SCIENTIFIC OPINION

Pest risk assessment of *Monilinia fructicola* for the EU territory and identification and evaluation of risk management options[1]

EFSA Panel on Plant Health (PLH)[2, 3]

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ABSTRACT

The EFSA Panel on Plant Health has delivered a pest risk assessment on the risk posed by *Monilinia fructicola* to the EU territory and has identified risk management options and evaluated their effectiveness in reducing the risk to plant health posed by this organism. The Panel has also analysed the effectiveness of the special requirements presently listed in Annex IV, Part A, Section I of Council Directive 2000/29/EC, in reducing the risk of introduction of this pest into the EU territory. The Panel concluded that the main pathways for entry into the EU territory are plant material for propagation purposes and fruit of host genera and that, with the exception of dried fruit, the probability of entry is very likely. The probability of establishment is also very likely due to the suitable environmental conditions and to the widespread presence of host species, susceptible for most of the year, on most of the risk assessment area. Cultural practices and control measures currently applied and competition with other *Monilinia* species cannot prevent the establishment of *M. fructicola*. The probability of spread is very likely because of the multiple ways of dispersal of the pest. The overall impact in the endangered area is estimated to be moderate. Neither additional cultural measures nor increased fungicide treatments would be needed to control of brown rot in the orchard after the introduction of *M. fructicola*.

KEY WORDS

Blossom and twig blight, brown rot, *Monilia fructicola, Prunus* spp., Rosaceae, stone fruit.

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SUMMARY

Following a request from the European Commission, the Panel on Plant Health was asked to deliver a scientific opinion on the risk posed by *Monilinia fructicola* (Winter) Honey to the EU territory and to identify risk management options and to evaluate their effectiveness in reducing the risk to plant health posed by this organism. The Panel was also requested to provide an opinion on the effectiveness of the special requirements linked to *M. fructicola*, presently listed in Annex IV, Part A, Section I of Council Directive 2000/29/EC[4], in reducing the risk of introduction of this pest into the EU territory.

Having given due consideration to the evidence, the Panel concludes that:

a. Entry of *M. fructicola* by means of plant propagation material, fresh fruits of susceptible genera and by natural means from infested European non-EU countries is very likely. It is very unlikely in case of dried fruit and natural means from infested non-European countries. In both cases the level of uncertainty is low.

b. Establishment of *M. fructicola* in the risk assessment area is very likely with a low level of uncertainty because of the avaialability of host plants with a long period of susceptibility and of suitable environmental conditions. Competition from other *Monilinia* species (*M. laxa* and *M. fructigena*) and currently applied cultural practices and control measures cannot prevent the establishment of the pest. In addition, the pest has already been detected in several Member States in the risk assessment area (France, Germany, Hungary, Italy, Poland, Romania, Slovenia and Spain).

c. Spread of *M. fructicola* within the risk assessment area is very likely with a low level of uncertainty because of its multiple ways to spread (natural and human assisted), to the wide distribution of host species in the risk assessment area and the absence of effective barriers.

d. Potential for yield reduction and negative effects on fruit production in orchards is estimated as moderate, with medium level of uncertainty mainly because of the incompleteness of data from the current area of distribution of the pest. Incidence and severity of the disease caused by the brown rot fungi, on flowers and twigs/branches are unlikely to increase compared to the situation in which only *M. fructigena* and *M. laxa* are present.

The Panel identified the following risk management options as highly effective in reducing:

a. The likelihood of entry of *M. fructicola*: (i) certification systems for plants for planting, (ii) control of movement of fruit or propagation material consignments by legislation from infested non-European countries and (iii) management of fruit waste

b. The likelihood of establishment of *M. fructicola*: (i) certification systems for plants for planting

c. The likelihood of spread and impact of *M. fructicola*: (i) certification systems for plants for planting and (ii) packaging of fruit, sanitation of packaging, storage facilities and means of transport

The Panel identified the following risk management options as moderately effectives in reducing:

[4] Council Directive 2000/29/EC of 8 May 2000 on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community. OJ L 169, 10.7.2000, p. 1-148.

a. The likelihood of entry of *M. fructicola*: (i) control of movement of fruit or propagation material consignments by legislation from infested European countries and (ii) limiting end use of consignments

b. The likelihood of establishment of *M. fructicola*: (i) cultural practices and chemical control, (ii) control of movement of fruit or propagation material consignments by legislation from infested European countries, (iii) limiting end use of consignments, (iv) sanitation measures (phytosanitary measures) of fruit or propagation material consignments, and (v) management of fruit waste.

c. The likelihood of spread of *M. fructicola*: (i) cultural practices and chemical control, (ii) monitoring and surveillance of growing crop, (iii) postharvest inspection of fruit, (iv) sanitation measures (phytosanitary measures) of fruit or propagation material consignments, and (v) management of fruit waste

d. The impact of of *M. fructicola*: (i) cultural practices and chemical control, (ii) monitoring and surveillance of growing crop, (iii) postharvest inspection of fruit, and (iv) sanitation measures (phytosanitary measures) of fruit or propagation material consignments

Other available measures (postharvest treatment of fruit, visual inspection of fruit or plants for planting in orchard, biological control and resistant cultivars) have been considered by the Panel scarcely effective in reducing the risk to plant health posed by this organism.

