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SCIENTIFIC OPINION

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Pest categorisation of *Pyrrhoderma noxium*

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Abstract

Following the commodity risk assessment of bonsai plants (*Pinus parviflora* grafted on *Pinus thunbergii*) from China performed by EFSA, the EFSA Plant Health Panel performed a pest categorisation of *Pyrrhoderma noxium*, a clearly defined plant pathogenic basidiomycete fungus of the order Hymenochaetales and the family Hymenochaetaceae. The pathogen is considered as opportunistic and has been reported on a wide range of hosts, mainly broad-leaved and coniferous woody plants, causing root rots. In addition, the fungus was reported to live saprophytically on woody substrates and was isolated as an endophyte from a few plant species. This pest categorisation focuses on the hosts that are relevant for the EU (e.g. *Citrus, Ficus, Pinus, Prunus, Pyrus, Quercus* and *Vitis vinifera*). *Pyrrhoderma noxium* is present in Africa, Central and South America, Asia and Oceania. It has not been reported in the EU. *Pyrrhoderma noxium* is not included in Commission Implementing Regulation (EU) 2019/2072. Plants for planting (excluding seeds), bark and wood of host plants as well as soil and other growing media associated with plant debris are the main pathways for the entry of the pathogen into the EU. Host availability and climate suitability factors occurring in parts of the EU are favourable for the establishment and spread of the pathogen. The introduction and spread of the pathogen into the EU are expected to have an economic and environmental impact in parts of the territory where hosts are present. Phytosanitary measures are available to prevent the introduction and spread of the pathogen into the EU. *Pyrrhoderma noxium* satisfies all the criteria that are within the remit of EFSA to assess for this species to be regarded as potential Union quarantine pest.

KEYWORDS

avocado, camellia, Diospyros, eucalyptus, Musa, *Phellinus noxius*, root rot

CONTENTS

1 | INTRODUCTION

1.1 | Background and Terms of Reference as provided by the requestor

1.1.1 | Background

The new Plant Health Regulation (EU) 2016/2031, on the protective measures against pests of plants, is applying from 14 December 2019. Conditions are laid down in this legislation in order for pests to qualify for listing as Union quarantine pests, protected zone quarantine pests or Union regulated non-quarantine pests. The lists of the EU regulated pests together with the associated import or internal movement requirements of commodities are included in Commission Implementing Regulation (EU) 2019/2072. Additionally, as stipulated in the Commission Implementing Regulation 2018/2019, certain commodities are provisionally prohibited to enter in the EU (high risk plants, HRP). EFSA is performing the risk assessment of the dossiers submitted by exporting to the EU countries of the HRP commodities, as stipulated in Commission Implementing Regulation 2018/2018. Furthermore, EFSA has evaluated a number of requests from exporting to the EU countries for derogations from specific EU import requirements.

In line with the principles of the new plant health law, the European Commission with the Member States are discussing monthly the reports of the interceptions and the outbreaks of pests notified by the Member States. Notifications of an imminent danger from pests that may fulfil the conditions for inclusion in the list of the Union quarantine pest are included. Furthermore, EFSA has been performing horizon scanning of media and literature.

As a follow-up of the above-mentioned activities (reporting of interceptions and outbreaks, HRP, derogation requests and horizon scanning), a number of pests of concern have been identified. EFSA is requested to provide scientific opinions for these pests, in view of their potential inclusion by the risk manager in the lists of Commission Implementing Regulation (EU) 2019/2072 and the inclusion of specific import requirements for relevant host commodities, when deemed necessary by the risk manager.

1.1.2 | Terms of Reference

EFSA is requested, pursuant to Article 29(1) of Regulation (EC) No 178/2002, to provide scientific opinions in the field of plant health.

EFSA is requested to deliver 53 pest categorisations for the pests listed in Annex 1A, 1B, 1D and 1E (for more details see mandate M-2021-00027 on the Open.EFSA portal). Additionally, EFSA is requested to perform pest categorisations for the pests so far not regulated in the EU, identified as pests potentially associated with a commodity in the commodity risk assessments of the HRP dossiers (Annex 1C; for more details see mandate M-2021-00027 on the Open.EFSA portal). Such pest categorisations are needed in the case where there are not available risk assessments for the EU.

When the pests of Annex 1A are qualifying as potential Union quarantine pests, EFSA should proceed to phase 2 risk assessment. The opinions should address entry pathways, spread, establishment, impact and include a risk reduction options analysis.

Additionally, EFSA is requested to develop further the quantitative methodology currently followed for risk assessment, in order to have the possibility to deliver an express risk assessment methodology. Such methodological development should take into account the EFSA Plant Health Panel Guidance on quantitative pest risk assessment and the experience obtained during its implementation for the Union candidate priority pests and for the likelihood of pest freedom at entry for the commodity risk assessment of High Risk Plants.

1.2 | Interpretation of the Terms of Reference

Phellinus noxius is one of a number of pests listed in Annex 1 to the Terms of Reference (ToR) to be subject to pest categorisation to determine whether it fulfils the criteria of a potential Union quarantine pest for the area of the EU excluding Ceuta, Melilla and the outermost regions of Member States referred to in Article 355(1) of the Treaty on the Functioning of the European Union (TFEU), other than Madeira and the Azores, and so inform EU decision-making as to its appropriateness for potential inclusion in the lists of pests of Commission Implementing Regulation (EU) 2019/2072. If a pest fulfils the criteria to be potentially listed as a Union quarantine pest, risk reduction options will be identified.

Considering the nomenclature provided by Index Fungorum (https://www.indexfungorum.org/; accessed on 1 September 2023) according to which *Pyrrhoderma noxium* is the current name of *Phellinus noxius* on the basis of both morphological and phylogenetic evidence (Zhou et al., 2018) (see Section 3.1.1 on Identity and Taxonomy), the Panel chose to use the name *Pyrrhoderma noxium* instead of *Phellinus noxius* throughout the pest categorisation.

1.3 | Additional information

This pest categorisation was initiated following the commodity risk assessment of bonsai plants (*Pinus parviflora* grafted on *Pinus thunbergii*) from China performed by EFSA (EFSA PLH Panel, 2022), in which *P. noxium* was identified as a relevant non-regulated EU pest, which could potentially enter the EU on bonsai plants.

2 | DATA AND METHODOLOGIES

2.1 | Data

2.1.1 | Information on pest status from NPPOs

In the context of the current mandate, EFSA is preparing pest categorisations for new/emerging pests that are not yet regulated in the EU. When official pest status is not available in the European and Mediterranean Plant Protection Organization (EPPO) Global Database (EPPO, online), EFSA consults the NPPOs of the relevant MSs.

2.1.2 | Literature search

A literature search on *P. noxium* was conducted at the beginning of the categorisation in the ISI Web of Science bibliographic database, using the scientific name of the pest as search term. Papers relevant for the pest categorisation were reviewed, and further references and information were obtained from experts, as well as from citations within the references and grey literature. Pest information on hosts and distribution was retrieved through the systematic literature search, using the EPPO Global Database and CABI (2022) as complementary sources.

2.1.3 | Database search

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 and TRACES databases were 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 as a subproject of PHYSAN (Phyto-Sanitary Controls) specifically concerned with plant health information. TRACES is the European Commission's multilingual online platform for sanitary and phytosanitary certification required for the importation of animals, animal products, food and feed of non-animal origin and plants into the European Union, and the intra-EU trade and EU exports of animals and certain animal products. Up until May 2020, the Europhyt database managed 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 Member States and the phytosanitary measures taken to eradicate or avoid their spread. The recording of interceptions switched from Europhyt to TRACES in May 2020.

GenBank was searched to determine whether it contained any nucleotide sequences for *P. noxium* which could be used as reference material for molecular diagnosis. GenBank® (www.ncbi.nlm.nih.gov/genbank/) is a comprehensive publicly available database that as of August 2019 (release version 227) contained over 6.25 trillion base pairs from over 1.6 billion nucleotide sequences for 450,000 formally described species (Sayers et al., 2020).

2.2 | Methodologies

The Panel performed the pest categorisation for *P. noxium*, following guiding principles and steps presented in the EFSA guidance on quantitative pest risk assessment (EFSA PLH Panel, 2018), the EFSA guidance on the use of the weight of evidence approach in scientific assessments (EFSA Scientific Committee, 2017) and the International Standards for Phytosanitary Measures No. 11 (FAO, 2013).

The criteria to be considered when categorising a pest as a potential Union quarantine pest (QP) is given in Regulation (EU) 2016/2031 Article 3 and Annex I, Section 1 of the Regulation. Table 1 presents the Regulation (EU) 2016/2031 pest categorisation criteria on which the Panel bases its conclusions. In judging whether a criterion is met the Panel uses its best professional judgement (EFSA Scientific Committee, 2017) by integrating a range of evidence from a variety of sources (as presented above in Section 2.1.) to reach an informed conclusion as to whether or not a criterion is satisfied.

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, deemed to be a risk management decision, the Panel will present a summary of the observed impacts in the areas where the pest occurs, and make a judgement about potential likely impacts in the EU. While the Panel may quote impacts reported from areas where the pest occurs in monetary terms, the Panel will seek to express potential EU impacts in terms of yield and quality losses and not in monetary terms, in agreement with the EFSA guidance on quantitative pest risk assessment (EFSA PLH Panel, 2018). Article 3 (d) of Regulation (EU) 2016/2031 refers to unacceptable social impact as a criterion for quarantine pest status. Assessing social impact is outside the remit of the Panel.

TABLE 1 Pest categorisation criteria under evaluation, as derived from 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 (article 3)
Identity of the pest (Section 3.1)	Is the identity of the pest clearly defined, or has it been shown to produce consistent symptoms and to be transmissible?
Absence/presence of the pest in the EU territory (Section 3.2)	Is the pest present in the EU territory? If present, is the pest in a limited part of the EU or is it scarce, irregular, isolated or present infrequently? If so, the pest is considered to be not widely distributed.
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 for entry and spread.
Potential for consequences in the EU territory (Section 3.5)	Would the pests' introduction have an economic or environmental impact on the EU territory?
Available measures (Section 3.6)	Are there measures available to prevent pest entry, establishment, spread or impacts?
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

3 | PEST CATEGORISATION

3.1 | Identity and biology of the pest

3.1.1 | Identity and taxonomy

Is the identity of the pest clearly defined, or has it been shown to produce consistent symptoms and/or to be transmissible?

Yes, the identity of *Pyrrhoderma noxium* is clearly defined and the pathogen has been shown to produce consistent symptoms and to be transmissible.

Pyrrhoderma noxium (Corner) L.W. Zhou & Y.C. Dai is a basidiomycete plant pathogenic fungus of the order Hymenochaetales and family Hymenochaetaceae (Index Fungorum; accessed on 1 September 2023).

This pathogen was first described as *Fomes noxius* by Corner in 1932 (Corner, 1932). It was then renamed as *Phellinus noxius* (Cunningham, 1965), which is the predominant name found in the literature, and thereafter as *Phellinidium noxium* (Bondartseva et al., 1992). More recently, morphological and phylogenetic molecular analysis reassigned *Phellinidium noxium* to the genus *Pyrrhoderma*, as *Pyrrhoderma noxium* (Zhou et al., 2018). Although this is the current name of the fungus (Index Fungorum; accessed on 1 September 2023), the phylogeny and taxonomy of this species should be further analysed (Stewart et al., 2020; Zhou et al., 2018). Indeed, recent phylogenetic analyses based on ITS (internal transcribed spacer) and LSU (28S nuclear large sub-unit) rDNA genes suggest that *Pyrrhoderma noxium* may represent several distinct genetic groups (Garfinkel et al., 2020). Moreover, Stewart et al. (2020) based on their phylogenetic study suggested that *Phellinus noxius* isolates from eastern Asia and Oceania are distinct from *Pyrrhoderma noxium* and that *Phellinus noxius* may represent one or more cryptic species. According to the same authors, these are preliminary results and further analyses were recommended to better resolve *P. noxium* species boundaries. Indeed, the LSU and ITS markers used in the work of Stewart et al. (2020) yield different clustering patterns, with the LSU showing a greater distinction between *Phellinus noxius* and *Pyrrhoderma noxium* than the ITS marker, suggesting that further analyses are needed to better resolve *P. noxium* species boundaries. The EPPO Global Database (EPPO, online) provides taxonomic identification only for the previous name *Phellinus noxius*, as followed:

Preferred name: *Phellinus noxius* (Corner) G. Cunningham
Order: Hymenochaetales
Family: Hymenochaetaceae
Genus: *Phellinus*
Species: *Phellinus noxius*

Nevertheless, in this pest categorisation, the Panel adopted the nomenclature provided by Index Fungorum (https://www.indexfungorum.org/; accessed on 1 September 2023) according to which *Pyrrhoderma noxium* is the current name of *Phellinus noxius* on the basis of both morphological and phylogenetic evidence (Zhou et al., 2018). As explained in Section 1.2, the Panel chose thus to use the name *Pyrrhoderma noxium* to refer to the pathogen throughout the pest categorisation.

Synonyms: *Fomes noxius* Corner (EPPO, online). Additional synonyms listed in Index Fungorum (accessed on 1 September 2023) include *Phellinidium noxium* (Corner) Bondartseva & S. Herrera, and *Phellinus noxius* (Corner) G. Cunn.

The EPPO code[1] (EPPO, 2019; Griessinger & Roy, 2015) for this species is PHELNO (EPPO, online).

3.1.2 | Biology of the pest

Pyrrhoderma noxium is a facultative pathogen that causes brown root-rot on a wide range of plant species, including mostly woody species but also herbaceous ones (see Section 3.1.3). It can also live saprophytically on woody substrates in soil and become a parasite when both favourable environmental conditions and hosts are present (Chang, 1996). In addition, this species has been also isolated as an endophyte from a few plant species (Chen et al., 2011), including rice (Absalan et al., 2023).

Infected roots, stumps and woody debris in the soil are reported as the main source of inoculum for infection and as substrates for the long-term (up to 10 years) survival of *P. noxium* (Chang, 1996). The fungus does not produce any long-lived survival structures, such as chlamydospores (Chang, 1996), and it has limited ability to grow in the soil under field conditions without the presence of woody plant debris (Wu et al., 2020). Therefore, soil without infected woody debris cannot be considered as a long-term reservoir of *P. noxium* inoculum (Wu et al., 2020). Nevertheless, artificial inoculation experiments showed that basidiospores, arthrospores (formed by fragmentation of the mycelium) and mycelia of *P. noxium* can survive in soil up to 4.5 months, 3.5 months and 10 weeks, respectively (Chang, 1996).

Although both basidiospores and arthrospores are apparently not suitable structures for long-term survival, they may play an important role in the long-distance dispersal of *P. noxium* via air currents (Chung et al., 2015). This role is mostly ascribed to basidiospores (Chung et al., 2015), since arthrospores have never been observed in nature (Bolland, 1984), but only in axenic culture (Leung et al., 2020; Sahashi et al., 2012). In contrast, basidiocarps and basidiospores of *P. noxium* have been observed under natural conditions on dead and fallen trees (Chung et al., 2015; Hsiao et al., 2019). Basidiospores of *P. noxium* can be produced on two different types of fructifications, a flat (resupinate) type and a bracket type, with the flat type being the most frequently found in nature (Hsiao et al., 2019). In addition, these basidiospores can be disseminated by wind (Cannon et al., 2022; Chung et al., 2015). Although the majority of basidiospores travel only few metres from the basidiocarps, it is likely that the effective dispersal range of a low number of basidiospores can be higher, reaching several kilometres (Chung et al., 2015). Basidiospores of *P. noxium* can directly infect stumps and lower stem/trunk (less than two metres from the ground) through wounds (Ann et al., 2002; Bolland, 1984; Hsiao et al., 2019).

However, infections by means of *P. noxium* basidiospores can also occur indirectly by first germinating and colonising plant debris in the soil, from which the mycelium grows to infect the lateral and taproots of a neighbouring host plant (Ann et al., 2002; Chung et al., 2015). Indeed, the most common way of infection of *P. noxium* is either between roots of a living tree and infected debris in the soil or root-to-root contact between infected trees and healthy adjacent ones (Ann et al., 2002; Chung et al., 2015). *Pyrrhoderma noxium* can remain viable in fragments of contaminated roots up to 2 years, and inside the root system of dead trees up to 10 years (Chang, 1996).

Infection by *P. noxium* usually begins in the roots. This fungus colonises the root system, grows towards the trunk and covers the stem base and the root collar of the tree with a dark brown to blackish mycelial crust (Bolland, 1984). The growth of this mycelial crust can reach heights up to 5 m, but it is more commonly found in the first 0.3–0.9 m from the tree trunk base (Cannon et al., 2022). During the colonisation, *P. noxium* secretes enzymes that break down the cellulose, haemicellulose and lignin in the woody root tissues, leading to the decay of the root structure (Cannon et al., 2022). This results in a significant reduction in physical support and in disruption of the flow of water and nutrients to the tree, further leading to its decline (Ann et al., 2002). Basidiocarps can develop on standing trees (bracket-like sporocarp) or trees blown down (resupinate-like sporocarp) (Bolland, 1984), especially under warm and humid weather conditions (Wu et al., 2020). Both basidiocarps produce airborne spores that can spread around and infect tree stumps and wounds in living trees, leading to the establishment of new infection sites (Ann et al., 2002; Hsiao et al., 2019; Wu et al., 2020).

Plants of all ages are susceptible to *P. noxium* infection (Ann et al., 2002). Nevertheless, the progression of the disease is generally faster in young trees than in old ones (Gray, 2017). The time from the initial infection to the appearance of visible signs and symptoms of the disease can vary widely depending on various factors, including the host plant species, environmental conditions and virulence of *P. noxium* genotypes (Cannon et al., 2022). In most tree species, it takes 1–2 months from the initial infection for symptoms to become apparent on the host, causing its death within 2–3 months (quick decline) (Ann et al., 2002; Ann, Lee, & Tsai, 1999). However, in some cases, symptoms of *P. noxium*-caused brown root rot disease may occur over periods of a year or more, generally culminating in tree death within 2–3 years (slow decline) (Ann et al., 2002; Ann, Lee, & Tsai, 1999).

