties |

| 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 |
|---|---|---|---|
| **Conclusion on pest categorisation (Section 4)** | *X. americanum* sensu stricto, *X. bricolense, X. californicum, X. inaequale, X. intermedium, X. rivesi (non-EU populations)* and *X. tarjanense* do satisfy all the criteria that are within the remit of EFSA to assess to be regarded as a Union quarantine pest | *X. americanum* sensu stricto, *X. bricolense, X. californicum, X. inaequale, X. intermedium, X. rivesi (non-EU populations) and X. tarjanense* do not meet the criteria of (a) occurring in the EU territory, and (b) plants for planting being the main means of spread | |
| **Aspects of assessment to focus on/scenarios to address in future if appropriate** | Routine identification methods (molecular tools) for species identification are needed. There is no method available at present to distinguish non-EU and EU populations of *X. rivesi* | | |

**Table 10:** 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 category II (*X. bacaniboia, X. citricolum, X. floridae, X. franci, X. georgianum, X. himalayense, X. incognitum, X. kosaigudense, X. laevistriatum, X. lambertii, X. luci, X. minor, X. neoelongatum, X. occiduum, X. oxycaudatum, X. pacificum, X. pakistanense, X. paramanovi, X. parvum, X. penevi, X. peruvianum, X. pseudoguirani, X. sheri, X. silvaticum, X. tenuicutis, X. thornei, X. utahense,* and *X. waimungui*)

| 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)** | Yes the identities of above-mentioned species are established | Yes the identities of above-mentioned species are established | Identification is only possible for experienced nematologists. Molecular methods are not available for routine diagnostics |
| **Absence/ presence of the pest in the EU territory (Section 3.2)** | No, abovementioned pests are not present in the EU | No, abovementioned pests are not present in the EU | No systematic surveillance in all MSs |
| **Regulatory status (Section 3.3)** | Nematodes belonging to the *X. americanum* sensu lato group are currently regulated by Council Directive 2000/29/EC as harmful organisms whose introduction into, and spread within, all member states shall be banned | Nematodes belonging to the *X. americanum* sensu lato group are currently regulated by Council Directive 2000/29/EC as harmful organisms whose introduction into, and spread within, all member states shall be banned | |
| **Pest potential for entry, establishment and spread in the EU territory (Section 3.4)** | Species mentioned above are able to enter and spread with soil, soil attached to plants for planting or to machinery, tools etc | Species mentioned above are able to spread with soil attached to plants but plants are not the only pathway | No uncertainties |

| 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)** | Species mentioned above are not reported to transmit economically important viruses. Direct damage due to nematode feeding activity is limited. No impact is expected | The presence of the pest on plants for planting is not reported to cause economic damage therefore no impact is expected | Transmission of viruses and damage potential of the nematodes species in the EU is not known |
| **Available measures (Section 3.6)** | Measures are available to inhibit entry via traded commodities (e.g. prohibition on the importation of soil and the introduction of plants for planting with soil or growing media attached) | Pest-free area and pest free places/ sites of production reduce the risk of the pest being present on plants for planting | No uncertainties |
| **Conclusion on pest categorisation (Section 4)** | Species mentioned above do not satisfy all the criteria that are within the remit of EFSA to assess to be regarded as a Union quarantine pest. The species are not known to cause economic or environmental damage | Species mentioned above do not meet the criteria of (a) occurring in the EU territory, and (b) plants for planting being the only means of spread | Transmission of viruses and damage potential of the nematodes species in the EU is not known. More species, which are currently not recognised as vectors may transmit viruses |
| **Aspects of assessment to focus on/ scenarios to address in future if appropriate** | Routine identification methods (molecular tools) for species identification are needed | | |

**Table 11:** 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 category III (*Xiphinema astaregiense, X. brevicolle, X. brevisicum, X. browni, X. diffusum, X. duriense, X. exile, X. fortuitum, X. incertum, X. lafoense, X. longistilum, X. madeirense, X. mesostilum, X. microstilum, X. opisthohysterum, X. pachtaicum, X. pachydermum, X. parabrevicolle, X. parapachydermum, X. parasimile, X. paratenuicutis, X. plesiopachtaicum, X. santos, X. simile, X. taylori* and *X. vallense*)

| 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)** | Yes the identities of above-mentioned species are established | Yes the identities of above-mentioned species are established | Identification is only possible for experienced nematologists. Molecular methods are not available for routine diagnostics |
| **Absence/ presence of the pest in the EU territory (Section 3.2)** | Abovementioned pests are present in the EU | Abovementioned pests are present in the EU | No systematic surveillance in all MSs |

| 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 |
|---|---|---|---|
| **Regulatory status (Section 3.3)** | Nematodes belonging to the *X. americanum* sensu lato group are currently regulated by Council Directive 2000/29/EC as harmful organisms whose introduction into, and spread within, all member states shall be banned | Nematodes belonging to the *X. americanum* sensu lato group are currently regulated by Council Directive 2000/29/EC as harmful organisms whose introduction into, and spread within, all member states shall be banned | |
| **Pest potential for entry, establishment and spread in the EU territory (Section 3.4)** | Species mentioned above are present in the EU | Species mentioned above are present in the EU | No uncertainties |
| **Potential for consequences in the EU territory (Section 3.5)** | Species mentioned above are not reported to transmit economically important viruses. Direct damage due to nematode feeding activity is limited. No impact is expected | The presence of the pest on plants for planting is not reported to cause economic damage therefore no impact is expected | Transmission of viruses and damage potential of the nematodes species in the EU is not known |
| **Available measures (Section 3.6)** | Measures are available to inhibit entry via traded commodities (e.g. prohibition on the importation of soil and the introduction of plants for planting with soil or growing media attached). However all species in this category are present in the EU | Pest-free area and pest free places/ sites of production reduce the risk of the pest being present on plants for planting | No uncertainties |
| **Conclusion on pest categorisation (Section 4)** | Species mentioned above do not satisfy all the criteria that are within the remit of EFSA to assess to be regarded as a Union quarantine pest. The species are present in the EU and are not known to cause economic or environmental damage | Species mentioned above do not meet the criteria of plants for planting being the only means of spread | Transmission of viruses and damage potential of the nematodes species in the EU is not known |
| **Aspects of assessment to focus on/ scenarios to address in future if appropriate** | Routine identification methods (molecular tools) for species identification are needed | | |

