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Pest categorisation of *Fusarium pseudograminearum*

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Abstract

The EFSA Plant Health Panel performed a pest categorisation of *Fusarium pseudograminearum* O'Donnell & T. Aoki. *F. pseudograminearum* is a soil-borne fungal pathogen, able to cause a disease known as Fusarium crown rot (FCR, also known as foot and root rot) and occasionally Fusarium head blight on small grain cereals, particularly *Triticum aestivum* L., *Triticum turgidum* L. spp. *durum* (Dest.), *Hordeum vulgare* L. and triticale (x*Triticosecale*). In addition, *F. pseudograminearum* has been isolated from soybean (*Glycine max* L.) and from some grass genera, such as *Phalaris*, *Agropyron* and *Bromus*, which represent potentially important inoculum reservoirs. This pathogen has been reported in arid and semi-arid cropping regions in Australia, New Zealand, North and South America, northern Africa and South Africa, the Middle East and Asia. In the EU, it has been reported in Italy since 1994 and later in Spain on field-grown durum wheat, but uncertainty remains regarding the actual distribution of the pathogen in the EU. The pathogen is not included in the EU Commission Implementing Regulation 2019/2072. Seeds of host plants and soil and other substrates are the main pathways for the entry and spread of the pathogen into the EU. There are no reports of interceptions of *F. pseudograminearum* in the EU. Host availability and climate suitability occurring in the EU favour establishment of the pathogen and allow it to establish in areas from which it has not been reported. Phytosanitary measures are available to prevent the introduction of the pathogen into the EU, and additional measures are available to mitigate the risk of spread. In the non-EU areas of its present distribution, the pathogen has a direct impact on cultivated hosts (e.g. wheat, barley, triticale and soybean) that are also relevant for the EU. However, no crop losses have been reported so far in the EU. The Panel concludes that *F. pseudograminearum* satisfies all the criteria to be regarded as a potential Union quarantine pest.

Keywords: Pest risk, plant health, plant pest, quarantine, Fusarium crown rot, Fusarium head blight, cereals

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Table of 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

Fusarium pseudograminearum 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 European Commission 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.

1.3. Additional information

This pest categorisation was initiated as a result of media monitoring, PeMoScoring and subsequent discussion in PAFF, resulting in it being included in the current mandate within the list of pests identified by Horizon Scanning and selected for pest categorisation.

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 and for which, when the pest is reported in an MS, an official pest status is not always available. To obtain information on the official pest status for *F. pseudograminearum*, EFSA has consulted the NPPOs of Italy and Spain. The results of this consultation are presented in Section 3.2.2.

2.1.2. Literature search

A literature search on *Fusarium pseudograminearum* 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.

2.1.3. Database search

Pest information, on host(s) and distribution, was retrieved from the European and Mediterranean Plant Protection Organization (EPPO) Global Database (EPPO, online), the CABI databases and scientific literature databases as referred above in Section 2.1.2.

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 (phytosanitary 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 *F. pseudograminearum* 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 *F. pseudograminearum,* 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) are 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. Whilst 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 the pest is clearly defined, it has been shown to produce consistent symptoms and to be transmissible.

Fusarium pseudograminearum O'Donnell & T. Aoki is a fungus of the family Nectriaceae, described as a new species in 1999 (Aoki and O'Donnell, 1999a). *F. pseudograminearum* was formerly known as *F. graminearum* Schwabe Group 1, which was first identified in Australia on wheat in 1983 (Burgess et al., 1987).

In the current pest categorisation, the PLH Panel has also considered the literature available on *F. graminearum* Group 1 to conclude on the pest status.

EPPO Global Database (EPPO, online) provides the following taxonomic identification for *F. pseudograminearum:*

Preferred scientific name: *Fusarium pseudograminearum* O'Donnell & T. Aoki
Order: Hypocreales
Family: Nectriaceae
Genus: *Fusarium*
Species: *Fusarium pseudograminearum*

Common names: Fusarium crown rot of cereals; Fusarium head blight of wheat.

Synonyms: *Gibberella coronicola* T. Aoki & O'Donnell, *Fusarium graminearum* Schwabe Group 1.

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

3.1.2. Biology of the pest

F. pseudograminearum is a soil-borne fungal pathogen, able to cause a disease known as Fusarium crown rot (FCR, also known as foot rot and root rot) on small grain cereals.

F. pseudograminearum is not the only fungal pathogen responsible for crown and root rot of cereals, a disease that may be caused also by other *Fusaria*, such as *Fusarium culmorum* (W.G. Smith) Sacc., *Fusarium graminearum sensu stricto* (Schwabe), *Fusarium avenaceum* Fr. (Sacc.) and *Fusarium poae* (Peck) Wollenw., as well as with other fungal pathogens (e.g. *Gaeumannomyces tritici* (J. Walker) Hern.-Restr. & Crous, *Bipolaris sorokiniana* Shoemaker) or oomycetes (*Pythium* spp.), which may cause similar disease symptoms (Akinsanmi et al., 2004; Smiley et al., 2005a; Chakraborty et al., 2006; Tunali et al., 2008; Gebremariam et al., 2018; Kazan and Gardiner, 2018).

As a causal agent of FCR, *F. pseudograminearum* is more common in warm and dry regions compared to *F. culmorum*, which is predominant in cooler regions with higher rainfall (Chakraborty et al., 2006; Poole et al., 2013; Sabburg et al., 2015), albeit this geographic distribution is not always strictly observed (Scherm et al., 2013). FCR may occur on its host plants at different growth stages. Infected germinating seeds and seedlings usually die before or after emergence. If seedlings survive, typical disease symptoms include brown discoloration of the roots, coleoptile, subcrown internode, of the first two/three internodes of the main stem and of lower leaf sheaths and adjacent stems and nodal tissues. Under high humidity conditions, a reddish-pink discoloration can often be easily observed on the nodes, caused by the presence of sporulating mycelium.

Infected plants may present tiller abortion and are more prone to lodging. The presence of white heads with shriveled seed – or bearing no seed at all – can be observed when the wheat head is still immature. Disease symptoms are exacerbated under drought conditions (Liu and Liu, 2016; Kazan and Gardiner, 2018; Alahmad et al., 2018), correlating with the observation that agricultural areas exposed to warm temperatures and dry soil conditions during the growing season are more conducive to the disease (Backhouse and Burgess, 2002; Poole et al., 2013; Sabburg et al., 2015).

F. pseudograminearum saprophytically survives and overwinters on crops residues (e.g. stubble, which represents the primary inoculum reservoir) as mycelium or chlamydospores: these are able to germinate and develop, by producing sporodochia bearing asexual macroconidia which can infect the host plant and induce disease symptoms upon artificial inoculation. Inoculum of the pathogen can be efficiently disseminated through infected seeds (Klein and Burgess, 1987; Marasas et al., 1988); however, it is uncertain, which is the main inoculum source in the field (Kazan and Gardiner, 2018). *F. pseudograminearum* can also undergo a sexual stage on crop residues, by producing sexual structures (perithecia) that discharge ascospores to the environment. However, perithecia production by its heterothallic teleomorph *Gibberella coronicola* T. Aoki and O'Donnell, 1999a,b has been rarely observed in the field (Summerell et al. 2001) or under laboratory conditions (Aoki and O'Donnell 1999b). Therefore, the role of ascospores in the epidemiology of the disease is a matter of debate. Rain splash of macroconidia originating from sporodochia produced around infected nodes in wet seasons may represent an important means of spread between infected host plants, thereby facilitating heterothallic fertilisation and recombination (Alahmad et al., 2018).

Mycelium originating from germinated macroconidia mostly penetrates via stomata and infects the coleoptile by moving into the subcrown internode and leaf sheaths and further into the stem epidermal

[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 (Griessinger and Roy, 2015; EPPO, 2019).

tissues. The pathogen then colonises the hypodermis, where it induces the typical browning of the stem and, subsequently, it moves into the vascular tissues (Kazan and Gardiner, 2018). Moreover, it has also been demonstrated that *F. pseudograminearum* is able to grow from the stem base to the heads through the pith parenchyma (Mudge et al., 2006). At least the three lower internodes of the host plant can be colonised by the pathogen. The presence of mycelium and spores in the vascular tissues hampers water and nutrient translocation within the plant, thereby contributing to the appearance of the typical white heads (Knight et al., 2012). *F. pseudograminearum* can infect plants systemically, albeit to a varying extent: some studies reported the ability of the fungus to colonise the entire plant until the head tissues (Mudge et al., 2006), whereas in other studies, the progression of the pathogen was limited to the first internodes (Knight et al., 2012). Systemic translocation of the trichothecene mycotoxin deoxynivalenol may also occur upon foot and root infection by the pathogen, as this mycotoxin has been detected in the head and in the kernels even in the absence of the pathogen (Beccari et al., 2018).

On wheat heads, *F. pseudograminearum* may also induce Fusarium head blight (FHB), particularly when warm and humid conditions occur during the flowering stage (Obanor and Chakraborty, 2014; Obanor et al., 2013). Similar to *F. graminearum*, FHB may be associated with typical necrotic and bleached spikelets, and resulting grains are often contaminated with trichothecene mycotoxins (Valverde-Bogantes et al., 2020). The majority of Australian *F. pseudograminearum* isolates reportedly produce the acetylated form of deoxynivalenol 3-acetyl-deoxynivalenol (3-ADON; Chakraborty et al., 2006; Obanor and Chakraborty, 2014), and some isolates from New Zealand produce nivalenol (Monds et al., 2005). The presence of both 3-ADON and 15-acetyl-deoxynivalenol (15-ADON) chemotypes has been reported from China (Deng et al., 2020). In addition to deoxynivalenol, *F. pseudograminearum* may produce other mycotoxins, such as diacetoxyscirpenol, zearalenone, nivalenol and fusarenon X (Clear et al., 2006).