In laboratory conditions, and in potato dextrose agar medium, *P. noxium* can grow at temperatures between 12°C and 36°C, with the optimal temperature near 30°C (Ann, Lee, & Huang, 1999), at which growth rate can reach 35 mm/day (Ann

[1]An EPPO code, formerly known as a Bayer code, is a unique identifier linked to the name of a plant or plant pest important in agriculture and plant protection. Codes are based on genus and species names. However, if a scientific name is changed, the EPPO code remains the same. This provides a harmonised system to facilitate the management of plant and pest names in computerised databases, as well as data exchange between IT systems (EPPO, 2019; Griessinger & Roy, 2015).

et al., 2002; Ann, Lee, & Huang, 1999). The fungus does not grow below 8°C or above 36°C (Ann, Lee, & Huang, 1999). *Pyrrhoderma noxium* prefers acid soils, since it has been shown to grow at pH ranging from 3.5 to 7.0, whereas at pH above 7.5, its growth is inhibited in potato dextrose broth (Ann, Lee, & Huang, 1999).

Genomic and transcriptomic studies on *P. noxium* revealed that this pathogen has at least 488 genes that encode plant cell wall-degrading enzymes, with slight differences on their expression during colonisation of different wood substrates (Ibarra Caballero et al., 2020). According to the same authors, these genomic features of *P. noxium* might be responsible for its wide host range and its capacity to quickly kill tree hosts.

3.1.3 | Host range/species affected

Pyrrhoderma noxium is an opportunistic pathogen reported to infect a wide range of plant species (Ann, Lee, & Huang, 1999; Chang, 1995b), including more than 430 species, from 246 genera and 85 families (Appendix A). The list of host plants encompasses mostly broad-leaved and coniferous woody species, and to a lesser extent herbaceous species (Appendix A). The most diversified (with most genera) families among its host range are Fabaceae, Moraceae, Lauraceae, Malvaceae, Euphorbiaceae, Myrtaceae, Meliaceae, Rosaceae, Arecaceae, Rubiaceae, Pinaceae and Rutaceae; while the most diversified (with most species) genera are *Ficus*, *Cinnamomum*, *Macaranga*, *Prunus*, *Acacia*, *Bauhinia*, *Eucalyptus*, *Citrus*, *Diospyros* and *Pinus*.

As shown in Appendix A, *P. noxium* has been mostly associated with tropical and subtropical plant species. However, *P. noxium* hosts also include many plant species with high relevance for the EU, namely *Acacia* spp. (Ann et al., 2002), *Bauhinia* spp. (e.g. Ann et al., 2002), *Citrus* spp. (Stewart et al., 2020; Tsai et al., 2017), *Camellia* spp. (Ann et al., 2002), *Diospyros* spp., including *D. kaki* (Ann et al., 2002; Ann, Lee, & Huang, 1999; Tsai et al., 2017), *Eucalyptus* spp. (Agustini et al., 2014; Ann et al., 2002; Glen et al., 2014; Hsiao et al., 2019), *Ficus* spp. (Ann et al., 2002; Brooks, 2002; Gray, 2017; Hsiao et al., 2019; Tsai et al., 2017), *Musa* spp. (Ivory & Daruhi, 1993; Stewart et al., 2020), *Persea americana* (Ann et al., 2002; Stewart et al., 2020), *Pinus* spp. (Abe et al., 1995; Ann et al., 2002), *Prunus* spp., including *P. armeniaca* (Tsai et al., 2017) and *P. persica* (Akiba et al., 2015; Ann et al., 2002; Tsai et al., 2017), *Pyrus* spp., including *P. communis* (Ann et al., 2002; Tsai et al., 2017), *Quercus* sp. (Chung et al., 2015) and *Vitis vinifera* (Ann et al., 2002; Tsai et al., 2017).

Given that the symptoms of *P. noxium* in the belowground tree parts and lower stem are rather specific and distinct from those of other root rot pathogens (see Section 3.1.5), there is less uncertainty about its host range than for other pathogens where the identification of hosts cannot be based on visual symptoms and molecular methods are needed to confirm host status (e.g. *Pestalotiopsis microspora*). However, it is likely that *P. noxium* can infect other plant species, given the ability of this pathogen to produce a great variety of plant cell wall-degrading enzymes (see Section 3.1.2), and thus enhancing its capacity to infect diverse hosts.

3.1.4 | Intraspecific diversity

Different molecular techniques, such as DNA sequencing and genotyping, have been used to analyse the genetic diversity within and among populations of *P. noxium*. All those studies found high levels of genetic diversity within populations. For example, population genetic analyses of *P. noxium* isolates from Taiwan and Japan, using simple sequence repeat (SSR) markers (Akiba et al., 2015; Chung et al., 2015) and whole-genome sequencing (Chung et al., 2017), revealed a high diversity of genotypes at population level. Similarly, distinct lineages were identified within 95 *P. noxium* isolates from geographically diverse locations across eastern Asia and Oceania, based on sequences of four nuclear DNA loci (Stewart et al., 2020). In contrast to the nuclear genome, the mitochondrial genome of *P. noxium* is nearly identical among isolates at protein-coding regions, but differs greatly in the length of the non-coding regions (i.e. intergenic sequences) (Lee et al., 2019).

There is evidence of mitochondrial exchange between *P. noxium* individual fungal cells, possibly occurring during hyphal fusion and mating (Lee et al., 2019). This exchange of mitochondrial material may lead to the formation of recombinant mitotypes (i.e. new combinations of mitochondrial DNA), potentially giving rise to novel genotypes (Lee et al., 2019). The ability of *P. noxium* to reproduce sexually (Chung et al., 2015, 2017) can also contribute to the increase of genetic diversity within populations. This may have implications on the plasticity and adaptation of the different *P. noxium* genotypes to various adverse environmental conditions, including fungicide exposure. It can also have important implications for *P. noxium* virulence. Indeed, differences in virulence have been detected among isolates of *P. noxium* obtained from either the same or from different host species (Nandris et al., 1987; Sahashi et al., 2010).

3.1.5 | Detection and identification of the pest

Are detection and identification methods available for the pest?

Yes, there are methods available for the detection and identification of *Pyrrhoderma noxium*.

Symptoms and signs

Pyrrhoderma noxium is a pathogen that primarily infects the root system of various tree species, causing brown root-rot (Ann et al., 2002). Trees infected by *P. noxium* often exhibit reduced plant growth, yellowing and wilting of leaves, defoliation, branch dieback, leading eventually to plant death within a few months (quick decline) to several years (slow decline) (Ann et al., 2002; Ann, Lee, & Tsai, 1999; Sahashi et al., 2012). In general, young trees showed more rapid death than older trees (Sahashi et al., 2012). However, these aboveground symptoms can vary greatly depending on the tree species, the age and environmental conditions and are visible only at a later stage of infection (Sahashi et al., 2012). In addition, most of those symptoms are similar to those caused by many root rot pathogens (Sahashi et al., 2012). In contrast, the symptoms of *P. noxium* in the belowground tree parts and lower stem are rather specific and distinct from those of other root rot pathogens. They are typically characterised by a dark brown-blackish thick mycelial sheath or crust formed on the surface of the roots and lower stem of infected trees (Sahashi et al., 2012). This crust/sheath may also have soil particles and small stones stuck to it when *P. noxium* is growing in contact with soil (Sahashi et al., 2012). The internal root tissue is brown at first and then turns white and soft, with a network of dark brown lines all over (Chung et al., 2015). In the advanced stages of decay, a thin white to brown mycelial mat forms between the bark and wood (Sahashi et al., 2012). The presence of *P. noxium* basidiocarps on the basal trunk or exposed roots can also be a sign of brown root-rot disease (Cannon et al., 2022). However, basidiocarps are not always present in natural conditions, especially during dry periods.

Morphology

Pyrrhoderma noxium can be easily isolated on culture media from roots or lower parts of basal stems exhibiting symptoms (Sahashi et al., 2012). A selective medium for *P. noxium* was developed by Chang (1995a), using malt extract agar as a basal medium amended with a set of antibiotics and fungicides. When growing in culture, *P. noxium* colonies exhibit certain characteristics that may aid in its identification. In potato sucrose agar, the mycelial colonies are at first white, turning to brown, with irregular dark brown lines or patches (Sahashi et al., 2012). In potato dextrose agar, the fungus produces brown mycelial colonies with irregular dark brown lines or patches permeating the culture (Ann et al., 2002). Nevertheless, the absence of clamp connections formed during mitosis leading to mycelial growth and the presence of trichocysts (small, hair-like projection on the surface of fungal cell) and arthrospores in culture are the main typical features of *P. noxium* (Figure 1) (Ann, Lee, & Huang, 1999; Sahashi et al., 2012). Other species of *Pyrrhoderma* rarely produce arthrospores in culture (Chung et al., 2015). On the other hand, on sawdust medium, *P. noxium* produces typical basidiocarps, after 3–4 months (Ann, Lee, & Huang, 1999). They are thin (with about 0.5–2.0 cm thick), hard and uneven, first yellowish-brown with a white margin and later become brown-dark grey (Ann et al., 2002; Ann, Lee, & Huang, 1999). Some morphological characteristics of the hymenium and hyphal construction of the basidiocarp can also be used to distinguish *P. noxium* from its closely related species *Pyrrhoderma lamaoense* (Ann et al., 2002). *Pyrrhoderma noxium* can be distinguished from *P. lamaoense* by having wide setal hyphae (specialised structures distinguished from the vegetative hyphae mostly by thickened walls) and the absence of setae (thick-walled cystidia) in the hymenium (see Figure 2 in Leung et al., 2020 for morphology pictures of *P. noxium* examined by light microscopy and scanning electron microscopy) (Abe et al., 1995; Ann et al., 2002; Leung et al., 2020). The basidiospores of *P. noxium* are smooth, hyaline and ovoid to broadly ellipsoid, averaging from 4.0 × 3.8 μm to 6.0 × 4.8 μm (Ann, Lee, & Huang, 1999). A more detailed morphological description of *P. noxium* is provided by Abe et al. (1995) and CABI (2022).

DNA-based identification

The molecular techniques available for the identification of *P. noxium* are mostly based on the sequencing of the internal transcribed spacers (ITS) of genomic rDNA, in particular the region ITS1–5.8S–ITS2, the nuclear large subunit rDNA (nrLSU) and protein-coding genes like the translation elongation factor 1-alpha (EF1-α) or the second largest subunits of RNA polymerase II (RPB2) (Leung et al., 2020; Stewart et al., 2020; Tsai et al., 2017). As for other fungi, the combined use of these genetic markers, often increase the accuracy of the identification and provides the resolution needed to separate *P. noxium* from closely related species. Moreover, species-specific primers based on the ITS region of rDNA were developed for *P. noxium* (Tsai et al., 2007; Wu et al., 2009). The presence and abundance of *P. noxium* in root tissues can also be evaluated by quantitative real-time PCR (Liu et al., 2022) using the specific primers G1F (5′-GCCCTTTCCTCCGCTTATTG-3′) and G1R2 (5′-ATTGGACTTGGGGACTGC-3′) targeting the ITS region (228 bp) developed by Wu et al. (2011). Nucleotide sequences and whole genome of *P. noxium* are available in GenBank (www.ncbi.nlm.nih.gov/genbank; 815 sequences retrieved on 5 October 2023) and could be used as reference material for molecular diagnosis.

More recently, loop-mediated isothermal amplification (LAMP) was developed as a diagnostic tool to detect and identify *P. noxium* in culture (mycelium) and in wood chips (Zhang et al., 2022).

No EPPO Standard is available for the detection and identification of *P. noxium*.

3.2 | Pest distribution

3.2.1 | Pest distribution outside the EU

Pyrrhoderma noxium has been reported to be present in Central (Costa Rica, Cuba, Panama, Puerto Rico) and South America (Brazil, Peru), Africa (Angola, Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Democratic Republic of the Congo, Gabon, Ghana, Guinea, Ivory Coast, Kenya, Liberia, Mali, Mauritania, Nigeria, Senegal, Sierra Leone, Tanzania, Togo, and Uganda), Asia (China, Hong Kong, India, Indonesia, Japan, Malaysia, Myanmar, Pakistan, Philippines, Singapore, Sri Lanka, Taiwan, Thailand, and Vietnam) and Oceania [American Samoa, Australia, Federated Stated of Micronesia (Chuuk, Kosrae, Pohnpei, Yap), Fiji, French Polynesia, Guam, Mariana Island, Niue, Papua New Guinea, Republic of Palau, Republic of Vanuatu, Rota Island, Saipan, Samoa and Solomon Islands]. The current geographical distribution of *P. noxium* is shown in Figure 1. A list of the countries and states/provinces from where the fungus has been reported is included in Appendix B. The records are based on the systematic literature search (Section 2.1.2), including information from CABI (2022).

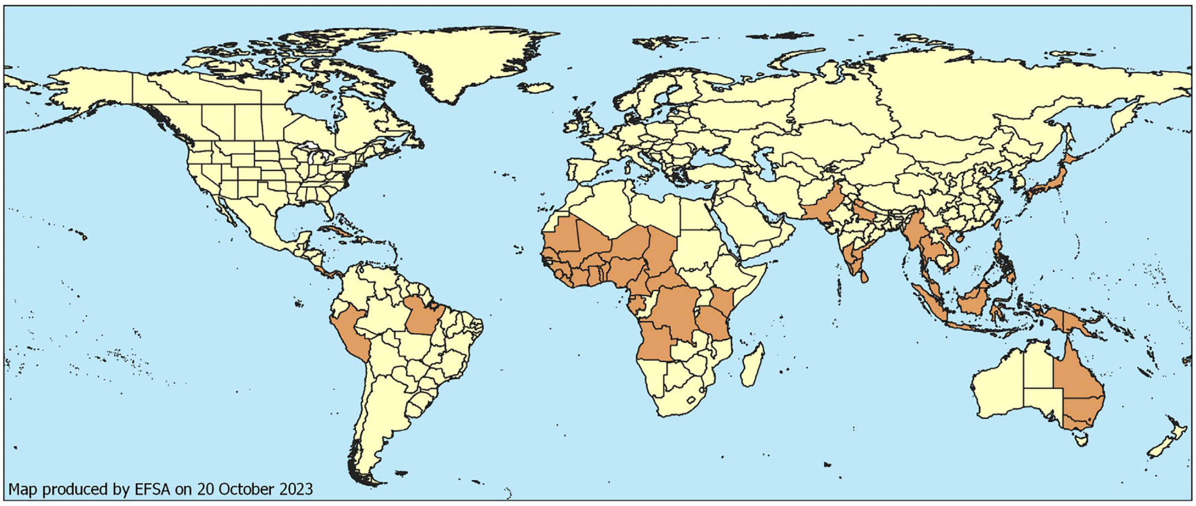


FIGURE 1 Global distribution of *Pyrrhoderma noxium*. Sources: systematic literature review (Section 2.1.2) and CABI (2022) (see Appendix B).

3.2.2 | Pest distribution in the EU

*Is the pest present in the EU territory? If present, is the pest in a limited part of the EU or is it scarce, irregular, isolated or present infrequently? If so, the pest is considered to be not widely distributed***.**

No. *Pyrrhoderma noxium* is not known to be present in the EU.

3.3 | Regulatory status

3.3.1 | Commission Implementing Regulation 2019/2072

Pyrrhoderma noxium is not listed in Annex II of Commission Implementing Regulation (EU) 2019/2072, an implementing act of Regulation (EU) 2016/2031, or in any emergency plant health legislation.

3.3.2 | Hosts or species affected that are prohibited from entering the union from third countries

A list of commodities included in Annex VI of Commission Implementing Regulation (EU) 2019/2072 is provided in Table 2. Some of the hosts relevant to the EU, *Persea americana, Diospyros* spp., *Prunus* spp. and *Quercus* spp., are included in the Commission Implementing Regulation (EU) 2018/2019 on high-risk plants.

TABLE 2 List of plants, plant products and other objects that are *Pyrrhoderma noxium* hosts whose introduction into the Union from certain third countries is prohibited (Source: Commission Implementing Regulation (EU) 2019/2072, Annex VI).