**Table 12:** 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 category IV (*Xiphinema rivesi* (EU-populations))

| 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)** | Yes the identity of *Xiphinema rivesi* is established. The distinction of EU-populations from non-EU-populations is not possible | Yes the identity of *Xiphinema rivesi* is established. The distinction of EU-populations from non-EU-populations is not possible | Identification is only possible for experienced nematologists. Molecular methods are not available for routine diagnostics. The distinction of EU-populations from non-EU-populations is not possible |
| **Absence/ presence of the pest in the EU territory (Section 3.2)** | Yes, the pest is present in the EU | Yes, the pest is present in the EU | No uncertainties |
| **Regulatory status (Section 3.3)** | Nematodes belonging to the *X. americanum* sensu lato group are currently regulated by Council Directive 2000/29/EC as harmful organisms whose introduction into, and spread within, all member states shall be banned | Nematodes belonging to the *X. americanum* sensu lato group are currently regulated by Council Directive 2000/29/EC as harmful organisms whose introduction into, and spread within, all member states shall be banned | No uncertainties |
| **Pest potential for entry, establishment and spread in the EU territory (Section 3.4)** | *Xiphinema rivesi* is already present in the EU and is non-EU populations are also able to enter and spread with soil, soil attached to plants for planting or to machinery, tools etc | *Xiphinema rivesi* is already present in the EU and is also able to enter and spread with soil and soil attached to plants for planting but plants for planting are not the main pathway | No uncertainties |
| **Potential for consequences in the EU territory (Section 3.5)** | *Xiphinema rivesi* populations present in the EU are vectors of important plant viruses. EU-populations have not been reported to transmit viruses under field conditions because these nematode populations are not associated with non-EU viruses or strains. | The presence of the pest on plants for planting is not reported to cause economic damage | Tomato ringspot virus has been reported to be present in the EU. Distribution of *X. rivesi* has also been reported from several locations in the EU. Association between these two organisms in the EU has not been reported |
| **Available measures (Section 3.6)** | No measures are available for populations that are already present in EU.<br>Measures to inhibit entry via traded commodities are available for non-EU populations (e.g. prohibition on the importation of soil and plants for planting with soil or growing media attached) | Not relevant for EU populations | No uncertainties |

| 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 |
|---|---|---|---|
| **Conclusion on pest categorisation (Section 4)** | *Xiphinema rivesi* (EU-populations) does not satisfy all the criteria that are within the remit of EFSA to assess to be regarded as a Union quarantine pest because it is already present in the EU. At present this species is not known to cause economic damage in the EU but the situation may change completely once compatible viruses or virus strains were to be introduced into the EU | *Xiphinema rivesi* (EU populations) does not meet the criteria of plants for planting being the main means of spread | Virus introduction would lead to a different assessment: a distinction of EU and non-EU populations |
| **Aspects of assessment to focus on/ scenarios to address in future if appropriate** | Routine identification methods (molecular tools) for species identification are needed.<br><br>Assessment of virus transmission specificity by *X. rivesi* | | |

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# Abbreviations

| | |
|---|---|
| CRLV | *Cherry rasp leaf virus* |
| 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 |
| MS | Member State |
| PLH | EFSA Panel on Plant Health |
| PRMV | Peach rosette mosaic virus |
| TFEU | Treaty on the Functioning of the European Union |
| ToRSV | *Tomato ringspot virus* |
| TRSV | *Tobacco ringspot virus* |
| ToR | Terms of Reference |

# Appendix A – Results of the literature search in Web of Science and Google using the key words specified in the table: (date of the search: 23.3.2018–8.4.2018); ALL DATABASES; no language limit; no years limit

| ID | Species | Is it transmitting viruses? Which one? | Is it present in EU28? Which country?(ISI web of Science and Google) | EPPO (PM7/95(2)) *Xiphinema americanum* sensu lato (presence in Europe- not specified EU28) |
|---|---|---|---|---|
| **1** | *X. americanum* (sensu stricto) | 'Xiphinema americanum AND sensu stricto AND virus' (4 hits)<br>cherry rasp leaf (CRLV), tobacco ringspot (TobRSV), and two strains of tomato ringspot (TomRSV) (Brown et al., 1994; Wang and Gergerich, 1998)<br>3 or 4 viruses (Taylor and Brown, 1997) | NO 'Xiphinema americanum AND sensu stricto' (8 hits) South Africa (Loots and Heyns, 1984 in Lamberti et al., 2000), USA Arizona (Wang and Gergerich, 1998), USA Pennsylvania (Halbrendt and Brown, 1994), USA: Arkansas, California, Pennsylvania, Rhode Island, Virginia (Robbins, 1993) | NO |
| **2** | *X. astaregiense* | 'Xiphinema astaregiense AND virus' (0 hits) | YES 'Xiphinema astaregiense AND virus' (2 hints)<br>Spain (Archidona-Yuste et al., 2016) | YES (only in Europe) |
| **3** | *X. bacaniboia* | 'Xiphinema bacaniboia AND virus' (0 hits) | NO 'Xiphinema bacaniboia' (2 hits) (Coomans and Luc, 1998), Fiji (Williams, 1984) | NO |
| **4** | *X. brevicolle* | 'Xiphinema brevicolle AND virus' (4 hits) not clear from the abstracts | YES 'Xiphinema brevicolle' (15 hits)<br>China (Barsalote et al., 2017), California in the USA (Robbins, 1993; Orlando et al., 2016), Florida (Robbins, 1993), Japan (Sakai et al., 2011), Brazil (Oliveira et al., 2004), Malaysia, Israel (Brown and Taylor, 1987) Kenya (Coomans and Heyns, 1997), Guiana and Martinique (Luc and Coomans, 1992) (Luc and Coomans, 1992), Germany (Brown and Taylor, 1987), Poland (Szczygiel, 1974; Lamberti and Bleve-Zacheo, 1979), Slovakia (Lišková et al., 1995), ex USSR (Brown et al., 1990) | YES |
| **5** | *X. brevisicum* | 'Xiphinema brevisicum AND virus' (0 hits) | YES 'Xiphinema brevisicum' (3 hits) no clear distribution from the abstracts<br>Portugal (Lamberti et al., 1994) | YES (only in the EU) |
| **6** | *X. bricolense* | 'Xiphinema bricolense AND virus' (0 hits)<br>'Xiphinema bricolensis AND virus'<br>cherry rasp leaf (CRLV), tobacco ringspot (TobRSV), tomato ringspot (TomRSV). (Brown et al., 1994; in (Lamberti et al., 2000), Peach rosette mosaic virus (PRMV) (Ozturk et al., 2017) | NO 'Xiphinema bricolense' (0 hits)<br>'Xiphnema bricolensis' (6 hits) North America: Arkansas, Georgia, Tennessee, Mississippi, Florida, Oklahoma, California, and North Dakota (Cho and Robbins, 1991), Canada (Graham et al., 1988)<br>No papers from EU28 | NO |