3.1.3. Host range/species affected

F. pseudograminearum has been reported from the following cultivated hosts: *Avena* sp. (Chekali et al., 2019), *Glycine max* (Zhang et al., 2018), *Hordeum* sp. (Cunnington, 2003), *Lolium multiflorum* × *Lolium perenne* (Reinhardt, 2015), *Medicago* sp. (Roux et al., 2001), *Panicum* sp. (Wright et al., 2012), *Triticum* spp. (Cunnington, 2003) and *Zea mays* (Izzati et al., 2011; Jiang et al. 2022), and from the following wild weed hosts: *Aegilops tauschii* (Xu et al., 2018), *Austrostipa aristiglumis* (Bentley et al., 2007), *Hordeum geniculatum* (Bentley et al., 2006) and *Panicum virgatum* (Ghimire et al., 2011). The following experimental hosts were also reported for *F. pseudograminearum* by Akinsamni et al. (2007): *Brassica napus*, *Cicer arietinum*, *Oryza sativa*, *Secale cereale*, *Sorghum* sp. and *Triticosecale rimpaui*.

The complete list of the host plants reported so far for *F. pseudograminearum* is included in Appendix A (last updated: 22/3/2022).

3.1.4. Intraspecific diversity

F. pseudograminearum, formerly known as *F. graminearum* Group 1, has been separated from *F. graminearum sensu stricto* based on morphological and molecular differences (Aoki and O'Donnell, 1999a). It is estimated that the two species have diverged from a common ancestor between 1.2 and 6.5 million years ago (O'Donnell et al., 2000). Multilocus sequence analysis of a large collection of *F. pseudograminearum* from different regions of the world has confirmed that it is a reproductively isolated and phylogenetically distinct species, without consistent lineage development (Scott and Chakraborty, 2006).

Amplified fragment length polymorphism (AFLP) analysis revealed a high level of genotypic diversity among isolates: 70 of 72 *F. pseudograminearum* isolates from Australia had distinct haplotypes, and 18 AFLP haplotypes were identified amongst 27 isolates collected from a single field (Akinsanmi et al., 2006). Bentley et al. (2008) confirmed a high level of genetic diversity by analysing the AFLP haplotype distribution among 217 isolates representing eight *F. pseudograminearum* populations from north-eastern, south central and south-western regions of the Australian grain belt. The southern populations diverged from the north-eastern populations by higher levels of population differentiation, raising the hypothesis that the populations from north-eastern and southern Australia could have originated from different founding events or from geographic isolation and the accumulation of genetic differences due to genetic drift and/or selection (Bentley et al., 2008).

Similar levels of genetic diversity were evidenced by Mishra et al. (2006), who employed a restriction analysis of the nuclear ribosomal DNA intergenic spacer region (IGS) and intersimple sequence-repeat (ISSR) molecular markers on a collection of isolates originating from Alberta and Saskatchewan in Canada. This study revealed a substantially high level of genetic diversity within each of these two populations, but a low genetic differentiation and frequent gene flow among populations. In fact, most genetic variability resulted from differences among isolates within populations, suggesting a panmictic genetic structure (therefore, no mating restrictions) and the occurrence of significant recombination in this species. Indeed, although the heterothallic teleomorph *Gibberella coronicola* has rarely been reported in field studies, the observation of *F. pseudograminearum* perithecia on infected stubble supports the hypothesis that sexual recombination may occur in agricultural settings (Kazan and Gardiner, 2018). The occurrence of gene flow and random mating between isolates from different populations may result in the potential evolution of new, more virulent genotypes displaying improved pathological and biological traits.

3.1.5. Detection and identification of the pest

Are detection and identification methods available for the pest?
Yes, detection and identification methods are available for the pathogen.

The species *F. pseudograminearum* has been first described by Aoki and O'Donnell (1999a) based on morphological features and on DNA sequence data from β-tubulin gene introns and exons. This *taxon* was previously known as *F. graminearum* Group 1, distinguished from *F. graminearum* Group 2 (which later became *F. graminearum sensu stricto*) in prior molecular studies based on randomly amplified polymorphic DNAs (RAPDs) (Schilling et al., 1996). Morphological differences observed by Aoki and O'Donnell (1999a) included growth rates on SNA (synthetic low nutrient agar; Nirenberg, 1990) medium amended with different carbon sources, slight differences in the morphology of macroconidia and, most importantly, the absence of homothallic production of perithecia.

Colonies of *F. pseudograminearum* grown on PDA are indistinguishable from those of *F. graminearum sensu stricto*, and may vary in colour from red, pastel-red, dull-red, pale-red, reddish-white, greyish-brown, brownish-orange, brownish-yellow to white. Reverse pigmentation may be red, deep-red, reddish-brown, brownish-red, brownish-violet, ruby, reddish-white to white. Chlamydospores are often absent but in some strains present, mostly subglobose, intercalary or occasionally terminal, single or in chains, formed from mycelium and/or macroconidia Typical sclerotia are absent. Sporulation occurs from conidiophores formed directly on aerial hyphae or aggregated in sporodochia on the agar surface. Conidiophores are branched verticillately or unbranched, forming monophialides on the apices. Macroconidia are typically falcate to fusiform, 1–7 septate, but some almost cylindrical and gently curved, dorsiventral and most frequently widest at the middle septum or at the midregion of their length, mostly tapering and curving equally towards both ends, with an elongated arcuate apical cell and a distinct basal foot cell. Microconidia are absent. A detailed morphological description of *F. pseudograminearum* and its teleomorph is provided by Aoki and O'Donnell (1999a and 1999b). A *F. pseudograminearum*-specific PCR primer pair (Fp1-1/Fp1-2) was designed based on the translation elongation factor EF-1α gene sequence, allowing the specific amplification of a PCR product of 523 bp from strains of *F. pseudograminearum* (Aoki and O'Donnell, 1999a,b). The PCR assay developed by Aoki and O'Donnell, 1999a,b has been subsequently found able to distinguish *F. pseudograminearum* from *F. graminearum*, *F. culmorum* and *F. crookwellense* isolates, but not from *F. acuminatum* (Williams et al., 2002).

Williams et al. (2002) developed a set of *F. pseudograminearum*-specific primers (PFG-F/PFG-R) based on the sequence of two randomly amplified polymorphic DNA fragments. These primers were validated on purified DNA from 79 isolates representative of 12 different *Fusarium* species and from seedlings infected with single or multiple isolates (Williams et al., 2002).

A real-time PCR assay based on the *tri5* gene encoding trichodiene synthase and TaqMan technology has been developed (Strausbaugh et al., 2005), but it could not distinguish *F. pseudograminearum* from *F. culmorum* and *F. graminearum*.

Knight et al. (2012) developed an alternative primer/probe set (TEF1α.2F, TEF1α.2R / TEF1α.2P) based on the translation elongation factor EF-1α gene sequence and validated their qPCR assay on DNA obtained from two isolates each of the following *Fusarium* species: *F. compactum*, *F. crookwellense*, *F. culmorum*, *F. equiseti*, *F. poae*, *F. proliferatum*, *F. scirpi*, *F. semitectum*, as well as from five isolates of *F. graminearum* and eight isolates of *F. pseudograminearum*. The primer/probe set proved specific for the target *F. pseudograminearum* and was subsequently used to assess the quantity of *F. pseudograminearum* biomass within wheat tissues in an attempt to correlate fungal growth with the expression of disease symptoms by the host tissues.

Another pair of *F. pseudograminearum*-specific primers (FPKY927890F/FPKY927890R) has been recently developed by Yin et al. (2020), based on the TEF-1α gene sequence to assess the effect of no-till and reduced tillage on crop root disease profiles in wheat fields in Northeast Oregon. By adopting a qPCR approach, *F. pseudograminearum* inoculum in soil samples was successfully quantified and distinguished from other soil-borne wheat pathogens, including *F. culmorum*, *Pythium* spp., *Rhizoctonia solani* and *Rhizoctonia oryzae* (Yin et al., 2020).

No EPPO Standard is available for the detection and identification of *F. pseudograminearum*.

3.2. Pest distribution

3.2.1. Pest distribution outside the EU

F. pseudograminearum (formerly *F. graminearum* Group 1) has been reported from several countries in America, Asia, Africa and Oceania (Figure 1).

In Asia, the pathogen is reported from Azerbaijan (Özer et al., 2020), China (Li et al., 2012; Ji et al., 2016; Xu et al., 2017, 2018; Zhang et al., 2018; Zhou et al., 2019), Iran (Farrokhi and Saremi, 2004), Malaysia (Izzati et al., 2011), Syria (Alkadri et al., 2013), Iraq (Hameed et al., 2012) and Turkey (Tunali et al., 2008).

In Africa, the pathogen is reported from Algeria (Abdallah-Nekache et al., 2019), South Africa (Marasas et al., 1988) and Tunisia (Gargouri et al., 2011).

In America, *F. pseudograminearum* is reported from Argentina (Castañares et al., 2012), Canada and USA (CABI CPC, online) and in Oceania, from Australia (Burgess et al., 1987) and New Zealand (CABI CPC, online).