Regarding the evaluation of the effectiveness of the special requirements linked to *M. fructicola* presently listed in Annex IV, Part A, Section I of Council Directive 2000/29/EC, the Panel recommends considering the following aspects:

1) *M. fructicola* is listed in Annex I, Part A, Section I, as a harmful organism not known to occur in any part of the Community and relevant for the entire Community while it occurs on several host plants in parts of the EU territory.

2) The special requirements linked to listing *M. fructicola* in Annex IV, Part A, Section I of Council Directive 2000/29/EC only partially contribute to reducing the risk of introduction of this pest into the EU territory, more specifically:

   - In Art. 15 (i) the listed species (*Chaenomeles* Lindl., *Crataegus* L., *Cydonia* Mill., *Eriobotrya* Lindl., *Malus* Mill., *Prunus* L. and *Pyrus* L.) constitute only part of the range of the potential host plants of *M. fructicola* and (ii) the observation of symptoms (visual inspection) at the production site during the last complete cycle of vegetation is insufficient to determine freedom from *M. fructicola*.

   - In Art. 16 (i) fruit *Prunus* L. genus is not the only one potential fruit pathway, (ii) the limitation from 15 February to 30 September doesn't take into consideration that infected fruit can be imported from southern hemisphere before 15 February and after 30 September and stored, therefore imported fruit presents a risk all year round; (iii) inspection prior to harvest and/or export cannot ensure freedom from *M. fructicola*; (iv) treatment procedures prior to harvest (pre or post harvest) and/or export can reduce but not eliminate *M. fructicola*.

The Panel considers that other legislation, not specific for *M. fructicola*, but concerning – mainly – *Erwinia amylovora*, may also contribute to reduce the risk because of the partial overlapping of host plants.

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BACKGROUND AS PROVIDED BY THE EUROPEAN COMMISSION

The current common plant health regime is established by Council Directive 2000/29/EC on protective measures against the introduction into the Community of organisms harmful to plants and plant products and against their spread within the Community (OJ L 169, 10.7.2000, p.l).

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

Monilinia fructicola (Winter) Honey, the causal agent of brown rot disease, is reported to be a serious fungal pathogen of stone fruit crops in North and South America, Japan and Australia. Its main host are rosaceous fruit trees, principally peaches and other *Prunus* spp., and to lesser extent apples and pears.

Monilinia fructicola is a regulated harmful organism in the European Union, listed in Annex I, Part A, Section I of Council Directive 2000/29/EC as a harmful organism not known to occur in any part of the Union, whose introduction into, and spread within, all Member States shall be banned. Annex IV, Part A, Section I of the same Directive stipulates the requirements that need to fulfil specific plants for planting as well as fruits of *Prunus* spp. need to fulfil for their introduction and movement within all Member States.

However, in the last years this pest has been found in some locations within a few Member States, where it is the subject of official control. Still, eradication may be in some cases no longer possible. Given this new development it is necessary to evaluate not only the appropriateness of listing *Monilinia fructicola* in Annex I, Part A, Section I, but also whether *Monilinia fructicola* should continue to be regulated as a harmful organism in the EU. Such a decision needs to be based on a recent Pest Risk Analysis covering the whole territory of the EU, which takes into account the latest scientific and technical knowledge for this organism, its present distribution in the EU, as well as information on the experience made by official bodies and growers of *Monilinia fructicola* host plants in areas where outbreaks of the pest have been detected.

TERMS OF REFERENCE AS PROVIDED BY THE EUROPEAN COMMISSION

EFSA is requested, pursuant to Article 29(1) and Article 22(5) of Regulation (EC) No 178/2002, to provide a pest risk assessment of *Monilinia fructicola* (Winter) Honey, and if appropriate, to identify risk management options and to evaluate their effectiveness in reducing the risk to plant health posed by this organism. The area to be covered by the requested pest risk assessment is the EU territory. EFSA is also requested to provide an opinion on the effectiveness of the special requirements linked to *Monilinia fructicola*, presently listed in Annex IV, Part A, Section I of Council Directive 2000/29/EC, in reducing the risk of introduction of this pest into the EU territory.

ASSESSMENT

1. Introduction

1.1. Purpose

This document presents a pest risk assessment prepared by the Panel on Plant Health for *Monilinia fructicola* (Winter) Honey, in response to a request from the European Commission. The risk assessment area is the territory of the European Community (EU 27), and the opinion includes identification and evaluation of risk management options in terms of their effectiveness in reducing the risk posed by the organism.

1.2. Scope

The scope of the opinion is to assess the risk of *M. fructicola* on the host species of the pathogen that are present in the risk assessment area, namely *Prunus* spp. and other woody species grown for fruit production and ornamental purposes (detailed in Section 3.1.4.).

2. Methodology and data

2.1. Methodology

2.1.1. The guidance document

The risk assessment has been conducted in line with the principles described in the document Guidance on a harmonised framework for pest risk assessment and the identification and evaluation of pest risk management options (EFSA Panel on Plant Health (PLH), 2010).

The EFSA-adapted EPPO scheme to conduct a risk assessment, presented in the Guidance document, has been used.

The assessment has been conducted on the condition of absence of the existing plant health legislation.

2.1.2. Conclusions of the risk assessment

The conclusions for entry, establishment, spread and impact are presented separately.

The ratings in the conclusions are made in accordance with specific descriptors that have been developed specifically for each chapter of the opinion, as described in Appendix A (Section 1.).