List of plants, plant products and other objects whose introduction into the union from certain third countries is prohibited			
	Description	**CN code**	**Third country, group of third countries or specific area of third country**
1.	Plants of […] *Pinus* L., […] other than fruit and seeds	ex 0602 20 20 ex 0602 20 80 ex 0602 90 41 ex 0602 90 45 ex 0602 90 46 ex 0602 90 47 ex 0602 90 50 ex 0602 90 70 ex 0602 90 99 ex 0604 20 20 ex 0604 20 40	Third countries other than: Albania, Andorra, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Canary Islands, Faeroe Islands, Georgia, Iceland, Liechtenstein, Moldova, Monaco, Montenegro, North Macedonia, Norway, Russia (only the following parts: Central Federal District (Tsentralny federalny okrug), Northwestern Federal District (Severo-Zapadny federalny okrug), Southern Federal District (Yuzhny federalny okrug), North Caucasian Federal District (Severo-Kavkazsky federalny okrug) and Volga Federal District (Privolzhsky federalny okrug)), San Marino, Serbia, Switzerland, Türkiye and Ukraine
2.	Plants of […] and *Quercus* L., with leaves, other than fruit and seeds	ex 0602 10 90 ex 0602 20 20 ex 0602 20 80 ex 0602 90 41 ex 0602 90 45 ex 0602 90 46 ex 0602 90 48 ex 0602 90 50 ex 0602 90 70 ex 0602 90 99 ex 0604 20 90 ex 1404 90 00	Third countries other than: Albania, Andorra, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Canary Islands, Faeroe Islands, Georgia, Iceland, Liechtenstein, Moldova, Monaco, Montenegro, North Macedonia, Norway, Russia (only the following parts: Central Federal District (Tsentralny federalny okrug), Northwestern Federal District (Severo-Zapadny federalny okrug), Southern Federal District (Yuzhny federalny okrug), North Caucasian Federal District (Severo-Kavkazsky federalny okrug) and Volga Federal District (Privolzhsky federalny okrug)), San Marino, Serbia, Switzerland, Turkey and Ukraine
5.	Isolated bark of *Quercus* L., other than *Quercus suber* L.	ex 1404 90 00 ex 4401 40 90	Canada, Mexico, United States
9.	Plants for planting of […] *Prunus* L. and *Pyrus* L. and their hybrids […], other than seeds	ex 0602 10 90 ex 0602 20 20 ex 0602 90 30 ex 0602 90 41 ex 0602 90 45 ex 0602 90 46 ex 0602 90 48 ex 0602 90 50 ex 0602 90 70 ex 0602 90 91 ex 0602 90 99	Third countries other than Albania, Algeria, Andorra, Armenia, Australia, Azerbaijan, Belarus, Bosnia and Herzegovina, Canada, Canary Islands, Egypt, Faeroe Islands, Georgia, Iceland, Israel, Jordan, Lebanon, Libya, Liechtenstein, Moldova, Monaco, Montenegro, Morocco, New Zealand, North Macedonia, Norway, Russia (only the following parts: Central Federal District (Tsentralny federalny okrug), Northwestern Federal District (Severo- Zapadny federalny okrug), Southern Federal District (Yuzhny federalny okrug), North Caucasian Federal District (Severo-Kavkazsky federalny okrug) and Volga Federal District (Privolzhsky federalny okrug)), San Marino, Serbia, Switzerland, Syria, Tunisia, Turkey, Ukraine, the United Kingdom (1) and United States other than Hawaii
10.	Plants of *Vitis* L., other than fruits	ex 0602 10 10 ex 0602 20 10 ex 0604 20 90 ex 1404 90 00	Third countries other than Switzerland
11.	Plants of *Citrus* L., [………], and their hybrids, other than fruits and seeds	ex 0602 10 90 ex 0602 20 20 ex 0602 20 30 ex 0602 20 80 ex 0602 90 45 ex 0602 90 46 ex 0602 90 47 ex 0602 90 50 ex 0602 90 70 ex 0602 90 91 ex 0602 90 99 ex 0604 20 90 ex 1404 90 00	All third countries
20.	Growing medium as such, other than soil, consisting in whole or in part of solid organic substances, other than that composed entirely of peat or fibre of *Cocos nucifera* L., previously not used for growing of plants or for any agricultural purposes	ex 2530 10 00 ex 2530 90 00 ex 2703 00 00 ex 3101 00 00 ex 3824 99 93	Third countries other than Switzerland

3.4 | Entry, establishment and spread in the EU

3.4.1 | Entry

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

Yes. *Pyrrhoderma noxium* could potentially enter the EU, mainly via host plants for planting (excluding seeds for sowing), parts of host plants (e.g. branches, bark, wood), and soil/plant growing media associated with debris of host plants.

Comment on plants for planting as a pathway.

Plants for planting are a main pathway of entry of the pathogen into the EU.

The Panel identified the following main pathways for the entry of *P. noxium* into the EU territory:

1. host plants for planting (excluding seeds for sowing),
2. bark and wood (timber, logs, sawdust, wooden pallets) of host plants, and
3. soil and other plant growing media associated with infected host plant debris, all originating in infested third countries.

Pyrrhoderma noxium is reported to infect the roots, base stem/trunk and root collar of plants (Section 3.1.2 Biology of the pest). Thus, the pathogen could potentially enter into the EU territory on plant parts (e.g. stems). However, this is considered a minor pathway for the entry of the pathogen into the EU.

Although there are no data available, basidiospores (and arthrospores if they are produced in natural conditions) of the pathogen may also be present as contaminants on other substrates or objects (e.g. second hand agricultural machinery and equipment, crates, fresh fruit, etc.) imported into the EU from infested countries. Nevertheless, these are considered minor pathways for the entry of the pathogen into the EU.

A list of all the potential pathways for the entry of the pathogen into the EU is included in Table 3.

TABLE 3 Potential pathways for entry of *Pyrrhoderma noxium* into the EU.

Pathways (e.g. host/intended use/source)	Life stage	Relevant mitigations (e.g. prohibitions [Annex VI], special requirements [Annex VII] or phytosanitary certificates [Annex XI] within Implementing Regulation 2019/2072)
Host plants for planting, other than seeds	Mycelium, basidiospores, arthrospores (if any)	Several main hosts identified in Section 3.1.3 are included in Commission Implementing Regulation 2019/2072. There is a temporary prohibition for high-risk plants (Regulation 2018/2019)
Parts of host plants, other than fruits and seeds (stems, roots)	Mycelium, basidiospores, arthrospores (if any)	A phytosanitary certificate is required for the introduction into the Union from third countries other than Switzerland, of parts of host plants other than fruits and seeds (Annex XI, Part B of Commission Implementing Regulation (EU) 2019/2072)
Soil as such not attached or associated with plants for planting	Mycelium, basidiospores, arthrospores (if any)	The introduction into the Union from third countries, other than Switzerland, of soil as such consisting in part of solid organic substances is banned (Annex VI (19) of Commission Implementing Regulation (EU) 2019/2072)
Growing medium as such, other than soil not attached or associated with plants for planting	Mycelium, basidiospores, arthrospores (if any)	A phytosanitary certificate is required for the introduction into the Union from third countries, other than Switzerland, of growing medium attached to or associated with plants, intended to sustain the vitality of the plants (Annex XI, Part A (1) of Commission Implementing Regulation (EU) 2019/2072). Special requirements also exist for this commodity (Annex VII (1) of Commission Implementing Regulation (EU) 2019/2072)
Growing medium, attached to or associated with host and non-host plants for planting carrying infected plant debris, with the exception of sterile medium of in vitro plants	Mycelium, basidiospores, arthrospores (if any)	A phytosanitary certificate is required for the introduction into the Union from third countries, other than Switzerland, of growing medium attached to or associated with plants, intended to sustain the vitality of the plants (Annex XI, Part A (1) of Commission Implementing Regulation (EU) 2019/2072). Special requirements also exist for this commodity (Annex VII (1) of Commission Implementing Regulation (EU) 2019/2072)
Machinery and vehicles with contaminated soil and/or infected debris of host plants	Mycelium, basidiospores, arthrospores (if any)	A phytosanitary certificate is required for the introduction into the Union from third countries, other than Switzerland, of machinery and vehicles (Annex XI, Part A (1) of Commission Implementing Regulation (EU) 2019/2072). Special requirements also exist for this commodity (Annex VII (2) of Commission Implementing Regulation (EU) 2019/2072)

The quantity of fresh produce of main hosts imported into the EU from countries where *P. noxium* is present is provided in Table 4.

TABLE 4 EU annual imports of fresh produce of main hosts from countries where *P. noxium* is present, 2016–2020 (in 100 kg) Source: Eurostat, accessed November 2023.

Commodity	HS code	2016	2017	2018	2019	2020
Live forest trees	0602 90	56	98	243	138	88

Notifications of interceptions of harmful organisms began to be compiled in Europhyt in May 1994 and in TRACES in May 2020. As of Nov 2023, there were no record of interception of *Pyrrhoderma noxium* in the Europhyt and TRACES databases.

3.4.2 | Establishment

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

Yes. Both the biotic (host availability) and abiotic (climate suitability) factors occurring in the EU suggest that *P. noxium* could establish in parts of the EU where hosts are grown.

Following its entry into the EU, *P. noxium* could establish in parts of the EU where hosts are grown and the climatic conditions are conducive to completing its life cycle. Based on its biology (see Section 3.1.2), *P. noxium* could potentially be transferred from the pathways of entry to the host plants grown in the EU by root-to-root contact, wind, water (irrigation, rain) splash, soil or other plant-growing media associated with infected plant debris, and possibly insects, as well as with birds and small mammals (see Section 3.4.3). The frequency of this transfer depends on the volume and frequency of the imported commodities, their destination (e.g. nurseries, retailers, packinghouses) and proximity to the hosts, as well as on the management of plant debris.

Climatic mapping is the principal method for identifying areas that could provide suitable conditions for the establishment of a pest taking key abiotic factors into account (Baker, 2002). Availability of hosts is considered in Section 3.4.2.1. Climatic factors are considered in Section 3.4.2.2.

3.4.2.1 | *EU distribution of main host plants*

As noted above and shown in Appendix A, *P. noxium* has a wide host range, also considering that it is able to colonise several of those plant species endophytically or to survive as a saprophyte in dead plant debris. Some of its main hosts (e.g. *Citrus* spp., *Prunus* spp., *Pyrus* spp., including *P. communis*, *Quercus* sp., and *Vitis vinifera*; see Section 3.1.3) are widely distributed in the EU, both in commercial production (nurseries, open fields, orchards) and in home gardens, parks or forests. The harvested area of most of the main hosts of *P. noxium* cultivated in the EU in recent years is shown in Table 5.

TABLE 5 Harvested area of some *Pyrrhoderma noxium* hosts relevant for the EU, 2017–2021 (1000 ha). Source: EUROSTAT (accessed November 2023).

Crop	Code	2017	2018	2019	2020	2021
Grapes	W1000	3133.32	3135.50	3155.20	3146.24	3120.22
Citrus fruits	T0000	502.84	508.99	512.83	522.10	519.96
Peaches/nectarines	F1210 F1220	221.64	214.97	206.87	203.32	194.01
Cherries	F1240	173.37	175.49	176.30	178.61	175.71
Pears	F1120	113.81	113.54	110.66	108.29	106.96
Apricots	F1230	72.23	72.57	73.22	76.13	73.48
Avocados	F2300	12.72	13.22	17.50	19.58	22.86
Bananas	F2400	18.91	17.94	18.27	22.11	22.01

3.4.2.2 | *Climatic conditions affecting establishment*

Based on the data available in the literature on the geographical coordinates of the locations from where *P. noxium* has been reported, the pathogen is present in non-EU areas with BSh, Cfa and Cfb, Köppen–Geiger climate zones. These climate zones also occur in the EU, where hosts of *P. noxium* are grown (Appendix D). Appendix D also provides a Koeppen–Geiger map based on all *P. noxium* records, also those without local coordinates. For a more accurate description of geographical areas suitable for establishment, a hardiness zone map was generated. This map is based on the 30-year average absolute minimum temperature and suggests that *P. noxium* would be able to establish in the EU, although in a restricted area along the Mediterranean (Figure 2). In addition, soil temperature maps (Figures 3 and 4) based on the temperature range (12–36°C) that allow *P. noxium* to grow (Ann, Lee, & Huang, 1999) also suggest that there are areas in the EU (coastal areas in Mediterranean countries) suitable for the establishment of this pathogen.

Regarding the interpretation of the soil temperature map, it should be kept in mind that:

- *P. noxium* is not a strict soilborne pathogen (freely living in the soil), but it is rather associated with plant/wood debris incorporated in the soil;
- The temperature data refer to the top layer of soil (0–7 cm), while most ot the roots of trees, and therefore pathogen inoculum, are expected to be present deeper in the soil, where temperatures may be different;
- Mycelial growth temperatures could be important to estimate the likelihood of establishment in this case (e.g. root-to-root transmission), but temperatures allowing the development of fruiting bodies and sporulation would be even more important. However, in this last case, the air temperature rather than the soil temperature would play a role, but this could be covered by the hardiness zone map (Figure 3).

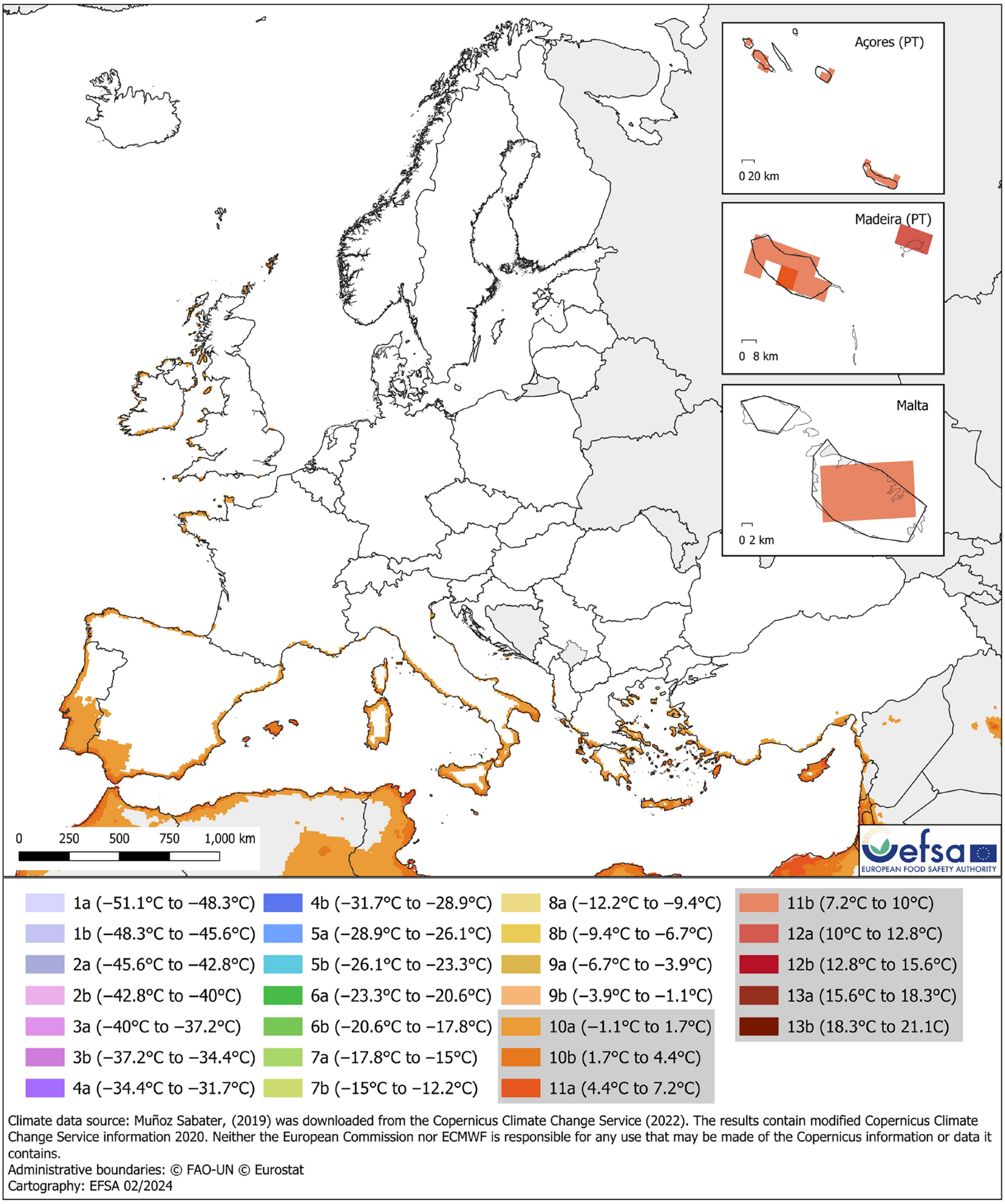


FIGURE 2 Hardiness zone map based on the average annual minimum temperature for the period 1993–2022. The map highlights the hardiness zones in Europe and some neighbouring areas where the average minimum temperature is higher or equal to the minimum value sampled using the pathogen occurrence. This value is included in the hardiness zones ≥ 10a (highlighted in grey in the legend). The map is based on the implementation of the USDA Plant Hardiness Zones (USDA, 2023).