Details of the current distribution of the pathogen outside the EU are presented in Appendix B.

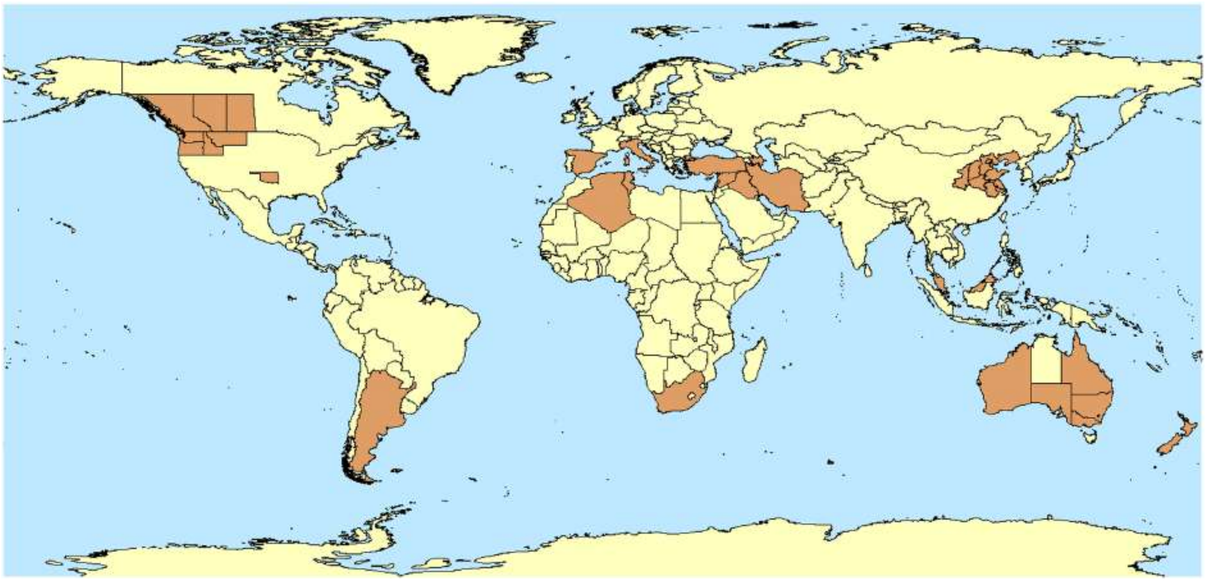

Figure 1: Global distribution of *Fusarium pseudograminearum* (Data Source: CABI CPC [accessed on 1 November 2022] and literature)

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.*
>
> **Yes**, *F. pseudograminearum* is reported to be present in the EU (Italy and Spain), with restricted distribution.

F. pseudograminearum, as *F. graminearum* Group 1, was reported in the EU for the first time by Balmas (1994), who isolated the pathogen from the basal stem of durum wheat (*Triticum turgidum* subsp. *durum* cv Ofanto) grown in Foggia, Southern Italy. In 2016, the pathogen was isolated from a wheat (*Triticum aestivum*) field in Cordoba, Spain (CABI CPC, online; Agustí-Brisach et al., 2018).

The NPPO of Spain stated that *F. pseudograminearum* is present in Galicia and Andalucia. The pathogen was detected in 2017 in wheat crop. No official actions are in place against the pathogen since there is no evidence that *F. pseudograminearum* is causing problems in the cultivation of wheat in Spain. The NPPO of Italy stated that *F. pseudograminearum* is often found on wheat seed and is endemic.

An additional report of *F. pseudograminearum* isolated from apple fruit in Croatia is available in the literature (Sever et al., 2012). However, no molecular identification of the isolates was carried out; therefore, the Panel cannot consider it as an official report of the presence of *F. pseudograminearum* in the country.

Considering the wide distribution of cereal crops in the EU, the reported presence of the pathogen since 1994, and the fact that symptoms and signs are shared with other *Fusarium* species affecting cereals, there is uncertainty on the current distribution of *F. pseudograminearum* in the EU territory.

3.3. Regulatory status

3.3.1. Commission Implementing Regulation 2019/2072

F. pseudograminearum is not listed in Annex II of Commission Implementing Regulation (EU) 2019/2072, an implementing act of Regulation (EU) 2016/2031.

3.3.2. Hosts of *Fusarium pseudograminearum* or species affected that are prohibited from entering the Union from third countries

Table 2 presents a list of plants, plant products and other objects that are *F. pseudograminearum* hosts and whose introduction into the European Union from certain third countries is prohibited.

Table 2: List of plants, plant products and other objects that are *Fusarium pseudograminearum* 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**
14.	Plants for planting of the family Poaceae, other than plants of ornamental perennial grasses of the subfamilies Bambusoideae and Panicoideae and of the genera Buchloe, Bouteloua Lag., Calamagrostis, Cortaderia	ex 0602 90 50 ex 0602 90 91 ex 0602 90 99	Third countries other than: Albania, Algeria*, Andorra, Armenia, Azerbaijan*, Belarus, Bosnia and Herzegovina, Canary Islands, Egypt, Faeroe Islands, Georgia, Iceland, Israel, Jordan, Lebanon, Libya, Liechtenstein, Moldova, Monaco, Montenegro, Morocco, 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,

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**
	Stapf., Glyceria R. Br., Hakonechloa Mak. ex Honda, Hystrix, Molinia, Phalaris L., Shibataea, Spartina Schreb., Stipa L. and Uniola L., other than seeds		Serbia, Switzerland, Syria*, Tunisia*, Turkey, Ukraine and the United Kingdom

*: *F. pseudograminearum* is reported to be present in Algeria, Azerbaijan, Syria and Tunisia: therefore, these pathways are still open.

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, the pest is able to enter the EU territory via the seed of host plants and the soil or other substrates.

Host plants for planting is not a pathway of entry, as hosts are traded as seeds.

The PLH Panel identified the following main pathways for the entry of the pathogen into the EU territory:

1) seed for sowing of host plants,
2) soil and other substrates, originating in infested third countries (Table 3).

Imported quantities of fresh produce of main hosts from countries where *Fusarium pseudograminearum* is present are included in Table 4.

F. pseudograminearum survives as a common soil inhabitant and, as other *Fusarium* species, is a strong competitor in soil associated with host crop residues (see Section 3.1.2 Biology of the pest). The inoculum is believed to occur mostly as hyphae in residue fragments, with most of the inoculum sources being present in the standing stubble (Hogg et al., 2010). Chlamydospores of *F. pseudograminearum* have been reported to survive in soil for over 5 years (Sitton and Cook, 1981). Therefore, besides seeds of host plants, soil and other substrates associated or not with host plants represent a potential pathway of further entry of the pathogen into the EU territory.

Population genetic studies provide strong evidence of sexual recombination (Akinsanmi et al., 2006), suggesting that ascospores (like macroconidia) may play a role in the dispersal of the pathogen under some circumstances. However, spatial aggregation of clones has been observed within plant rows in the field (Bentley et al., 2009) and the disease incidence correlates with the bulk of infested residues (Backhouse, 2006). This evidence suggests that inoculum dispersal occurs only over short distances from each focus. There is a lack of evidence on the possibility that ascospores and macroconidia may contribute to long-distance dispersal. Therefore, the pathogen is unlikely to enter new areas of the EU by natural means (wind, rain, etc.). Although there are no quantitative data available, different types of propagules (mycelium, macroconidia, chlamydospores, ascospores) of the pathogen may be also present as contaminants on other substrates (e.g. non-host plants for planting or seed, straw and husks, plant debris and contaminated machinery and equipment) imported into the EU from infested third countries.

Table 3: Potential pathways for *Fusarium pseudograminearum* into the EU 27

Pathways	Life stage	Relevant mitigations [e.g. prohibitions (Annex VI), special requirements (Annex VII) or phytosanitary certificates (Annex XI) within Implementing Regulation 2019/2072]
Description (e.g. host/ intended use source)		
Grain of the genera *Triticum* L., *Secale* L. and × *Triticosecale* Wittm. ex A. Camus	Mycelium and macroconidia	Annex XI, A (1.) requires phytosanitary certificate for the introduction into the Union territory from certain third countries: Afghanistan, India, Iran, Iraq, Mexico, Nepal, Pakistan, South Africa and the USA. However, cereal grains can still enter without a phytosanitary certificate from infested third countries (e.g. Azerbaijan).
Seeds of wheat and meslin	Mycelium and macroconidia	Annex XI, A (1.) requires phytosanitary certificate for the introduction into the Union territory from certain third countries among which Iran, Iraq, South Africa and United States are listed, where the pest is known to occur.
Seeds of Brassicaceae, Poaceae, *Trifolium* spp.	Mycelium and macroconidia	Annex XI, A (8.) requires phytosanitary certificate for the introduction into the Union territory from certain third countries among which Argentina, Australia and New Zealand are listed, where the pest is known to occur.
Seeds of *Triticum* L., *Secale* L. and × *Triticosecale* Wittm. ex A. Camus	Mycelium and macroconidia	Annex XI, A (8.) requires phytosanitary certificate for the introduction into the Union territory from certain third countries among which Iran, Iraq, South Africa and United States are listed, where the pest is known to occur.
Soil and other substrates associated or not with host plants for planting	Mycelium, macroconidia and chlamydospores	Annex VI (19., 20.) bans the introduction into the Union from third countries other than Switzerland of soil as such and 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.
Growing medium attached to or associated with plants intended to sustain the vitality of the plants	Mycelium, macroconidia and chlamydospores	Annex XI A (1.) requires phytosanitary certificate for growing medium, attached to or associated with plants, intended to sustain the vitality of the plants originating in third countries other than Switzerland.
ADD STRAW Cereal straw and husks	Mycelium, macroconidia and chlamydospores	Annex XI A (1.) requires phytosanitary certificate for harvesting or threshing machinery, including straw or fodder balers, originating in third countries other than Switzerland.
Machinery and vehicles which have been operated for agricultural or forestry purposes	Chlamydospores, macroconidia, mycelium attached to plant debris	Annex VII (2.) requires official statement that the machinery or vehicles are cleaned and free from soil and plant debris. Annex XI, A (1.) requires phytosanitary certificate for the introduction into the Union territory of machinery and vehicles from third countries other than Switzerland.