The risk components have not been rated separately and no combinations of ratings have been performed.

2.1.3. Evaluation of management options

When evaluating the effectiveness of the risk management options to reduce the level of risk, the Panel used the ratings and descriptors that have been developed specifically for *M. fructicola*, as described in Appendix A (Section 2.).

2.1.4. Level of uncertainty

For the risk assessment conclusions on entry, establishment, spread and impact and for the evaluation of the effectiveness of the management options, the level of uncertainty has been rated in accordance with the descriptors that have been developed specifically for *M. fructicola*, as described in Appendix A (Section 3.).

2.2. Data

2.2.1. Literature search

Literature searches were performed consulting several sources such as ISI web of Knowledge database including Web of Science, Current Content Connect, CABI CAB Abstracts, Food Science and Technology Abstracts and Journal Citation Reports. The web pages of the national authorities concerned were consulted. Searches on the Internet were also carried out.

Among the documents that were consulted to support the risk assessment activity, peer-reviewed publications, PhD theses and technical reports from national authorities were included.

2.2.2. Data collection

For the purpose of this opinion, the following data were collected and considered:

- For the list of potential host plant species in Europe, the online database of Flora Europaea was consulted and results listed in Appendix B. Flora Europaea is held in the PANDORA taxonomic data base system at the Royal Botanic Garden, Edinburgh.

- A questionnaire was prepared and sent by EFSA to the representatives of the Member States National Phytosanitary Authorities in order to obtain the following information:

    a. Surveying and detection methodologies

    b. Presence and status of the pest in the country

    c. Official measures applied and control methods suggested

    The blank questionnaire form is presented in Appendix H to this document, while the results are summarised in Appendices I and J (on the general results and on the applied control measures respectively).

- The list of locations where *M. fructicola* is reported to be present has been obtained fromthe results of the EFSA questionnaire, from the national surveys (2007, 2008), from the EPPO reporting services and from additional publications.

- For the evaluation of the probability of entry and spread of the organism in the EU, EUROSTAT and FAOSTAT databases were consulted in order to obtain information on trade movements within the EU for the relevant pathways.

- For the evaluation of the probability of entry, Europhyt database was consulted, searching for pest-specific and/or host/specific notifications. Europhyt is a web-based network launched by DG Health and Consumers Protection, and is a sub-project of PHYSAN (Phyto-Sanitary Controls) specifically concerned with plant health information. Europhyt database manages notifications of interceptions of plants or plant products that do not comply with EU legislation notifications.

3. Risk assessment

3.1. Pest characterization

3.1.1. Identity of the pest

3.1.1.1. Scientific name

***Monilinia fructicola* (Winter) Honey (teleomorph)**

Monilia fructicola L.R. Batra (anamorph)

Synonyms:

Cyboria fructicola (Winter)

Monilia cinerea f. *americana* Wormald

Sclerotinia fructicola (Winter) Rehm

Stromatinia fructigena Ritz. Bos 1904

3.1.1.2. Common name of the disease caused by the pathogen

No specific common name exists for the disease(s) caused by *M. fructicola*. The following names may indicate diseases caused by other *Monilinia* species as well.

Braunfaule der Früchte (German)

Brown rot, blossom and twig blight (English)

Marciume bruno (Italian)

Pourriture brune des fruits (French)

3.1.1.3. Taxonomic position

Fungi, Ascomycota, Helotiales, Sclerotiniaceae

The teleomorph of the fungus, presently known as *Monilinia fructicola* was first observed on mummified peach fruit and described as *Ciboria fructicola* (Winter) (Winter, 1883). It was then transferred to the genus *Sclerotinia* by Rehm [1906] and to *Monilinia* by Honey (1928). The current accepted name is *Monilinia fructicola* (G. Winter) Honey (Batra, 1991; Cline, 2005).

The current name for the anamorph is *Monilia fructicola* Batra. The designation of the anamorph as *M. fructicola*, although invalid before the formal description provided by Batra (1991), had been in use since 1928 (Cline, 2005).

In old literature from North America (before 1900), the name *Sclerotinia fructigena* can often be found, though referring to *Monilinia fructicola* as we know it now. In Europe, Aderhold and Ruhland (1905) described the anamorph and perfect state of a brown rot fungus found in Germany, which they named *Sclerotinia fructigena*. At the same time, Norton (1902) gave a description of the perfect state of a brown rot fungus collected in the USA. From that paper, it appeared that size of asci and ascospores differed from the description of the brown rot fungus given by Aderhold and Ruhland (1905). Based on these differences, and on the fact that the American brown rot fungus did not produce buff-coloured pustules, but instead ash-grey ones, Conel (1914) concluded that the American brown rot fungus could not be *S. fructigena* Aderh. & Ruhl.

3.1.2. Risk assessment area

The risk assessment area is the territory of the European Community (EU 27).

3.1.3. Occurrence

3.1.3.1. In risk assessment area

In order to obtain updated information on the occurrence of the pest in the 27 Member States, a questionnaire was sent (Appendix H) and answers collected and analysed (Appendices I and J).

From the answers received (16/27), the Panel can conclude that the pest has not been detected in Belgium, Czech Republic, Denmark, Estonia, Finland, Latvia, Portugal, Sweden, UK (9/15), detected in Hungary, Italy, Poland, Romania, Slovenia, Spain (6/15) and detected and eradicated in Slovak Republic.

