SCIENTIFIC OPINION

Scientific Opinion on the pest categorisation of *Ditylenchus destructor* Thorne[1]

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ABSTRACT

The Panel on Plant Health performed a pest categorisation of *Ditylenchus destructor*, the potato rot nematode. *D. destructor* is listed in Annex II, Part A, Section II of Council Directive 2000/29/EC as a harmful organism known to occur in the Union and relevant for the entire Union. *D. destructor* is a distinct taxonomic entity that can be identified in a straightforward way, and which is present in the majority of EU member states, although sporadically (but data from systematic surveys are lacking). Many hosts of *D. destructor* are present in the RA area and the climatic conditions in the whole risk assessment area are favourable for the completion of the pest life cycle. *D. destructor* can cause significant damage to the below-ground parts (roots, tubers, bulbs) of host crops such as potato and several ornamental plants. However, during recent decades only minor damage has been reported (except in some Eastern European countries). Plants for planting are a pathway for introduction and spread of *D. destructor*, which may cause severe impacts on the intended use of the plants for planting.

KEY WORDS

Ditylenchus destructor, European Union, nematodes, pest categorisation, plant health, potato rot nematode

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BACKGROUND AS PROVIDED BY THE EUROPEAN COMMISSION

The current European Union plant health regime is established by Council Directive 2000/29/EC 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, 10.7.2000, p. 1).

The Directive lays down, amongst others, the technical phytosanitary provisions to be met by plants and plant products 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, the list of harmful organisms whose introduction into or spread within the Union is prohibited and the control measures to be carried out at the outer border of the Union on arrival of plants and plant products.

The Commission is currently carrying out a revision of the regulatory status of organisms listed in the Annexes of Directive 2000/29/EC. This revision targets mainly organisms which are already locally present in the EU territory and that in many cases are regulated in the EU since a long time. Therefore it is considered to be appropriate to evaluate whether these organisms still deserve to remain regulated under Council Directive 2000/29/EC, or whether, if appropriate, they should be regulated in the context of the marketing of plant propagation material, or be deregulated. The revision of the regulatory status of these organisms is also in line with the outcome of the recent evaluation of the EU Plant Health Regime, which called for a modernisation of the system through more focus on prevention and better risk targeting (prioritisation).

In order to carry out this evaluation, a recent pest risk analysis is needed which takes into account the latest scientific and technical knowledge on these organisms, including data on their agronomic and environmental impact, as well as their present distribution in the EU territory. In this context, EFSA has already been asked to prepare risk assessments for some organisms listed in Annex IIAII. The current request concerns 23 additional organisms listed in Annex II, Part A, Section II as well as five organisms listed in Annex I, Part A, Section I, one listed in Annex I, Part A, Section II and nine organisms listed in Annex II, Part A, Section I of Council Directive 2000/29/EC. The organisms in question are the following:

Organisms listed in Annex II, Part A, Section II:

- *Ditylenchus destructor* Thome
- *Circulifer haematoceps*
- *Circulifer tenellus*
- *Helicoverpa armigera* (Hübner)
- *Radopholus similis* (Cobb) Thome (could be addressed together with the HAI organism *Radopholus citrophilus* Huettel Dickson and Kaplan)
- *Paysandisia archon* (Burmeister)
- *Clavibacter michiganensis* spp. *insidiosus* (McCulloch) Davis *et al.*
- *Erwinia amylovora* (Burr.) Winsl. *et al.* (also listed in Annex IIB)
- *Pseudomonas syringae* pv. *persicae* (Prunier *et al.*) Young *et al*.
- *Xanthomonas campestris* pv. *phaseoli* (Smith) Dye
- *Xanthomonas campestris* pv. *pruni* (Smith) Dye Ref. Ares(2014)970361 - 28/03/2014
- *Xylophilus ampelinus* (Panagopoulos) Willems *et al*.
- *Ceratocystis fimbriata* f. sp. *platani* Walter (also listed in Annex IIB)
- *Cryphonectria parasitica* (Murrill) Barr (also listed in Annex IIB)

- *Phoma tracheiphila* (Petri) Kanchaveli and Gikashvili
- *Verticillium albo-atrum* Reinke and Berthold
- *Verticillium dahliae* Klebahn
- Beet leaf curl virus
- Citrus tristeza virus (European isolates) (also listed in Annex IIB)
- Grapevine flavescence dorée MLO (also listed in Annex IIB)
- Potato stolbur mycoplasma
- *Spiroplasma citri* Saglio *et al*.
- Tomato yellow leaf curl virus

Organisms listed in Annex I, Part kA, Section I:

- *Rhagoletis cingulata* (Loew)
- *Rhagoletis ribicola* Doane
- Strawberry vein banding virus
- Strawberry latent C virus
- Elm phloem necrosis mycoplasm

Organisms listed in Annex I, Part A, Section II:

- *Spodoptera littoralis* (Boisd.)

Organisms listed in Annex II, Part A, Section I:

- *Aculops fuchsiae* Keifer
- *Aonidiella citrina* Coquillet
- Prunus necrotic ringspot virus
- Cherry leafroll virus
- *Radopholus citrophilus* Huettel Dickson and Kaplan (could be addressed together with IIAII organism *Radopholus similis* (Cobb) Thome)
- *Scirtothrips dorsalis* Hendel
- *Atropellis* spp.
- *Eotetranychus lewisi* McGregor
- *Diaporthe vaccinii* Shaer.

TERMS OF REFERENCE AS PROVIDED BY THE EUROPEAN COMMISSION

EFSA is requested, pursuant to Article 29(1) and Article 22(5) of Regulation (EC) No 178/2002, to provide a pest risk assessment of *Ditylenchus destructor* Thome, *Circulifer haematoceps, Circulifer tenellus, Helicoverpa armigera* (Hübner), *Radopholus similis* (Cobb) Thome, *Paysandisia archon* (Burmeister), *Clavibacter michiganensis* spp. *insidiosus* (McCulloch) Davis *et al, Erwinia amylovora* (Burr.) Winsl. *et al*, *Pseudomonas syringae pv. persicae* (Prunier *et al)* Young *et al. Xanthomonas campestris* pv. *phaseoli* (Smith) Dye, *Xanthomonas campestris* pv. *pruni* (Smith) Dye, *Xylophilus ampelinus* (Panagopoulos) Willems *et al*, *Ceratocystis fimbriata* f. sp. *platani* Walter, *Cryphonectria* *parasitica* (Murrill) Barr, *Phoma tracheiphila* (Petri) Kanchaveli and Gikashvili, *Verticillium alboatrum* Reinke and Berthold, *Verticillium dahliae* Klebahn, Beet leaf curl virus, Citrus tristeza virus (European isolates), Grapevine flavescence dorée MLO, Potato stolbur mycoplasma, *Spiroplasma citri* Saglio *et al*, Tomato yellow leaf curl virus, *Rhagoletis cingulata* (Loew), *Rhagoletis ribicola* Doane, Strawberry vein banding virus, Strawberry latent C virus, Elm phloem necrosis mycoplasma, *Spodoptera littoralis* (Boisd.), *Aculops fuchsiae* Keifer, *Aonidiella citrina* Coquillet, Prunus necrotic ringspot virus, Cherry leafroll virus, *Radopholus citrophilus* Huettel Dickson and Kaplan (to address with the IIAII *Radopholus similis* (Cobb) Thome), *Scirtothrips dorsalis* Hendel, *Atropellis* spp., *Eotetranychus lewisi* McGregor *md Diaporthe vaccinii* Shaer., for the EU territory.

In line with the experience gained with the previous two batches of pest risk assessments of organisms listed in Annex II, Part A, Section II, requested to EFSA, and in order to further streamline the preparation of risk assessments for regulated pests, the work should be split in two stages, each with a specific output. EFSA is requested to prepare and deliver first a pest categorisation for each of these 38 regulated pests (step 1). Upon receipt and analysis of this output, the Commission will inform EFSA for which organisms it is necessary to complete the pest risk assessment, to identify risk reduction options and to provide an assessment of the effectiveness of current EU phytosanitary requirements (step 2). *Clavibacter michiganensis* spp. *michiganensis* (Smith) Davis *et al.* and *Xanthomonas campestris* pv. *vesicatoria* (Doidge) Dye, from the second batch of risk assessment requests for Annex IIAII organisms requested to EFSA (ARES(2012)880155), could be used as pilot cases for this approach, given that the working group for the preparation of their pest risk assessments has been constituted and it is currently dealing with the step 1 “pest categorisation”. This proposed modification of previous request would allow a rapid delivery by EFSA by May 2014 of the first two outputs for step 1 “pest categorisation”, that could be used as pilot case for this request and obtain a prompt feedback on its fitness for purpose from the risk manager’s point of view.

As indicated in previous requests of risk assessments for regulated pests, in order to target its level of detail to the needs of the risk manager, and thereby to rationalise the resources used for their preparation and to speed up their delivery, for the preparation of the pest categorisations EFSA is requested, in order to define the potential for establishment, spread and impact in the risk assessment area, to concentrate in particular on the analysis of the present distribution of the organism in comparison with the distribution of the main hosts and on the analysis of the observed impacts of the organism in the risk assessment area.