Table 4: EU 27 annual imports of fresh produce of main hosts from countries where *Fusarium pseudograminearum* is present, 2016–2020 (in 100 kg) Source: EUROSTAT accessed on 25/1/22

Commodity	HS code	2016	2017	2018	2019	2020
Wheat and meslin	1001	243,12325.64	187,35125.93	146,53700.31	195,70470.92	310,78306.29
Soya beans, whether or not broken	1201	64,830,599.12	57,209,358.37	82,503,563.08	80,014,749.47	63,433,263.78
Grain sorghum	1007	24,828.82	13,111.05	5,210,092.81	4,185,520.66	25,724.73

Commodity	HS code	2016	2017	2018	2019	2020
Maize or corn	1005	15,935,991.19	15,612,197.10	37,162,428.42	10,165,312.90	7,495,260.54
Millet (excl. Grain sorghum)	1008 21 00	55,758.18	37,197.58	35,550.6	130,650.9	88,713.63
Barley	1003	4,054.75	22,631.45	14,528.08	1,947.32	6,002.85
Oats	1004	1,781.89	1,128.33	801.77	4,624.00	1,764.13
Cereal straw and husks	1213 00 00	865.1	731.46	1,586.13	13,862.88	1,630.85
	Sum	1,051,66204.7	91,631,481.27	139,582,251.2	114,087,139.1	102,130,666.8

Notifications of interceptions of harmful organisms began to be compiled in Europhyt in May 1994 and in TRACES in May 2020. As at 26/1/2022, there were no records of interception of *F. pseudograminearum* or *F. graminearum* Group 1 in the Europhyt and TRACES databases. However, two interceptions of *Fusarium* sp. are reported in Europhyt and TRACES with the last interception in 2021.

3.4.2. Establishment.

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

Yes. The pest could establish in the risk assessment area.

Given its biology, *F. pseudograminearum* could potentially be transferred from the pathways of entry (seed and soil) to the host plants grown in the EU via the contaminated soil, irrigation water, and to a lesser extent as wind-disseminated and splash-dispersed spores. The frequency of this transfer will depend on the volume and frequency of imported commodities.

F. pseudograminearum is frequently detected as causal agent of crown rot (FCR) in areas characterised by low elevations, low moisture and high temperatures (Backhouse and Burgess, 2002; Chakraborty et al., 2006; Poole et al., 2013). On cereals, FCR severity is strongly dependent on the level of rainfall and on the degree of moisture stress occurring late in the growing season (Liu and Liu, 2016; Melloy et al., 2010). Therefore, it is expected that this pathogen could establish particularly in the Southern regions of the EU territory (e.g. Spain, Portugal, Italy, Greece) where cereals are widely grown and the climatic conditions are suitable to pathogen survival and disease development.

3.4.2.1. EU distribution of main host plants

In Table 5, the EU distribution of the reported host plants of *F. pseudograminearum* is outlined.

Table 5: Harvested area of *Fusarium pseudograminearum* reported hosts in EU 27, 2016–2020 (1,000 ha). Source EUROSTAT (accessed 19/1/2022)

Crop	2016	2017	2018	2019	2020
Wheat and spelt	25,210.30	24,138.62	23,751.66	24,212.28	22,876.72
Barley	11,179.59	10,862.69	11,144.80	11,138.94	11,025.28
Oats	2,476.62	2,520.59	2,566.96	2,390.76	2,563.41
Soya	831.18	962.39	955.40	907.91	947.67
Green maize	6,061.45	5,985.90	6,134.91	6,210.36	6,325.68
Grain maize and corn-cob-mix	8,541.42	8,266.64	8,252.47	8,910.74	9,354.73
Other cereals n.e.c. (buckwheat, millet, canary seed, etc.)	323.00	337.77	326.54	292.77	348.63

3.4.2.2. Climatic conditions affecting establishment

F. pseudograminearum has been reported from all continents except the Arctic and Antarctica. Based on the few data available, the climatic zones (BSh, BSk, Cfa, Cfb, Cfc, Csa, Csb, Csc, Dfb and Dfc; Kottek et al., 2006) in parts of Azerbaijan, China, Iran, Malaysia, Syria, Iraq, Turkey (in Asia), Algeria, Tunisia, South Africa (in Africa), Argentina, Canada, USA (in America), Australia and New Zealand (in Oceania), where the pathogen is present, are comparable to climatic zones within the EU

(Figure 2). The climate zones in the areas in Italy and Spain from where the pathogen has been reported also occur in other parts of the EU.

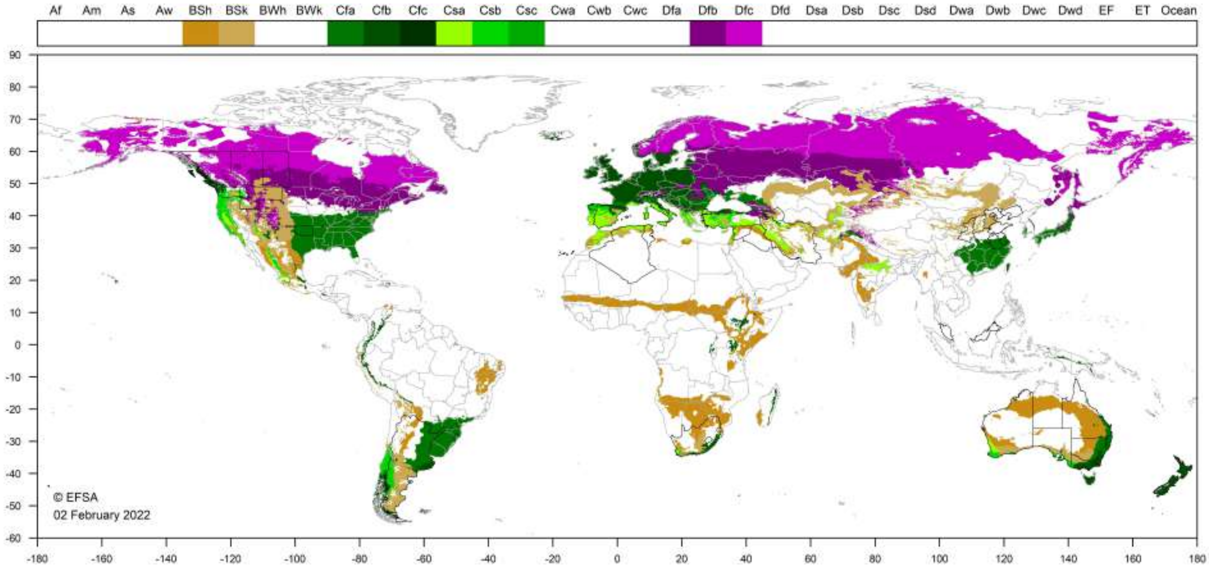

Figure 2: Distribution of 10 Köppen–Geiger climate types, BSh, BSk, Cfa, Cfb, Cfc, Csa, Csb, Csc, Dfb and Dfc that occur in the EU and in countries where *Fusarium pseudograminearum* has been reported. The legend shows the list of Köppen–Geiger climates

3.4.3. Spread

Describe how the pest would be able to spread within the EU territory following establishment?
F. pseudograminearum could potentially spread within the EU by both natural and human-assisted means.

Following its introduction into the EU territory, *F. pseudograminearum* would be able to spread within the EU by both natural and human-assisted means.

Spread by natural means. The fungus overwinters as mycelium or macroconidia or perithecia in infected plant residues and in seed, or as chlamydospores in soil (Kazan and Gardiner, 2018; Chakraborty et al., 2006). Macroconidia, and possibly ascospores of the teleomorph *G. coronicola*, are dispersed locally by wind, water or rain-splash (Obanor and Chakraborty, 2014). There is uncertainty on the possibility that ascospores and macroconidia may contribute to long-distance dispersal, although experimental evidence has outlined spatial aggregation of clonal haplotypes, thereby implying some restrictions in the dispersal of the fungal propagules at a local scale (Bentley et al., 2009).

Spread by human-assisted means. The pathogen could potentially spread over long distances via the movement of infected seeds, plant debris (e.g. straw, mulching material), soil and substrates and contaminated equipment. It has been recently hypothesised that the introduction and spread of this pathogen in the Huanghuai wheat-growing area in China could be related to the trans-regional operation of farm machinery, which has become an extensive commercial service in this region (Deng et al., 2020).

3.5. Impacts

Would the pests' introduction have an economic or environmental impact on the EU territory?
Yes, the pathogen may have a direct impact on some crops (e.g. wheat, barley, maize, soybean) that are relevant for the EU.