In order to complete the picture, the information was integrated with the use of additional sources, allowing the Panel to state that in the risk assessment area the pest was found in the following Member States:

- France: first finding in 2001, in peach orchards in the Rhône valley (OEPP/EPPO, 2002),
- Germany: 2 outbreaks in 2009, on plums and blackberries in two orchards in the southwest (Hinrichs-Berger and Mueller, 2010; OEPP/EPPO, 2010),
- Hungary: first findings in 2007, in orchards, gardens and urban sites, on apples, apricots, peaches, pears, plums, sour and sweet cherries from 14 counties (Appendix I),
- Italy: first finding in 2008, in two nectarine orchards of Piedmont (OEPP/EPPO, 2009a; Pellegrino et al., 2009),
- Poland: first findings in 2010, in orchards, on apples, pears and plums from 9 voivodeship (Appendix I),
- Romania: first findings in 2010, in orchards, on peaches and plums from two counties (Appendix I),
- Slovenia: first finding in 2009 in a peach orchard of Nova Gorica (Munda and Viršček Marn, 2010),
- Spain: first two outbreaks in 2005, in peach orchards of Huesca and Lleida, (Appendix I; De Cal et al., 2009; Patocchi et al., 2009).

It has been declared eradicated in Austria (OEPP/EPPO, 2006) and in the Slovak Republic (Appendix I).

It has only been intercepted in the UK. In addition, *M. fructicola* is also present in Switzerland, where it was first found in market, on apricots and nectarines (Patocchi et al., 2009).

The fact that information from different sources was collected from different years and that some of the 27 EU Member States are missing from the list, increases the level on uncertainty on this matter, in particular regarding the presence of the pest inside a country: the Panel coundn't state in how many countries *M. fructicola* has been established.

3.1.3.2. Outside the risk assessment area

Outside Europe the pest is present in: Asia (China: Hebei, Shandong; India: Himachal Pradesh, Uttar Pradesh; Japan: Honshu; Korea Republic; Taiwan; Yemen), Africa (Nigeria; Zimbabwe), North America (Canada: Alberta, British Columbia, Manitoba, New Brunswick, Nova Scotia, Ontario, Prince Edward Island, Quebec, Saskatchewan; Mexico; USA: Alabama, Arizona, Arkansas, California, Connecticut, Delaware, District of Columbia, Florida, Georgia, Hawaii, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachussetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Vermont, Virginia, Washington, West Virginia, Wisconsin), Central America and Caribbean (Guatemala; Panama), South America (Argentina; Bolivia; Brazil: Minas Gerais, Parana, Rio Grande do Sul, São Paulo; Ecuador; Paraguay; Peru; Uruguay; Venezuela), Oceania (Australia: New South Wales, Queensland, South Australia, Tasmania, Victoria, Western Australia; New Caledonia; New Zealand), Europe (Switzerland) (see Figure 1).

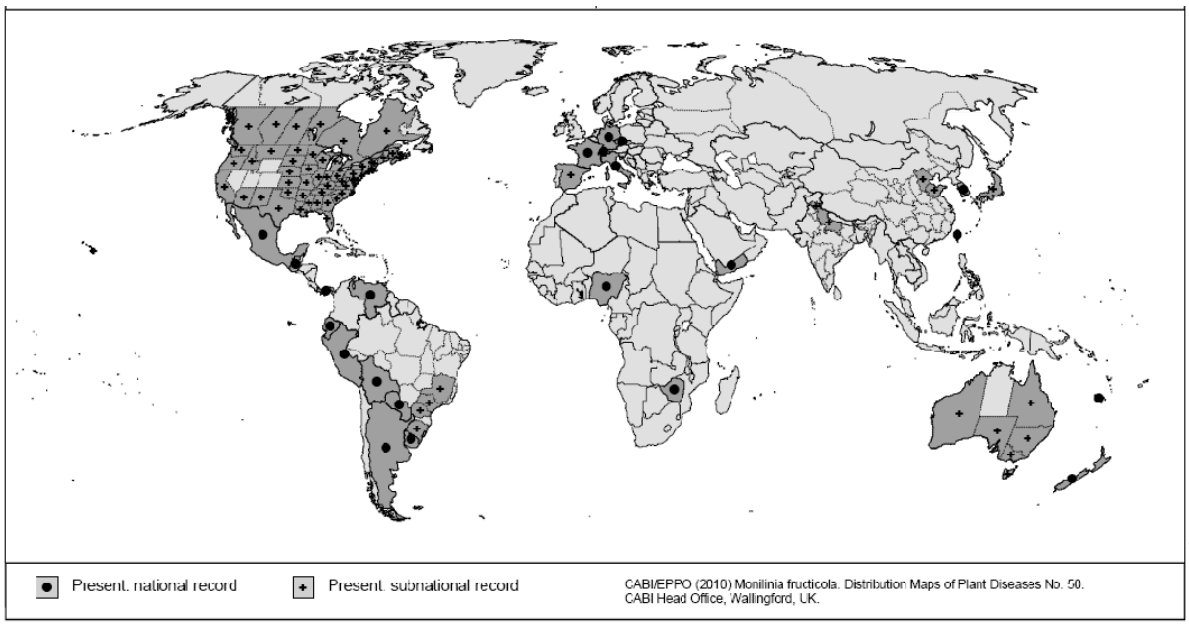


Figure 1: Distribution map of *Monilinia fructicola* (G. Winter) Honey as compiled by CABI in association with EPPO (CABI/EPPO, 2010)