ASSESSMENT

1. Introduction

1.1. Purpose

This document presents a pest categorization prepared by the EFSA Scientific Panel on Plant Health (hereinafter referred to as the Panel) for the species *Ditylenchus destructor* in response to a request from the European Commission.

1.2. Scope

The pest risk assessment area is the territory of the European Union (hereinafter referred to as the EU) with 28 Member States (hereinafter referred to as EU MSs), restricted to the area of application of Council Directive 2000/29/EC, which excludes Ceuta and Melilla, the Canary Islands and the French overseas departments.

2. Methodology and data

2.1. Methodology

The Panel performed the pest categorisation for *Ditylenchus destructor* following the guiding principles and steps presented in the EFSA Guidance on a harmonised framework for risk assessment (EFSA PLH Panel, 2010) and as defined in the International Standard for Phytosanitary Measures No 11 (FAO, 2004).

In accordance with the Guidance on a harmonised framework for pest risk assessment in the EU (EFSA PLH Panel, 2010), this work is initiated as result of the review or revision of phytosanitary policies and priorities. As explained in the background of the European Commission request, the objective of this mandate is to provide updated scientific advice to the European risk managers for their evaluation of whether these organisms listed in the Annexes of the Directive 2000/29/EC still deserve to remain regulated under Council Directive 2000/29/EC, or whether they should be regulated in the context of the marketing of plant propagation material, or be deregulated. Therefore, to facilitate the decision making process, in the conclusions of the pest categorisation, the Panel addresses explicitly each criterion for quarantine pest according to ISPM 11 (FAO, 2013) but also for regulated non quarantine pest according to ISPM 21 (FAO, 2004) and includes additional information required as per the specific terms of reference received by the EC. In addition, for each conclusion the Panel provides a short description of its associated uncertainty.

Table 1 presents the ISPM 11 (FAO, 2013) and ISPM 21 (FAO, 2004) pest categorisation criteria against which the Panel provides its conclusions. It should be noted that the Panel’s conclusions are formulated respecting its remit and particularly with regards to the principle of separation between risk assessment and risk management (EFSA founding regulation), 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, in agreement with the EFSA guidance on the harmonised framework for pest risk assessment (EFSA PLH Panel, 2010).

Table 1: International Standards for Phytosanitary Measures ISPM 11 (FAO, 2013) and ISPM 21 (FAO, 2004) pest categorisation criteria under evaluation

Pest categorisation criteria	ISPM 11 for being a potential quarantine pest	ISPM 21 for being a potential regulated non-quarantine pest
Identity of the pest	The identity of the pest should be clearly defined to ensure that the assessment is	The identity of the pest is clearly defined

Pest categorisation criteria	ISPM 11 for being a potential quarantine pest	ISPM 21 for being a potential regulated non-quarantine pest
	being performed on a distinct organism, and that biological and other information used in the assessment is relevant to the organism in question. If this is not possible because the causal agent of particular symptoms has not yet been fully identified, then it should have been shown to produce consistent symptoms and to be transmissible	
Presence (ISPM 11) or absence (ISPM 21) in the PRA area	The pest should be **absent from all or a defined part of the PRA area**	The pest is **present** in the PRA area
Regulatory status	If the pest is present but not widely distributed in the PRA area, it should be under official control or expected to be under official control in the near future	The pest is under official control (or being considered for official control) in the PRA area with respect to the specified plants for planting
Potential for establishment and spread in the PRA area	The PRA area should have ecological/climatic conditions including those in protected conditions suitable for the establishment and spread of the pest and, where relevant, host species (or near relatives), alternate hosts and vectors should be present in the PRA area	–
Association of the pest with the plants for planting and the effect on their intended use	–	Plants for planting are a pathway for introduction and spread of this pest
Potential for consequences (including environmental consequences) in the PRA area	There should be clear indications that the pest is likely to have an unacceptable economic impact (including environmental impact) in the PRA area	–
Indication of impact(s) of the pest on the intended use of the plants for planting	–	The pest may cause severe economic impact on the intended use of the plants for planting
Conclusion	If it has been determined that the pest has the potential to be a quarantine pest, the PRA process should continue. If a pest does not fulfil all of the criteria for a quarantine pest, the PRA process for that pest may stop. In the absence of sufficient information, the uncertainties should be identified and the PRA process should continue	If a pest does not fulfil all the criteria for an regulated non-quarantine pest, the PRA process may stop

In addition, in order to reply to the specific questions listed in the terms of reference, three issues are specifically discussed only for pests already present in the EU: (1) the analysis of the present EU distribution of the organism in comparison with the EU distribution of its main hosts, (2) the analysis of the observed impact of the organism in the EU and (3) the pest control and cultural measures currently implemented in the EU.

The Panel will not indicate in its conclusions of the pest categorisation whether to continue the PRA process as it is clearly stated in the terms of reference that at the end of the pest categorisation the European Commission will indicate if further risk assessment work is required following their analysis of the Panel's scientific opinion.

2.2. Data

2.2.1. Literature search

An extensive literature search on *D. destructor* was conducted at the beginning of the mandate. Further references and information were obtained from experts and from citations within the references.

2.2.2. Data collection

To complement the information provided by the literature and online databases on pest distribution, damage and management, the PLH Panel sent a short questionnaire on the current situation at country level (based on the information available in the European and Mediterranean Plant Protection Organization Plant Quarantine Retrieval (EPPO PQR) to the National Plant Protection Organization (NPPO) contacts of all the EU MSs. A summary table on the pest status, based on EPPO PQR and MS replies, is presented in section 3.2.2.

Information on the distribution of main host plants was obtained from the EUROSTAT database. The EUROPHYT database was consulted, searching for pest-specific notifications on interceptions. EUROPYHT is a web-based network launched by the Directorate General for Health and Consumers (DG SANCO), and is a sub-project 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.

3. Pest categorisation

3.1. Identity and biology

3.1.1. Taxonomy

3.1.1.1. Nematoda: Tylenchida: Anguinidae

When tuber rot disease was first discovered, its causal organism was identified as *Anguillula dipsaci* Kühn, which became known as *Ditylenchus dipsaci* almost 100 years later (Brodie, 1984). The complexity of the taxon *D. dipsaci* was recognised some time later from research by Thorne (1945), who proposed and described *D. destructor* as a separate species. Much of the earlier literature, therefore, provides information which may not be entirely reliable, particularly in relation to the potato, as this research actually accounts for two species (CABI, 2014).

The genus *Ditylenchus*, with over 90 described species, belongs to the family Anguinidae. Among several genera belonging to this family, *Ditylenchus* spp. have the widest impact on agriculture (Brzeski, 1991; Duncan and Moens, 2006), but only four of them (*D. dipsaci*, *D. destructor*, *D. africanus* and *D. angustus*) are of great economic importance causing considerable damage to a range of cultivated higher plants (Sturhan and Brzeski, 1991; Plowright et al., 2002).

Name:

Ditylenchus destructor Thorne.

Common names:

Potato tuber nematode, potato rot nematode (English). Maladie vermiculaire de la pomme de terre (French). Anguilulosis de la patata, nematodo de la patata (Spanish). Kartoffelkrätzeälchen (German).

Description:

The potato rot nematode, *D. destructor*, is a migratory endoparasite of plants such as potato tubers, stolons, bulbous iris and garlic, invading mainly those parts of the plant below ground, usually with no visible above-ground symptoms (Sturhan and Brzeski, 1991). The nematodes enter tubers through lenticels and multiply rapidly. They produce enzymes, such as amylase and pectinase (Decker, 1969), that digest starch and pectin, leading to cell disintegration. With regard to damage, the potato rot nematode is considered to be the second ranking nematode pest of potato, with potato cyst nematodes ranking first (Brodie, 1984).

D. destructor was originally described by Thorne (1945) in the United States of America and is commonly found in temperate areas such as North America, Europe, central Asia and South Africa. This nematode species is highly polyphagous: it is able to invade and feed on the below ground parts of more than 100 plant species (Sturhan and Brzeski, 1991). All stages of this nematode can be found either in the host plant tissues or in the surrounding soil. The nematode can move into, out of, or within the host tissue (Brodie, 1984). It can continue to live and reproduce within harvested tubers in storage (Brodie, 1984; CABI, 2014). In addition to the economically important host potato, *D. destructor* may feed on many cultivated plants, including a large number of common weeds, and on the mycelium of over 65 species of soil-inhabiting fungi (Brodie, 1984; Esser, 1985; Sturhan and Brzeski, 1991).