Despite *F. pseudograminearum* is mainly reported as a causal agent of crown rot, it has also been responsible for major epidemics in Australia of Fusarium head blight (Burgess et al. 1987), a disease that is considered one of the major threats to global wheat production (Goswami and Kistler 2004;

Savary et al., 2019; Haile et al., 2019). Epidemics can result in significant economic losses as a consequence of the reduction in grain quality and quantity and through grain contamination with trichothecene mycotoxins (Scott and Chakraborty, 2008).

Yield loss estimates reported from the USA Pacific Northwest have indicated that FCR is able to cause up to 35% reductions in wheat yield under standard field conditions (Smiley et al., 2005b). In Australia, FCR caused by *F. pseudograminearum* routinely determines 10% yield reduction in cereals, with some cultivars suffering yield reductions of more than 40% (Hüberli et al., 2018). It has been estimated that under favourable conditions, or in the absence of proper disease management, the pathogen could cause severe losses to the Australian cereal industry (Murray and Brennan, 2009, 2010).

Given the relevance of the diseases caused by the pathogen, it is likely that its establishment and spread in the Southern areas of the EU may have a potential impact, especially on small grain cereal crops (e.g. wheat, barley and triticale) and possibly on maize and soybean. However, no associated crop losses have been reported so far in the EU territory despite the pathogen has been detected on durum wheat since 1994.

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 *F. pseudograminearum*, existing phytosanitary measures (see Sections 3.3.2 and 3.4.1) mitigate the likelihood of the pathogen's entry on certain host plants, plant products and other objects into the EU territory. Potential additional measures are also available to further mitigate the risk of entry and spread 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 hosts of *F. pseudograminearum* (e.g. *Panicoideae*), although measures in Annex VII of Commission Implementing Regulation 2019/2072 do not specifically refer to this pest (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 et al., 2018) for pest entry/establishment/spread/impact in relation to currently unregulated hosts and pathways. Control measures are measures that have a direct effect on pest abundance

Control measure/Risk reduction option (Blue underline = Zenodo doc, Blue = WIP)	**RRO summary**	**Risk element targeted (entry/ establishment/ spread/impact)**
Require pest freedom	Plant or plant products should come from a country officially free from the pest, or from a pest-free area or from a pest-free place of production.	Entry/Spread
Managed growing conditions	The use of pathogen-free propagative material, proper field drainage, irrigation with non-contaminated water, increased sowing density, destruction of infected crop residues, and crop rotation represent effective methods to manage *F. pseudograminearum*. Availability of nutrients in soil has also been reported to affect FCR disease development: nitrogen fertilisers can increase the disease incidence and severity in wheat. In contrast, the availability of sufficient amounts of zinc is important to maintain	Entry (reduce contamination/ infestation)/Spread/ Impact

Control measure/Risk reduction option (Blue underline = Zenodo doc, Blue = WIP)	RRO summary	Risk element targeted (entry/ establishment/ spread/impact)
	adequate levels of durum and bread wheat yields as zinc is effective in restricting the colonisation of wheat stems by *F. pseudograminearum*. DNA testing can be applied to provide reliable estimates of the inoculum level in soils and crop residues and to support management decisions.	
Crop rotation, associations and density, weed/ volunteer control	Non-host cereal crops (e.g. sorghum, oats) can be effective at reducing FCR in subsequent plantings. Similarly, non-cereal species (i.e. canola, mustard, lentil, lupine, clover) used in rotations have positive effects in reducing FCR inoculum levels in the field. The appropriate control of weed grasses that harbour FCR inocula is another agronomic practice that can reduce the disease incidence and is therefore recommended as part of an integrated strategy to manage crown rot.	Establishment/ Spread/Impact
Use of resistant and tolerant plant species/varieties	No absolute resistance is available against *F. pseudograminearum*, albeit tolerant cereal genotypes may be able to maintain their yield potential under infection or show reduced symptom development despite being exposed to high pathogen pressure. Partial FCR resistance is also found in existing cultivars, in wild relatives (e.g. *T. monococcum*, *T. timopheevii*, *T. turgidum* var. *dicoccum* and *T. turgidum* var. *carthlicum*) and in landraces of wheat and barley. Short durum wheat isolines are reported to have stronger FCR resistance than do tall isolines.	Establishment/ Spread/Impact
Roguing and pruning	Incorporating stubble into the soil can significantly reduce *F. pseudograminearum* inoculum levels.	Spread/Impact
Timing of planting and harvesting	Early sowing time allows grain-fill to occur under cooler conditions and less moisture stress which may reduce the impact of FCR. Planting dates should be selected in such a way that the occurrences of dry conditions during grain fill will be avoided during maturity. To control FHB, it is advisable to sowing *Fusarium*-free seed, avoiding sowing highly susceptible wheat varieties, staggered sowing to avoid all crops flowering during periods when weather is favourable for FHB infection.	Entry (reduce contamination/ infestation)/Impact
Biological control and behavioural manipulatio	*Trichoderma* spp. show strong inhibitory effects on *F. pseudograminearum* when sprayed onto straw colonised by this pathogen, thereby reducing FCR inoculum levels in the field (Stummer et al., 2022). Similarly, other biocontrol agents, such as arbuscular mycorrhizae, may provide significant protection against FCR (Spagnoletti et al., 2021).	Establishment/ Impact
Chemical treatments on crops including reproductive material	The treatment of seeds with fungicides or the application of fungicides to stem bases does not seem to provide sufficient protection from FCR. Common FHB management includes applying fungicides (generally tebuconazole).	Entry/Establishment/ Spread/Impact
Chemical treatments on consignments or during processing	The application of some preservative compounds (e.g. antimicrobial volatile organic compounds) to grain after harvest, during process or packaging operations and storage may contribute to inhibit the fungus and prevent the post-harvest contamination with mycotoxins.	Entry/Spread

Control measure/Risk reduction option (Blue underline = Zenodo doc, Blue = WIP)	**RRO summary**	**Risk element targeted (entry/ establishment/ spread/impact)**
Physical treatments on consignments or during processing	Microwave and γ-irradiation of infected stubble has been shown to reduce *F. pseudograminearum* inoculum levels in cereal residues under laboratory conditions (Petronaitis et al., 2018). However, the feasibility of these methods for grain treatment is yet to be established.	Entry/Spread
Cleaning and disinfection of facilities, tools and machinery	Phytosanitary measures to mitigate the risk of entry and spread of the pathogen on machinery and vehicles are included in CIR (EU) 2019/2072. Additional measures, such as cleaning, disinfection and disinfestation of tools and facilities (including premises, storage areas, etc.), may further mitigate the risk of entry or spread of *F. pseudograminearum*.	Entry/Spread
Limits on soil	Plants, plant products and other objects (e.g. used farm machinery) should be free from soil or growing medium. The growing medium should be free from soil and organic matter and should have not been previously used for growing plants or for any other agricultural purposes, or it should be composed entirely of peat or fibre, or subjected to effective fumigation or heat to ensure freedom from pests.	Entry/Spread
Soil treatment	Soil solarisation, tillage and stubble management, crop rotation and the application of antagonistic microorganisms can influence pest inoculum persistence and availability.	Entry/Establishment/ Impact
Use of non-contaminated water	Albeit the pathogen is able to spread through contaminated water, chemical and physical treatment of water is unfeasible under field conditions.	Entry/Spread
Waste management	Waste management (incineration, production of bioenergy) takes place in authorised facilities and official restriction on the movement of infected material is in force to prevent the pest from escaping. Proper waste management could mitigate the risk of spread of the pathogen.	Establishment/ Spread
Conditions of transport	When potentially infected/contaminated material has to be transported (including proper disposal of infected waste material), specific transport conditions (kind of packaging/ protection, time of transport, transport mean) should be defined to prevent the pest from escaping (see Annex C Information sheet 1.15).	Entry/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	The symptoms commonly reported on seedlings and on grain as incited by *F. pseudograminearum* (i.e. seedling blight with death of the plant before or after emergence; brown discoloration on roots and coleoptiles of the infected seedlings; brown discoloration on subcrown internodes and on the first two/three internodes of the main stem; tiller abortion; formation of whiteheads with shrivelled white grains; Fusarium head blight: prematurely bleached spikelets or blighting of the entire head, which remains empty or contains shrunken dark kernels) are similar to those caused by other *Fusarium* species affecting cereals (e.g. *F. culmorum* and *F. graminearum sensu stricto*). Therefore, it is unlikely that the pathogen could be detected based on visual inspection only.	Entry/Establishment/Spread
Laboratory testing	Diagnostic protocols are available to detect the pathogen unambiguously by PCR and RT- (quantitative)PCR.	Entry/Establishment/Spread
Sampling	Necessary as part of other RROs.	Establishment/Spread
Phytosanitary certificate and plant passport	Recommended for host plants, including seeds for sowing.	Entry/Spread
Certified and approved premises	If plant material originates from an approved premise, e.g. from a pest-free area, the likelihood of commodity being infected is assumed to be reduced.	Entry/Spread
Certification of reproductive material (voluntary/official)	Seeds come from within an approved propagation scheme and are certified pest free (level of infestation) following testing. Used to mitigate against pests that are included in a certification scheme.	Entry/Spread
Delimitation of Buffer zones	Delimitation of a buffer zone is an effective measure to prevent further spread of the pathogen.	Spread
Surveillance	Surveillance is an effective measure to define pest-free areas or pest-free places of production as well as to prevent further spread of the pathogen.	Spread

3.6.1.3. Biological or technical factors limiting the effectiveness of measures

- The similarity of symptoms and signs caused by *F. pseudograminearum* with those caused by other FCR-causing *Fusarium* species makes it impossible to detect the pathogen based on symptomatology and morphology only.
- The ability of the pathogen to survive in soil may favour its unintentional introduction of the pathogen by tourists traveling from infested areas (e.g. through contaminated soil particles adhering to footwear).The pathogen cannot be visually detected in contaminated soil.