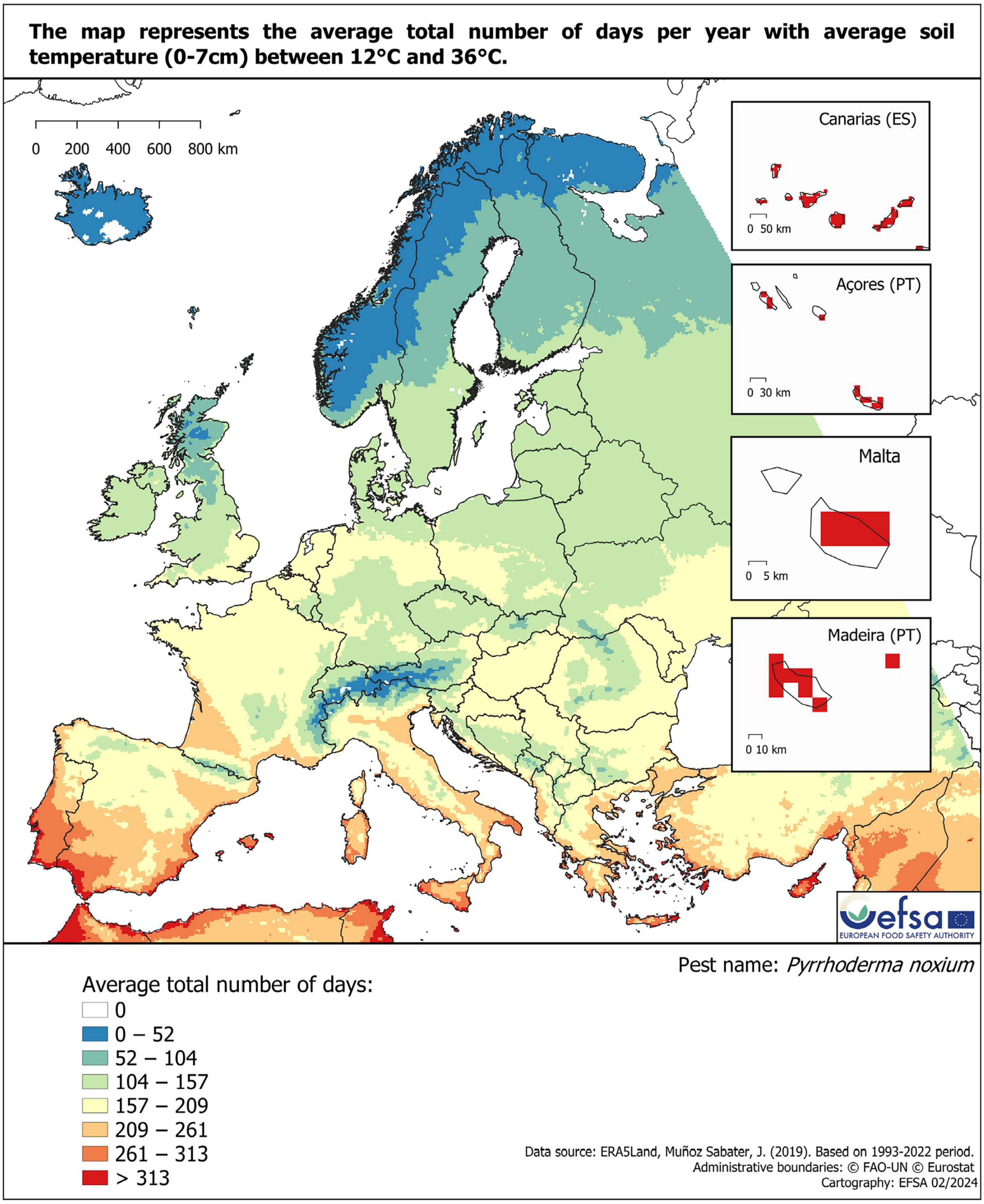
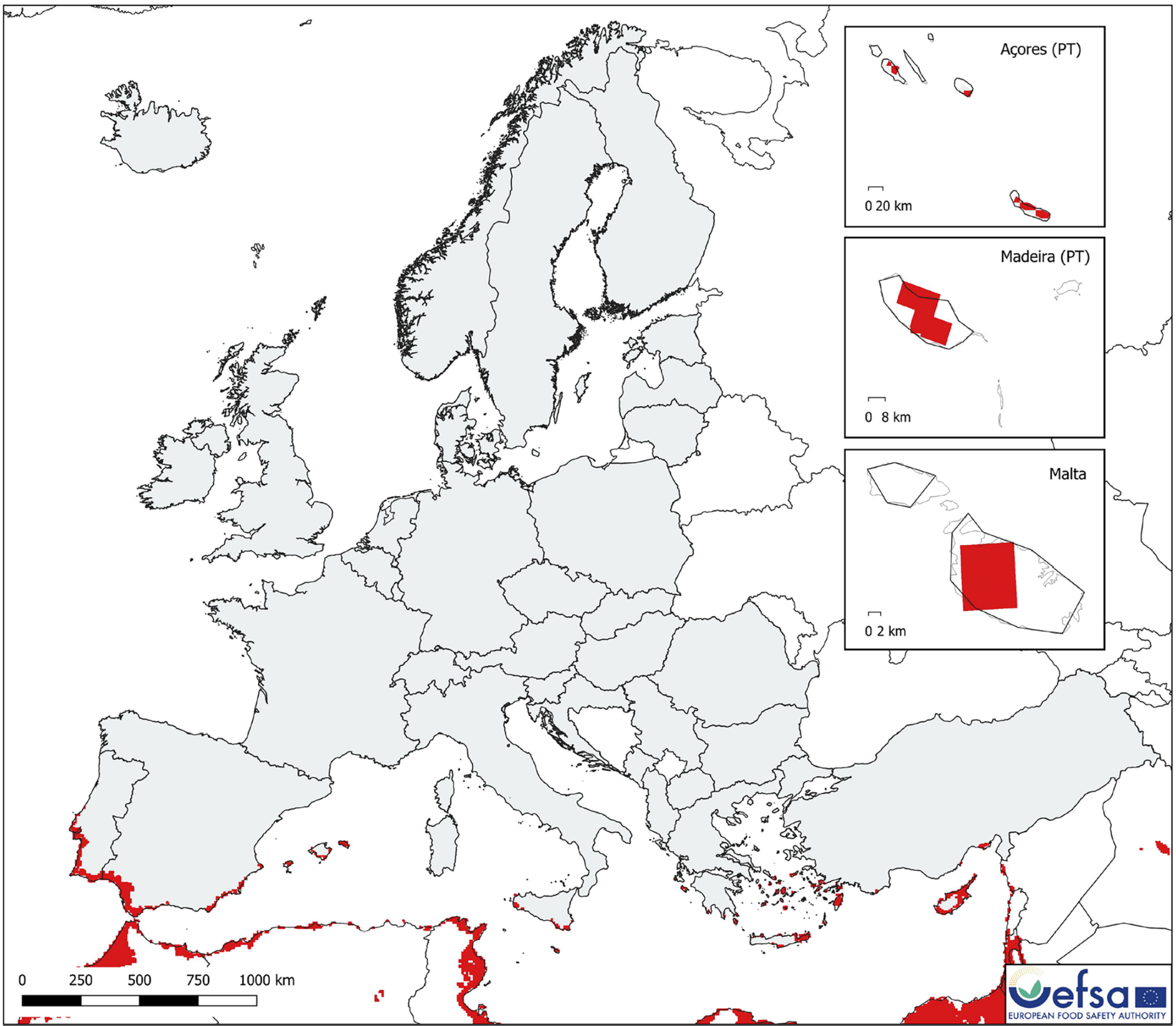


FIGURE 3 Average total number of days with average soil temperature (0–7 cm) between 12°C and 36°C for Europe and neighbouring areas, with days in seven classes. Data Source: Muñoz-Sabater et al. (2021). Based on the 1993–2022 period.



Climate data source: Muñoz Sabater, (2019) was downloaded from the Copernicus Climate Change Service (2022). The results contain modified Copernicus Climate Change Service information 2020. Neither the European Commission nor ECMWF is responsible for any use that may be made of the Copernicus information or data it contains.
Administrative boundaries: © FAO-UN © Eurostat
Cartography: EFSA 02/2024

FIGURE 4 Average total number of days with average soil temperature (0–7 cm) between 12°C and 36°C including only the areas in Europe and neighbouring areas that have average total number of days greater than a threshold of 315 days, obtained from the points of observation. Same data source as Figure 4. Please note that the pest distribution locations from remote islands may not have available information for soil temperature (0–7 cm). This may have an effect on the threshold extracted for this pest.

3.4.3 | Spread

*Describe how the pest would be able to spread within the EU territory following establishment***.**

Following its establishment in the EU, *Pyrrhoderma noxium* could potentially spread within the EU by both natural and human-assisted means.

Host plants for planting are a main means of spread of *P. noxium* within the EU.

Pyrrhoderma noxium could potentially spread within the EU by natural and human-assisted means.

Spread by natural means. The rate of root-to-root spread of *P. noxium* is variable. Under optimal climatic conditions (warm temperature and wet weather), a growth of 6 m per year of the mycelium along a row of susceptible trees is reported (Cannon et al., 2022). This growth rate is likely to be lower under dry conditions and on resistant host trees (Cannon et al., 2022). The survival and short-distance dispersion of *P. noxium* depends on infected plant tissues in the soil close to host plants; while basidiospores are more likely to be involved in long-distance dispersal of the fungus (Hsiao et al., 2019). Although it has not been studied in the case of *P. noxium*, wind, wind-driven rain, insects and small animals may also contribute to the dispersal of basidiospores and arthrospores.

Spread by human-assisted means. The pathogen can spread over long distances through the movement of infected host plants for planting (e.g. rootstocks, grafted plants, scions), including dormant plants, as well as contaminated soil/plant-growing media associated with plant debris and agricultural machinery, tools, etc. Similarly, infected wood (e.g. timber, logs, sawdust) and wooden components (e.g. pallets), can serve as potential carriers for the spread of *P. noxium* (Cannon et al., 2022).

3.5 | Impacts

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

Yes, the introduction into and spread within the EU of *Pyrrhoderma noxium* is expected to have economic and environmental impacts where hosts are grown.

The brown root rot caused by *P. noxium* has been reported as one of the most serious diseases of trees in the tropics and subtropics (Ann et al., 2002). Indeed, *P. noxium* is a destructive and fast-growing pathogen that frequently causes rapid death of a wide range of woody species (Cannon et al., 2022). In Japan, up to 41% tree mortality/decline due to *P. noxium* was recorded in plantations, encompassing mostly *Casuarina equisetifolia*, *Calophyllum inophyllum*, *Podocarpus macrophyllus*, *Garcinia subelliptica*, *Delonix regia* and *Erythrina variegata* (Abe et al., 1995). In the Ivory Coast, rubber tree (*Hevea brasiliensis*) plantations, around 25% incidence of trees infected by *P. noxium* was reported, with 63% mortality (Nandris et al., 1988). Severe *P. noxium* damage on several woody tree species has also been reported from Taiwan (Chang, 1995b), Mariana Islands (Hodges & Tenorio, 1984), Malaysia (Farid et al., 2005, 2009) and Australia (Bolland, 1984).

Besides plantations and native forest trees, *P. noxium* also caused significant yield losses in some fruit crop species. For example, in avocado (*Persea americana*) orchards in Taiwan (Ann et al., 2002) and Australia (Dann et al., 2009), *P. noxium* was reported to cause considerable losses to avocado growers by killing the trees. In Australia, there are reports of mortality rate of 10% in several avocado orchards, with an estimated economic loss of $AUD5400 per hectare (Dann et al., 2009; Everett & Siebert, 2018). Moreover, *P. noxium* can persist in the soil, even after infected plants are removed (see Section 3.1.2). This long-term presence in the environment can continue to affect subsequent crops, leading to continuing yield losses if not properly managed. In tropical countries where *P. noxium* has been noticed for a long time, it has established a reputation of being a very aggressive pathogen (e.g. Ann, Lee, & Huang, 1999; Chang, 1995b; Farid et al., 2009).

Based on the above, it is expected that the introduction into and spread within the EU of *P. noxium* would potentially have an economic and environmental impact where hosts are grown. Damage in those areas may be significant with mortality of established trees, and failure of replanting. *Pyrrhoderma noxium* is a polyphagous pathogen (Ann, Lee, & Huang, 1999; Chang, 1995b), so it may infect many plant species growing in the EU, whose susceptibility to *P. noxium* is unknown. Should these species be suitable hosts of *P. noxium*, the economic and environmental impacts are likely to be high as the pathogen can kill host plants.

3.6 | Available measures and their limitations

Are there measures available to prevent pest entry, establishment, spread or impacts such that the risk becomes mitigated?

Yes. Although not specifically targeted against *Pyrrhoderma noxium*, existing phytosanitary measures (see Sections 3.3.2 and 3.4.1) mitigate the likelihood of the pathogen's entry into the EU territory on certain host plants. Potential additional measures are also available to further mitigate the risk of entry, establishment, spread and impacts of the pathogen in the EU (see Section 3.6.1).

3.6.1 | Identification of potential additional measures

Phytosanitary measures (prohibitions) are currently applied to some host plants for planting (see Section 3.3.2).

Additional potential risk reduction options and supporting measures are shown in Sections 3.6.1.1 and 3.6.1.2.

3.6.1.1 | *Additional potential risk reduction options*

Potential additional control measures are listed in Table 6.

TABLE 6 Selected control measures (a full list is available in EFSA PLH Panel, 2018) for pest entry/establishment/spread/impact in relation to currently unregulated hosts and pathways. Control measures are measures that have a direct effect on pest abundance.

Control measure/risk reduction option (Blue underline = Zenodo doc, Blue = WIP)	**RRO summary**	**Risk element targeted (entry/establishment/spread/impact)**
Require pest freedom	Plants, plant products and other objects must come from a pest-free country or a pest-free area or a pest-free place of production	Entry/Spread
Growing plants in isolation	Description of possible exclusion conditions that could be implemented to isolate the crop from pests and if applicable relevant vectors. E.g. a dedicated structure such as glass or plastic greenhouses Growing nursery plants in isolation may represent an effective control measure	Entry/Establishment/Spread
Managed growing conditions	Proper field drainage, plant distancing, use of pathogen-free agricultural tools (e.g. pruning scissors, saws and grafting blades), and removal of infected plants and plant debris in the nursery/field/orchard could potentially mitigate the likelihood of infection at origin as well as the spread of the pathogen	Entry/Spread/Impact
Crop rotation, associations and density, weed/volunteer control	Crop rotation, associations and density, weed/volunteer control are used to prevent problems related to pests and are usually applied in various combinations to make the habitat less favourable for pests The measures deal with (1) allocation of crops to field (over time and space) (multi-crop, diversity cropping) and (2) to control weeds and volunteers as hosts of pests/vectors Although *P. noxium* has been isolated either as an endophyte or as a pathogen from a wide range of hosts (Appendix A), crop rotation (wherever feasible) may represent an effective means to reduce inoculum sources and potential survival of the pathogen (Ann et al., 2002)	Establishment/Spread/Impact
Use of resistant and tolerant plant species/varieties	Resistant plants are used to restrict the growth and development of a specified pest and/or the damage they cause when compared to susceptible plant varieties under similar environmental conditions and pest pressure • It is important to distinguish resistant from tolerant species/varieties An approach to control root rot induced by *P. noxium* is to replant the infested areas with resistant species (Ann, Lee, & Huang, 1999)	Entry/Establishment/Impact
Roguing and pruning	Roguing is defined as the removal of infested plants and/or uninfested host plants in a delimited area, whereas pruning is defined as the removal of infested plant parts only without affecting the viability of the plant. *P. noxium* survives as a saprophyte or colonises as an endophyte infected attached plant organs, which can act as inoculum sources. Thus, roguing of host plants may be an effective measure for reducing the inoculum sources and the spread capacity of the pathogen in the field	Entry/Spread/Impact
Biological control, Biopesticides and behavioural manipulation	Biological control of *P. noxium* has been investigated at the laboratory scale only on leaf oils obtained from the plant *Cinnamomum osmophloeum* (Cheng et al., 2018), antagonistic fungi such as *Trichoderma asperellum* (Chou et al., 2019), bacteria such as *Streptomyces* sp. and *Bacillus* sp. (Leung et al., 2020) The potential for biocontrol in the rhizosphere has been demonstrated, particularly with species of *Trichoderma* (Jacob et al., 1991; Kothandaraman et al., 1991)	Entry/Impact
Chemical treatments on crops including reproductive material	Various fungicides have been found to have activity against the pathogen (Lim et al., 1990; Mappes and Hiepko, 1984), but routine field treatments with these fungicides are not economical	Entry/Establishment/Impact
Chemical treatments on consignments or during processing	Use of chemical compounds that may be applied to plants or to plant products after harvest, during process or packaging operations and storage The treatments addressed in this information sheet are: a. fumigation; b. spraying/dipping pesticides; c. surface disinfectants; d. process additives; e. protective compounds As an example, the treatment of pallets can be mentioned	Entry/Spread
Physical treatments on consignments or during processing	This information sheet deals with the following categories of physical treatments: irradiation/ionisation; mechanical cleaning (brushing, washing); sorting and grading, and; removal of plant parts (e.g. debarking wood). This information sheet does not address: heat and cold treatment (information sheet 1.14); roguing and pruning (information sheet 1.12) Physical treatments (irradiation, mechanical cleaning, sorting, etc.) may reduce or mitigate the risk of entry/spread of *P. noxium* although no specific information is available for this fungal species	Entry/Spread

TABLE 6 (Continued)

Control measure/risk reduction option (Blue underline = Zenodo doc, Blue = WIP)	RRO summary	Risk element targeted (entry/establishment/spread/impact)
Cleaning and disinfection of facilities, tools and machinery	The physical and chemical cleaning and disinfection of facilities, tools, machinery, transport means, facilities and other accessories (e.g. boxes, pots, pallets, palox, supports, hand tools). The measures addressed in this information sheet are washing, sweeping and fumigation *P. noxium* infects its host plants mostly through contact of the inoculum with roots. Therefore, and although no specific information is available on this species, cleaning and surface sterilisation of soil tilling tools as well as of equipment and facilities (including premises, storage areas) are good cultural and handling practices employed in the production and marketing of any commodity and may mitigate the likelihood of entry or spread of the pathogen	Entry/Spread
Limits on soil	*P. noxium* survives in the soil and on plant debris in or on the soil surface. Therefore, plants, plant products and other objects (e.g. used farm machinery) should be free from soil to ensure freedom from *P. noxium*	Entry/Spread
Soil treatment	The control of soil organisms by chemical and physical methods listed below: a. Fumigation; b. Heating; c. Solarisation; d. Flooding; e. Soil suppression; f. Augmentative Biological control; g. Biofumigation Many soil treatments have been tested and numerous experiments have been performed to find an effective way of eliminating such inoculum. Currently, the most efficient method of destroying the residual inoculum is by flooding the field, and the most practical way is to fumigate the infested soil with ammonia generated from urea amended in soil under alkaline conditions (Ann and Ko, 1994; Chang, 1996; Chang & Chang, 1999)	Entry/Establishment/Impact
Use of non-contaminated water	Chemical and physical treatment of water to eliminate waterborne microorganisms. The measures addressed in this information sheet are chemical treatments (e.g. chlorine, chlorine dioxide, ozone); physical treatments (e.g. membrane filters, ultraviolet radiation, heat); ecological treatments (e.g. slow sand filtration) Considering that *P. noxium* may spread via contaminated irrigation water, physical or chemical treatment of irrigation water may be applied in nurseries and greenhouses. However, also disinfected water, once used to clean plant material, can transfer inoculum from a source to other plants	Entry/Spread
Waste management	• Treatment of the waste (deep burial, composting, incineration, chipping, production of bio-energy…) in authorised facilities and official restriction on the movement of waste. Waste management in authorised facilities and official restriction on its movement may prevent the pathogen from escaping in the environment. On-site proper management of roguing residues is also recommended as an efficient measure	Establishment/Spread
Heat and cold treatments	Controlled temperature treatments aimed to kill or inactivate pests without causing any unacceptable prejudice to the treated material itself. The measures addressed in this information sheet are autoclaving; steam; hot water; hot air; cold treatment In laboratory conditions, the fungus does not grow below 8°C or above 36°C (Ann, Lee, & Huang, 1999). Kiln drying of wood and heat treatment of pallets are relevant measures here, although specific data on effectiveness against *P. noxium* are lacking	Entry/Spread
Conditions of transport	Specific requirements for mode and timing of transport of commodities to prevent escape of the pest and/or contamination. a. Physical protection of consignment b. Timing of transport/trade If plant material, potentially infected or contaminated with *P. noxium* (including waste material) must be transported, specific transport conditions (type of packaging/protection, transport means) should be defined to prevent the pathogen from escaping. These may include, albeit not exclusively: physical protection, sorting prior to transport, sealed packaging, etc.	Entry/Spread

(Continues)

TABLE 6 (Continued)

Control measure/risk reduction option (Blue underline = Zenodo doc, Blue = WIP)	RRO summary	Risk element targeted (entry/establishment/spread/impact)
Post-entry quarantine and other restrictions of movement in the importing country	This information sheet covers post-entry quarantine (PEQ) of relevant commodities; temporal, spatial and end-use restrictions in the importing country for import of relevant commodities; Prohibition of import of relevant commodities into the domestic country 'Relevant commodities' are plants, plant parts and other materials that may carry pests, either as infection, infestation or contamination Recommended for plant species known to be hosts of *P. noxium*. This measure does not apply to fruits of host plants	Establishment/Spread

3.6.1.2 | *Additional supporting measures*

Potential additional supporting measures are listed in Table 7.