3.1.2. Biology

3.1.2.1. Life cycle

D. destructor is an obligate parasite of higher and lower plants. It is a polyphagous nematode attacking and damaging mainly below-ground parts of its host plants (tuber and stolons of potato, bulbs of lilies, rhizomes of mint and roots of hop and lilac). It can also, though seldom, penetrate above-ground plant parts causing dwarfing, thickening and branching of the stem and dwarfing, curling and discoloration of leaves (Sturhan and Brzeski, 1991). On entering a tuber, potato rot nematodes start feeding on the tissue just beneath the skin (Thorne, 1961). Development and reproduction of the nematode occur in the range from 5 to 34 ºC, with an optimum temperature at 20–27 ºC (Sturhan and Brzeski, 1991). *D. destructor* completes its life cycle within 18 days at 27–28 °C, 20–26 days at 20–24 °C and 68 days at 6–10 °C (according to Ladygina, Ustinov and Tereshchenko; cited in Decker, 1969; Sturhan and Brzeski, 1991). According to Safyanov, six to nine generations of *D. destructor* can occur during one potato-growing season in the Almaty region of Kazakhstan (Decker, 1969).

Moist soils are particularly favourable for *D. destructor* as these facilitate development and movement in the soil. The nematode cannot withstand desiccation (Brodie, 1984; CABI, 2014). It has also been reported that this species cannot survive relative humidities below 40 % (Sturhan and Brzeski, 1991). Increased soil moisture is linked to considerable increases in the infection of tubers by this nematode. This is experimentally proved by Ryss, who found that up to 11 %, 62.8 % and 92.7 % of tubers were infested at 40 %, 60 % and 80 % of soil moisture content, respectively (Decker, 1969).

The majority of the life cycle of this species occurs inside the host tissue. After feeding within a host for some time, and being fertilised by a male, females lay eggs throughout the plant tissue while moving from cell to cell. Egg hatch occurs in the spring and larvae are able to invade hosts immediately. *D. destructor* moults a total of four times during its life cycle. After hatching from an egg (first juvenile stage—first moult occurring within the egg), the emergent second-stage juvenile (J2) can immediately invade the host and undergo a series of three moults through the third (J3) and fourth (J4) juvenile stages to reach the adult stage. Once hatched, the juveniles either move throughout the surrounding plant tissue or leave the plant from which they hatched to a nearby, healthy host (CABI, 2014). Potato rot nematodes overwinter on leftover plant debris or in soil as adults or juveniles and may even multiply during a warmer winter by feeding on alternative weed hosts, unharvested potato tubers or soil-inhabiting fungi (Švilponis et al., 2011). This nematode can also overwinter as an egg (CABI/EPPO, 1997). The lethal temperature at which 90 % of a population of potato rot nematodes is killed is higher for adults (–7.4 °C) than for J4 and younger juveniles (–9.4 °C and 14.5 °C, respectively) (Švilponis et al., 2011). Švilponis et al. (2011) also found that the lower lethal temperature for adults was –15 °C and that a few second stage juveniles (J2) were able to survive temperatures as low as –30 °C.

D. destructor is mycophagous and can survive in soil in the absence of host plants by feeding on many soil borne fungi (Sturhan and Brzeski, 1991). It can also live and reproduce in harvested tubers in storage (Brodie, 1984).

Seed potato infected by *D. destructor* is crucial for establishment of new field infestations. This nematode spreads through the stolons from diseased seed tuber to new developing tubers (Decker, 1969). The soil infection route to potato is also important, and weed hosts seem to be important for maintaining nematode soil infestations both inside and outside crop fields (Andersson, 1967). In addition, infested bulbs, rhizomes and roots of other host plants are important sources for establishment of new infestations.

3.1.2.2. Symptomatology

In this section, the symptomatology of *D. destructor*, an important pest of potato tubers in Europe and North America (Duncan and Moens, 2006), is presented. It attacks mainly underground parts of plants, but may occasionally invade above-ground parts; mainly the base of the stem (EPPO, 2008). The nematode first feeds on the roots and later enters potato tubers through lenticels, causing a dry rot of the tubers. After entering the tuber, *D. destructor* feeds and multiplies just below the skin, leading to the development of soft white spots in the tuber tissue surrounded by white rings that are visible when the tuber is peeled. Heavily infested tubers shrink and the outer skin becomes papery and cracked (Figure 1). The tissue below the skin darkens and may become spongy in texture forming lumpy masses. Secondary invasions of bacteria, fungi and free-living nematodes can occur (EPPO, 2008). Tubers in storage may show various types of dry (tubers dry out and harden) or wet rot, which spreads to neighbouring tubers (Sturhan and Brzeski, 1991). Above-ground symptoms caused by potato rot nematodes are usually not very specific, although heavily infested plants are often weaker and smaller and can have smaller, curled or discoloured leaves.

Figure 1: The nematode attack on tuber tissue causes white mealy spots under the skin, and later an expanding dry rot, which makes the tissues dry out and the skin to shrink and crack (plates courtesy of Christer Magnusson; Bioforsk ©)

In ornamental plants such as irises and tulips, symptoms of infested bulbs are similar to those of potatoes, except infection usually occurs at the bulb's base and extends up to the fleshy scales with yellow to dark brown lesions. Secondary rotting may occur destroying the bulbs.

In carrots and sugar beets, transverse cracks in the skin with white patches in the sub-cortical tissue appear. The patches are easily seen in a transverse cut. In the final phase of potato rot nematode infection, colonisation by secondary fungi and bacteria results in decay and rot (Figure 2).

Figure 2: Symptoms on carrots can be seen as external cracks (left-hand panel) and internal white spots at the loci of infections (right-hand panel) (plates courtesy of Christer Magnusson; Bioforsk ©)

3.1.3. Intraspecific diversity

Many authors reported on differences in host range, pathogenicity and virulence among *D. destructor* populations from different hosts. However, so far, no biological races of this nematode have been defined and characterised (Sturhan and Brzeski, 1991). Subbotin et al. (2011) indicated that this nematode might represent a complex of species or subspecies. The same authors concluded that further comprehensive molecular and morphological analyses of different populations of *D. destructor* from different hosts and different geographical regions should be performed to see if this nematode species is indeed polytypic or not.

3.1.4. Detection and identification

To detect the presence of *D. destructor* on potato, tubers should be cut or peeled to look for the characteristic white pockets under the skin in which most of the nematodes are found. Light infections with this nematode can be easily overlooked by visual inspection (Švilponis et al., 2008). Microscopic examination of the nematode is necessary for correct identification of the species. Nematodes should be extracted from plant samples on a Baermann funnel (EPPO, 2013). The mistifier technique, originally described by Seinhorst, can also be used to extract motile nematodes such as *D. destructor* (this technique can provide active nematodes for a longer period). *D. destructor* can also be extracted from soil using the Baermann funnel (EPPO, 2009), but it should be noted that these nematodes are rarely found in soil, unless the soil has been associated with an infested host. After extraction, nematodes must be examined using a high-power microscope (EPPO, 2008).

Morphological examination is the first step in identification (Brzeski, 1998; Plowright et al., 2002). *D. destructor* can readily be identified on morphological criteria. The nematode is 0.7 to 1.9 mm long. Males are morphologically similar to the female, apart from sexual organs. The head of the potato rot nematode is flattened, and continuous with the body contour. The stylet is 10–12 µm long with distinct rounded knobs and the cone is about half of the stylet length. The median oesophageal bulb is muscular, with distinct valves. The posterior bulb overlaps the intestine on the dorsal side for about half of the body width. The lateral field has six incisures. The female reproductive system is prodelphic, composed of a single ovary with oocytes arranged in one to two rows, stretching to the bottom of the oesophagus; a postvulval sac is present and extends about three-quarters of the vulva-anus distance. The testis is also outstretched to a point close to the base of the oesophagus; the 24- to 27-µm-long spicules are ventrally curved with a tubular head. The tail is short, conical with rounded terminus and a bursa surrounding about two-thirds of the tail length (Sturhan and Brzeski, 1991; Brzeski, 1998; EPPO, 2008).

Several molecular methods for identifying *D. destructor* have been developed (EPPO, 2008). Wendt et al. (1993) were first to show by PCR–RFLP (polymerase chain reaction–restriction fragment length polymorphism) of the nuclear rRNA ITS (internal transcribed spacer) region that *D. destructor* can be clearly separated from other *Ditylenchus* species (*D. dipsaci* and *D. myceliophagus*). Recently, several methods using PCR-specific primers designed in the ITS region were developed to detect *D. destructor* (according to Liu et al. and Wan et al.; cited in Marek et al., 2010; Subbotin et al., 2011; Jeszke et al., in press).

3.2. Current distribution

3.2.1. Global distribution

The potato rot nematode, *D. destructor,* has been reported mainly in temperate regions. It has been detected in many parts of Europe and is also known to occur in localised areas in North America (in parts of Canada, the USA and Mexico), Asia, Oceania (restricted distribution in New Zealand) and South Africa (Brodie, 1984; Sturhan and Brzeski, 1991; CABI, 2014) (Table 2 and Figure 3).