3.7. Uncertainty

Uncertainty over the present distribution of the pathogen worldwide and in the EU territory.

Uncertainty over the possibility that ascospores and macroconidia may contribute to long-distance dispersal.

4. Conclusions

F. pseudograminearum is known to be present in the EU (Italy and Spain) with a restricted distribution. The pathogen satisfies the criteria that are within the remit of EFSA to assess for this species to be regarded as a 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 the pathogen is clearly defined and has been shown to be transmissible.	None.
Absence/presence of the pest in the EU (Section 3.2)	The pathogen is present in the EU territory with a restricted distribution. Its presence has been reported from Italy and Spain. A reported presence of the pathogen in Croatia is considered as not sufficiently supported.	Uncertainty exists about the current distribution of *F. pseudograminearum* in the EU.
Pest potential for entry, establishment and spread in the EU (Section 3.4)	The pathogen is able to enter into, become established in, and spread within, the EU territory. The main pathways for the entry of the pathogen into, and spread within, the EU territory are: (i) seeds and (ii) soil and substrates associated or not with host plants. Propagules of the pathogen may also be present as contaminants in other substrates (e.g. non-host plants, soils and substrates). The pathogen could potentially establish in the EU territory as biotic and abiotic factors are favourable. Following establishment, *F. pseudograminearum* could spread within the EU territory by natural and human-assisted means.	There is uncertainty over the possibility that ascospores and macroconidia may contribute to long-distance dispersal of the pathogen.
Potential for consequences in the EU (Section 3.5)	The introduction and spread of *F. pseudograminearum* in the EU territory would likely have yield and quality impacts on some hosts (e.g. cereals and soybean) that are widely grown in the EU.	None.
Available measures (Section 3.6)	Yes. Although not specifically targeted against *F. pseudograminearum*, existing phytosanitary measures mitigate the likelihood of the pathogen's further entry into the EU territory. Potential additional measures also exist to mitigate the risk of entry into, establishment or spread of the pathogen within the EU.	None
Conclusion (Section 4)	*F. pseudograminearum* meets all the criteria assessed by EFSA for consideration as a Union quarantine pest. No associated crop losses have been reported so far in the EU territory.	
Aspects of assessment to focus on/scenarios to address in future if appropriate:	The main knowledge gap concerns the need to ascertain the present distribution of this pathogen within the EU territory. Given that all the data available in the literature have been explored, the Panel considers that specific surveys should be carried out by using available species-specific PCR protocols on durum and bread wheat produced in the main cereal-growing areas. *Fusarium* isolates originated in the EU and maintained in culture collections should be re-evaluated using appropriate pest identification methods (e.g. multilocus gene sequencing analysis).	

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Glossary

Containment (of a pest)	Application of phytosanitary measures in and around an infested area to prevent spread of a pest (FAO, 2018).
Control (of a pest)	Suppression, containment or eradication of a pest population (FAO, 2018).
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, 2018).
Eradication (of a pest)	Application of phytosanitary measures to eliminate a pest from an area (FAO, 2018).
Establishment (of a pest)	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO, 2018).
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 and 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, 2018).
Pathway	Any means that allows the entry or spread of a pest (FAO, 2018).
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, 2018).
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, 2018).
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, 2018).

Abbreviations

EPPO	European and Mediterranean Plant Protection Organization
FAO	Food and Agriculture Organization

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

Appendix A – *Fusarium pseudograminearum* host plants/species affected

Source: CABI CPC (online) and ARS/USDA Fungal Database (online).

Host status	Host name	Plant family	Common name	Reference[A]
Cultivated hosts	*Avena sativa*	Poaceae	Oat	Chekali et al. (2019)
	Avena sp.	Poaceae	Oat	Chekali et al. (2019)
	Glycine max	Fabaceae	Soybean	CABI CPC
	Hordeum sp.	Poaceae	Barley	Cunnington (2003)
	Hordeum vulgare	Poaceae	Barley	CABI CPC
	Medicago sp.	Fabaceae	Lucerne/Alfalfa	
	Medicago truncatula	Fabaceae	Strong-spined medick	Roux et al. (2001)
	Panicum sp.	Poaceae	Millets	CABI CPC
	Panicum miliaceum	Poaceae	Millet	CABI CPC
	Triticum sp.	Poaceae	Wheat	Cunnington (2003)
	Triticum aestivum	Poaceae	Wheat	CABI CPC
	Triticum turgidum subsp. durum	Poaceae	Durum wheat	CABI CPC
	Zea mays	Poaceae	Maize	CABI CPC; Jiang et al. (2022)
Wild weed hosts	*Aegilops tauschii*	Poaceae	Tausch's goatgrass	Xu et al. (2018)
	Austrostipa aristiglumis	Poaceae	plain grass	Bentley et al. (2007)
	Hordeum geniculatum	Poaceae	Sea barley grass	Bentley et al. (2006)
	Panicum virgatum	Poaceae	Switchgrass	Ghimire et al. (2011)
Artificial/experimental host	*Brassica napus*	Brassicaceae	Canola	Akinsanmi et al. (2007)
	Cicer arietinum	Fabaceae	Chickpea	Akinsanmi et al. (2007)
	Oryza sativa	Poaceae	Rice	Akinsanmi et al. (2007)
	Secale cereale	Poaceae	Rye	Akinsanmi et al. (2007)
	Sorghum sp.	Poaceae	Sorghum	Akinsanmi et al. (2007)
	Triticosecale rimpaui	Poaceae	Triticale	Akinsanmi et al. (2007)

Appendix B – Distribution of *Fusarium pseudograminearum*

Distribution records based on CABI CPC (online) and ARS/USDA Fungal Database (online).

Region	Country	Subnational (e.g. State)	Status	References
North America	Canada	Alberta	Present	CABI CPC
		British Columbia	Present	CABI CPC
		Saskatchewan	Present	CABI CPC
	USA	Idaho	Present	CABI CPC
		Montana	Present	CABI CPC
		Oklahoma	Present	Ghimire et al. (2011)
		Oregon	Present	CABI CPC
		Washington	Present	CABI CPC
South America	Argentina		Present	Castañares et al. (2012)
EU (27)	Italy		Present	Balmas (1994)*
	Spain		Present	Agustí-Brisach et al. (2018)
Africa	Algeria		Present	Abdallah-Nekache et al. (2019)
	South Africa		Present	Marasas et al. (1988)*
	Tunisia		Present	Gargouri et al. (2011)
Asia	Azerbaijan		Present	Özer et al. (2020)
	China	Henan; Hebei; Shandong; Shanxi; Shaanxi; Anhui; North China Plain	Present	Li et al. (2012), Ji et al. (2016), Xu et al. (2017, 2018), Zhang et al. (2018), Zhou et al. (2019)
	Iran		Present	Farrokhi and Saremi (2004)
	Malaysia		Present	Izzati et al. (2011)
	Syria		Present	Alkadri et al. (2013)
	Iraq		Present	Hameed et al. (2012)
	Turkey		Present	Tunali et al. (2008)
Oceania	Australia	New South Wales	Present	CABI CPC
		Queensland	Present	CABI CPC
		South Australia	Present	CABI CPC
		Victoria	Present	CABI CPC
		Western Australia	Present	CABI CPC
	New Zealand		Present	CABI CPC

*: Reported as *Fusarium graminearum* Group 1.

Appendix C – EU 27 annual imports of fresh produce of hosts from countries where *Fusarium pseudograminearum* is present, 2016–2020 (in 100 kg)

Source: Eurostat accessed on 25 January 2022.

	Country/ Year	2016	2017	2018	2019	2020
Wheat and meslin	Canada	15,432,654.97	10,831,542.44	7,080,605.42	11,484,505.27	20,493,780.58
	USA	6,710,478.26	4,576,798.42	5,743,028.31	7,779,082.40	9,740,873.51
	Algeria	12.00	10.00	60.00		
	Argentina	875,157.88	208,558.72	10,404.08	6,590.89	5.77
	Australia	1,284,126.20	2,449,536.29	1,628,585.53	1.65	411.67
	Azerbaijan					
	China	2,075.29	794.35	423.87	466.87	467.40
	Iran	43.16	288,189.28	8.16	19.44	117.00
	Malaysia			0.01	0.01	
	New Zealand	7,087.42	4,753.10	1,866.04	1,950.84	2,868.37
	Syria	5.06	10.55	34.51		7.10
	Tunisia			0.50	0.16	
	Turkey	685.40	374,932.78	188,683.88	297,853.39	839,770.57
	South Africa					4.32
	Sum	24,312,325.64	18,735,125.93	14,653,700.31	19,570,470.92	31,078,306.29
	Country/ Year	**2016**	**2017**	**2018**	**2019**	**2020**
Barley	Canada	101.38	81.33	138.15	189.37	248.72
	USA	897.27	153.92	64.82	215.68	91.97
	Argentina	595.82	14,612.52	7,951.27	302.14	12.63
	Australia	1,251.13	6,615.52	4,823.58	6.42	3.64
	China	177.17	294.36	748.14	765.07	2,006.11
	Iran	385.00	34.94	29.77	26.27	2.30
	Malaysia	63.97	4.62	11.00		0.41
	New Zealand	581.01	444.24	712.35	442.37	3,637.05
	Tunisia			49.00		
	Turkey	2.00	390.00			0.02
	Sum	4,054.75	22,631.45	14,528.08	1,947.32	6,002.85
	Country/ Year	**2016**	**2017**	**2018**	**2019**	**2020**
Oats	Canada	101.05	298.60	720.93	2896.34	399.08
	USA	392.26	206.68	37.66	7.90	70.99
	Argentina	100.00	408.25		1,650.00	1,220.00
	Australia	357.81	1.92	0.12	0.19	0.01
	China	22.75	38.49	27.45	61.83	66.93
	Iran				3.00	
	Malaysia				0.01	
	New Zealand	4.77	1.79		4.73	5.76
	Turkey			6.05	0.00	1.20
	South Africa	803.25	172.60	9.56		0.16
	Sum	1,781.89	1,128.33	801.77	4,624.00	1,764.13