TABLE 7 Selected supporting measures (a full list is available in EFSA PLH Panel, 2018) in relation to currently unregulated hosts and pathways. Supporting measures are organisational measures or procedures supporting the choice of appropriate risk reduction options that do not directly affect pest abundance.

Supporting measure	Summary	Risk element targeted (entry/establishment/spread/impact)
Inspection and trapping	Due to its possible endophytic lifestyle, *P. noxium* may remain quiescent or latent within asymptomatic host tissues. On symptomatic plants, the symptoms caused by *P. noxium* are similar to those caused by other root rot pathogens. Therefore, it is unlikely that *P. noxium* could be detected based on visual inspection only	Entry/Establishment/Spread
Laboratory testing	Macroscopic examination of the basidiocarps and of symptoms at the below ground parts of plants, microscopic examination of morphological features such mycelium, trichocysts and basidispores and DNA-based identification allow the reliable detection and identification of *P. noxium* (see Section 3.1.5)	Entry/Establishment/Spread
Sampling	Necessary as part of other risk reduction options	Entry/Establishment/Spread
Phytosanitary certificate and plant passport	Recommended for plant species known to be hosts of *P. noxium*, including plant parts, but excluding seeds for sowing	Entry/Spread
Certified and approved premises	Certified and approved premises may reduce the likelihood of the plants and plant products originating in those premises to be infected by *P. noxium*	Entry/Spread
Certification of reproductive material (voluntary/official)	The risk of entry and/or spread of *P. noxium* is reduced if host plants for planting, excluding seeds for sowing, are produced under an approved certification scheme and tested free of the pathogen	Entry/Spread
Delimitation of Buffer zones	Delimitation of a buffer zone around an outbreak area can prevent spread of the pathogen and maintain a pest-free area, site or place of production	Spread
Surveillance	Surveillance to guarantee that plants and plant products originate from a pest-free area could be an option	Entry/Establishment/Spread

3.6.1.3 | *Biological or technical factors limiting the effectiveness of measures*

- Latently infected (asymptomatic) host plants and plant products are unlikely to be detected by visual inspection.
- The similarity of symptoms of *P. noxium* with those of other root rot pathogens poses a serious challenge to the detection and identification of the pathogen based solely on visual inspection of the above ground parts of hosts.
- The wide host range of the pathogen and its ability to survive endophytically on asymptomatic plants limit the possibility to develop standard diagnostic protocols for all potential hosts.

3.7 | Uncertainty

No key uncertainty was identified.

4 | CONCLUSIONS

Pyrrhoderma noxium satisfies all the criteria that are within the remit of EFSA to assess for this species to be regarded as potential Union quarantine pest (Table 8).

TABLE 8 The Panel's conclusions on the pest categorisation criteria defined in Regulation (EU) 2016/2031 on protective measures against pests of plants (the number of the relevant sections of the pest categorisation is shown in brackets in the first column).

Criterion of pest categorisation	Panel's conclusions against criterion in regulation (EU) 2016/2031 regarding union quarantine pest	Key uncertainties
Identity of the pest (Section 3.1)	The identity of *Pyrrhoderma noxium* is clearly defined. The pathogen has been shown to produce consistent symptoms and to be transmissible	None
Absence/presence of the pest in the EU (Section 3.2)	*Pyrrhoderma noxium* is not known to be present in the EU	None
Pest potential for entry, establishment and spread in the EU (Section 3.4)	*Pyrrhoderma noxium* could potentially enter, established in and spread within the EU. The main pathways for entry of the pathogen into the EU are: (i) host plants for planting (ii) bark and wood of host plants and (iii) soil and other plant growing media containing plant debris, all originating in infested third countries. Both the biotic (host availability) and abiotic (climate suitability) factors occurring in parts of the EU where hosts are grown are favourable for the establishment of the pathogen. Following its establishment, the pathogen could spread within the EU by both natural and human-assisted means	None
Potential for consequences in the EU (Section 3.5)	*Pyrrhoderma noxium* introduction into and spread within the EU may have an economic and environmental impact where hosts are grown	None
Available measures (Section 3.6)	Although not specifically targeted against *P. noxium*, existing phytosanitary measures mitigate the likelihood of the pathogen's entry, establishment and spread in the EU territory. Potential additional measures also exist to further mitigate the risk of introduction and spread of the pathogen in the EU	None
Conclusion (Section 4)	*Pyrrhoderma noxium* satisfies all the criteria that are within the remit of EFSA to assess for this species to be regarded as potential Union quarantine pest	None
Aspects of assessment to focus on/ scenarios to address in future if appropriate:	Further phylogenetic analyses would make it possible to better resolve *P. noxium* species boundaries	

ABBREVIATIONS

EPPO	European and Mediterranean Plant Protection Organization
FAO	Food and Agriculture Organization
HRP	high-risk plants
IPPC	International Plant Protection Convention
ISPM	International Standards for Phytosanitary Measures
MS	Member State
PLH	EFSA Panel on Plant Health
PZ	Protected Zone
TFEU	Treaty on the Functioning of the European Union
ToR	Terms of Reference

GLOSSARY

Containment (of a pest)	Application of phytosanitary measures in and around an infested area to prevent spread of a pest (FAO, 2022).
Control (of a pest)	Suppression, containment or eradication of a pest population (FAO, 2022).
Entry (of a pest)	Movement of a pest into an area where it is not yet present, or present but not widely distributed and being officially controlled (FAO, 2022).
Eradication (of a pest)	Application of phytosanitary measures to eliminate a pest from an area (FAO, 2022).
Establishment (of a pest)	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO, 2022).
Greenhouse	A walk-in, static, closed place of crop production with a usually translucent outer shell, which allows controlled exchange of material and energy with the surroundings and prevents release of plant protection products (PPPs) into the environment.
Hitchhiker	An organism sheltering or transported accidentally via inanimate pathways including with machinery, shipping containers and vehicles; such organisms are also known as contaminating pests or stowaways (Toy & Newfield, 2010).
Impact (of a pest)	The impact of the pest on the crop output and quality and on the environment in the occupied spatial units.

Introduction (of a pest)	The entry of a pest resulting in its establishment (FAO, 2022).
Pathway	Any means that allows the entry or spread of a pest (FAO, 2022).
Phytosanitary measures	Any legislation, regulation or official procedure having the purpose to prevent the introduction or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests (FAO, 2022).
Quarantine pest	A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled (FAO, 2022).
Risk reduction option (RRO)	A measure acting on pest introduction and/or pest spread and/or the magnitude of the biological impact of the pest should the pest be present. A RRO may become a phytosanitary measure, action or procedure according to the decision of the risk manager.
Spread (of a pest)	Expansion of the geographical distribution of a pest within an area (FAO, 2022).

CONFLICT OF INTEREST

If you wish to access the declaration of interests of any expert contributing to an EFSA scientific assessment, please contact interestmanagement@efsa.europa.eu.

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APPENDIX A

Pyrrhoderma noxium host plants/species affected

Host status	Host name	Plant family	Common name	Reference
Cultivated hosts	*Acacia auriculiformis*	Fabaceae	Earleaf acacia	Lewis and Arentz (1988)
	Acacia confusa	Fabaceae	Taiwan acacia	Ann et al. (2002), Akiba et al. (2015), Ann, Lee, and Tsai (1999), Hsiao et al. (2019)
	Acacia crassicarpa	Fabaceae	Northern Wattle	Ivory and Daruhi (1993)
	Acacia excelsa	Fabaceae	Ironwood	Cannon et al. (2022)
	Acacia mangium	Fabaceae	Brown salwood	Stewart et al. (2020)
	Acacia nilotica	Fabaceae	Gum arabic tree	Kutama et al. (2012)
	Acaciella glauca (Syn. *Leucaena glauca*)	Fabaceae	Amourette, Redwood	Heubel (1939)
	Acer saccharum	Aceraceae	Sugar Maple	Ibarra Caballero et al. (2020)
	Actinodaphne pedicellata	Lauraceae	Litsea	Ann et al. (2002)
	Adenanthera pavonina	Fabaceae	Sandalwood Tree, red-bead tree	Brooks (2002), Cannon et al. (2022)
	Agathis macrophylla	Araucariaceae	Fijian kauri	Neil (1988)
	Albizia falcataria (Syn. *Falcataria falcata*)	Fabaceae	Albizia	Singh and Pandey (1989)
	Albizia lebbeck	Fabaceae	Siris tree, Woman's Tongue, East Indian Walnut	Hodges and Tenorio (1984)
	Albizia spp.	Fabaceae		Ram (1975)
	Aleurites fordii (Syn. *Vernicia fordii*)	Euphorbiaceae	Tung oil tree	Ann et al. (2002)
	Aleurites moluccanus	Euphorbiaceae	Candle nut tree	Wu et al. (2011)
	Aleurites montanus (Syn. *Vernicia montana*)	Euphorbiaceae	Wood oil tree	Bertus (1935)
	Alstonia scholaris	Apocynaceae	Blackboard tree	Ann et al. (2002)
	Amherstia nobilis	Fabaceae		Ann, Lee, and Tsai (1999)
	Anacardium occidentale	Anacardiaceae	Cashew nut	Supriadi et al. (2004)
	Annona montana	Annonaceae	Mountain soursop	Ann et al. (2002)
	Annona squamosa	Annonaceae	Custard apple, Sugar apple	Ann, Lee, and Huang (1999), Ann et al. (2002), Tsai et al. (2017)
	Annona squamosa × *A. cherimola*	Annonaceae	Atimoya	Ann et al. (2002)
	Antiaris toxicaria	Moraceae	Bark cloth tree	Neil (1988)
	Antirhea chinensis	Rubiaceae	Bois goudron	Wu et al. (2011)
	Aralia elata	Araliaceae	Angelica tree	Sahashi et al. (2007)
	Araucaria cunninghamii	Araucariaceae	Hoop pine	Ann et al. (2002), Tsai et al. (2017), Hsiao et al. (2019)
	Araucaria heterophylla	Araucariaceae	Norfolk Island pine	Chang and Yang (1998), Ann et al. (2002)
	Araucaria hunsteinii	Araucariaceae	Klinki Pine	Singh and Pandey (1989)
	Ardisia sieboldii	Primulaceae		Akiba et al. (2015), Sahashi et al. (2015)
	Areca catechu	Arecaceae	Areca-nut palm	Farr et al. (2021)
	Areca triandra	Arecaceae		Singh (1966)
	Argusia argentea	Boraginaceae	Velvet soldierbush	Sahashi et al. (2012)
	Artocarpus	Moraceae		Riggenbach (1958)
	Artocarpus altilis	Moraceae	Breadfruit	Hsiao et al. (2019)
	Artocarpus heterophyllus	Moraceae	Jack fruit	Ann et al. (2002)
	Averrhoa carambola	Oxalidaceae	Carambola, Star fruit	Ann, Lee, and Huang (1999), Ann et al. (2002), Wu et al. (2011), Tsai et al. (2017)

Host status	Host name	Plant family	Common name	Reference
	Azadirachta excelsa	Meliaceae	Sentang	Stewart et al. (2020)
	Barringtonia asiatica	Lecythidaceae	Sea poison tree	Brooks (2002), Cannon et al. (2022)
	Barringtonia petiolata	Lecythidaceae		Ivory and Daruhi (1993)
	Barringtonia samoensis	Lecythidaceae		Brooks (2002), Cannon et al. (2022)
	Bauhinia × blakeana	Fabaceae		Hsiao et al. (2019), Stewart et al. (2020)
	Bauhinia × hybrid	Fabaceae	Butterfly tree	Ann et al. (2002), Tsai et al. (2017)
	Bauhinia acuminata	Fabaceae	Dwarf white orchid tree	Farr et al. (2021)
	Bauhinia purpurea	Fabaceae	Purple bauhinia	Ann et al. (2002)
	Bauhinia racemosa	Fabaceae		Abe et al. (1995)
	Bauhinia sp.	Fabaceae		Ann, Lee, and Tsai (1999)
	Bauhinia variegata	Fabaceae	Orchid tree	Ann et al. (2002), Tsai et al. (2017), Hsiao et al. (2019)
	Betula papyrifera	Betulaceae	Paper birch	Nicole et al. (1995)
	Bidens pilosa	Asteraceae	Beggartick	Chen et al. (2023)
	Bischofia javanica	Phyllanthaceae	Autumn maple tree	Ann et al. (2002), Sahashi et al. (2010, 2015)
	Boehmeria nivea	Urticaceae	Ramio, China-grass	McIntosh (1951)
	Bomba × ceiba	Malvaceae	Silk cotton	Ann et al. (2002)
	Bridelia monoica	Phyllanthaceae	Pop gun seed	Wu et al. (2011)
	Broussonetia kazinoki	Moraceae	Small paper mulberry	Ann et al. (2002)
	Broussonetia papyrifera	Moraceae	Paper mulberry	Ann et al. (2002)
	Burckella thurstonii	Sapotaceae		Singh et al. (1980)
	Buxus bodinieri	Buxaceae		Sahashi et al. (2012)
	Caesalpinia ferrea	Fabaceae	Brazilian ironwood	Stewart et al. (2020)
	Caesalpinia gilliesii	Fabaceae	Bird-of-paradise shrub	Adra et al. (2022)
	Cajanus cajan	Fabaceae	Bengal pea	Stewart et al. (2020)
	Callicarpa japonica	Lamiaceae	Japanese beautyberry	Sahashi et al. (2012)
	Calocedrus formosana	Cupressaceae	Taiwan incense cedar	Ann et al. (2002), Tsai et al. (2017), Hsiao et al. (2019)
	Calophyllum inophyllum	Calophyllaceae	Indian poon beauty leaf	Abe et al. (1995), Ann et al. (2002), Akiba et al. (2015), Sahashi et al. (2010, 2015)
	Calophyllum neoebudicum	Calophyllaceae		Brooks (2002), Cannon et al. (2022)
	Camellia japonica	Theaceae	Camellia	Ann et al. (2002)
	Camellia sinensis	Theaceae	Tea	Ann et al. (2002)
	Cananga odorata	Annonaceae	Ylang-ylang	Brooks (2002), Cannon et al. (2022)
	Canarium harveyi	Burseraceae		Brooks (2002), Cannon et al. (2022)
	Carica papaya	Caricaceae	Papaya	Neil (1988)
	Cassia fistula	Fabaceae	Yellow golden shower tree	Ann et al. (2002), Hsiao et al. (2019)
	Cassia grandis	Fabaceae	Horse cassia	Farr et al. (2021)
	Cassia siamea	Fabaceae	Cassia tree	Hsiao et al. (2019)
	Casuarina equisetifolia	Casuarinaceae	Ironwood tree	Abe et al. (1995), Ann et al. (2002), Sahashi et al. (2010, 2015), Wu et al. (2011), Akiba et al. (2015), Tsai et al. (2017)
	Casuarina spp.	Casuarinaceae		Hodges and Tenorio (1984)
	Casuarina torulosa	Casuarinaceae	Australian mahogany	Farr et al. (2021)
	Cedrela odorata	Meliaceae	Bastard cedar	Farr et al. (2021)
	Cedrela spp.	Meliaceae		Mallet et al. (1985)

(Continues)