| ID | Species | Is it transmitting viruses? Which one? | Is it present in EU28? Which country?(ISI web of Science and Google) | EPPO (PM7/95(2)) *Xiphinema americanum* sensu lato (presence in Europe- not specified EU28) |
|---|---|---|---|---|
| **7** | *X. browni* | 'Xiphinema browni AND virus' (0 hits) | YES 'Xiphinema browni' (1 hit) Czech Republic, Morocco, Slovakia (Lazarova et al., 2016) | YES (only in Europe) (Lazarova et al., 2016) |
| **8** | *X. californicum* | 'Xiphinema californicum AND virus' (8 hits) cherry rasp leaf (CRLV), tobacco ringspot (TobRSV), and two strains of tomato ringspot (TomRSV) (Brown et al., 1994) | NO 'Xiphinema californicum' (13 hits) California (Orlando et al., 2016) | NO |
| **9** | *X.citricolum* | 'Xiphinema citricolum AND virus' (0 hits) | NO 'Xiphinema citricolum' (2 hits) Florida (Lamberti et al., 2002) | NO |
| **10** | *X. diffusum* | 'Xiphinema diffusum AND virus' (2 hits) not clear/no info in the abstracts | YES 'Xiphinema diffusum' (10 hits) Brazil (Oliveira et al., 2003)<br>Not in ISI web of knowledge: Portugal (Lamberti et al., 1994) | YES |
| **11** | *X. duriense* | 'Xiphinema duriense AND virus' (1 hit) | YES 'Xiphinema duriense' (3 hits), Spain (Archidona-Yuste et al., 2016), Portugal (Lamberti et al., 2002) | YES (only in Europe) |
| **12** | *X. exile* | 'Xiphinema exile AND virus' (0 hits) | YES 'Xiphinema exile' (0 hits)<br>In google: Portugal (Roca et al., 1988) | YES |
| **13** | *X. floridae* | 'Xiphinema florida AND virus' (0 hits) | NO 'Xiphinema floridae' (2 hits) Florida (Gozel et al., 2003) | NO |
| **14** | *X. fortuitum* | 'Xiphinema fortuitum AND virus' (1 hit) | YES 'Xiphinema fortuitum' (4 hits) Italy (Roca et al., 1987) | YES (only in Europe) |
| **15** | *X. franci* | 'Xiphinema franci AND virus' (0 hits) | NO 'Xiphinema franci' (3 hits)<br>Madagascar (Razak and Loof, 1998) | NO |
| **16** | *X. georgianum* | 'Xiphinema georgianum AND virus' (0 hits) | NO 'Xiphinema georgianum' (7 hits) Florida USA (Gozel et al., 2006), Brazil (Lamberti et al., 2000) | NO |
| **17** | *X. himalayense* | 'Xiphinema himalayense' AND virus' (0 hits) | NO 'Xiphinema himalayense' (2 hits) India (Ahmad et al., 1998) | NO |
| **18** | *X. inaequale* | 'Xiphinema inaequale AND virus' (2 hits) tomato ringspot virus ToRSV (Verma et al., 2003) | NO 'Xiphinema inaequale' (11 hits) India (Srivastava et al. 2000), Peru and Chile (Lamberti et al., 2000) | NO |
| **19** | *X. incertum* | 'Xiphinema incertum AND virus' (2 hits) raspberry ring spot nepovirus (Choleva et al., 1992) | YES 'Xiphinema inaequale' (13 hits) Bulgaria and Croatia (Peneva and Choleva, 1992; Lamberti et al., 2000), Serbia (Barsi and Lamberti, 2002) | YES (only in Europe) |

| ID | Species | Is it transmitting viruses? Which one? | Is it present in EU28? Which country?(ISI web of Science and Google) | EPPO (PM7/95(2)) *Xiphinema americanum* sensu lato (presence in Europe- not specified EU28) |
|---|---|---|---|---|
| **20** | *X. incognitum* | 'Xiphinema incognitum AND virus' (2 hits) | NO 'Xiphinema incognitum' (15 hits) Egypt (Lamberti et al., 1996), Japan (Lamberti et al., 2000),Taiwan (Chen et al., 2005) | NO |
| **21** | *X. intermedium* | 'Xiphinema intermedium AND virus' (3 hits) Tomato ringspot virus (in the lab on tomato and tobacco), Bermuda grass decline (Leone et al. 1997) | NO 'Xiphinema intermedium' (9 hits) Pakistan (Lamberti et al., 1987), Florida and Mississippi | NO |
| **22** | *X. kosaiguadense* | 'Xiphinema kosaiguadense AND virus' (0 hits) | NO 'Xiphinema kosaiguadense' (0 hits)<br>India (Lamberti et al., 2000) | NO |
| **23** | *X. laevistriatum* | 'Xiphinema laevistriatum AND virus' (0 hits) | NO 'Xiphinema laevistriatum' (6 hits) Florida (only) (Lamberti and Bleve-Zacheo, 1979) | NO |
| **24** | *X. lafoense* | 'Xiphinema lafoense AND virus' (0 hits) | YES 'Xiphinema lafoense' (1 hit) Portugal (Roca et al., 1987) | YES |
| **25** | *X. lambertii* | 'Xiphinema lambertii AND virus' (0 hits) | NO 'Xiphinema lambertii' (8 hits) India (Bajaj and Jairajpuri, 1976) | NO |
| **26** | *X. longistilum* | 'Xiphinema longistilum AND virus (0 hits) | YES 'Xiphinema longistilum' (2 hits), Portugal (Lamberti et al., 1994) | YES (only in Europe) |
| **27** | *X. luci* | 'Xiphinema luci AND virus (1 hit – not relevant from the abstract) | NO 'Xiphinema luci' (16 hits) Brazil (Silva et al., 2008), Senegal (Lamberti and Bleve-Zacheo, 1979) | NO |
| **28** | *X. madeirense* | 'Xiphinema madeirense AND virus' (1 hit – not clear?) | YES 'Xiphinema madeirense' (5 hits) Madeira (Brown et al., 1992), Portugal mainland (Lamberti et al., 1994) | YES (only in Europe) |
| **29** | *X. mesostilum* | 'Xiphinema mesostilum AND virus' (0 hits) | YES 'Xiphinema mesostilum' (2 hits) Portugal (Lamberti et al., 1994) | YES (only in Europe) |
| **30** | *X. microstilum* | 'Xiphinema microstilum AND virus' (0 hits) | YES 'Xiphinema microstilum' (2 hits) Portugal (Lamberti et al., 1994) | YES (only in Europe) |
| **31** | *X. minor* | 'Xiphinema minor AND virus' (19 hits) not specific for X.minor | NO 'Xiphinema minor' (186 hits) not specific because of the word'minor'<br>India (Ahmad et al., 1998) | NO |
| **32** | *X. neoelongatum* | 'Xiphinema neoelongatum AND virus' (0 hits) | NO 'Xiphinema neoelongatum' (3 hits) India (Bajaj and Jairajpuri, 1976; Luc et al., 1984) | NO |
| **33** | *X. occiduum* | 'Xiphinema occiduum AND virus' (1 hit) probably yes, but not confirmed (Vrain and Yorston, 1987; Lamberti et al., 2000) | NO 'Xiphinema occiduum' (3 hits) Canada (Ebsary et al., 1984) | NO |