	Country/ Year	2016	2017	2018	2019	2020
Maize or corn	Canada	8,561,158.89	6,624,917.95	14,272,409.90	7,996,006.38	5,468,820.31
	USA	5,232,706.82	6,638,863.65	17,748,274.58	175,400.69	113,408.35
	Algeria				0.01	
	Argentina	1,885,921.39	1,895,102.34	2,418,558.86	1,397,943.12	1,485,999.86
	Australia	19,916.87	19,821.10	20,988.74	30.32	1.97
	Azerbaijan			18.00		
	China	330.80	49,315.06	13,505.70	1,857.99	536.71
	Iran		13.71	198.98		
	Malaysia	0.10				8.05
	New Zealand	16,327.70	11,497.71	6,745.75	12,994.65	966.30
	Syria	9.80	5.95	10.00	1.90	
	Tunisia		0.01		11.74	
	Turkey	189,147.60	327,064.31	118,147.55	72,199.53	107,505.34
	South Africa	30,471.22	45,595.31	2,563,570.36	508,866.58	318,013.64
	Sum	15,935,991.19	15,612,197.10	37,162,428.42	10,165,312.90	7,495,260.54
	Country/ Year	**2016**	**2017**	**2018**	**2019**	**2020**
Grain sorghum	Canada			966.05	12.50	
	USA	15,168.59	10,835.83	5,204,254.29	4,181,234.30	20,396.56
	Argentina	5,836.96	156.92	183.94	266.72	2,371.90
	Australia	3,665.50	1,667.28	3,694.90	2,263.98	1,978.50
	Azerbaijan					
	China	157.77	224.30	206.49	263.47	533.57
	Tunisia			20.16	20.18	
	Turkey				340.00	4.00
	South Africa		226.72	766.98	1,119.51	440.20
	Sum	24,828.82	13,111.05	5,210,092.81	4,185,520.66	25,724.73
	Country/Year	**2016**	**2017**	**2018**	**2019**	**2020**
Millet (excl. Grain sorghum)	Canada		445.80	926.27	23,576.78	4,501.34
	USA	15,248.16	11,807.53	13,208.7	43,371.41	14,397.65
	Argentina	4,173.32	2,026.6	1,400.8	20,616.1	37,753.3
	Australia	6,145.51	3,297.12	2,411.1	2.8	5,543.7
	Turkey	1,319.00	12.50		0.11	122.00
	South Africa		159	173.16	320	210
	Malaysia					0.01
	China	28,872.19	19,449.03	17,430.46	42,763.81	26,185.63
	Sum	55,758.18	37,197.58	35,550.6	130,650.9	88,713.63
	Country/ Year	**2016**	**2017**	**2018**	**2019**	**2020**
Soya beans, whether or not broken	Canada	10,611,196.88	10,053,763.51	8,350,806.67	12,097,591.61	13,620,967.17
	USA	52,881,397.81	46,059,027.06	73,716,535.24	67,208,322.53	48,474,696.90
	Argentina	1,001,117.40	784,117.81	20.78	330,206.58	1,189,965.72
	Australia		1,224.16	0.16	228.75	0.02
	China	217,569.88	275,802.32	375,025.50	377,904.32	147,251.45
	Iran	62.73	123.14	152.64	266.21	382.28
	Malaysia		4.40	2.43	0.09	0.16
	New Zealand		0.02			

	Country/Year	2016	2017	2018	2019	2020
	Syria		0.23			
	Turkey	119,198.80	35,287.90	61,000.06	224.02	0.00
	South Africa	55.62	7.82	19.60	5.36	0.08
	Sum	64,830,599.12	57,209,358.37	82,503,563.08	80,014,749.47	63,433,263.78
	Country/Year	**2016**	**2017**	**2018**	**2019**	**2020**
Cereal straw and husks, unprepared, whether or not chopped, ground, pressed or in the form of pellets	Argentina				0.45	
	Australia		3.27	100.78		
	Canada			0.80		
	China	103.41	165.50	944.99	1181.08	223.93
	Malaysia		0.06			
	South Africa	4.62				
	Turkey	23.62				1,035.97
	USA	733.45	562.63	539.56	12,681.35	370.95
	Sum	865.1	731.46	1,586.13	13,862.88	1,630.85

Appendix D – EU 27 and member state cultivation/harvested/production area of *Fusarium pseudograminearum* hosts (in 1,000 ha)

Source EUROSTAT (accessed 19/01/2022)

Wheat and spelt	2016	2017	2018	2019	2020
EU 27	25,210.30	24,138.62	23,751.66	24,212.28	22,876.72
Belgium	215.72	197.59	195.69	203.76	194.66
Bulgaria	1,192.59	1,144.52	1,212.01	1,198.68	1,200.18
Czechia	839.71	832.06	819.69	839.45	798.58
Denmark	583.00	586.60	425.80	573.40	502.60
Germany	3,201.70	3,202.60	3,036.30	3,118.10	2,835.50
Estonia	164.50	169.75	154.58	166.98	168.04
Ireland	67.92	67.05	57.98	63.48	46.99
Greece	537.59	415.95	404.49	350.49	355.88
Spain	2,256.85	2,062.71	2,063.68	1,920.09	1,914.66
France	5,542.25	5,332.08	5,234.09	5,244.25	4,512.42
Croatia	171.40	118.38	138.46	143.15	147.84
Italy	1,912.42	1,806.57	1,821.73	1,754.64	1,711.22
Cyprus	8.39	8.68	10.20	10.59	12.50
Latvia	479.10	446.80	417.20	492.70	498.20
Lithuania	880.53	811.95	772.89	895.76	893.51
Luxembourg	13.81	14.11	12.87	13.36	11.93
Hungary	1,044.31	966.40	1,026.15	1,015.64	936.62
Malta	0.00	0.00	0.00	0.00	0.00
Netherlands	127.33	115.92	111.66	120.55	108.91
Austria	317.76	297.28	294.29	278.34	279.02
Poland	2,364.08	2,391.85	2,417.23	2,511.33	2,373.31
Portugal	38.20	29.02	27.03	28.53	30.14
Romania	2,137.73	2,052.92	2,116.15	2,168.37	2,281.69
Slovenia	31.46	28.02	27.82	26.73	27.28
Slovakia	417.71	373.67	403.37	406.82	387.08
Finland	215.10	194.28	177.80	197.60	198.80
Sweden	449.15	471.87	372.50	469.49	449.17

Barley	2016	2017	2018	2019	2020
EU 27	11,179.59	10,862.69	11,144.80	11,138.94	11,025.28
Belgium	55.43	45.29	42.16	46.76	43.98
Bulgaria	159.83	128.37	103.57	112.03	130.76
Czechia	325.73	327.71	324.72	319.58	331.91
Denmark	706.90	665.40	795.30	583.20	653.20
Germany	1,605.00	1,566.10	1,662.00	1,708.80	1,667.30
Estonia	135.40	102.49	138.49	123.38	130.73
Ireland	189.21	180.19	185.21	179.36	193.18
Greece	132.80	133.38	129.19	132.57	136.97
Spain	2,563.20	2,597.53	2,569.46	2,693.51	2,749.04
France	1,917.55	1,904.86	1,767.97	1,944.19	1,972.27
Croatia	56.48	53.95	50.99	53.66	66.33
Italy	249.37	250.53	262.48	261.41	263.43
Cyprus	14.54	10.95	12.80	11.58	18.50
Latvia	94.40	70.30	118.30	86.80	84.40
Lithuania	172.54	141.65	225.91	174.77	164.87