Host status	Host name	Plant family	Common name	Reference
	Ceiba pentandra	Malvaceae	Kapok	Ann et al. (2002), Stewart et al. (2020)
	Ceiba speciosa	Malvaceae	Chorisia	Akiba et al. (2015)
	Celtis boninensis	Cannabaceae		Akiba et al. (2015), Sahashi et al. (2015)
	Celtis sinensis	Cannabaceae	Chinese elm	Tsang et al. (2020)
	Celtis sp.	Cannabaceae		Steyaert (1948)
	Cerbera manghas	Apocynaceae	Odollam cerberus tree	Ann et al. (2002), Cannon et al. (2022)
	Chamaecyparis formosensis	Cupressaceae	Taiwan red cypress	Ann et al. (2002)
	Chamaecyparis obtusa	Cupressaceae	Japanese false cypress	Sahashi et al. (2014)
	Chionanthus retusus	Oleaceae	Chinese fringe tree	Chen et al. (2023)
	Chorisia speciosa	Malvaceae	Floss silk tree	Ann et al. (2002), Hsiao et al. (2019)
	Chrysalidocarpus lutescens	Arecaceae	Yellow areca palm	Ann et al. (2002), Hsiao et al. (2019)
	Cinchona spp.	Rubiaceae		Riggenbach (1958)
	Cinnamomum burmannii	Lauraceae	Cinnamon	Wu et al. (2011), Stewart et al. (2020)
	Cinnamomum camphora	Lauraceae	Camphor	Ann et al. (2002), Tsai et al. (2017), Hsiao et al. (2019), Tsang et al. (2020)
	Cinnamomum cassia	Lauraceae	Padang cassia	Chung et al. (2015)
	Cinnamomum doederleinii	Lauraceae		Akiba et al. (2015)
	Cinnamomum insularimontanum	Lauraceae		Hsiao et al. (2019)
	Cinnamomum japonicum	Lauraceae	Japanese cinnamon	Sahashi et al. (2010)
	Cinnamomum kanehirae	Lauraceae	Stout camphor	Ann et al. (2002), Chung et al. (2015), Hsiao et al. (2019)
	Cinnamomum osmophloeum	Lauraceae	Taiwan cinnamon	Tsai et al. (2017)
	Cinnamomum pseudopedunculatum	Lauraceae		Akiba et al. (2015), Sahashi et al. (2015)
	Cinnamomum yabunikkei	Lauraceae		Akiba et al. (2015)
	Cinnamomum zeylanicum (Syn. *Cinnamomum verum)*	Lauraceae	Ceylon cinnamon	Ann et al. (2002)
	Cinnamomum kotoense	Lauraceae	Botel tobago cinnamon tree	Tsai et al. (2017)
	Citrus limon	Rutaceae	Lemon	Tsai et al. (2017)
	Citrus limonia	Rutaceae	Mandarin lime	Stewart et al. (2020)
	Citrus spp.	Rutaceae		Farr et al. (2021)
	Cleyera japonica	Pentaphylacaceae	Japanese cleyera	Chung et al. (2015)
	Cocos nucifera	Arecaceae	Coconut	Farr et al. (2021)
	Codiaeum variegatum	Euphorbiaceae	Croton	Ann et al. (2002)
	Coffea arabica	Rubiaceae	Coffee	Ann et al. (2002)
	Coffea liberica	Rubiaceae		Mallamaire (1935)
	Cola nitida	Malvaceae	Kola	Adebayo (1975)
	Cordia alliodora	Boraginaceae	Ecuador laurel	Neil (1986)
	Cordia aspera	Cordiaceae		Brooks (2002), Cannon et al. (2022)
	Cordia dichotoma	Boraginaceae	Cordia	Ann et al. (2002)
	Corymbia citriodora (Syn. *Eucalyptus citriodora)*	Myrtaceae	Lemon gum	Ann et al. (2002), Tsai et al. (2017)
	Crossostylis biflora	Rhizophoraceae		Brooks (2002), Cannon et al. (2022)
	Cryptocarya concinnai	Lauraceae	Konishi crytocarya	Ann et al. (2002)
	Cryptomeria japonica	Cupressaceae	Japanese cedar	Sahashi et al. (2014)
	Cyathea lunulata (Syn. *Sphaeropteris lunulata*)	Cyatheaceae		Singh et al. (1980)
	Cyathocaly × sp.	Annonaceae		Singh et al. (1980)

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	Cycas taitungensis	Cycadaceae		Chang and Yang (1998), Ann, Lee, and Huang (1999)
	Cycas taiwaniana	Cycadaceae	Taiwan cycas	Chang and Yang (1998), Ann et al. (2002)
	Dalbergia sissoo	Fabaceae	Sissoo tree	Ann et al. (2002)
	Delonix regia	Fabaceae	Flame tree	Abe et al. (1995), Ann et al. (2002), Tsai et al. (2017)
	Dillenia biflora	Dilleniaceae		Singh et al. (1980)
	Dimocarpus longan	Sapindaceae	Longan	Ann et al. (2002), Tsai et al. (2017)
	Diospyros decandra	Ebenaceae		Ann, Lee, and Tsai (1999)
	Diospyros egbert-walkeri (Syn. *Diospyros ferrea, D. vera)*	Ebenaceae	Sea ebony	Akiba et al. (2015)
	Diospyros ferrea var. buxifolia	Ebenaceae	Philippine ebony persimmon	Ann et al. (2002)
	Diospyros kaki	Ebenaceae	Persimmon	Ann, Lee, and Huang (1999), Ann et al. (2002), Tsai et al. (2017)
	Diospyros oldhamii	Ebenaceae	Oldham persimmon	Ann et al. (2002)
	Diospyros samoensis	Ebenaceae		Brooks (2002), Cannon et al. (2022)
	Distylium gracile	Hamamelidaceae		Hsiao et al. (2019)
	Distylium lepidotum	Hamamelidaceae		Akiba et al. (2015), Shashi et al. (2015)
	Distylium racemosum	Hamamelidaceae	Isu tree	Akiba et al. (2015)
	Dracaena draco	Asparagaceae	Dragon tree	Stewart et al. (2020)
	Dracaena fragrans	Asparagaceae	Dracena	Stewart et al. (2020)
	Dracontomelon vitiense	Anacardiaceae		Neil (1988)
	Duranta repens (Syn. *D. erecta)*	Verbenaceae	Creeping sky flower	Ann et al. (2002), Tsai et al. (2017)
	Dypsis lutescens	Arecaceae	Yellow butterfly palm	Huang et al. (2015)
	Dysoxylum amooroides	Meliaceae		Ivory and Daruhi (1993)
	Dysoxylum richii	Meliaceae		Singh et al. (1980)
	Dysoxylum samoense	Meliaceae		Brooks (2002), Cannon et al. (2022)
	Ehretia dichotoma	Ehretiaceae		Sahashi et al. (2012)
	Ehretia philippinensis	Ehretiaceae		Akiba et al. (2015)
	Elaeagnus rotundata	Elaeagnaceae		Sahashi et al. (2015)
	Elaeis guineensis	Arecaceae	African oil palm	Pinruan et al. (2010)
	Elaeis sp.	Arecaceae		Riggenbach (1958)
	Elaeocarpus decipiens (Syn. *Elaeocarpus zollingeri)*	Elaeocarpaceae	Japanese blueberry tree	Akiba et al. (2015)
	Elaeocarpus kambi	Elaeocarpaceae		Singh et al. (1980)
	Elaeocarpus serratus	Elaeocarpaceae	Ceylon olive	Ann et al. (2002)
	Elaeocarpus sylvestris	Elaeocarpaceae		Chung et al. (2015)
	Elateriospermum tapos	Euphorbiaceae	Tapos	Stewart et al. (2020)
	Elattostachys falcata	Sapindaceae		Brooks (2002), Cannon et al. (2022)
	Endospermum macrophyllum	Euphorbiaceae		Singh et al. (1980)
	Eriobotrya japonica	Rosaceae	Loquat	Ann, Lee, and Huang (1999), Ann et al. (2002), Tsai et al. (2017)
	Eriodendron	Malvaceae		Riggenbach (1958)
	Erythrina	Fabaceae		Hodges and Tenorio (1984)
	Erythrina lithosperma (Syn. *Erythrina subumbrans)*	Fabaceae		Ram (1975)
	Erythrina variegata (Syn. *E. indica)*	Fabaceae	Indian coral tree	Abe et al. (1995), Akiba et al. (2015), Shashi et al. (2015)
	Erythrospermum acuminatissimum	Achariaceae		Singh et al. (1980)

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	Eucalyptus camaldulensis	Myrtaceae	Murray red gum eucalyptus	Ann et al. (2002)
	Eucalyptus deglupta	Myrtaceae		Ivory and Daruhi (1993)
	Eucalyptus grandis	Myrtaceae	Maiden eucalyptus	Ann et al. (2002)
	Eucalyptus pellita	Myrtaceae	red mahogany	Agustini et al. (2014), Glen et al. (2014)
	Eucalyptus robusta	Myrtaceae	Beakpod eucalyptus	Hsiao et al. (2019)
	Eucalyptus spp.	Myrtaceae		Sahashi et al. (2012), Agustini et al. (2014), Farr et al. (2021)
	Eucalyptus urophylla	Myrtaceae		Ivory and Daruhi (1993)
	Eugenia uniflora	Myrtaceae	Surinam cherry, pitanga	Akiba et al. (2015)
	Euonymus boninensis	Celastraceae		Sahashi et al. (2015)
	Euphorbia pulcherrima	Euphorbiaceae		Ann, Tsai, Wang, and Hsien (1999)
	Ficus benghalensis	Moraceae	Banyan	Akiba et al. (2015), Sahashi et al. (2015)
	Ficus benjamina	Moraceae	Weeping fig	Hsiao et al. (2019)
	Ficus carica	Moraceae	Common fig	Cannon et al. (2022)
	Ficus drupacea	Moraceae		Chen et al. (2023)
	Ficus elastica	Moraceae	Rubber plant	Ann et al. (2002); Akiba et al. (2015), Sahashi et al. (2015), Hsiao et al. (2019)
	Ficus hanceana (Syn. *Ficus pumila)*	Moraceae	Creeping fig	Chang and Yang (1998)
	Ficus macrocarpa	Moraceae	Small-leafed banyan	Ann et al. (2002)
	Ficus macrophylla	Moraceae	Moreton Bay fig	Gray (2017)
	Ficus microcarpa	Moraceae	Curtain fig	Akiba et al. (2015), Tsai et al. (2017), Tsang et al. (2020)
	Ficus obliqua	Moraceae	Small-leaved fig	Brooks (2002), Cannon et al. (2022)
	Ficus pumila var. awkeotsang (Syn. *Ficus awkeotsang)*	Moraceae	Jellyfig	Ann, Lee, and Huang (1999), Ann et al. (2002), Tsai et al. (2017)
	Ficus punctata	Moraceae		Ann, Lee, and Tsai (1999)
	Ficus religiosa	Moraceae	Bo tree fig	Ann et al. (2002), Tsai et al. (2017), Hsiao et al. (2019)
	Ficus septica	Moraceae		Neil (1988)
	Ficus simplicissima	Moraceae	Asian fig	Wu et al. (2011)
	Ficus sp.	Moraceae		Brooks (2002), Cannon et al. (2022)
	Ficus superba	Moraceae	Deciduous fig	Chung et al. (2015)
	Ficus tinctoria	Moraceae	Dye fig	Brooks (2002), Akiba et al. (2015), Cannon et al. (2022)
	Ficus variegata	Moraceae	Red-stem fig	Wu et al. (2011)
	Ficus virgata	Moraceae		Akiba et al. (2015)
	Firmiana simplex	Sterculiaceae	Chinese parasol	Ann et al. (2002)
	Flindersia brayleyana	Rutaceae		Singh and Pandey (1989)
	Flemingia macrophylla	Fabaceae	Wild hop	Farr et al. (2021)
	Flueggea flexuosa	Phyllanthaceae		Brooks (2002), Cannon et al. (2022)
	Fraxinus formosana	Oleaceae	Formosan ash	Ann et al. (2002), Hsiao et al. (2019)
	Garcinia mangostana	Clusiaceae	Mangosteen	CABI (2022)
	Garcinia myrtifolia	Clusiaceae		Singh et al. (1980)
	Garcinia subelliptica	Clusiaceae	Happiness tree, Fukugi tree	Abe et al. (1995), Sahashi et al. (2010), Akiba et al. (2015)
	Gardenia jasminoides	Rubiaceae	Cape jasmine	Ann et al. (2002)
	Garuga floribunda	Burseraceae		Neil (1988)
	Gleditsia fera	Fabaceae		Stewart et al. (2020)
	Gliricidia sepium	Fabaceae	Quick stick	Neil (1988)

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	Glochidion obovatum	Euphorbiaceae		Akiba et al. (2015)
	Glochidion ramiflorum	Phyllanthaceae		Brooks (2002), Cannon et al. (2022)
	Gmelina arborea	Lamiaceae	Snapdragon tree	Brooks (2002)
	Grevillea	Proteaceae		Riggenbach (1958)
	Grevillea robusta	Proteaceae	Silver oak	Ann et al. (2002), Stewart et al. (2020)
	Guamia mariannae (Syn. *Meiogyne cylindrocarpa)*	Annonaceae		Stewart et al. (2020)
	Heliotropium foertherianum	Heliotropiaceae	Tree heliotrope, Argusia	Akiba et al. (2015)
	Heritiera littoralis	Malvaceae	Looking glass tree	Chen et al. (2023)
	Heritiera sp.	Malvaceae		Singh et al. (1980)
	Hernandia nymphaeifolia	Hernandiaceae	Sea hearse	Brooks (2002), Cannon et al. (2022)
	Hevea brasiliensis	Euphorbiaceae	Rubber tree	Brooks (2002)
	Hevea sp.	Euphorbiaceae		Riggenbach (1958)
	Hibiscus glaber	Malvaceae	Dwarf Mahoe	Sahashi et al. (2015)
	Hibiscus rosa-sinensis	Malvaceae	Hibiscus	Abe et al. (1995), Ann et al. (2002), Akiba et al. (2015)
	Hibiscus schizopetalus	Malvaceae	Fringed hibiscus	Ann et al. (2002)
	Hibiscus tiliaceus	Malvaceae	Linden hibiscus	Ann et al. (2002), Akiba et al. (2015), Cannon et al. (2022)
	Hydrangea chinensis	Hydrangeaceae	Chinese hydrangea	Ann et al. (2002)
	Ilex mertensii	Aquifoliaceae		Sahashi et al. (2015)
	Ilex rotunda	Aquifoliaceae	Round-leaf holly	Sahashi et al. (2007)
	Inocarpus fagifer	Fabaceae		Brooks (2002), Cannon et al. (2022)
	Intsia bijuga	Fabaceae	Moluccan ironwood	Brooks (2002), Cannon et al. (2022)
	Ixora chinensis	Rubiaceae	Jungle flame	Chung et al. (2015)
	Ixora x williamsii		Hybrid	Chung et al. (2015)
	Jacaranda sp.	Bignoniaceae	Jacaranda	Adra et al. (2022)
	Jatropha integerrima (Syn. *J. pandurifolia)*	Euphorbiaceae	Peregrina	Shashi et al. (2015)
	Juniperus chinensis var. kaizuka	Cupressaceae	Dragon juniper	Tsai et al. (2017)
	Keteleeria davidiana var. formosana	Pinaceae	Taiwan keteleeria	Ann et al. (2002)
	Khaya ivorensis	Meliaceae		Singh and Pandey (1989)
	Khaya senegalensis	Meliaceae	African mahogany	Burcham et al. (2015), Wang et al. (2016)
	Kigelia pinnata (Syn. *Kigelia africana)*	Bignoniaceae	Sausage tree	Ann et al. (2002), Tsai et al. (2017)
	Kleinhovia hospita	Malvaceae		Farr et al. (2021)
	Koelreuteria elegans	Sapindaceae	Flamegold tree	Stewart et al. (2020)
	Koelreuteria elegans var. formosana (Syn. *Koelreuteria henryi)*	Sapindaceae	Flame gold rain tree	Ann et al. (2002), Tsai et al. (2017), Hsiao et al. (2019)
	Koelreuteria paniculata	Sapindaceae	Golden rain tree	CABI (2022)
	Lagerstroemia micrantha	Lythraceae		Chung et al. (2015)
	Lagerstroemia speciosa	Lythraceae	Queen's crepe myrtle	Ann et al. (2002)
	Lagerstroemia subcostata	Lythraceae		Sahashi et al. (2007)
	Lagerstroemia turbinate	Lythraceae	Crepe myrtle	Ann et al. (2002)
	Lannea coromandelica	Anacardiaceae		Supriadi et al. (2004)
	Lantana camara	Verbenaceae	Lantana	Ann et al. (2002)
	Larix kaempferi	Pinaceae		Sahashi et al. (2014)
	Leptopetalum grayi	Rubiaceae		Sahashi et al. (2015)
	Leucaena leucocephala	Fabaceae	White popinac	Ann et al. (2002); Akiba et al. (2015), Sahashi et al. (2015)

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	Leucaena sp.	Fabaceae		Cannon et al. (2022)
	Ligustrum japonicum	Oleaceae	Japanese privet	Sahashi et al. (2012)
	Ligustrum micranthum	Oleaceae		Akiba et al. (2015), Shashi et al. (2015)
	Liquidambar formosana	Hamamelidaceae	Formosa sweet gum	Ann et al. (2002), Tsai et al. (2017), Hsiao et al. (2019)
	Litchi chinensis	Sapindaceae	Litchi	Ann, Lee, and Huang (1999); Ann et al. (2002); Akiba et al. (2015), Tsai et al. (2017)
	Litsea glutinosa	Lauraceae	Indian laurel	Ann et al. (2002)
	Litsea hypophaea	Lauraceae	Mountain pepper	Ann et al. (2002)
	Litsea japonica	Lauraceae	Litsea	Akiba et al. (2015)
	Litsea monopetala	Lauraceae	Many flowered litsea	Wu et al. (2011)
	Livistona chinensis	Arecaceae	Chinese fan palm	Wu et al. (2011)
	Lophostemon confertus	Myrtaceae		Zhang et al. (2022)
	Macaranga graeffeana	Euphorbiaceae		Singh et al. (1980)
	Macaranga harveyana	Euphorbiaceae		Brooks (2002), Cannon et al. (2022)
	Macaranga mappa	Euphorbiaceae		Cannon et al. (2022)
	Macaranga sp.	Euphorbiaceae		Liao et al. (2023)
	Macaranga stipulosa	Euphorbiaceae		Brooks (2002), Cannon et al. (2022)
	Macaranga tanarius	Euphorbiaceae	Macaranga	Ann et al. (2002), Hsiao et al. (2019)
	Macaranga tanarius var. tomentosa	Euphorbiaceae		Akiba et al. (2015)
	Macaranga thompsonii	Euphorbiaceae	Pengua tree	Stewart et al. (2020)
	Machilus chekiangensis	Lauraceae		Zhang et al. (2022)
	Machilus kobu	Lauraceae		Sahashi et al. (2015)
	Machilus thunbergii (Syn. *Persea thunbergii)*	Lauraceae	Japanese bay tree, red machilus, tabunoki	Sahashi et al. (2007, 2010), Akiba et al. (2015)
	Machilus zuihoensis (Syn. *Persea zuihoensis)*	Lauraceae	Incense machilus	Ann et al. (2002)
	Maesa tenera	Myrsinaceae	Taiwan maesa	Ann et al. (2002)
	Mallotus paniculatus	Euphorbiaceae	Turn in the wind	Ann et al. (2002), Tsang et al. (2020)
	Malpighia emarginata	Malpighiaceae	Acerola	Sahashi et al. (2015)
	Mangifera indica	Anacardiaceae	Mango	Akiba et al. (2015), Sahashi et al. (2015, 2017), Hsiao et al. (2019)
	Maytenus diversifolia	Celastraceae		Sahashi et al. (2012)
	Melaleuca bracteata	Myrtaceae	Black tea tree	Tsai et al. (2017)
	Melaleuca leucadendron	Myrtaceae	Weeping paperbark	Ann et al. (2002)
	Melia azedarach	Meliaceae	China berry	Ann et al. (2002), Akiba et al. (2015), Hsiao et al. (2019)
	Melia azedarach var. subtripinnata	Meliaceae		Sahashi et al. (2010, 2015)
	Melodinus angustifolius	Apocynaceae	Narrow leafed melodinus	Ann et al. (2002)
	Metroxylon sp.	Arecaceae		Neil (1988)
	Michelia compressa	Magnoliaceae	Formosan michelia	Ann et al. (2002)
	Michelia figo	Magnoliaceae	Banana magnolia	Ann et al. (2002)
	Michelia sp.	Magnoliaceae		Ann, Lee, and Tsai (1999)
	Microcos paniculata	Malvaceae	Garden mint	Wu et al. (2011)
	Morinda citrifolia	Rubiaceae	Indian mulberry	Brooks (2002), Cannon et al. (2022)
	Morus australis	Moraceae	Korean mulberry	Akiba et al. (2015), Sahashi et al. (2015)
	Muntingia calabura	Muntingiaceae	Indian cherry	Ann et al. (2002)
	Murraya paniculata	Rutaceae	Orange jasmine	Ann et al. (2002), Tsai et al. (2017), Hsiao et al. (2019)