| ID | Species | Is it transmitting viruses? Which one? | Is it present in EU28? Which country?(ISI web of Science and Google) | EPPO (PM7/95(2)) *Xiphinema americanum* sensu lato (presence in Europe- not specified EU28) |
|---|---|---|---|---|
| **34** | *X. opisthohysterum* | 'Xiphinema opisthohysterum AND virus' (3 hits) | YES 'Xiphinema opisthohysterum' (17 hits) Bulgaria (Stoyanov, 1964), Spain (Gutierrez-Gutierrez et al., 2012), Portugal (Sturhan, 1983), India (Siddiqi, 1961; Lamberti and Bleve-Zacheo, 1979) | YES |
| **35** | *X. oxycaudatum* | 'Xiphinema oxycaudatum AND virus' (1 hit) not relevant | NO 'Xiphinema oxycaudatum' (5 hits) Brazil (Oliveira et al., 2004), Iran (Fadaei et al., 2003), Kenya (Coomans and Heyns, 1997), Taiwan (Chen et al., 2005) | NO |
| **36** | *X. pachtaicum* | 'Xiphinema pachtaicum AND virus' (19 hits), 'yellow mosaic' disease' (Tzortzakakis et al., 2001) | YES 'Xiphinema pachtaicum' (49 hits) Spain (Palomares Rius et al., 2015), 'from southern England, Germany, Portugal, Switzerland, Hungary and Bulgaria. X. pachtaicum has also been found in soil in a glasshouse near Oslo, Norway '(Brown and Taylor, 1987), Africa, Asia, Former Soviet Union, Central and South Africa,<br>In google<br>Macedonia, Montenegro, Serbia (Barsi and Lamberti, 2002) | YES |
| **37** | *X. pachydermum* | 'Xiphinema pachydermum AND virus' (0 hits) | YES 'Xiphinema pachydermum' (3 hits)<br>Not in ISI web of science: Portugal in Lamberti et al., 2000 and Sturhan, 1983) | YES (only in Europe) |
| **38** | *X. pacificum* | 'Xiphinema pacificum AND virus' (1 hit) possible: uncertainty about species determination ans transmission of viruses in Vrain, 1993; | NO 'Xiphinema pacificum' (3 hits) Canada (Graham et al., 1988; Vrain, 1993) | NO |
| **39** | *X. pakistanense* | 'Xiphinema pakistanense AND virus' (0 hits) Xiphinema pakistanensis AND virus' (0 hits) | NO 'Xiphinema pakistanense' (0 hits)<br>Other name: 'Xiphinema pakistanensis' (10 hits) Pakistan (Nasira and Maqbool, 1998) | NO |
| **40** | *X. parabrevicolle* | 'Xiphinema parabrevicolle AND virus' (1 hit) | YES 'Xiphinema parabrevicolle' (1 hit) Italy (Gutierrez-Gutierrez et al., 2012) | YES (only in Europe) |
| **41** | *X. paramanovi* | 'Xiphinema paramanovi AND virus' (0 hits)<br>'Xiphinema paramonovi AND virus' (0 hits) | NO 'Xiphinema paramanovi' (0 hits)<br>'Xiphinema paramonovi' (5 hits) former Soviet Union (Lamberti et al., 2000) | NO |
| **42** | *X. parapachydermum* | 'Xiphinema parapachydermum AND virus' (0 hits) | YES 'Xiphinema parapachydermum' (3 hits) Spain (Archidona-Yuste et al., 2016) | YES (only in Europe) |