3.1.4. Host plants

The main host range of this fungus covers the rosaceous stone fruit trees (*Prunus* spp.), other *Prunus* spp. and, to a lesser extent apples (*Malus* spp.) and pears (*Pyrus* spp.). The fungus has also been found on flowering quinces (*Chaenomeles* spp.), hawthorns (*Crataegus* spp.), quinces (*Cydonia* spp.), loquat (*Eriobotrya japonica*) and blackberries (*Rubus fruticosus*) (CABI/EPPO, 2010; OEPP/EPPO, 2010). A report from Japan (Visarathanonth et al., 1988) claims that *M. fructicola* also causes a brown rot of *Vitis vinifera*. Infected grapes were found in a wholesale market in Tokyo and inoculation tests were successful (OEPP/EPPO, 1997). A detailed list of the potential host species in Europe is provided in Appendix B.

3.1.5. Biology and epidemiology of *M. fructicola*

Brown rot caused by *Monilinia* spp. is an important fungal disease of stone fruit, and is responsible for substantial pre- and post-harvest losses (Ogawa and English, 1991). *M. fructicola* is an ascomycete, which was originally described as anamorphic species (*Monilia fructicola*). On potato dextrose agar (PDA) at the beginning mycelia are hyaline, developing dark and irregular stromata as colonies age (Mordue, 1979). Abundant macroconidia are produced in moniliform chains, simple or dicotomously

branched, and grouped in sporodochia (Byrde and Willetts, 1977). Macroconidia are single-celled, hyaline and lemon-shaped. Macroconidia dimensions are 14.5-16 × 9.5-11 µm, depending on temperature and culture media (OEPP/EPPO, 1997). Following germination on plant material, macroconidia produce apressoria (Cruickshank and Wade, 1992; Lee and Bostock, 2006). Microconidia are single-celled, 2 µm in diameter. Microconidia are formed on bottle-shaped phialides borne on microconidiophores, which are dichotomously branched hyphae of 2.5-5.3 µm in diameter, in many cases grouping in clusters similar to a pycnidium (pycnidium-like masses). Microconidia are produced both in culture media and on mummified fruit. Microconidia do not germinate; it seems that they possess a spermatide function for the formation of apothecia. In the case of *M. fructicola*, apothecia develop on mummified fruit on the orchard floor. Apothecial initials develop in the medulla of the stroma. Mature apothecia are orange, cup-shaped, 5-20 mm in diameter. Asci are of 102-215 × 6-13 µm and the single-celled, ovoid ascospores of 6-15 × 4-8.2 µm (Byrde and Willetts, 1977). Apothecia of *M. fructicola* have not yet been found in Europe (Gell et al., 2009; Villarino et al., 2010), but they are known to be readily produced in other continents (Biggs and Northover, 1985; Holtz et al., 1998; Hong et al., 1996; Landgraf and Zehr, 1982; Sanoamuang, 1992).

On infected symptomatic plant organs, and under favourable environmental conditions, the pathogen produces sporodochia (diameter 0.4-0.8 mm) with conidia. Discrete sclerotia are not usually formed on the hosts (such survival structures are usually formed only on artificial media). Nevertheless, infected fruit may develop dry substratal stromata ("mummies") in which a stromatic layer replaces most of the pericarp (Mordue, 1979).

Host infection by *M. fructicola* is favoured by high humidity and mild temperatures (Biggs and Northover, 1988a; Koball et al., 1997; Wilcox, 1989). Temperature affects germination, infection, period of incubation and latency of the pathogen. Conidial germination and penetration of fruit needs free water or moisture near to the saturation point. Conidia of *M. fructicola* germinate over a wide range of temperatures (0-35 ºC), but no germination occurs at 38 ºC (Casals et al., 2010a). Germination is also very slow at 0-5 ºC and progressively faster, up to an optimum, between 15 and 30 ºC. Conidial germination is markedly influenced by the interaction of temperature and water activity (a_w) and *M. fructicola* infection is related to temperature and wetness duration (Luo and Michailides, 2003; Luo et al, 2001a). Germination is very slow at 0.90 a_w and progressively faster, up to an optimum at 0.99 a_w (Casals et al., 2010a). A minimum of 3-4 h of wetness duration at 20-22 ºC is necessary for germination of *M. fructicola* conidia to take place before infection of cherries (Wilcox, 1989). Nevertheless, at least 17-24 h of wetness duration are necessary for the infection of blossoms by *M. fructicola* (Watson et al., 2002).

Brown rot has two infection phases: the blossom blight phase and the fruit rot phase (Luo et al., 2005) (see Figures 1 and 2).

Figure 2: Blossom blight caused by *Monilinia* spp. on peach

Figure 3: Fruit rot of peach caused by *Monilinia* spp.

The sources of primary inoculum differ according to the *Monilinia* species causing the disease. All four *Monilinia* species (*M. fructigena, M. laxa, M. fructicola, Monilia polystroma*) overwinter as mycelium on mummified fruit, fruit peduncles, cankers on twigs and branches, leaf scars and buds that sporulate and produce infective conidia under favourable conditions (Byrde and Willetts, 1977).