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	Musa acuminata x Musa balbisiana	Musaceae	Banana	Stewart et al. (2020)
	Musa spp.	Musaceae		Ivory and Daruhi (1993)
	Musa textilis	Musaceae		Berwick (1949)
	Myristica castaneifolia	Myristicaceae		Singh et al. (1980)
	Myristica fatua (Syn. *Virola surinamensis)*	Myristicaceae	Banak	Brooks (2002), Cannon et al. (2022)
	Nageia nagi	Podocarpaceae	Nagi	Chung et al. (2015)
	Nandina domestica	Berberidaceae	Orange jessamine	Akiba et al. (2015)
	Neolitsea parvigemma	Lauraceae	Small bud neolitsea	Ann et al. (2002)
	Neolitsea sericea	Lauraceae		Sahashi et al. (2015)
	Neonauclea forsteri	Rubiaceae		Brooks (2002), Cannon et al. (2022)
	Nerium oleander	Apocynaceae	Oleander	Ann et al. (2002)
	Ochroma lagopus	Malvaceae	Balsa tree	Farr et al. (2021)
	Ochrosia mariannensis	Apocynaceae	Fago	Stewart et al. (2020)
	Ochrosia nakaiana	Apocynaceae		Sahashi et al. (2015)
	Oncidium Gower Ramsey	Orchidaceae		Tsai et al. (2017)
	Osmanthus fragrans	Oleaceae	Sweet Osmanthus	Ann et al. (2002), Tsai et al. (2017)
	Osmanthus insularis	Oleaceae		Akiba et al. (2015), Sahashi et al. (2015)
	Osmoxylon sp.	Araliaceae		Neil (1988)
	Pachira macrocarpa (Syn. *P. aquatica)*	Malvaceae	Malabar chestnut	Ann et al. (2002); Sahashi et al. (2015), Hsiao et al. (2019)
	Palaquium formosanum	Sapotaceae	Formosan nato tree	Ann et al. (2002)
	Palaquium hornei	Sapotaceae		Singh et al. (1980)
	Pandanus boninensis	Pandanaceae		Sahashi et al. (2015)
	Pangium edule	Achariaceae		Ivory and Daruhi (1993)
	Parinari insularum	Chrysobalanaceae		Singh et al. (1980)
	Parinari laurina (Syn. *Atuna excelsa* subsp. *racemosa*)	Chrysobalanaceae	Atuna	Singh et al. (1980)
	Passiflora edulis	Passifloraceae	Purple Passion Fruit	Ann, Tsai, Wang, and Hsien (1999)
	Persea americana	Lauraceae	Avocado	Ann et al. (2002), Stewart et al. (2020)
	Persea kobu (Syn. *Machilus kobu)*	Lauraceae		Sahashi et al. (2015)
	Phyllanthus myrtifolius	Phyllanthaceae	Ceylon mirtle	Leung et al. (2020)
	Pinus caribaea	Pinaceae		Almonicar (1992)
	Pinus elliottii	Pinaceae		Farr et al. (2021)
	Pinus luchuensis	Pinaceae	Luchu pine	Abe et al. (1995)
	Pinus ponderosa	Pinaceae	Ponderosa pine	Ibarra Caballero et al. (2020)
	Pinus spp.	Pinaceae		Ibarra Caballero et al. (2020)
	Pinus thunbergii (syn. *Pinus thunbergiana)*	Pinaceae	Black pine	Ann et al. (2002)
	Piper nigrum	Pinaceae	Black Pepper	Farr et al. (2021)
	Pipturus argenteus	Urticaceae		Brooks (2002), Cannon et al. (2022)
	Pistacia chinensis	Anacardiaceae	Chinese pistache	Ann et al. (2002)
	Pittosporum tobira	Pittosporaceae	Japanese pittosporum	Akiba et al. (2015)
	Planchonella grayana	Sapotaceae		Brooks (2002), Cannon et al. (2022)
	Planchonella obovata	Sapotaceae	Sea gutta	Akiba et al. (2015), Sahashi et al. (2015)

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	Planchonella samoensis	Sapotaceae		Brooks (2002), Cannon et al. (2022)
	Planchonella torricellensis	Sapotaceae		Brooks (2002)
	Podocarpus macrophyllus	Podocarpaceae	Yew	Abe et al. (1995), Ann et al. (2002), Sahashi et al. (2010), Tsai et al. (2017)
	Pometia pinnata	Sapindaceae		Brooks (2002), Cannon et al. (2022)
	Pongamia pinnata	Fabaceae	Pongamia	Ann et al. (2002)
	Populus deltoides	Salicaceae	Poplar	Singh and Pandey (1989)
	Prunus armeniaca	Rosaceae	Apricot	Tsai et al. (2017)
	Prunus campanulata	Rosaceae	Taiwan cherry	Tsai et al. (2017)
	Prunus cerasoides var. campanulata (Syn. *Cerasus campanulata)*	Rosaceae	Bell-flowered cherry	Akiba et al. (2015), Sahashi et al. (2015)
	Prunus mahaleb	Rosaceae	Mahaleb cherry	Ibarra Caballero et al. (2020)
	Prunus mume	Rosaceae	Japanese apricot, plum	Ann et al. (2002), Tsai et al. (2017)
	Prunus persica (syn. *Amygdalus persica)*	Rosaceae	Peach	Ann et al. (2002), Tsai et al. (2017), Akiba et al. (2015)
	Prunus serrulata	Rosaceae	Oriental cherry	Chung et al. (2015)
	Prunus spp.	Rosaceae		Ibarra Caballero et al. (2020)
	Psidium cattleianum f. lucidum	Myrtaceae	Strawberry guava	Sahashi et al. (2015)
	Psidium guajava	Myrtaceae	Guava	Tsai et al. (2017)
	Pterocarpus indicus	Fabaceae	Rose wood	Ann et al. (2002), Tsai et al. (2017)
	Pterospermum acerifolium	Malvaceae		Chen et al. (2023)
	Pyrus communis	Rosaceae	European pear	Ann, Lee, and Huang (1999)
	Pyrus pyrifolia	Rosaceae	Pear	Ann, Lee, and Huang (1999), Ann et al. (2002), Tsai et al. (2017)
	Pyrus sp.	Rosaceae		Chung et al. (2015)
	Quercus sp.	Fagaceae		Chung et al. (2015)
	Reevesia formosana	Malvaceae	Taiwan Reevesia	Fu and Cheung (2023)
	Rhaphiolepis indica var. umbellata	Rosaceae	India hawthorne	Akiba et al. (2015), Sahashi et al. (2015)
	Rhaphiolepis umbellata (Syn. *Laurus umbellate)*	Rosaceae	Japanese-hawthorn	Sahashi et al. (2010)
	Rhododendron obtusum	Ericaceae	Rhododendron	Ann et al. (2002)
	Rhododendron simsii	Ericaceae	Sims's azalea	Chung et al. (2015)
	Rhus succedanea (Syn. *Toxicodendron succedaneum)*	Anacardiaceae	Japanese wax tree	Sahashi et al. (2015)
	Rhus taitensis	Anacardiaceae		Brooks (2002), Cannon et al. (2022)
	Roystonea regia	Arecaceae	Royal palm	Ann et al. (2002)
	Salix babylonica	Salicaceae	Willow	Ann et al. (2002)
	Salix nigra	Salicaceae	Black willow	Ibarra Caballero et al. (2020)
	Salix spp.	Salicaceae		Ibarra Caballero et al. (2020)
	Samanea saman	Fabaceae	Rain tree	Brooks (2002), Cannon et al. (2022)
	Santalum album	Santalaceae		Burgess et al. (2018)
	Schefflera octophylla	Araliaceae	Scheffera	Ann et al. (2002)
	Schima mertensiana (Syn. *Schima boninensis)*	Theaceae		Akiba et al. (2015), Sahashi et al. (2015)
	Schinus terebinthifolia	Anacardiaceae	Brazilian peppertree	Tsai et al. (2017)
	Scolopia saeva	Salicaceae		Stewart et al. (2020)
	Sonneratia sp.	Lythraceae		Stewart et al. (2020)
	Spathodea campanulata	Bignoniaceae	African tulip tree	Tsai et al. (2017), Hsiao et al. (2019)
	Spondias dulcis	Anacardiaceae	Otaheite apple	Sahashi et al. (2015), Cannon et al. (2022)

Host status	Host name	Plant family	Common name	Reference
	Stachytarpheta jamaicensis	Verbenaceae	Jamaica vervain	Sahashi et al. (2015)
	Sterculia foetida	Sterculiaceae	Hazel sterculia	Ann et al. (2002)
	Sterculia lanceolata	Malvaceae		Wu et al. (2011), Huang et al. (2016)
	Sterculia nobilis	Malvaceae	Ping pong	Ann et al. (2002), Tsai et al. (2017)
	Swietenia macrophylla	Meliaceae	Big leaved mahogany	Hsiao et al. (2019)
	Swietenia mahagoni	Meliaceae	Mahogany	Ann et al. (2002)
	Syzygium inophylloides	Myrtaceae		Brooks (2002), Cannon et al. (2022)
	Syzygium samarangense	Myrtaceae	Wax apple	Ann, Lee, and Huang (1999), Ann et al. (2002), Tsai et al. (2017)
	Syzygium sp.	Myrtaceae		Brooks (2002), Cannon et al. (2022)
	Tabebuia chrysantha	Bignoniaceae	Yellow golden bell tree	Ann et al. (2002)
	Taiwania cryptomerioides	Chrysomelidae	Taiwania	Ann et al. (2002)
	Tamarindus indica	Fabaceae	Tamarind tree	Hsiao et al. (2019)
	Taxodium distichum	Cupressaceae	Deciduous cypress	Chung et al. (2015)
	Tectona grandis	Lamiaceae	Teak	Hsiao et al. (2019), Stewart et al. (2020)
	Tephrosia vogelii	Fabaceae		Beeley (1938)
	Terminalia boivinii	Combretaceae	Bovinii	Ann et al. (2002)
	Terminalia calamansanai	Combretaceae		Neil (1988)
	Terminalia catappa	Combretaceae	Indian almond	Ann et al. (2002); Akiba et al. (2015), Sahashi et al. (2015), Tsai et al. (2017)
	Terminalia ivorensis	Combretaceae	Ivory Coast almond	Cannon et al. (2022)
	Terminalia richii	Combretaceae		Brooks (2002), Cannon et al. (2022)
	Theobroma	Malvaceae		Riggenbach (1958)
	Theobroma cacao	Malvaceae	Cocoa	Brooks (2002)
	Thevetia peruviana (Syn. *Cascabela thevetia*)	Apocynaceae	Lucky-nut, Milk tree	Ann, Tsai, Wang, and Hsien (1999)
	Toona australis	Meliaceae		Neil (1988)
	Toona sinensis (Syn. *Cedrela sinensis)*	Meliaceae	Chinese cedar	Tsai et al. (2017)
	Tournefortia argentea	Boraginaceae	Tree heliotrope	Hsiao et al. (2019)
	Trachelospermum asiaticum	Apocynaceae	Asiatic jasmine	Sahashi et al. (2015)
	Trema orientalis	Ulmaceae	Charcoal tree	Akiba et al. (2015), Sahashi et al. (2015), Hsiao et al. (2019)
	Ulmus parvifolia	Ulmaceae	Chinese elm	Ann et al. (2002)
	Veitchia spp.	Arecaceae		Neil (1988)
	Vitis sp.	Vitaceae		Chung et al. (2015)
	Vitis vinifera	Vitaceae	Grape	Ann, Lee, and Huang (1999), Ann et al. (2002), Tsai et al. (2017)
	Wikstroemia pseudoretusa	Thymelaeaceae		Sahashi et al. (2015)
	Zanthoxylum ailanthoides var. boninshimae	Rutaceae	Japanese prickly ash	Sahashi et al. (2015)
	Zelkova formosana	Ulmaceae		Chung et al. (2015)
	Zelkova serrata	Ulmaceae	Zelkova	Ann et al. (2002), Hsiao et al. (2019)
	Zelkova sp.	Ulmaceae		Ann, Lee, and Tsai (1999)
	Ziziphus mauritiana	Rhamnaceae	Indian jujube	Tsai et al. (2017)
Wild weed hosts	*Artemisia capillaris*	Asteraceae	Wormwood	Ann et al. (2002)
	Artemisia princeps	Asteraceae	Mugwort	Ann et al. (2002)
	Dendrocnide sp.	Urticaceae		Neil (1988)
	Digitaria ciliaris	Poaceae		Chen et al. (2023)
	Ipomoea pes-caprae	Convolvulaceae	Morning glory	Ann et al. (2002)

(Continues)

Host status	Host name	Plant family	Common name	Reference
	Lactuca indica	Asteraceae	Wild lettuce	Chang and Yang (1998), Ann et al. (2002)
	Melicope merrilli	Rutaceae	Melicope	Ann et al. (2002)
	Oplismenus compositus	Poaceae	Basket grass	Chen et al. (2023)
	Paspalum distichum	Poaceae		Chen et al. (2023)
	Saurauia oldhamii (Syn. *Saurauia tristyla)*	Actinidiaceae		Ann et al. (2002)
	Typhonium blumei	Araceae		Chen et al. (2023)
	Urena lobata	Malvaceae	Cadillo	Ann et al. (2002)
	Zoysia matrella	Poaceae	Manila grass	Chen et al. (2023)
Artificial/ experimental host	*Calophyllum vexans*	Calophyllaceae		Abe et al. (1995)
	Cassia bicapsularis (Syn. *Senna bicapsularis)*	Fabaceae	Christmas bush	Ann, Tsai, Wang, and Hsien (1999)
	Citrus grandis (Syn. *Citrus maxima)*	Rutaceae	Pampelmuse	Ann, Tsai, Wang, and Hsien (1999)
	Citrus reticulata	Rutaceae	Mandarin orange	Ann, Tsai, Wang, and Hsien (1999)
	Citrus sinensis	Rutaceae	Sweet orange	Ann, Tsai, Wang, and Hsien (1999)
	Euphoria longana (Syn. *Dimocarpus longan)*	Sapindaceae	Longan	Ann, Lee, and Huang (1999)
	Fagus crenata	Fagaceae	Siebold's beech, Japanese beech	Abe et al. (1995)
	Jasminum sambac	Oleaceae	Arabian jasmine	Ann, Tsai, Wang, and Hsien (1999)
	Paspalum conjugatum	Poaceae		Chen et al. (2023)
	Quercus acutissima	Fagaceae		Abe et al. (1995)
	Thespesia populnea	Malvaceae	Portia tree	Hodges and Tenorio (1984)

APPENDIX B

Distribution of *Pyrrhoderma noxium*

Region	Country	Sub-national (e.g. state)	Status	References
North America	Cuba		Present, no details	CABI (2022)
	Puerto Rico		Present, no details	CABI (2022)
Central America	Costa Rica		Present, no details	CABI (2022)
	Panama		Present, no details	Zhou et al. (2018)
South America	Brazil		Present, no details	Mendes & Urben (2023)
	Peru		Present, no details	CABI (1969)
Africa	Angola		Present, no details	CABI (2022)
	Benin		Present, no details	CABI (2022)
	Burkina Faso		Present, no details	CABI (2022)
	Cameroon		Present, no details	Nicole et al. (1985), CABI (2022)
	Central African Republic		Present, no details	CABI (2022)
	Chad		Present, no details	CABI (1969)
	Democratic Republic of the Congo		Present, no details	CABI (2022)
	Gabon		Present, no details	CABI (2022)
	Ghana		Present, no details	CABI (2022)
	Guinea		Present, no details	CABI (1969)
	Ivory Cost		Present, no details	CABI (2022)
	Kenya		Present, no details	CABI (2022)
	Liberia		Present, no details	Nicole et al. (1985)
	Mali		Present, no details	CABI (1969)
	Mauritania		Present, no details	CABI (1969)
	Nigeria	Cross-River, Ondo, Ikom	Present, no details	CABI (2022)
	Senegal		Present, no details	CABI (1969)
	Sierra Leone		Present, no details	CABI (2022)
	Tanzania		Present, no details	CABI (2022)
	Togo		Present, no details	CABI (2022)
	Uganda		Present, no details	CABI (2022)
Asia	China		Present, no details	Zhou et al. (2018)
	Hong Kong		Present, no details	Stewart et al. (2020)
	India		Present, no details	CABI (2022)
	Indonesia	Java, Sumatra	Present, no details	CABI (2022)
	Japan		Present, no details	Akiba et al. (2015)
	Malaysia		Present, no details	Stewart et al. (2020)
	Myanmar		Present, no details	CABI (2022)
	Pakistan		Present, no details	CABI (2022)
	Philippines		Present, no details	Glen et al. (2014)
	Singapore		Present, no details	CABI (2022)
	Sri Lanka		Present, no details	Silva et al. (2017)
	Taiwan		Present, no details	Hsiao et al. (2019), Ann et al. (2002)
	Thailand		Present, no details	Samseemoung et al. (2011), Sunthudlakhar et al. (2022)
	Vietnam		Present, no details	CABI (2022)

(Continues)

Region	Country	Sub-national (e.g. state)	Status	References
Oceania	American Samoa		Present, no details	Brooks (2002), Cannon et al. (2022)
	Australia		Present, no details	Stewart et al. (2020)
	Federated Stated of Micronesia	Chuuk, Kosrae, Pohnpei, Yap	Present, no details	Akiba et al. (2015), Cannon et al. (2022)
	Fiji		Present, no details	CABI (2022)
	French Polynesia	Tahiti	Present, no details	Mallet et al. (1985)
	Guam		Present, no details	Cannon et al. (2022)
	Mariana Island		Present, no details	Cannon et al. (2022)
	Niue		Present, no details	CABI (2022)
	Papua New Guinea		Present, no details	CABI (2022)
	Republic of Palau		Present, no details	Cannon et al. (2022)
	Republic of Vanuatu		Present, no details	CABI (2022)
	Rota Island		Present, no details	Cannon et al. (2022)
	Saipan		Present, no details	Cannon et al. (2022)
	Samoa		Present, no details	CABI (2022)
	Solomon Islands		Present, no details	CABI (2022)

APPENDIX C

Harvested area of *Pyrrhoderma noxium* main hosts in the EU MS

Harvested area of *Pyrrhoderma noxium* main hosts in the EU MS, 2017–2021 (1000 ha). Source: EUROSTAT (accessed November 2023).