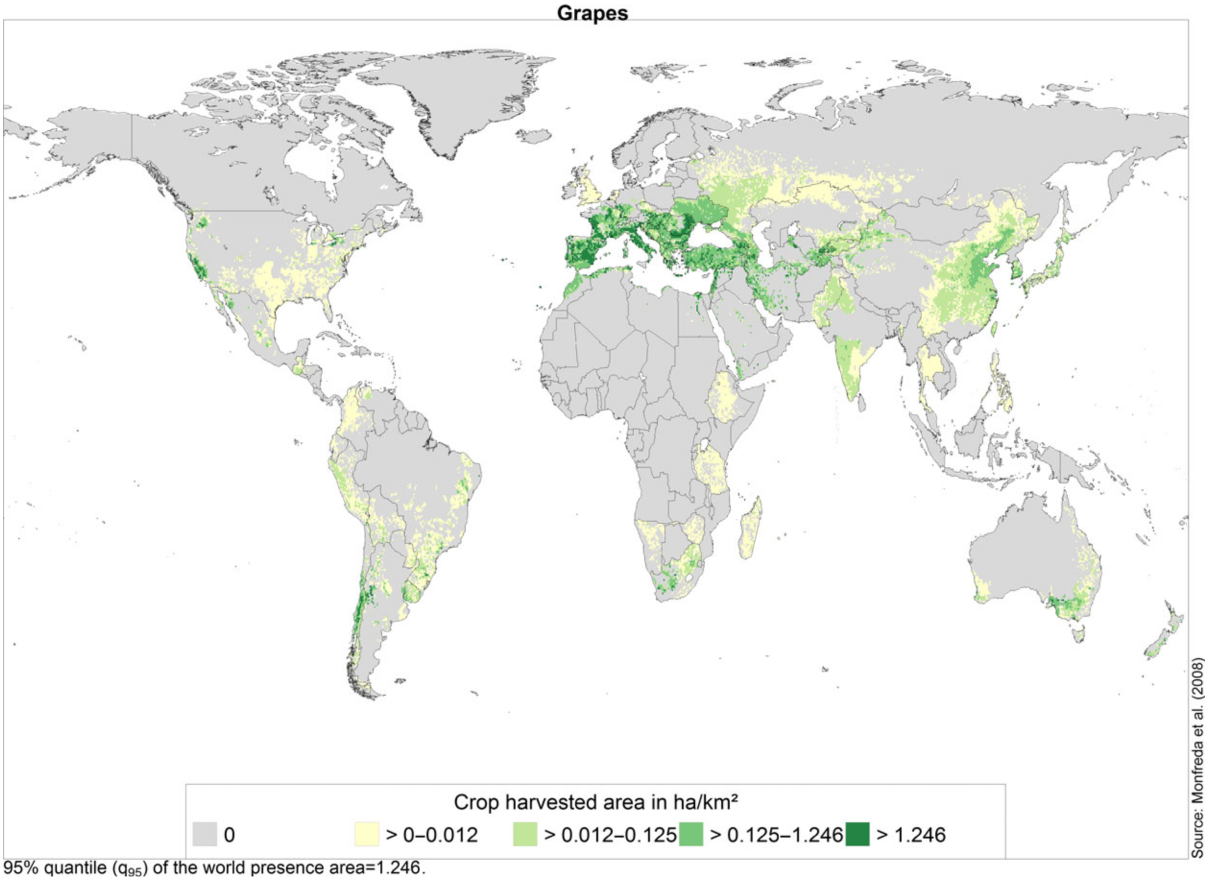
| ID | Species | Is it transmitting viruses? Which one? | Is it present in EU28?<br>Which country?(ISI web of Science and Google) | EPPO (PM7/95(2)) *Xiphinema americanum* sensu lato (presence in Europe- not specified EU28) |
|---|---|---|---|---|
| 43 | *X. parasimile* | 'Xiphinema parasimile AND virus' (1 hit) not relevant? | YES 'Xiphinema parasimile' (5 hits) Bulgaria (Lazarova et al., 2016), Romania (Bonta (Groza) et al., 2012); Serbia (Lazarova et al., 2008) | YES (only in Europe) |
| 44 | *X. paratenuicutis* | 'Xiphinema paratenuicutis AND virus' (1 hit – not relevant) | YES 'Xiphinema paratenuicutis' (1 hit) Spain (Gutierrez-Gutierrez et al., 2012) | YES (only in Europe) |
| 45 | *X. parvum* | 'Xiphinema parvum AND virus' (1 hit – not relevant) | NO 'Xiphinema parvum' (5 hits) Jamaica (Lamberti et al., 1991) | NO |
| 46 | *X. penevi* | 'Xiphinema penevi AND virus' (0 hits) | NO 'Xiphinema penevi' (1 hit) Morocco (Lazarova et al., 2016) | NO |
| 47 | *X. peruvianum* | 'Xiphinema peruvianum AND virus' (3 hits) not relevant | NO 'Xiphinema peruvianum' (10 hits) Chile (Lamberti et al., 1988), Peru (Alkemade and Loof, 1990; Lamberti et al., 1987; Venezuela (Crozzoli et al., 1998) | NO |
| 48 | *X. plesiopactaicum* | 'Xiphinema plesiopactaicum AND virus' (0 hits)<br>'Xiphinema plesiopachtaicum AND virus' (0 hits) | YES 'Xiphinema plesiopactaicum' (0 results)<br>'Xiphinema plesiopachtaicum'(results) Spain (Archidona-Yuste et al., 2016) | YES (only in Europe) |
| 49 | *X. pseudoguirani* | 'Xiphinema pseudoguirani AND virus' (0 hits) | NO 'Xiphinema pseudoguirani' (3 hits) Madagascar (Lamberti et al., 1991), islands in the Western Indian Ocean (Heyns and Coomans, 1994) | NO |
| 50 | *X. rivesi* | 'Xiphinema rivesi AND virus' (63 hits)<br>TRSV and ToRSV<br>cherry rasp leaf (CRLV), tobacco ringspot (TobRSV), and two strains of tomato ringspot (TomRSV) (Brown et al., 1994)<br>- Transmits Tomato ringspot virus to Cucumber (Auger et al., 2009), Tobacco ringspot virus and Tomato ringspot virus to cucumber (Širca et al., 2007) | YES 'Xiphinema rivesi' (128 hits) France, Bulgaria, Spain (Bello et al., 2005; Gutierrez-Gutierrez et al., 2011), Portugal (Lamberti et al., 2000), Slovenia (Urek et al., 2005; Širca et al., 2007; Peneva et al., 2012), Italy (Lazarova et al., 2016), Moldova (Poiras et al., 2014), North America (Robbins, 1993), Pakistan (Khan and Tareen, 2012), Egypt (Handoo et al., 2015), interception from China to Italy (Gao et al., 2013), Argentina (Chaves and Mondino, 2013), Chile (Auger et al., 2009), Guadeloupe, Martinique et Guyane (Quénéhervé and Van den Berg, 2005), Australia (Sharma et al., 2003), Iran (Fadaei et al., 2003), Canada (Van Driel et al., 1990), Peru (Alkemade and Loof, 1990) | YES |
| 51 | *X. santos* | 'Xiphinema santos AND virus' (1 hit) not relevant | YES 'Xiphinema santos' (5 hits) Spain (Gutierrez-Gutierrez et al., 2012), Portugal (Lamberti et al., 1993), Egypt (Lamberti et al., 2000) | YES |