Table 2: Current reports of potato rot nematode (*Ditylenchus destructor*) outside the EU

Potato rot nematode	Country	References
D. destructor	ASIA: Azerbaijan, Brunei Darussalam, China (Anhui, Guangdong, Hainan, Hebei, Henan, Hubei, Jiangsu, Liaoning, Shandong), Iran, Japan (Honshu), Kazakhstan, Kyrgyzstan, Malaysia, Pakistan, Saudi Arabia, South Korea, Tajikistan, Turkey, Uzbekistan	EPPO PQR, 2014; CABI, 2014
	AFRICA: South Africa	
	NORTH AMERICA: Canada (British Columbia, Ontario, Prince Edward Island), Mexico, USA (Arkansas, California, Hawaii, Idaho, Indiana, Oregon, South Carolina, Washington, West Virginia, Wisconsin)	
	CENTRAL AMERICA AND CARIBBEAN: –	
	SOUTH AMERICA: Ecuador	
	EUROPE (excluding EU-28): Albania, Belarus, Moldova, Norway, Russian Federation (Central Russia, Northern Russia, Southern Russia), Switzerland, Ukraine	
	OCEANIA: New Zealand	

–, no information available.

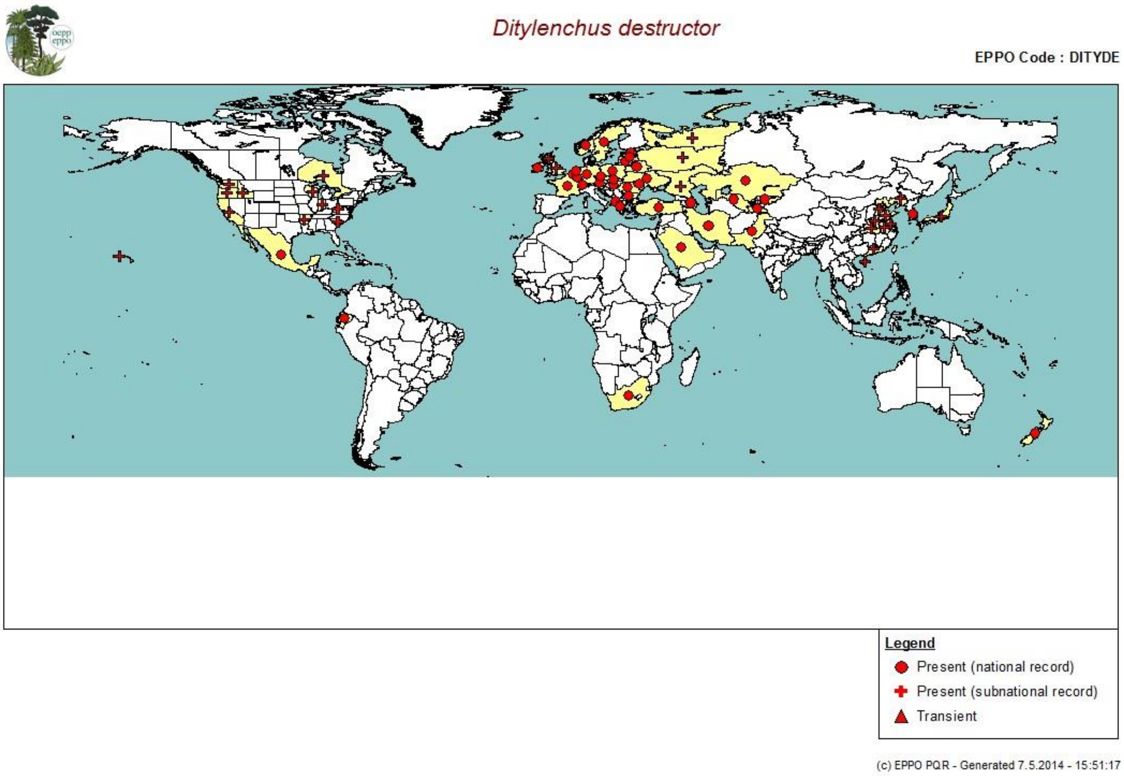

Figure 3: Global distribution of *Ditylenchus destructor* (extracted from EPPO PQR (2014, version 5.3.1.) accessed May 2014). Red circles represent pest presence as national records, red crosses pest presence as subnational records. There are no red triangles (which would indicate transient pest presence) in the figure (note that this figure combines information from different dates, some of which could be out of date)

There are very few EUROPHYT interceptions of *D. destructor* by EU MSs originating from third countries (Table 3). Sometimes *Ditylenchus* species are intercepted but not identified at the species level (Kruus, 2012); therefore, the effective number of interceptions of *D. destructor* could be higher (some of the interceptions of *Ditylenchus* spp. could actually be of *Ditylenchus destructor*).

Table 3: *Ditylenchus destructor* interceptions on consignments from third countries reported in EUROPHYT (data extracted from EUROPHYT (online) 6 June 2014)

Year	Country	Origin	Intercepted commodity
2011	Bulgaria	Turkey	*Solanum tuberosum*
2009	Bulgaria	Turkey	*Solanum tuberosum*
1996	Germany	Malaysia	Unknown

3.2.2. Distribution in the risk assessment area

According to data on the current distribution of *D. destructor* in the risk assessment area received from the EU-28 MSs, Iceland and Norway, the nematode is present in over 66 % of EU MSs. However, in most MSs, this nematode is reported to have a very limited distribution (Table 4).

Table 4: The current distribution of *Ditylenchus destructor* in the risk assessment area, based on answers received from the EU-28 MSs, Iceland and Norway

Member State*	Current situation	Source
Austria	**Present,** restricted distribution	MS questionnaire
Belgium	**Present,** restricted distribution, no records since 2007	MS questionnaire
Bulgaria	**Present**, restricted distribution	MS questionnaire
Croatia	**Absent**	MS questionnaire
Cyprus[(a)]	**Absent**	EPPO PQR (2014)
Czech Republic	**Present**, few occurrences	MS questionnaire
Denmark	**Absent**	MS questionnaire
Estonia	**Present**, restricted distribution	MS questionnaire
Finland	**Absent**, intercepted only	MS questionnaire
France	**Present**, restricted distribution	MS questionnaire
Germany	**Present**, restricted distribution	MS questionnaire
Greece[(a)]	**Present**, restricted distribution	EPPO PQR (2014)
Hungary	**Present**, restricted distribution	MS questionnaire
Ireland[(a)]	**Present**, few occurrences	EPPO PQR (2014)
Italy	**Absent**, intercepted only	MS questionnaire
Latvia [(a)]	**Present**, restricted distribution	EPPO PQR (2014)
Lithuania[(a)]	**Present**, restricted distribution	EPPO PQR (2014)
Luxembourg [(a)]	**Present**, restricted distribution	EPPO PQR (2014)
Malta	**Present**, no details	MS questionnaire
Poland	**Present**, restricted distribution	MS questionnaire
Portugal	**Absent**	MS questionnaire
Romania[(a)]	**Present**, restricted distribution	EPPO PQR (2014)
Slovak Republic	**Present**, restricted distribution	MS questionnaire
Slovenia	**Absent**	MS questionnaire
Spain	**Absent**	MS questionnaire
Sweden	**Present,** few occurrences	MS questionnaire
The Netherlands	**Present**, wherever crops are grown	MS questionnaire
United Kingdom	**Present,** few occurrences	MS questionnaire
Iceland[(a)]	**Absent**, no records	EPPO PQR (2014)
Norway[(a)]	**Present,** few occurrences	EPPO PQR (2014)

(a): When no information was made available to EFSA, the pest status in the EPPO PQR (2014) was used. EPPO PQR, European and Mediterranean Plant Protection Organization Plant Quarantine Data Retrieval System; MS, Member State; NPPO, National Plant Protection Organization.

*Note: the definition of "no pest records" has in some cases been interpreted as "no pest surveys".

There are very few interceptions of *D. destructor* by EU MSs originating from other EU MSs according to EUROPHYT (Table 5). However, several detections have been made in both seed and ware potato in Lithuania and Estonia (Kruus, 2012) indicating that *D. destructor* may be more frequent in some locations.

Table 5: *Ditylenchus destructor* interceptions on consignments originating from EU MSs reported in EUROPHYT (data extracted from EUROPHYT (online) 6 June 2014)

Year	Country	Origin	Intercepted commodity
2013	Poland	Netherlands	*Iris*
2011	Romania	Hungary	*Solanum tuberosum*

3.3. Regulatory status

3.3.1. Legislation addressing *Ditylenchus destructor* (Directive 2000/29/EC)

In some areas of the EU, *D. destructor* may cause considerable damage. It can also affect international trade in certain commodities (especially potatoes). As a serious, harmful organism it is regulated in more than 50 countries (Hockland et al., 2006).

In the EPPO region, *D. destructor* was included on the EPPO A2 quarantine list until 1984, when it was deleted because of its minor importance and very wide distribution throughout the EPPO region (EPPO, 1987; CABI/EPPO, 1997).

In the EU, *D. destructor* is listed in Annex II, Part A, Section II, of Council Directive 2000/29/EC as a harmful organism known to occur in the Union and relevant for the entire Union, whose introduction into, and spread within, all Member States shall be banned if present on flower bulbs and corms of *Crocus* L., miniature cultivars and their hybrids of the genus *Gladiolus* Tourn. ex L., such as *Gladiolus callianthus* Marais, *Gladiolus colvillei* Sweet, *Gladiolus nanus* hort., *Gladiolus ramosus* hort., *Gladiolus tubergenii* hort., *Hyacinthus* L., *Iris* L., *Trigridia* Juss, *Tulipa* L., intended for planting, and potato tubers (*Solanum tuberosum* L.), intended for planting.