Crop	2017	2018	2019	2020	2021
Grapes (W1000)	3133.32	3135.50	3155.20	3146.24	3120.22
Belgium	0.24	0.30	0.38	0.49	0.56
Bulgaria	34.11	34.11	30.05	28.74	28.53
Czechia	15.81	15.94	16.08	16.14	16.36
Denmark	0.00	0.00	0.00	0.00	0.00
Germany	:	:	:	:	:
Estonia	0.00	0.00	0.00	0.00	0.00
Ireland	0.00	0.00	0.00	0.00	0.00
Greece	101.75	100.34	101.85	104.21	89.84
Spain	937.76	939.92	936.89	931.63	929.39
France	750.46	750.62	755.47	759.59	757.83
Croatia	21.90	20.51	19.82	21.45	21.21
Italy	670.09	675.82	697.91	703.90	702.67
Cyprus	5.93	6.67	6.67	6.18	6.16
Latvia	0.00	0.00	0.00	0.00	0.00
Lithuania	0.00	0.00	0.00	0.00	0.00
Luxembourg	1.26	1.25	1.24	1.24	1.23
Hungary	67.08	66.06	64.92	59.63	59.07
Malta	0.68	0.42	0.42	0.45	0.46
Netherlands	0.16	0.17	0.16	0.17	0.19
Austria	46.33	46.50	46.36	46.16	42.84
Poland	0.67	0.73	0.74	1.00	1.00
Portugal	178.95	179.25	175.65	175.67	175.62
Romania	175.32	172.80	176.34	165.60	163.61
Slovenia	15.86	15.65	15.57	15.29	14.90
Slovakia	8.47	8.01	7.92	7.73	7.75
Finland	0.00	0.00	0.00	0.00	0.00
Sweden	0.04	0.05	0.05	0.08	0.09

Citrus fruits (T0000)	2017	2018	2019	2020	2021
EU	502.84	508.99	512.83	522.10	519.96
Greece	43.47	46.26	44.23	45.62	41.16
Spain	294.26	297.62	296.48	297.97	300.50
France	4.27	4.39	4.61	6.80	6.77
Croatia	2.06	1.97	2.20	2.10	2.14
Italy	135.36	134.64	140.74	145.10	144.70
Cyprus	2.92	3.05	3.20	3.03	2.91
Malta	0.00	0.00	0.00	0.00	0.11
Portugal	20.51	21.07	21.37	21.48	21.68

Peaches (F1210) & nectarines (F1220)	2017	2018	2019	2020	2021
EU	221.64	214.97	206.87	203.32	194.01
Belgium	0.00	0.00	0.00	0.00	0.00
Bulgaria	3.89	3.52	3.21	2.78	2.67
Czechia	0.37	0.38	0.34	0.34	0.32
Denmark	0.00	0.00	0.00	0.00	0.00

(Continues)

Peaches (F1210) & nectarines (F1220)	2017	2018	2019	2020	2021
Germany	0.00	0.00	0.00	0.00	0.00
Estonia	0.00	0.00	0.00	0.00	0.00
Ireland	0.00	0.00	0.00	0.00	0.00
Greece	41.38	42.65	41.41	45.43	38.55
Spain	84.22	80.31	77.69	72.13	72.06
France	9.32	9.10	9.03	11.66	11.77
Croatia	0.96	0.86	0.88	0.78	0.80
Italy	67.02	64.30	60.44	58.68	56.54
Cyprus	0.30	0.29	0.31	0.34	0.35
Latvia	0.00	0.00	0.00	0.00	0.00
Lithuania	0.00	0.00	0.00	0.00	0.00
Luxembourg	0.00	0.00	0.00	0.00	0.00
Hungary	5.62	5.20	5.06	4.17	4.14
Malta	0.00	0.00	0.00	0.00	0.00
Netherlands	0.00	0.00	0.00	0.00	0.00
Austria	0.16	0.18	0.18	0.18	0.18
Poland	2.13	2.12	2.15	0.80	1.00
Portugal	3.90	3.74	3.78	3.80	3.76
Romania	1.77	1.70	1.79	1.69	1.37
Slovenia	0.28	0.26	0.25	0.25	0.24
Slovakia	0.32	0.36	0.35	0.31	0.28
Finland	0.00	0.00	0.00	0.00	0.00
Sweden	0.00	0.00	0.00	0.00	0.00

Crop	2017	2018	2019	2020	2021
Cherries (F1240)	173.37	175.49	176.30	178.61	175.71
Belgium	1.40	1.14	1.14	1.12	1.13
Bulgaria	10.06	11.23	12.16	11.73	11.93
Czechia	2.11	2.07	2.16	2.15	2.12
Denmark	0.66	0.56	0.53	0.61	0.56
Germany	7.96	7.94	7.94	7.89	7.81
Estonia	0.01	0.00	0.00	0.01	0.00
Ireland	0.00	0.00	0.00	0.00	0.00
Greece	15.83	16.21	16.24	20.70	16.93
Spain	27.59	27.50	27.60	27.91	29.61
France	8.01	8.13	8.03	7.51	7.50
Croatia	3.53	2.94	2.85	3.12	3.20
Italy	29.27	29.16	29.21	29.01	28.06
Cyprus	0.23	0.22	0.23	0.23	0.22
Latvia	0.10	0.10	0.12	0.10	0.10
Lithuania	0.73	0.76	0.77	0.77	0.76
Luxembourg	0.00	0.00	0.00	0.00	0.00
Hungary	15.65	15.88	15.93	16.62	16.79
Malta	0.00	0.00	0.00	0.00	0.00
Netherlands	0.81	0.79	0.78	0.79	0.77
Austria	0.25	0.30	0.30	0.30	0.29
Poland	36.44	36.91	37.29	35.20	35.00
Portugal	6.30	6.14	6.50	6.49	6.41
Romania	6.02	7.06	6.09	5.94	6.12
Slovenia	0.19	0.20	0.21	0.22	0.22
Slovakia	0.19	0.21	0.20	0.16	0.13

Crop	2017	2018	2019	2020	2021
Finland	0.00	0.00	0.00	0.00	0.00
Sweden	0.03	0.03	0.03	0.04	0.05

Pears (F1120)	2017	2018	2019	2020	2021
EU	113.81	113.54	110.66	108.29	106.96
Belgium	10.02	10.15	10.37	10.66	10.45
Bulgaria	0.45	0.57	0.70	0.50	0.55
Czechia	0.71	0.75	0.80	0.83	0.80
Denmark	0.30	0.29	0.30	0.30	0.30
Germany	2.14	2.14	2.14	2.14	2.14
Estonia	0.00	0.00	0.00	0.00	0.00
Ireland	0.00	0.00	0.00	0.00	0.00
Greece	4.07	4.41	4.34	5.42	4.37
Spain	21.89	21.33	20.62	20.22	20.02
France	5.25	5.24	5.25	5.90	5.89
Croatia	0.71	0.80	0.86	0.73	0.75
Italy	31.73	31.34	28.71	26.60	26.79
Cyprus	0.07	0.06	0.06	0.07	0.08
Latvia	0.20	0.20	0.20	0.20	0.20
Lithuania	0.82	0.82	0.82	0.85	0.85
Luxembourg	0.02	0.02	0.02	0.01	0.01
Hungary	2.90	2.84	2.81	2.62	2.74
Malta	0.00	0.00	0.00	0.00	0.00
Netherlands	9.70	10.00	10.09	10.00	10.07
Austria	0.46	0.49	0.50	0.54	0.55
Poland	7.26	7.30	7.22	5.80	5.60
Portugal	11.54	11.21	11.33	11.33	11.16
Romania	3.12	3.10	3.08	3.09	3.17
Slovenia	0.20	0.21	0.21	0.22	0.23
Slovakia	0.11	0.12	0.11	0.10	0.09
Finland	0.04	0.05	0.04	0.05	0.05
Sweden	0.12	0.11	0.10	0.11	0.11

Apricots (F1230)	2017	2018	2019	2020	2021
EU	72.23	72.57	73.22	76.13	73.48
Belgium	0.00	0.00	0.00	0.00	0.00
Bulgaria	2.90	2.55	2.91	1.84	3.06
Czechia	1.10	1.15	1.15	1.17	1.12
Denmark	0.00	0.00	0.00	0.00	0.00
Germany	0.23	0.23	0.23	0.23	0.23
Estonia	0.00	0.00	0.00	0.00	0.00
Ireland	0.00	0.00	0.00	0.00	0.00
Greece	7.31	7.94	8.35	12.24	8.96
Spain	21.00	20.57	20.24	19.78	19.44
France	12.20	12.27	12.28	12.08	11.88
Croatia	0.28	0.27	0.26	0.29	0.31
Italy	17.36	17.81	17.91	17.81	17.74
Cyprus	0.19	0.18	0.18	0.20	0.21
Latvia	0.00	0.00	0.00	0.00	0.00
Lithuania	0.00	0.00	0.00	0.00	0.00
Luxembourg	0.00	0.00	0.00	0.00	0.00

(Continues)

Apricots (F1230)	2017	2018	2019	2020	2021
Hungary	4.97	5.04	4.99	5.94	6.05
Malta	0.00	0.00	0.00	0.00	0.00
Netherlands	0.00	0.00	0.00	0.00	0.00
Austria	0.79	0.83	0.82	0.83	0.86
Poland	0.96	0.97	1.06	0.90	0.90
Portugal	0.56	0.56	0.54	0.52	0.53
Romania	2.11	1.97	2.04	2.03	1.92
Slovenia	0.08	0.08	0.08	0.09	0.09
Slovakia	0.19	0.16	0.18	0.20	0.19
Finland	0.00	0.00	0.00	0.00	0.00
Sweden	0.00	0.00	0.00	0.00	0.00

Crop	2017	2018	2019	2020	2021
Avocados (F2300)	12.72	13.22	17.50	19.58	22.86
Greece	0.60	0.72	1.08	1.10	1.93
Spain	11.81	12.16	14.10	15.85	18.06
France	0.23	0.24	0.24	0.13	0.13
Cyprus	0.08	0.10	0.10	0.16	0.17
Portugal	0.00	0.00	1.98	2.34	2.57

Crop	2017	2018	2019	2020	2021
Bananas (F2400)	18.91	17.94	18.27	22.11	22.01
Greece	0.09	0.09	0.10	0.10	0.10
Spain	9.08	9.09	9.06	9.10	9.10
France	8.49	7.50	7.78	11.58	11.48
Cyprus	0.21	0.22	0.21	0.22	0.21
Portugal	1.04	1.05	1.12	1.12	1.12

APPENDIX D

Köppen–Geiger maps

Figure D.1 shows the Köppen–Geiger map for *P. noxium* based on report locations with geographical coordinates only. Figure D.2 shows the Köppen–Geiger map for *P. noxium* based on report locations with and without geographical coordinates.

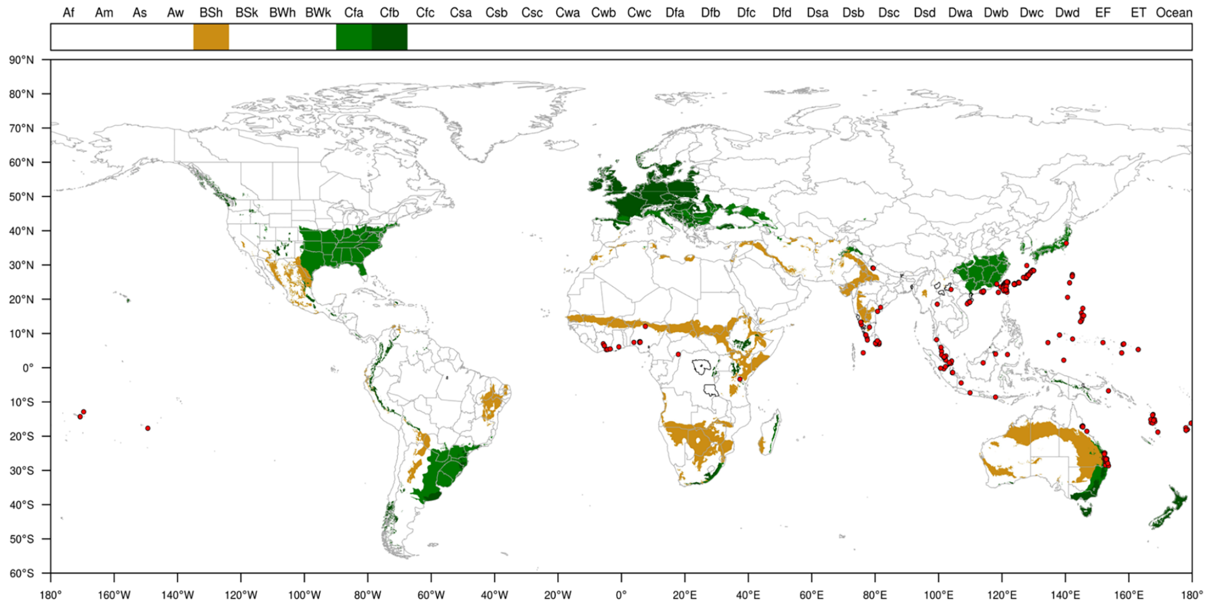

FIGURE D.1 Distribution of three Köppen–Geiger climate types, i.e. BSh, Cfa and Cfb, that occur in the EU and in third countries where *Pyrrhoderma noxium* has been reported (locations with geographical coordinates only). The legend shows the list of Köppen–Geiger climates. Red dots indicate point locations where *P. noxium* was reported.

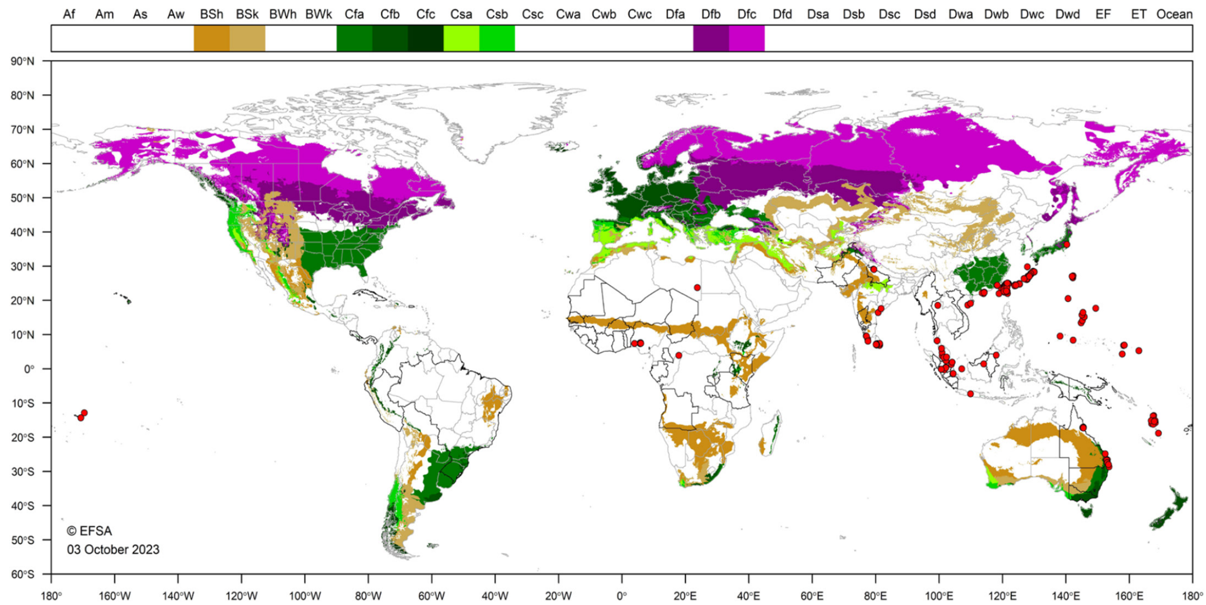

FIGURE D.2 Koeppen–Geiger map based on the pathogen records with local geographical coordinates (as Figure 3), but also on those records without local coordinates, which were thus assigned to large administrative areas (e.g. Pakistan, Japan), and thus include several climate types.