| ID | Species | Is it transmitting viruses? Which one? | Is it present in EU28? Which country?(ISI web of Science and Google) | EPPO (PM7/95(2)) *Xiphinema americanum* sensu lato (presence in Europe- not specified EU28) |
|---|---|---|---|---|
| **52** | *X. sheri* | 'Xiphinema sheri AND virus' (0 hits) | NO 'Xiphinema sheri' (9 hits) Thailand (Lamberti and Bleve-Zacheo, 1979), USA Florida (Robbins, 1993) | NO |
| **53** | *X. silvaticum* | 'Xiphinema silvaticum AND virus' (0 hits) | NO 'Xiphinema silvaticum' (4 hits)Mauritius (Lamberti et al., 1987)<br>In google: Mauritius (Luc and Williams, 1978) | NO |
| **54** | *X. simile* | 'Xiphinema simile AND virus' (10 hits) not relevant | YES 'Xiphinema simile' (43 hits) Bulgaria (Lazarova et al., 2016), Czech Republic (Lazarova et al., 2016), Serbia (Lazarova et al., 2016), Crete – Greece (Lazarova et al., 2016), Hungary (Repasi et al., 2008), Kenya (Coomans and Heyns, 1997), Moldova (Lazarova et al., 2016), Slovakia (Lazarova et al., 2016), Romania (Bonta (Groza) et al., 2012)<br>In google: Serbia (Barsi and Lamberti, 2002) | YES |
| **55** | *X. tarjanense* | 'Xiphinema tarjanense AND virus' (1 hit OEPP Bulletin) in laboratory transmitted tomato and tobacco ringspot viruses (Brown et al., 1993) | NO 'Xiphinema tarjanense' (9 hits) USA Florida (Gozel et al., 2006) | NO |
| **56** | *X. taylori* | 'Xiphinema taylori AND virus' (11 hits) not vector (Subikova et al., 2002) | YES 'Xiphinema taylori' (29 hits) Italy (Lamberti et al., 1993; Roca and Lamberti, 1994), Slovakia (Lišková et al., 2007; Barsalote et al., 2017), Romania (Bonta (Groza) et al., 2012); former Yugoslavia (Barsi, 1994), China (Wang et al., 1996) (Barsalote et al., 2017), Poland and Hungary (Lamberti et al., 2002) previously determined as brevicolleIn google: Serbia (Barsi and Lamberti, 2002), | YES |
| **57** | *X. tenuicutis* | 'Xiphinema tenuicutis AND virus' (0 hits) | NO 'Xiphinema tenuicutis' (2 hits) USA-Tennessee (Lamberti and Bleve-Zacheo, 1979), Arkansas (Lamberti et al., 2000) | NO |
| **58** | *X. thornei* | 'Xiphinema thornei AND virus' (10 hits) not relevant | NO 'Xiphinema thornei' (81 hits – many of them are Pratylenchus thornei) USA: Colorado and Idaho (Lamberti and Morgan Golden, 1986), Pakistan (Nasira and Maqbool, 1998 in Lamberti et al., 2002), Far East of Russia (Lamberti et al., 2000), China (Chang, 1993) | NO |
| **59** | *X. utahense* | 'Xiphinema utahense AND virus' (0 hits) | NO 'Xiphinema utahense' (5 results) USA-Utah (Lamberti and Bleve-Zacheo, 1979),USA-Oregon (Lamberti and Morgan Golden, 1986) Chile (Lamberti et al., 1988) | NO |

| ID | Species | Is it transmitting viruses? Which one? | Is it present in EU28? Which country?(ISI web of Science and Google) | EPPO (PM7/95(2)) *Xiphinema americanum* sensu lato (presence in Europe- not specified EU28) |
|---|---|---|---|---|
| **60** | *X. vallense* | 'Xiphinema vallense AND virus' (0 hits) | YES 'Xiphinema vallense' (2 hits) Spain (Archidona-Yuste et al., 2016) | YES |
| **61** | *X. waimungui* | 'Xiphinema waimungui AND virus' (0 hits) | NO 'Xiphinema waimungui' (2 hits) New Zealand (Yeates et al., 1997; Sturhan and Wouts, 2008) | NO |

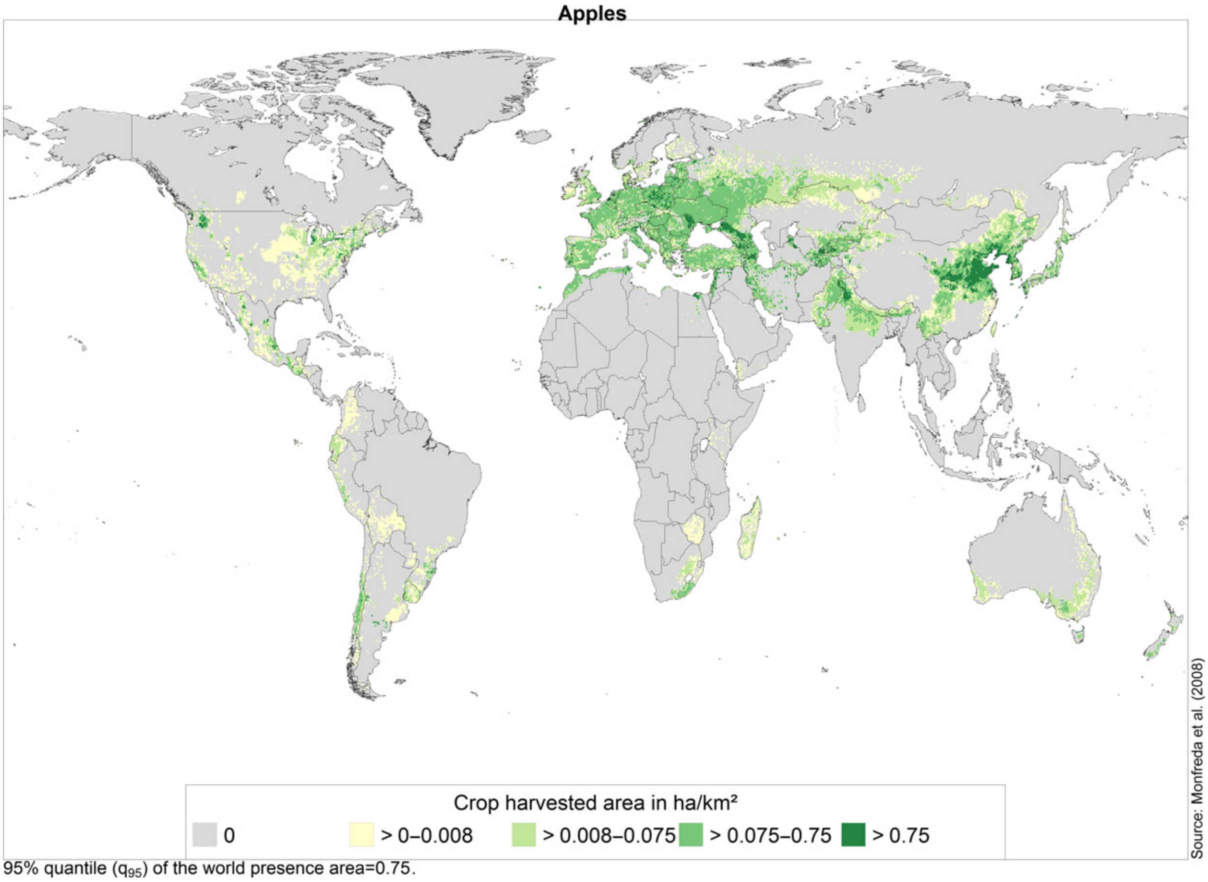
# Appendix B – Global distribution of the density of harvested grapes, apples, plums, cherries, nectarines and peaches