3.3.2. Legislation addressing hosts of *Ditylenchus destructor* (Directive 2000/29/EC)

In this section (Tables 6 and 7), the Panel lists only the legislative articles of Annex III and Annex V that are relevant for the cultivated host plants of *D. destructor* mentioned in Annex II, Part A, section II (potato and flower bulbs and corms of *Crocus* L., and miniature cultivars and their hybrids of the genus *Gladiolus* Tourn. ex L., such as *Gladiolus callianthus* Marais, *Gladiolus colvillei* Sweet, *Gladiolus nanus* hort., *Gladiolus ramosus* hort., *Gladiolus tubergenii* hort., *Hyacinthus* L., *Iris* L., *Trigridia* Juss, *Tulipa* L.).

Table 6: Cultivated host plants of *Ditylenchus destructor* and soil and growing medium in Council Directive 2000/29/EC (Annex III)

Annex III, Part A	Plants, plant products and other objects the introduction of which shall be prohibited in all Member States	
10.	Tubers of *Solanum tuberosum* L., seed potatoes	Third countries other than Switzerland
11.	Plants of stolon- or tuber-forming species of *Solanum* L. or their hybrids, intended for planting, other than those tubers of *Solanum tuberosum* L. as specified under Annex III A (10)	Third countries
13.	Plants of Solanaceae intended for planting, other than seeds and those items covered by Annex III A (10), (11) or (12)	Third countries, other than European and Mediterranean countries
14.	Soil and growing medium used as such, which consists in whole or in part of soil or solid organic substances such as parts of plants, humus including peat or bark, other than that composed entirely of peat	Turkey, Belarus, Estonia, Latvia, Lithuania, Moldavia, Russia, Ukraine and third countries not belonging to continental Europe, other than the following: Cyprus, Egypt, Israel, Libya, Malta, Morocco, Tunisia

Annex III, Part A	Plants, plant products and other objects the introduction of which shall be prohibited in all Member States	
Annex IV Part A Section I	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	
Section I	Plants, plant products and other objects originating outside the Community	
34	Soil and growing medium, attached to or associated with plants, consisting in whole or in part of soil or solid organic substances such as parts of plants, humus including peat or bark or consisting in part of any solid inorganic substance, intended to sustain the vitality of the plants, originating in: • Turkey, • Belarus, Georgia, Moldova, Russia, Ukraine, • non-European countries, other than Algeria, Egypt, Israel, Libya, Morocco, Tunisia	Official statement that: (a) the growing medium, at the time of planting, was: • either free from soil, and organic matter, or • found free from insects and harmful nematodes and subjected to appropriate examination or heat treatment or fumigation to ensure that it was free from other harmful organisms, or • subjected to appropriate heat treatment or fumigation to ensure freedom from harmful organisms, and (b) since planting: • either appropriate measures have been taken to ensure that the growing medium has been maintained free from harmful organisms, or • within two weeks prior to dispatch, the plants were shaken free from the medium leaving the minimum amount necessary to sustain vitality during transport, and, if replanted, the growing medium used for that purpose meets the requirements laid down in (a).

Table 7: Cultivated host plants of *Ditylenchus destructor* and soil and growing medium in Council Directive 2000/29/EC (Annex V)

Annex V	Plants, plant products and other objects which must be subject to a plant health inspection (at the place of production if originating in the community, before being moved within the community—in the country of origin or the consignor country, if originating outside the community) before being permitted to enter the community
Part A	Plants, plant products and other objects originating in the community
I.	Plants, plant products and other objects which are potential carriers of harmful organisms of relevance for the entire Community and which must be accompanied by a plant passport
1.3.	Plants of stolon- or tuber-forming species of *Solanum* L. or their hybrids, intended for planting.
3.	Bulbs and corms intended for planting, produced by producers whose production and sale is authorised to persons professionally engaged in plant production, other than those plants, plant products and other objects which are prepared and ready for sale to the final consumer, and for which it is ensured by the responsible official bodies of the Member States, that the production thereof is clearly separate from that of other products of *Camassia* Lindl., *Chionodoxa* Boiss., *Crocus flavus* Weston Golden Yellow., *Galanthus* L., *Galtonia candicans* (Baker) Decne., miniature cultivars and their hybrids of the genus *Gladiolus* Tourn. ex L., such as *Gladiolus callianthus* Marais, *Gladiolus colvillei* Sweet, *Gladiolus nanus* hort., *Gladiolus ramosus* hort. and *Gladiolus tubergenii* hort., *Hyacinthus* L., *Iris* L., *Ismene* Herbert, *Muscari* Miller, *Narcissus* L., *Orinthogalum* L., *Puschkinia* Adams, *Scilla* L. *Tigridia* Juss. and *Tulipa* L.
II	Plants, plant products and other objects which are potential carriers of harmful organisms of relevance for certain protected zones, and which must be accompanied by a plant passport valid

	for the appropriate zone when introduced into or moved within that zone Without prejudice to the plants, plant products and other objects listed in Part I
1.	Plants, plant products and other objects.
1.5	Tubers of *Solanum tuberosum* L., intended for planting.
Part B	Plants, plant products and other objects originating in territories, other than those territories referred to in part A
I	Plants, plant products and other objects which are potential carriers of harmful organisms of relevance for the entire Community
1.	Plants, intended for planting […].
4.	Tubers of *Solanum tuberosum* L.

3.3.3. Legislation addressing hosts in marketing directives

Some of the host plants of *D. destructor* are also regulated under marketing directives of the EU (Table 8).

Table 8: Hosts of *Ditylenchus destructor* object of marketing directives

Plant propagation material	**Marketing directive**
Allium cepa, *Allium sativum*, *Apium graveolens*, *Beta vulgaris*, *Daucus carota*, *Cucumis sativis*, *Cucurbita pepo*, *Raphanus sativus*, *Phaseolus vulgaris*, *Pisum sativum*, *Rheum rabarbarum*, *Solanum melongena*, *Vicia faba*, *Zea mays*	Council Directive 2008/72/EC on the marketing of vegetable propagating and planting material, other than seed
Citrus spp.	Council Directive 2008/90/EC on the marketing of fruit plant propagating material and fruit plants intended for fruit production
Solanum tuberosum	Council Directive 2002/56/EC on the marketing of seed potatoes
Gossypium spp.	Council Directive 2002/57/EC on the marketing of seed of oil and fibre plants
Medicago sativa, *Trifolum repens*	Council Directive 66/401/EEC on the marketing of fodder plant seed
Hordeum spp.	Council Directive 66/402/EEC on the marketing of cereal seed
Ornamental plants including bulb, corm, rhizome and tuber forming plants	Council Directive 98/56/EC on the marketing of propagating material of ornamental plants

3.4. Elements to assess the potential for establishment and spread in the EU

3.4.1. Host range

D. destructor is a polyphagous nematode attacking underground parts of plants such as tubers, bulbs, corms, rhizomes, stolons and roots (Decker, 1969). It has a broad host range and is able to parasitise more than 100 cultivated plants and weeds belonging to a wide variety of families (Decker, 1969; Sturhan and Brzeski, 1991). *D. destructor* is economically most important as a pest of potatoes, although potato is an inferior host. In spite of the damage caused by the nematode infection, the continuous cultivation of potato actually leads to a decrease in the nematode populations (Goodey 1935). *D. destructor* can also damage many other cultivated plant species (Table 9). However, all these hosts differ widely in their susceptibility to the nematode and are not infested to the same extent; some of them (pepper, tomato, pumpkin, cucumber and garlic) may be only slightly infested, while some others (e.g. onion, strawberry, radish, alfalfa, beans) frequently remain unattacked in infested areas (Sturhan and Brzeski, 1991).