Barley	**2016**	**2017**	**2018**	**2019**	**2020**
Luxembourg	6.90	6.59	6.00	6.06	6.00
Hungary	313.09	268.08	244.17	247.37	261.38
Malta	0.00	0.00	0.00	0.00	0.00
Netherlands	34.43	29.72	35.97	33.39	38.38
Austria	140.43	138.90	139.27	137.24	134.80
Poland	915.30	953.78	975.74	975.29	675.27
Portugal	20.62	23.20	20.53	21.94	19.02
Romania	481.61	455.46	423.50	448.89	445.74
Slovenia	19.18	20.37	20.99	21.14	22.21
Slovakia	114.85	120.33	124.16	126.37	130.86
Finland	435.90	358.30	405.10	397.90	392.10
Sweden	318.92	309.28	360.81	291.76	292.66
Oats	**2016**	**2017**	**2018**	**2019**	**2020**
EU 27	2,476.62	2,520.59	2,566.96	2,390.76	2,563.41
Belgium	3.67	4.04	3.47	3.86	3.98
Bulgaria	15.32	13.27	11.34	12.15	13.40
Czechia	37.57	44.07	42.82	42.53	46.74
Denmark	53.10	58.13	82.89	49.29	74.75
Germany	115.50	128.10	140.40	126.30	157.10
Estonia	29.30	33.65	39.65	37.26	41.03
Ireland	23.21	24.44	17.78	23.82	25.44
Greece	96.00	88.96	80.06	72.44	67.51
Spain	509.85	558.77	556.50	453.43	506.17
France	85.33	113.29	91.83	87.47	98.16
Croatia	26.57	23.14	15.89	18.50	19.40
Italy	107.06	108.46	107.45	103.79	103.46
Cyprus	0.37	0.25	0.22	0.22	0.22
Latvia	62.10	54.00	86.80	83.20	97.70
Lithuania	70.76	75.99	102.96	86.11	104.90
Luxembourg	1.09	1.31	1.24	1.40	1.59
Hungary	36.31	37.25	22.63	21.77	25.76
Malta	0.00	0.00	0.00	0.00	0.00
Netherlands	1.48	1.46	1.41	1.43	1.57
Austria	22.51	23.25	21.45	20.60	20.14
Poland	472.50	491.24	497.22	495.50	500.12
Portugal	42.41	35.44	37.33	36.58	37.27
Romania	170.35	165.76	161.48	161.19	101.34
Slovenia	1.33	1.45	1.25	1.21	0.81
Slovakia	14.70	14.82	12.93	12.09	12.26
Finland	304.90	269.50	288.70	297.50	324.50
Sweden	173.34	150.58	141.27	141.13	178.12
Other cereals n.e.c. (buckwheat, millet, canary seed, etc.)	**2016**	**2017**	**2018**	**2019**	**2020**
EU 27	323.00	337.77	326.54	290.81	348.63
Belgium	3.52	3.47	3.00	3.26	4.07
Bulgaria	3.11	2.69	2.88	3.63	5.66
Czechia	5.23	4.69	4.50	4.51	5.50
Denmark	0.00	0.00	0.00	0.00	0.00
Germany	:	:	:	:	:

Other cereals n.e.c. (buckwheat, millet, canary seed, etc.)	2016	2017	2018	2019	2020
Estonia	3.10	5.28	2.91	1.65	3.29
Ireland	0.00	0.00	0.00	0.00	0.03
Greece	0.26	0.17	0.26	0.37	0.27
Spain	6.80	3.00	6.67	9.12	9.31
France	58.45	74.88	57.37	64.47	100.52
Croatia	0.85	0.84	0.70	0.63	1.04
Italy	28.70	33.21	34.35	32.96	33.91
Cyprus	0.00	0.00	0.00	0.00	0.00
Latvia	17.00	18.30	25.60	13.30	14.70
Lithuania	43.70	48.59	52.79	27.80	39.36
Luxembourg	0.12	0.19	0.17	0.14	0.05
Hungary	11.03	12.68	9.58	10.27	6.88
Malta	0.00	0.00	0.00	0.00	0.00
Netherlands	1.05	0.00	0.92	0.97	1.05
Austria	8.43	8.93	8.07	7.72	10.67
Poland	108.40	97.39	96.24	93.86	92.32
Portugal	2.00	2.00	2.00	1.18	1.18
Romania	4.65	3.30	2.76	0.88	1.58
Slovenia	3.73	4.22	4.14	3.69	4.70
Slovakia	1.87	1.15	1.33	1.60	1.83
Finland	2.60	3.40	3.40	1.50	1.20
Sweden	0.00	0.00	0.00	0.00	0.00
Soya	**2016**	**2017**	**2018**	**2019**	**2020**
EU 27	831.18	962.39	955.40	907.91	947.67
Belgium	0.00	0.00	0.00	0.00	0.00
Bulgaria	14.16	11.53	2.32	3.86	4.51
Czechia	10.61	15.34	15.23	12.24	14.15
Denmark	0.00	0.00	0.00	0.00	0.00
Germany	15.80	19.10	24.10	28.90	33.80
Estonia	0.00	0.00	0.00	0.00	0.00
Ireland	0.00	0.00	0.00	0.00	0.00
Greece	1.55	1.46	0.61	1.03	0.99
Spain	1.00	1.69	1.48	1.57	1.45
France	136.52	141.83	153.85	163.80	186.72
Croatia	78.61	85.13	77.09	78.33	86.19
Italy	288.06	322.42	326.59	273.33	256.13
Cyprus	0.00	0.00	0.00	0.00	0.00
Latvia	0.00	0.00	0.00	0.00	0.00
Lithuania	1.85	2.47	1.92	1.82	2.07
Luxembourg	0.00	0.00	0.00	0.00	0.01
Hungary	61.03	75.67	62.12	58.23	58.67
Malta	0.00	0.00	0.00	0.00	0.00
Netherlands	0.00	0.00	0.54	0.48	0.00
Austria	49.79	64.47	67.62	69.21	68.50
Poland	7.60	9.33	5.45	7.92	7.17
Portugal	0.00	0.00	0.00	0.00	0.00
Romania	127.27	165.14	169.42	158.15	174.61
Slovenia	2.47	2.91	1.76	1.43	1.64

Soya	**2016**	**2017**	**2018**	**2019**	**2020**
Slovakia	34.87	43.90	45.30	47.60	51.07
Finland	0.00	0.00	0.00	0.00	0.00
Sweden	0.00	0.00	0.00	0.00	0.00
Green maize	**2016**	**2017**	**2018**	**2019**	**2020**
EU 27	6,061.45	5,985.90	6,134.91	6,210.36	6,325.68
Belgium	168.74	171.28	179.74	175.30	181.54
Bulgaria	31.10	29.93	27.24	27.50	30.44
Czechia	234.40	223.21	224.11	232.39	226.16
Denmark	182.40	166.70	179.60	186.40	188.70
Germany	2,137.60	2,095.90	2,195.90	2,222.70	2,299.70
Estonia	7.96	9.18	10.55	13.71	13.60
Ireland	10.92	11.88	17.76	16.62	14.77
Greece	118.69	125.55	129.64	128.07	103.19
Spain	106.24	107.36	107.34	116.46	115.12
France	1,423.73	1,406.01	1,415.73	1,438.25	1,418.89
Croatia	30.98	28.29	25.35	25.41	30.11
Italy	325.04	342.10	355.33	367.42	379.07
Cyprus	0.20	0.17	0.12	0.14	0.11
Latvia	25.90	22.10	25.50	23.80	22.80
Lithuania	26.59	24.34	28.25	32.94	29.92
Luxembourg	14.94	15.19	15.88	15.78	16.87
Hungary	76.41	69.05	66.40	66.30	62.04
Malta	0.00	0.00	0.00	0.00	0.00
Netherlands	203.81	203.51	203.22	186.23	194.65
Austria	84.64	82.19	83.35	85.68	86.86
Poland	597.00	596.01	601.58	599.86	674.75
Portugal	80.26	78.43	74.33	71.94	71.27
Romania	51.42	50.10	47.76	51.81	47.24
Slovenia	28.69	29.19	29.82	30.15	30.59
Slovakia	78.05	81.44	73.11	75.10	67.58
Finland	0.00	0.00	0.00	0.00	0.00
Sweden	15.74	16.80	17.29	20.39	19.72
Grain maize and corn-cob-mix	**2016**	**2017**	**2018**	**2019**	**2020**
EU 27	8,541.42	8,266.64	8,252.47	8,910.74	9,354.73
Belgium	52.10	49.00	53.99	48.64	51.88
Bulgaria	406.94	398.15	444.62	560.91	581.53
Czechia	86.41	86.00	81.85	74.83	87.23
Denmark	5.70	5.10	6.30	5.40	6.20
Germany	416.30	432.00	410.90	416.00	419.30
Estonia	0.00	0.00	0.00	0.00	0.00
Ireland	0.00	0.00	0.00	0.00	0.00
Greece	139.48	132.49	113.45	115.50	116.78
Spain	359.28	333.63	322.37	356.83	343.78
France	1,442.81	1,435.70	1,426.26	1,506.10	1,691.13
Croatia	252.07	247.12	235.35	255.89	288.40
Italy	660.73	645.74	591.21	628.80	602.86
Cyprus	0.00	0.00	0.00	0.00	0.00
Latvia	0.00	0.00	0.00	0.00	0.00
Lithuania	12.43	9.93	13.39	12.77	20.20

Grain maize and corn-cob-mix	2016	2017	2018	2019	2020
Luxembourg	0.13	0.08	0.09	0.14	0.12
Hungary	1,011.56	988.82	939.08	1027.59	981.01
Malta	0.00	0.00	0.00	0.00	0.00
Netherlands	12.27	12.25	13.76	19.01	19.42
Austria	195.25	209.48	209.90	220.69	212.60
Poland	593.50	562.11	645.41	664.95	946.06
Portugal	88.61	86.52	83.36	77.02	72.99
Romania	2,584.22	2,405.24	2,443.95	2,681.93	2,680.10
Slovenia	36.39	38.29	37.08	38.88	39.84
Slovakia	183.54	187.81	179.03	197.24	191.48
Finland	0.00	0.00	0.00	0.00	0.00
Sweden	1.71	1.19	1.11	1.62	1.85