## B.1. Global distribution of the density of harvested grapes (ha crop/km$^2$) (source CAPRA database accessed on 23 April 2018)



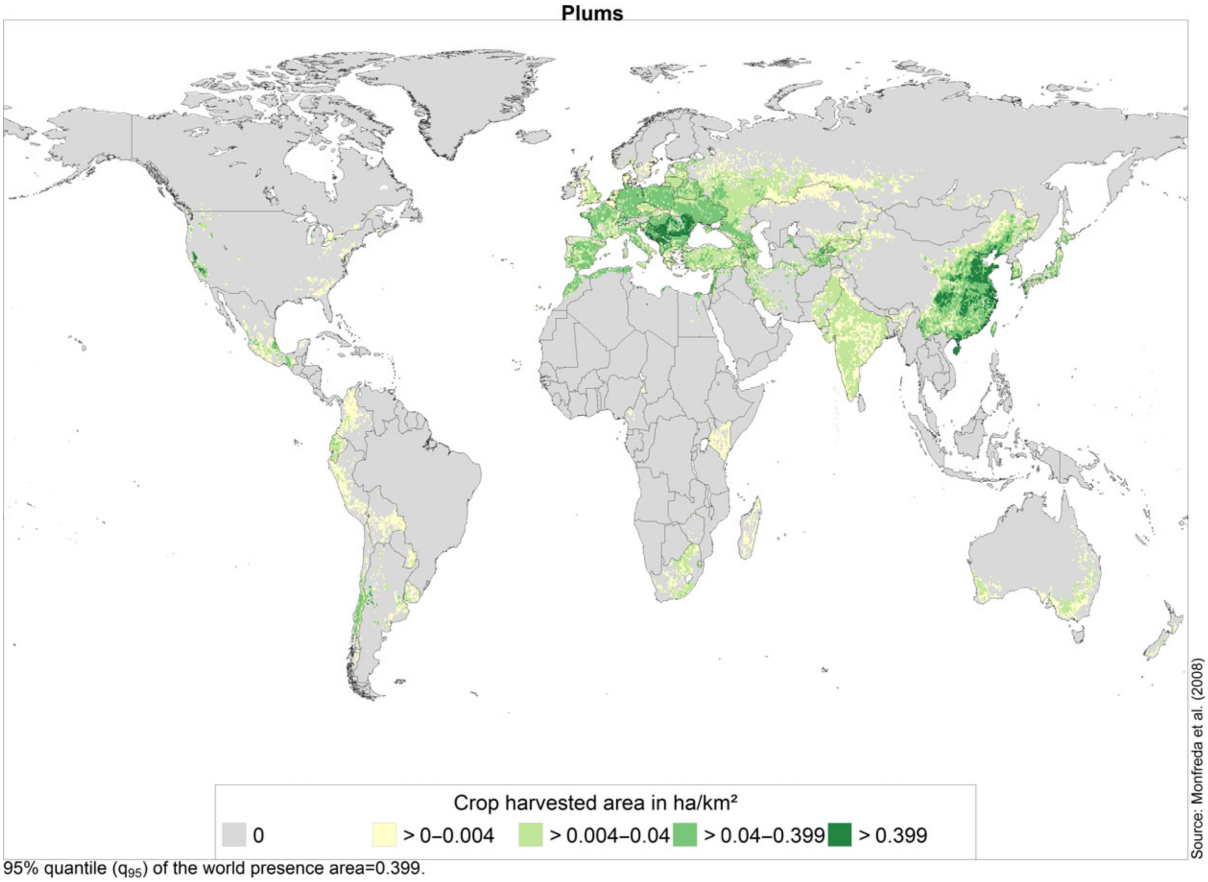

95% quantile ($q_{95}$) of the world presence area=1.246.

## B.2. Global distribution of the density of harvested apples (ha crop/km$^2$) (source CAPRA database accessed on 23 April 2018)