Table 9: Overview of cultivated hosts of *Ditylenchus destructor* (Esser, 1985; Sturhan and Brzeski, 1991; CABI, 2014; NEMAPLEX, 2014)

Common name	**Latin name**
Onion	*Allium cepa*
Garlic	*Allium sativum*

Common name	Latin name
Celery	*Apium graveolens*
Groundnut	*Arachis hypogaea*
Begonias	*Begonia* spp.
Sugar beet	*Beta vulgaris*
Chard	*Beta vulgaris* ssp. *cicla*
Tea	*Camellia sinensis*
Canna	*Canna indica*
Chrysanthemum	*Chrysanthemum* spp.
Chick pea	*Cicer arietinum*
Watermelon	*Citrullus lanatus*
Sweet orange	*Citrus sinensis*
Cucumber	*Cucumis sativus*
Pumpkin	*Cucurbita moschata*
Dahlias	*Dahlia* spp.
Carrot	*Daucus carota*
Strawberry	*Fragaria ananassa*
Gladioli	*Gladiolus* spp.
Soybean	*Glycine max*
Cotton	*Gossypium hirsutum*
Sunflower	*Helianthus annuus*
Barley	*Hordeum vulgare*
Hop	*Humulus lupulus*
Hyacinths	*Hyacinthus orientalis*
Sweet potato	*Ipomoea batatas*
Bulbous iris	*Iris* spp.
Alfalfa	*Medicago sativa*
Mints	*Mentha* spp.
Tobacco	*Nicotiana tabacum*
Ginseng	*Panax* spp.
Parsnip	*Pastinaca sativa*
Parsley	*Petroselinum crispum*
Bush bean	*Phaseolus vulgaris*
Pepper	*Piper nigrum*
Pea	*Pisum sativum*
Purslane	*Portulaca* spp.
Radish	*Raphanus sativus*
Rhubarb	*Rheum rabarbarum*
Sugarcane	*Saccharum* spp.
Tomato	*Solanum lycopersicon*
Aubergine	*Solanum melongena*
Sorghum	*Sorghum bicolor*
Clovers	*Trifolium* spp.
Wheat	*Triticum* spp.
Tulips	*Tulipa* spp.
Vetch	*Vicia* spp.
Cowpea	*Vigna unguiculata*
Maize	*Zea mays*

Among weeds and wild plants, *D. destructor* has been recorded to parasitise a variety of species (Table 10).

Table 10: Overview of wild plant hosts of *Ditylenchus destructor* (Esser, 1985; Sturhan and Brzeski, 1991; CABI, 2014; NEMAPLEX, 2014)

Common name	Latin name
Couch grass	*Elytrigia* (=*Agropyron*) *repens*
Love lies bleeding	*Amaranthus caudatus*

Mugwort	*Artemisia vulgaris*
Daisy	*Bellis perenis*
Wintercress	*Barbarea vulgaris*
Shepherd's purse	*Capsella bursa-pastoris*
Lamb's quarters	*Chenopodium album*
Black cohosh	*Cimicifuga racemosa*
Creeping thistle	*Cirsium arvense*
Autumn crocus	*Colchicum speciosum*
Dutch crocus	*Crocus vernus*
Nutgrass	*Cyperus rotundus*
Thorn apple	*Datura stramonium*
Indian goosegrass	*Eleusine indica*
Meadow-fescue	*Festuca pratensis*
Earth smoke	*Fumaria officinalis*
Hairy vetchling	*Lathyrus hirsutus*
Common toadflax	*Linaria vulgaris*
Scentless mayweed	*Matricaria inodora* [*Matricaria perforata*]
Scentless mayweed	*Matricaria maritimum* (=*Tripleurospermum maritimum*)
Yellow sweet clover	*Melilotus officinalis*
Field mint	*Mentha arvensis*
Plantain	*Plantago major*
Silverweed	*Potentilla anserina*
Sorrel	*Rumex* spp.
Narrow-leaf blue-eyed grass	*Sisyrinchium angustifolium*
Grass-leaved goldenrod	*Solidago graminifolia*
Sow thistle	*Sonchus* spp.
Black nightshade	*Solanum nigrum*
Marsh woundwort	*Stachys palustris*
Stinking Roger	*Tagetes minuta*
Dandelion	*Taraxacum officinale*
Tiger flower	*Tigridia* spp.
Wreath nasturtium	*Tropaeolum polyphyllum*
Coltsfoot	*Tussilago farfara*
Common cocklebur	*Xanthium strumarium*

3.4.2. EU distribution of main hosts

Potato is one of the most important staple foods in the world. It is grown in all EU countries and therefore the host is present throughout the EU (Figure 4 and Table 11).

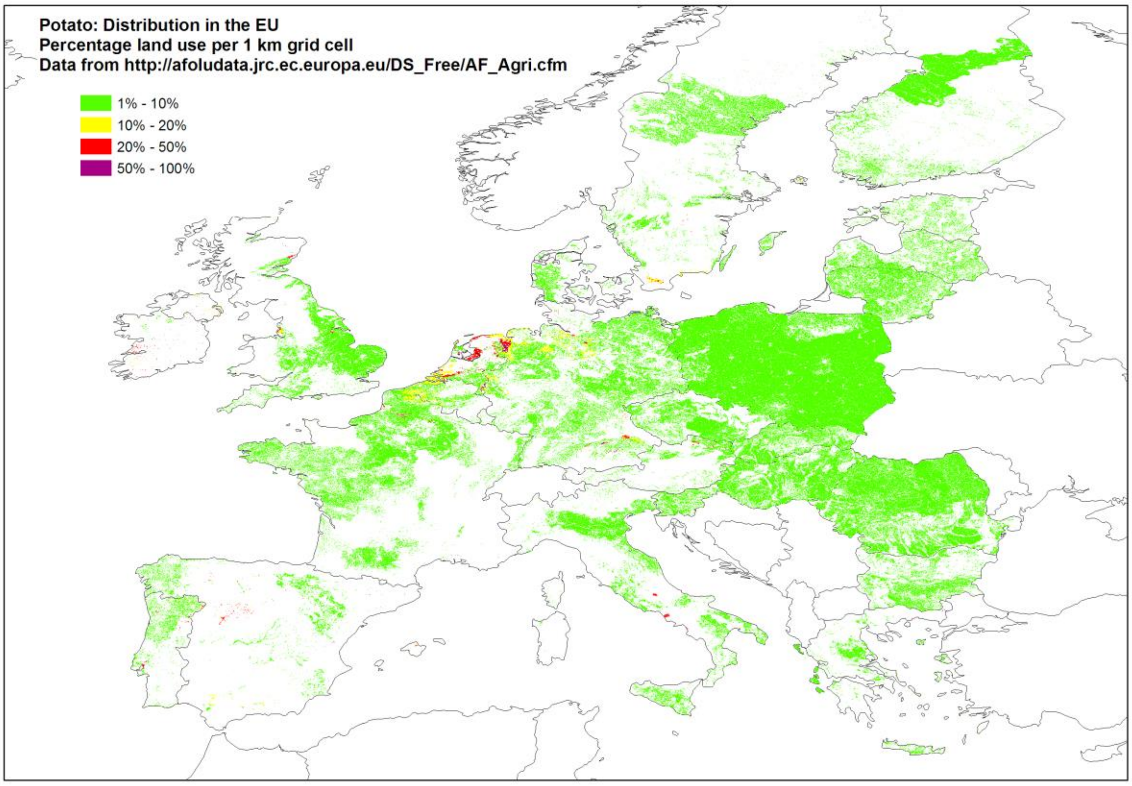

Figure 4: Distribution of potato-growing area in the EU. Source: EFSA PLH Panel (2012)

Table 11: Area of production (in 1000 ha) for potato in 2010–2013, from the EUROSTAT database (Crops products—annual data [apro_cpp_crop], extracted 6 June 2014)

Country/year	2010	2011	2012	2013
Austria	22.0	22.9	21.8	21.1
Belgium	–	82.3	67.0	75.4
Bulgaria	13.8	16.2	14.9	14.0
Croatia	11.0	10.9	10.2	10.0
Cyprus	4.3	4.5	3.9	4.6
Czech Republic	27.1	26.5	23.7	23.2
Denmark	38.4	41.6	39.5	39.8
Estonia	6.1	9.2	5.5	4.6
Finland	25.2	24.4	20.7	22.1
France	157.1	158.6	154.1	160.7
Germany	254.4	258.7	238.3	242.8
Greece	31.4	28.5	24.2	32.7
Hungary	20.8	21.0	25.1	20.3
Ireland	12.2	10.4	9.0	10.4
Italy	62.4	62.1	58.7	38.9
Latvia	18.3	14.4	12.2	12.4
Lithuania	36.2	37.3	31.7	28.2
Luxembourg	0.6	0.6	0.6	0.6
Malta	0.7	0.7	0.7	0.7
Netherlands	157.0	159.2	150.0	155.8
Poland	388.3	393.0	373.0	337.2
Portugal	25.5	26.5	25.1	26.7
Romania	242.1	248.6	228.9	207.0
Slovakia	11.0	10.4	8.9	9.0

Country/year	2010	2011	2012	2013
Slovenia	4.1	3.6	3.4	3.3
Spain	77.4	79.9	72	71.1
Sweden	27.2	27.7	24.7	23.8
United Kingdom	138.0	146.0	149.0	139.0
EU (changing components)		1914	1785	1735

–, data not available.

3.4.3. Analysis of the potential pest distribution in the EU

3.4.3.1. Availability of suitable host plants (outdoors, in protected cultivation or both)

Suitable host plants for *D. destructor* are present in all EU MSs. Potato, which is considered the most economically important host of *D. destructor*, is now, after being introduced into Europe from Peru in 1570 by Spanish conquistadors (Evans et al., 1975), a worldwide crop grown throughout the EU. In addition, many ornamental plants such as bulbous iris, tulips, hyacinths, gladioli and dahlias are cultivated in many EU countries. *D. destructor* has also been reported to attack many other cultivated plants (e.g. alfalfa, barley, clovers, cucumber, garlic, maize, onion, pea, pepper, pumpkin, radish, rhubarb, sorghum, soybean, tomato, wheat) that are widely grown in the EU (see also section 3.4.1). However, all these hosts differ widely in their status as a host for *D. destructor*. Potato rot nematodes can also feed and reproduce on several common weed species that are also distributed through the EU.