However, an additional source of primary inoculum of *M. fructicola* can also be pseudosclerotial mummified fruit that produce apothecia from which ascospores are discharged in the spring (Byrde and Willetts, 1977). Apothecia of *M. fructigena* and *M. laxa* are rarely found in the field, and have not been produced in culture (Gell et al., 2009; Villarino et al., 2010). Recent studies carried out in Spain showed that *Monilinia* species overwinter and produce primary inoculum from mycelia on mummified fruit and necrotic twigs, especially on mummified fruit on the trees (Villarino et al., 2010). The existence of a positive relationship between the number of mummified fruit on the tree and the incidence of post-harvest brown rot ($P=0.05$, $r=0.75$, $n=8$) has been demonstrated (Villarino et al., 2010): according to the regression equation that describes the relationship between the incidence of post-harvest brown rot and the number of *Monilinia*-infected mummies, one overwintered *Monilinia*-infected mummy on a tree is capable of causing post-harvest brown rot on all fruit harvested from this stone fruit orchard.

Under favourable weather conditions in early spring, the conidia or ascospores produced from primary inoculum sources are capable of infecting firstly blossoms and then immature fruit (Biggs and Northover, 1985; Gell et al., 2009).

Under unfavourable weather conditions, the primary infections may remain latent in the blossoms and/or immature fruit (Emery et al., 2000; Gell et al., 2008), and persist as latent infections throughout the growing season until the weather conditions become conducive to disease expression (Gell et al., 2008; Luo et al., 2001b; Luo and Michailides, 2003). The occurrence of latent infections is very important for the epidemiology of the disease as several studies have shown (Emery et al., 2000; Luo et al., 2001a and b; Northover and Cerkauskas, 1994).

Primary conidial dissemination occurs from mummified fruit (on the tree or on the orchard floor), blighted blossoms, twig cankers, aborted, non-abscised fruit, thinned fruit on the orchard floor and infected green fruit on the tree. Conidia are disseminated by rainwater, air currents and insects (Jenkins, 1968; Kable, 1965a; Tate and Ogawa, 1975) to infect healthy fruit. Fruit may become infected by *M. fructicola* at all stages of their development. Luo and Michailides (2001) reported that immature and mature plum fruit are more susceptible to infection than middle-aged fruit (late May to early June) and that the most susceptible stage of fruit development is before pit hardening (late April to early May). Similarly, Biggs and Northover (1988b) have shown that young peach fruit are highly susceptible to infection, they are resistant at pit hardening, and later they become increasingly susceptible particularly 2-3 weeks before harvest. Although the injury of the fruit may lead to an increase in infection, the fungus readily infects when no wound or fruit-to-fruit contact is present (Michailides and Morgan, 1997).

Mycelium, especially under humid conditions, produces infection pegs on hyphae which exercise pressure in the epidermis, coming out and forming numerous sporodochia on infected tissues, from where secondary conidia are liberated (Byrde and Willetts, 1977). At the same time, mycelium

advances rapidly towards green fruit, shoots or bark. Fruit can be infected at any time, but their susceptibility to the infection increases with ripeness (Ogawa et al., 1995; Smith et al., 1992). *M. fructicola* can also infect fruit through wounds or natural openings and the subsequent colonization of fruit tissues occurs with rapidity (Michailides and Morgan, 1997).

Secondary inoculum produces new infections that will result in a new production of conidia. Depending on the weather conditions the new production of conidia takes place seven days after infection (Melgarejo and De Cal, 2010). Secondary inoculum can arise from any infected tissue in which the moisture content is sufficient for conidial sporulation (Landgraf and Zehr, 1982). Depending on the climatic conditions, several generations of conidia may occur during the growing season. These conidia infect fruit and may either cause brown rot under favourable climatic conditions or remain latent when climatic conditions are unfavourable. A positive correlation between the incidence of latent infections of *M. fructicola* in immature plums and nectarines and fruit rot incidence at harvest and post-harvest has been found (Emery et al., 2000; Luo and Michailides, 2001; Northover and Cerkauskas, 1994). Infected fruit can rot within a few days and either fall on the orchard floor or remain on the tree. Stromata may be produced on infected fruit. Stromatisation on fruit is a prerequisite for apothecia production (Holtz et al., 1998; Terui and Harada, 1966; Willets and Harada, 1984). Fruit remaining on the tree dry off, wrinkle and turn into mummies, which are typical of the disease (Byrde and Willetts, 1977). Mumies may be colonised by other fungal species; mycoflora of mummies may contribute to the decline of primary inoculum (Hong et al., 2000). Fruit with latent infections may also become mummified and serve as sources of primary inoculum the following spring (Luo et al., 2001a). Fruit infection and activation of latent infections may also occur after harvest.