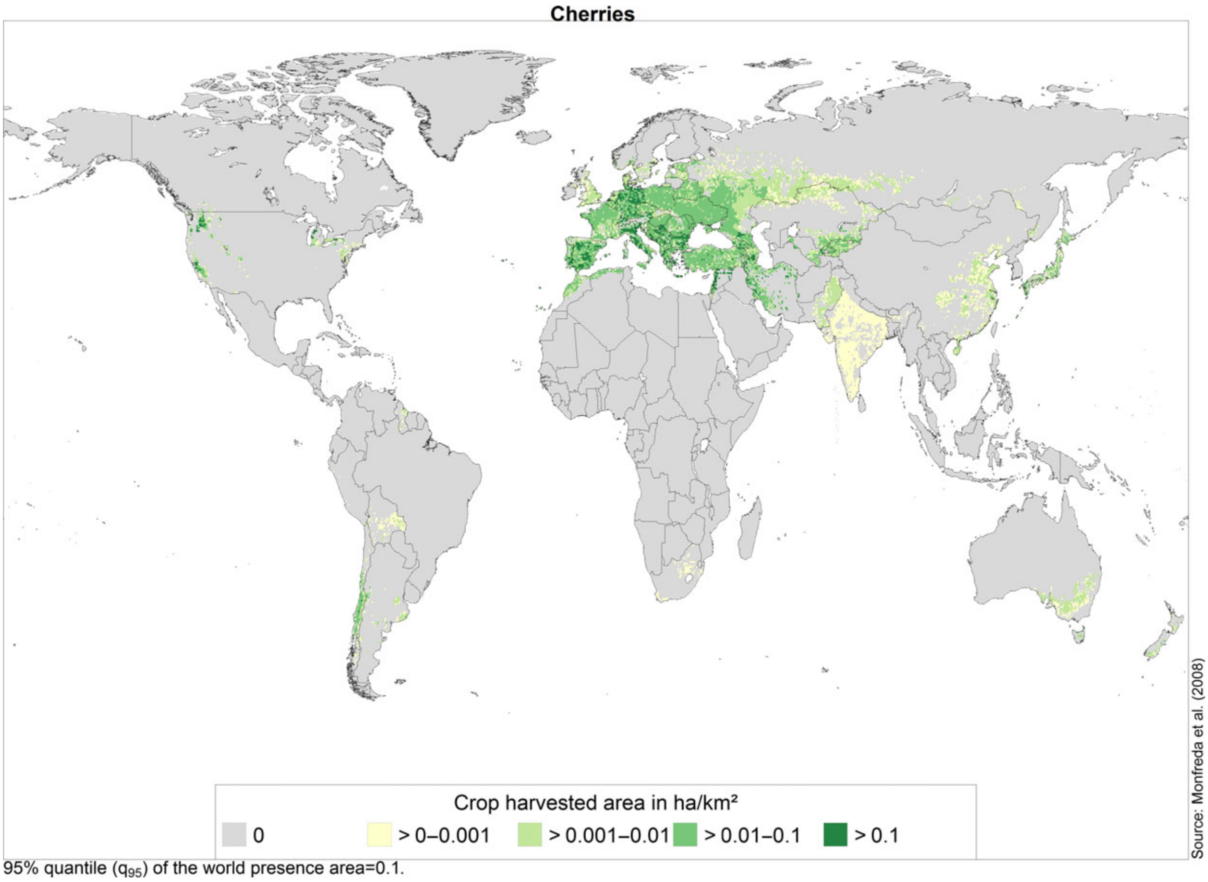

95% quantile ($q_{95}$) of the world presence area=0.75.

## B.3. Global distribution of the density of harvested plums (ha crop/km$^2$) (source CAPRA database accessed on 23 April 2018)



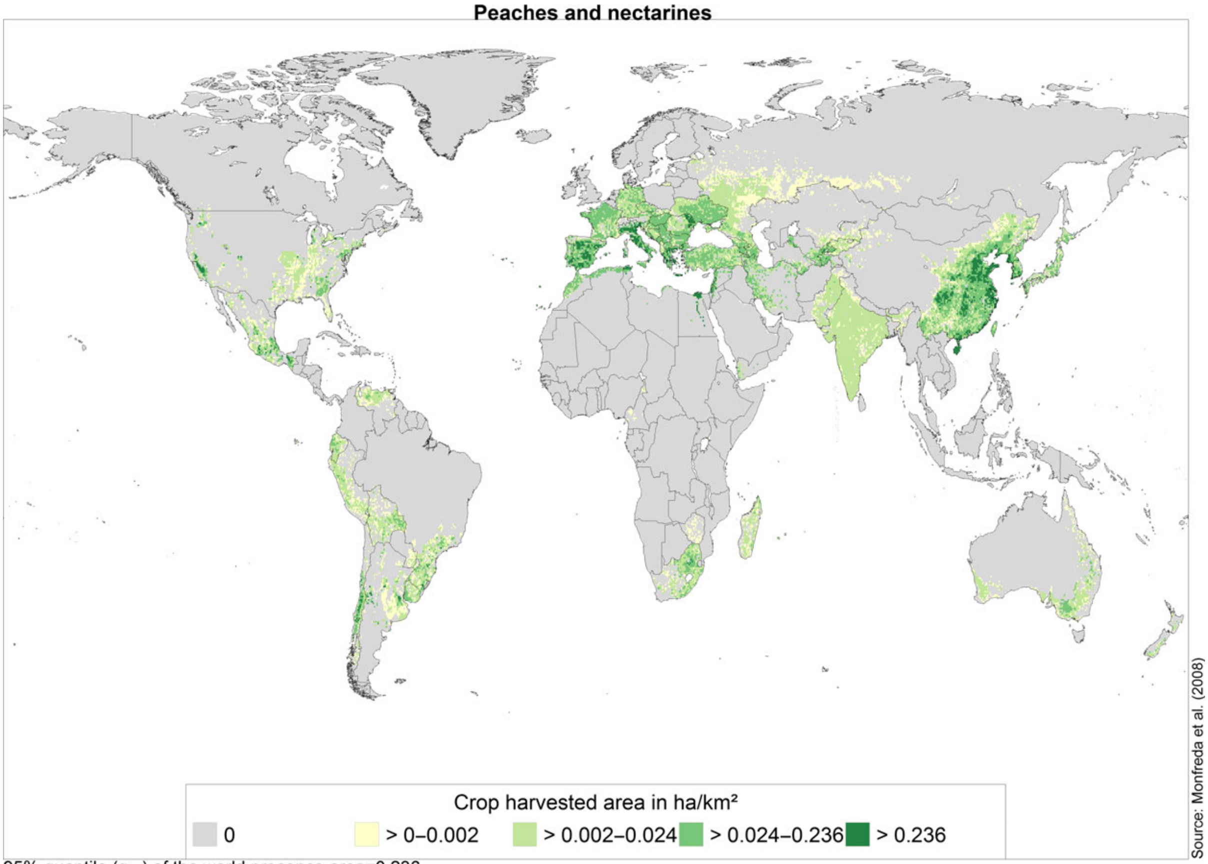

95% quantile ($q_{95}$) of the world presence area=0.399.

## B.4. Global distribution of the density of harvested cherries (ha crop/km$^2$) (source CAPRA database accessed on 23 April 2018)




95% quantile ($q_{95}$) of the world presence area=0.1.

## B.5. Global distribution of the density of harvested peaches and nectarines (ha crop/km²) (source CAPRA database accessed on 23 April 2018)




95% quantile ($q_{95}$) of the world presence area=0.236.