D. destructor is well adapted to the life cycle of its hosts, including potato grown within the EU. In the absence of its higher plant hosts, it can survive in the soil, feeding and reproducing on the mycelium of a wide range of soil-inhabiting fungi.

3.4.3.2. Climatic conditions (including protected conditions)

The optimal temperature for infestation by *D. destructor* is reported as 15–20 ºC. However, there is evidence of adaptation of this nematode species to different climatic conditions. Development and reproduction of *D. destructor* may occur in a range between 5 and 34 ºC (Sturhan and Brzeski, 1991). Unlike the closely related species *D. dipsaci*, *D. destructor* lacks a protective resting stage and is unable to survive extended periods of desiccation. It also needs enough moisture and cannot survive relative humidities below 40 % (Sturhan and Brzeski, 1991). Increased soil moisture considerably increases the intensity of infestations. The most serious damage caused by potato rot nematode has been observed at temperatures between 15 and 20 °C and at 90–100 % relative humidity (Sturhan and Brzeski, 1991). *D. destructor* is, therefore, considered an important plant parasite primarily under cool, moist conditions.

Potato rot nematodes overwinter as adults or juveniles and in warmer winters may even multiply by feeding on alternative weed hosts, unharvested potato tubers or soil-inhabiting fungi (Švilponis et al., 2011). This nematode may also overwinter as an egg (CABI/EPPO, 1997). The lethal temperature at which 90 % of population of potato rot nematodes is killed is higher for adults (–7.4 °C) than for J4 and younger juveniles (–9.4 °C and –14.5 °C, respectively). It was also found that the lower lethal temperature for adults was –15 °C and that a few second stage juveniles (J2) were able to survive temperatures as low as –30 °C (Švilponis et al., 2011). This means that the nematodes can survive winter in all agricultural areas used for potato growing.

In conclusion, the climatic conditions in Europe are favourable to *D. destructor* development. All developmental stages of this nematode are able to overwinter successfully throughout the EU.

3.4.3.3. Cultural practices

Cultural practices such as (i) planting of infested planting material (e.g. seed potato, bulbs of ornamental plants), (ii) the use of infested farm equipment and machinery and (iii) flooding irrigation are important in moving nematodes and can greatly contribute to nematode dissemination within and between fields.

Therefore, the use of certified planting material and of disinfected farm equipment and machinery, the avoidance of the movement of infested soil and of flooding irrigation system, can contribute to the control of this pest.

3.4.4. Spread capacity

D. destructor can move actively only over short distances. Its primary means of long-distance dispersal is via infestation of below-ground parts of plants such as tubers, bulbs (especially ornamental plants), rootstock and corms (CABI/EPPO, 1997; CABI, 2014). Transport of infested soil attached to planting material, machinery and vehicles is also an important means of spread of this nematode. Infested tools and machinery can greatly contribute to dissemination of this nematode within a farmer's field, between fields of one farmer and from farm to farm, especially when some of the farm work is carried out by contracted labourers using their own machinery.

Water may also carry the nematode. Therefore, irrigation (or run-off and flooding occurring during a period of heavy rainfall) can contribute considerably to *D. destructor* dispersal (Lehman, 1994). Run-off of rain water may transport nematodes to the ditches alongside the fields and into the irrigation systems. If this water is later used for the irrigation of crops, the nematodes may be carried and distributed to the irrigated fields. Spread of nematodes with run-off rain water is mainly dependent on local climatic conditions and is most pronounced in those areas with high precipitation and frequent showers (EFSA PLH Panel, 2012). The range of dispersal is limited to fields within the vicinity of the infested field and therefore to the local growing area of *D. destructor* host plants.

3.5. Elements to assess the potential for consequences in the risk assessment area

3.5.1. Potential pest effects

The reproductive potential of *D. destructor* is high (Basson et al., 1990). At 28 ºC, its life cycle (from egg to adult) lasts between six and seven days (DeWaele and Wilken, 1990). One female can produce up to 250 eggs (AgroAtlas, 2009). Six to nine generations have been reported to develop in potatoes in the Almaty region (Kazakhstan) during the vegetation period (according to Safyanov; cited in Decker, 1969). Based on these data, it can be assumed that even a small population of *D. destructor,* present in the soil at the beginning of the growing season, could develop into a very large population causing severe damage to infested host plant (Basson et al., 1990).

D. destructor can cause significant damage to the below-ground parts (roots, tubers, bulbs) of host crops such as potato and several ornamental plants. It reduces harvest yields of host crops and causes additional damage during storage. The nematode is widespread and locally damaging and may become a significant pest of potatoes at temperatures of 15–20 °C and at relative humidity above 90 % (CABI, 2014). In the 1950s to 1970s, the potato rot nematode was an important pest of potato in Europe and the USA, but today, as a result of general sanitation measures such as weed control, use of clean planting material and removal of infested tubers from the field, the incidence of *D. destructor* is low and the nematode is of minor importance. In Eastern Europe, however, it causes serious, local economic damage (Sturhan and Brzeski, 1991; Plowright et al., 2002; Švilponis et al., 2011).

In the 1970s, when healthy seed potatoes were planted in infested fields in Sweden, yield losses on potato of 41–70 % due to potato rot nematodes were observed (according to Andersson; cited in CABI, 2014). One of the most severe cases of the progressive dry rot of potato tubers caused by *D. destructor* was recorded in Estonia in the 1960s, where the degree of infestation on farms ranged from 2 to 9 %, but up to 80–90 % of tubers from some fields became infected during storage (according to Kikas; cited in CABI, 2014). Problems caused by the nematode were alleviated in the 1990s using *in vitro* cultivated basic potato seed material. However, 10 years later, *D. destructor* re-appeared as a problem in many locations in Estonia (Švilponis et al. 2008).

In recent years, potato tuber nematodes have seriously damaged sweet potato production in China (according to Lin et al., cited in Plowright et al., 2002) and caused serious problems on iris and garlic crops in Japan (according to Nishizawa, 1999; cited in EPPO, 1999).

There are no expected consequences of potato rot nematode on the environment except as an indirect consequence of damage on the production of potato and several ornamental crops. However, indirect effects may be possible if high levels of nematicides were used in EU MSs for the control of *D. destructor* infestations.

3.5.2. Observed pest impact in the EU

Significant pest impacts on potato production (see previous section) have been reported in the past from several European countries such as Belarus, Estonia, Lithuania, Sweden, and Russia (EPPO, 2005; Švilponis, 2008; Kruus, 2012; CABI, 2014). The most recent report from Lithuania mentions losses of about 942 tonnes of seed potato (8 farms) and about 894 tonnes of ware potato (26 farms) (EPPO, 2005). Of the EU MSs that answered the EFSA questionnaire (about 75 % of MSs; Table 4), only Bulgaria and the Czech Republic reported impacts of *D. destructor*.

3.6. Currently applied control and risk reduction options in the EU

3.6.1. Control methods

3.6.1.1. Agrotechnical control methods

Agrotechnical control methods include methods such as use of uninfested planting materials, removal of crop residue from the fields, proper fertilisation, weed control, use of resistant or tolerant cultivars and crop rotation.

The exclusive use of uninfested, certified potato seed (or other planting material) is essential to prevent the introduction into new areas and further spread of *D. destructor* on potato or other host plants.

Crop rotation and some other management practices affect the vigour of the crop plant as well as *D. destructor* populations within infested fields. Owing to the polyphagous character of *D. destructor*, its control by crop rotation is difficult. However, it was shown that this nematode can be satisfactorily controlled by planting potato in three- to four-year crop rotation with small grains, vetch or lupins (Kiryanova and Krall, 1971). In crop rotation experiments in Lithuania, three years of monoculture of buckwheat, carrots or lupins planted in soil heavily infested with *D. destructor* controlled the nematode so that the potato crop in the fourth year was undamaged (according to Efremenko and Burshtein; cited in CABI, 2014). According to Abylova and Vasilevskii (cited in Whitehead, 1998), a potato rot nematode population was considerably decreased when uninfested potato seed was planted late in the spring as the last crop in the four-crop rotation after rice, lucerne and winter rye, and the daughter tubers were harvested early.

The removal of potato residue and infested volunteer potatoes from the field, as well as other sanitation procedures including weed control, may reduce infestations of *D. destructor*. Weed problems are well-known in organic farming, and the increased occurrence of weeds as a result of increased organic farming could enhance nematode field infestations. On the other hand, the presence of weeds is important for biodiversity conservation and for the biological control of other pests.

It was also shown that amide forms of nitrogenous fertilisers slightly reduced the prevalence of infection of seed potatoes by *D. destructor*, whereas ammonium-nitrate fertilisers favoured nematode multiplication (according to Artem'ev; cited in CABI, 2014). The effect of different concentrations of fertilisers on the area of nematode infestation on the surface of potato tubers, the intensity of tuber respiration and the weight reduction during storage were also measured. Fertiliser levels of N 360, P 240, K 360 over three years showed the lowest loss of tubers during storage. Untreated control tubers showed the highest weight losses and the highest respiration rate (according to Glez; cited in CABI, 2014).