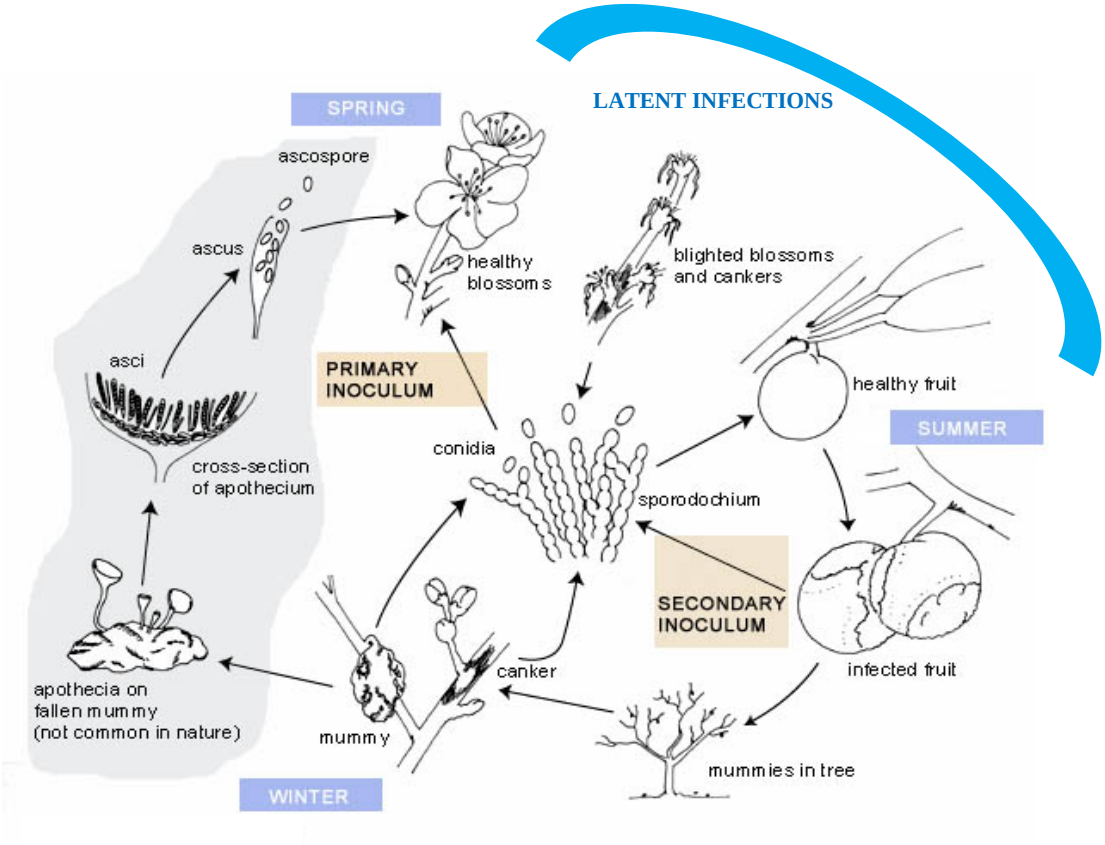


Figure 4: Life cycle of *Monilinia fructicola* (from Ritchie, 2000, modified).

Incidence of blossom blight depends on several factors, such as the quantity of primary inoculum, the bloom stage and the environmental conditions, especially temperature and wetness duration. Optimum temperatures for the infection of blossoms are 20 to 25 ºC, and no infection occurs below 10 ºC and over 30 ºC, or with less than 4 h of wetting (Luo et al., 2001b). With periods of more than 4 h of wetness duration, disease incidence increases linearly. Based on these factors, Luo et al. (2001b) developed a model for the prediction of risk of blossom blight.

The incidence of latent infections on immature fruit and the incidence of brown rot on fruit at harvest and post-harvest are also influenced by the quantity of inoculum, the fruit phenological state (Biggs and Northover, 1988; Emery et al., 2000; Gell et al., 2008; Luo and Michailides, 2003; Ogawa et al., 1995), and the environmental conditions (temperature and wetness duration) (Gell et al., 2008; Hong, et al., 1998; Luo and Michailides, 2003; Wade and Cruikshank, 1992). Temperature and wetness duration are considered the most crucial factors affecting fruit infection by *M. fructicola* (Biggs and Northover, 1988a; Luo and Michailides, 2001, 2003).

Latent infections by *M. fructicola* have been documented in apricot, peach, plum and cherry fruit (Kable, 1971; Northover and Cerkauskas, 1994; Wade, 1956; Wade and Cruickshank, 1992; Wittig et al., 1997). A positive correlation between the number of conidia on fruit surface and the incidence of latent infection has been reported for *M. laxa* and *M. fructigena* (Gell et al., 2009). However, not all latent infections induce fruit rot before harvest (Cruickshank and Wade, 1992; Northover and Cerkauskas, 1994). In most cases, infections remain latent even after harvest and act as sources of post-harvest brown rot during fruit cold storage. Latent infections may remain invisible (true latent infections) or appear as small, circular necrotic lesions (quiescent infections) that enlarge rapidly as fruit ripen (Ogawa et al., 1995). Under favourable environmental conditions, fruit rot increases to involve larger areas on the fruit and may spread by contact to adjacent fruit either on the tree or in transit and storage (Ogawa et al., 1995).

Fruit rot may develop from conidia contaminating fruit surfaces or from recent infections or latent ones. Under favourable environmental conditions, fruit rot increases to involve larger areas on the fruit and may spread by contact to adjacent fruit either on the tree or in transit and storage. As fruit ripen, its invasion by the fungus is very rapid resulting in fruit rot before or after harvest even when environmental conditions at harvest time are not conducive to infection (Adaskaveg et al., 2005). Fruit infection also takes place after harvest, during transit and storage (Agrios, 2005). Infected fruit will continue to rot after harvest, whereas the mycelium may directly attack healthy fruit in contact with infected ones.