3.6.1.2. Host-plant resistance

So far, resistance to *D. destructor* is the exception among potato cultivars, but partial resistance has been found in some cultivars (Whitehead, 1998). Some commercial potato cultivars have been observed to suffer less damage than the others (Brodie, 1984; Mutua et al., 2011). In cultivation experiments in Poland, the cultivars Belg, Grom, Pimpernel, Robijn and Rode star had only 5 % tuber infestation with up to 10 % of surface damage and were therefore found to be very slightly susceptible to *D. destructor* (according to Stefan; see CABI, 2014; Whitehead, 1998).

Many varieties of sweet potato tested in China were found to be resistant to *D. destructor* (according to Wang et al. and Sun et al.; cited in CABI, 2014).

3.6.1.3. Chemical treatment

Nematicides and soil fumigation can effectively suppress *D. destructor*, but are most effective when combined with cultural practices that reduce nematode populations. Excellent control of *D. destructor* with soil fumigation using ethylene dibromide (EDB) was reported from Wisconsin, USA, in 1953, where the nematode was successfully eradicated (Thorne, 1961) and where, in addition to fumigation, a strict quarantine limiting movement, storage and sales of infected tubers was initiated together with supervision of the disposition of potato tubers from infested fields (Darling et al., 1983). Application of metham-sodium to the soil before planting reduced infestation of harvested tubers from 27.5 to 4 % (according to Adylova and Vasilevskii; cited in CABI, 2014); but in some soils this chemical may be phytotoxic (according to Chukantseva; cited in CABI, 2014). However, soil fumigation is usually uneconomical and for ecotoxicological reasons is no longer recommended (Sturhan and Brzeski, 1991; Whitehead, 1998).

Many other chemicals such as heterophos, fenamiphos, dimethoate and others can also effectively suppress the population of *D. destructor* (CABI, 2014).

When applied to seed tubers, heterophos decreased infestation of daughter tubers and increased their yield (according to Chukantseva; see Whitehead, 1998). The infestation of potato was also reduced when heterophos was applied to soil infested with *D. destructor* (according to Vorona; see Whitehead, 1998). *D. destructor* populations decreased by 37 to 48 % when 10 % Basudin (diazinon) was used (Rasinya, 1972). Fenamiphos, applied as a liquid or granule directly on the bulbs at time of planting, was reported by Haglund (1983) to be effective for the control of *D. destructor* on iris. Applied at planting, oxamyl and carbofuran have also been effective against *D. destructor* on iris (Whitehead, 1998).

EU Directive 91/414/EEC requires that nematicides currently used in potato production are removed from the market by 2014, or their use restricted; thus, there is the need to develop alternative and complementary management methods.

3.6.1.4. Physical control methods

Hot water treatment of infested below-ground plant parts is an important method that can be effectively used for *D. destructor* control. Infested bulbs and tubers may be made free of nematodes by dipping them in hot water at chosen temperatures for a period that is long enough to kill all viable nematodes (Whitehead, 1998). *D. destructor*, for example, may be controlled by immersion of dormant iris and other flower bulbs in hot water at 43.6 °C for three hours (Sturhan and Brzeski, 1991). The nematode can be almost completely eradicated from infested iris bulbs by dipping them in hot water containing formaldehyde at 43.5 °C for three hours. After such treatment, the bulbs should be spread out to cool and dry in a well-ventilated place (Thorne, 1961), but some varieties may be injured during this treatment (CABI, 2014). *D. destructor* infesting garlic bulbs and potato tubers has also been reported to be effectively controlled by dry heat treatment (e.g. dry storage of harvested garlic at temperatures of

34–36 °C for 12–17 days greatly decreased the *D. destructor* population in the tissues) (according to Fujimura et al., cited in Whitehead, 1998; Sturhan and Brzeski, 1991).

3.7. Uncertainty

The main uncertainties relate to the potential consequences for the PRA area. In principle, the pest has the potential to cause considerable damage, but currently and over the last few decades, only minor damage has been reported (see section 3.5.1). There is also medium uncertainty about the environmental consequences of widespread outbreaks of the pest and their control measures.

4. Conclusions

The Panel summarises in Table 12 the conclusions on the key elements addressed in this opinion.

Table 12: The Panel's conclusions on the pest categorisation criteria defined in the International standards for Phytosanitary measures No 11 and No 21, and on the additional questions formulated in the terms of reference

Criterion of pest categorisation	Panel's conclusions against ISPM11 criterion	Panel's conclusions against ISPM21 criterion	List of main uncertainties
Identity of the pest	*Is the identity of the pest clearly defined? Do clearly discriminative detection methods exist for the pest?* *D. destructor* is a true species that is clearly distinguished from other *Ditylenchus* spp. morphologically and by using molecular methods		–
Absence/presence of the pest in the PRA area	*Is the pest absent from all or a defined part of the PRA area?* The nematode is sporadically present in the majority of EU countries and it is not possible to define a part of the PRA area where the pest is absent ('not known to occur' does not imply absence when systematic surveys are lacking)	*Is the pest present in the PRA area?* The nematode is sporadically present in the majority of EU countries	Pest distribution, due to the lack of available data from systematic surveys
Regulatory status	*In consideration that the pest under scrutiny is already regulated just mention in which annexes of 2000/29/EC and the marketing directives the pest and associated hosts are listed without further analysis. (the RM will have to consider the relevance of the regulation against official control)* In the EU, *D. destructor* is listed in Annex II, Part A, Section II of Council Directive 2000/29/EC as a harmful organism known to occur in the Union and relevant for the entire Union. Table 7: Hosts of *D. destructor* are regulated in Council Directive 2000/29/EC (Annex III and V). Given the very polyphagous nature of the pest, it is unlikely that the pest is regulated in all of its hosts		–
Potential establishment and spread	*Does the PRA area have ecological conditions (including climate and those in protected conditions) suitable for the establishment and spread of the pest?* *And, where relevant, are host species (or near relatives), alternate hosts and vectors present in the PRA area?* Many hosts of *D. destructor* are present in the RA area. The	*Are plants for planting a pathway for introduction and spread of the pest?* Plants for planting are a pathway for introduction and spread of *D. destructor*	–

	climatic conditions in the whole RA area support the life cycle of the pest		
Potential for consequences in the PRA area	*What are the potential for consequences in the PRA area?* *Provide a summary of impact in terms of yield and quality losses and environmental consequences* *D. destructor* can cause significant damage to the below-ground parts (roots, tubers, bulbs) of host crops such as potato and several ornamental plants. There are no environmental consequences expected	*If applicable is there indication of impact(s) of the pest as a result of the intended use of the plants for planting?* The pest may cause severe impacts on the intended use of the plants for planting	Lack of data on environmental consequences of widespread outbreaks of the pest and their control measures
Conclusion on pest categorisation	*D. destructor* affects a variety of important hosts and has a wide distribution, although sporadic, in the RA area. Moreover, in the last few decades only minor damage has been reported (except in some East-European countries)	*D. destructor* is sporadically present in the majority of the countries of the RA area, is introduced and spread through the plants for planting pathway and may cause severe damage on the intended use of plants for planting	Pest distribution and environmental consequences
Conclusion on specific ToR questions	*If the pest is already present in the EU, provide a brief summary of* • *the analysis of the present distribution of the organism in comparison with the distribution of the main hosts, and the distribution of hardiness/climate zones, indicating in particular if in the PRA area, the pest is absent from areas where host plants are present and where the ecological conditions (including climate and those in protected conditions) are suitable for its establishment,* *D. destructor* is sporadically present in the majority of EU MSs; it has been reported in more than two-thirds of the EU MSs (including Iceland and Norway). Potato (economically the most important host plant of this nematode) is present throughout the EU. The climatic conditions in Europe are favourable for the completion of the life cycle of *D. destructor*. All developmental stages of this nematode are able to overwinter successfully throughout the EU. Therefore, further spread is potentially possible as (i) *D. destructor* is very polyphagous, (ii) many hosts are traded, (iii) the pest is not present in all EU MSs, and (iv) it is thought to be only sporadically present in the MSs in which it is known to occur. *and* • *the analysis of the observed impacts of the organism in the risk assessment area* In the last few decades, only minor damage due to *D. destructor* has been reported, except in some MSs (e.g. Lithuania).		

MS, Member State; PRA, pest risk assessment; RA, risk assessment; RM, risk manager; ToR, terms of reference.

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ABBREVIATIONS

EFSA:	European Food Safety Authority
EPPO:	European and Mediterranean Plant Protection Organization
EPPO-PQR:	European and Mediterranean Plant Protection Organization Plant Quarantine Retrieval System
EU:	European Union
ISPM:	International Standard for Phytosanitary Measures
MS(s):	Member State(s)
NPPO:	National Plant Protection Organisation
PLH Panel:	Plant Health Panel
PRA:	Pest Risk Assessment
RM:	Risk Manager