Fruit, that are apparently healthy at harvest, can be contaminated with conidia at any time between harvest and consumption. However, not all latent infections induce fruit rot before harvest (Cruickshank and Wade, 1992). In most cases, infections remain latent even after harvest and act as sources for post-harvest fruit rot during cold storage (Byrde and Willetts, 1977).

In the case of infection of peaches and plums by *M. fructicola,* the incidence of latent infections shows a positive linear and/or exponential relationship with increased wetness duration at different growth stages (Luo et al., 2001a, 2001b). The optimum temperatures for latent infection of plum fruit by *M. fructicola*, at the pit hardening stage, ranges from 14 to 18 ºC, but the effect of temperature on latent infection is reduced at more resistant phenological stages (Luo and Michailides, 2001).

The disease is particularly severe if, following blossom blight: high inoculum levels are produced, rainfall is prevalent during the growing season up to harvest and temperature is favourable. Other inoculum sources, such as old cankers, peduncles, mummified fruit and rotten immature fruit may produce sufficient inoculum for epidemic levels of brown rot in any wet year. The prolific production of conidia, which are disseminated by wind and rain, allows for rapid epidemic development within an orchard or a region (Schnabel, 2002). Under wet conditions, powdery tufts (sporodochia) of brown gray spores (conidia) are visible on the outside of infected blossoms and on infected fruit or twig surfaces.

The pathogen can potentially infect all aerial host plant parts, such as blossoms, buds, shoots, twigs, branches, peduncles and fruit (Cline, 2005; De Cal and Melgarejo, 2000; Ogawa et al., 1995). In plum, even leaves can be infected by *M. fructicola* (Michailides et al., 2007).

The level of susceptibility and resistance to infection by *Monilinia* spp. changes with the degree of fruit ripeness (Fideghelli, 1993; Gell et al., 2008; Lee and Bostock, 2007; Luo et al., 2001a; Luo and Michailides, 2003; Northover and Biggs, 1990) or the cultivar of the host (Feliciano et al., 1987; Gradziel and Wang, 1993; Wagner et al., 2005).

M. fructicola is known to have melanin associated with the cell walls of the conidia and the outer rind of its stroma (fruit mummy) (Rehnstrom and Free, 1996). The importance of melanin for the survival of the conidia and the integrity of the stroma was assessed by isolating and characterising melanin-deficient mutants. These mutants produced conidia which were more readily killed by high temperatures, desiccation, freezing, UV irradiation, and digestion with hydrolytic enzymes. Mutant stroma was shown to have reduced tensile strength. In *M. fructicola*, melanin functions to provide the conidia with resistance to a variety of environmental stresses (Rehnstrom and Free, 1996). In general, the presence of melanin in the walls of sclerotia, hyphae, or spores of several fungi confer tolerance to environmental stresses, such as ultraviolet radiation (Bell and Wheeler, 1986), microbial lysis (Bloomfield and Alexander, 1967) and defense responses of the host plant against fungal infection. It had been previously demonstrated that melanin content plays an important role in the infection process of peach twigs by *M. laxa* (De Cal and Melgarejo, 1993). A melanin-deficient mutant strain (albino mutant) and a wild strain of *M. laxa* treated with pyroquilon, the inhibitor of melanin biosynthesis in *M. laxa*, could not induce peach twig blight (De Cal and Melgarejo, 1994).

Concerning the survival of *M. fructicola* in host tissues, a study conducted in New Zealand showed that all isolates resistant and sensitive to benzimidazole and dicarboximide fungicides survived effectively for at least one year as mycelium in twig cankers and for at least one season in mummified fruit (Sanoamuang, 1992). Conidia produced from these sources were highly viable and pathogenic. Although their pathogenicity appeared to be maintained for at least a year, the number of conidia recovered from infected tissues was found to be strain-related. The dicarboximide resistant isolates produced fewer conidia on both twig cankers and mummified fruit compared to the benzimidazole resistant and sensitive isolates. Sporulation ability of resistant and sensitive isolates from overwintering mummified fruit and one year old twig cankers was relatively high during blossoming (Sanoamuang, 1992).

3.1.6. Identification of the organism

M. fructicola belongs to the group of brown rot fungi of fruit crops. Currently, four species are included within this group: *M. fructicola*, *M. fructigena*, *M. laxa* and the anamorph species *Monilia polystroma* (Byrde and Willetts, 1977; van Leeuwen et al., 2002a). *M. fructigena* and *M. laxa* are established in the EU for a long time; *M. polystroma*, a close relative of *M. fructigena*, was only known from Japan (van Leeuwen et al., 2002a), but lately it has also been reported from Hungary (Petróczy and Palkovics, 2009). Accurate and rapid identification of *Monilinia* spp. is the most essential first step towards early and adequate measures to prevent introduction and further spread of *M. fructicola* within the EU.

Traditionally, *Monilinia* spp. are differentiated based on morphological and cultural traits (see Figure 5), which require at least 10 days (De Cal and Melgarejo, 1999; van Leeuwen and van Kesteren, 1998). These methods generally require skilled personnel with specialised taxonomic expertise, which often takes many years to acquire. Furthermore, visual identification is not always unambiguous due to qualitative, partly shared morphological characteristics among *Monilinia* species, so that identification has to be conducted under standardised conditions and on pure cultures (van Leeuwen and van Kesteren, 1998).

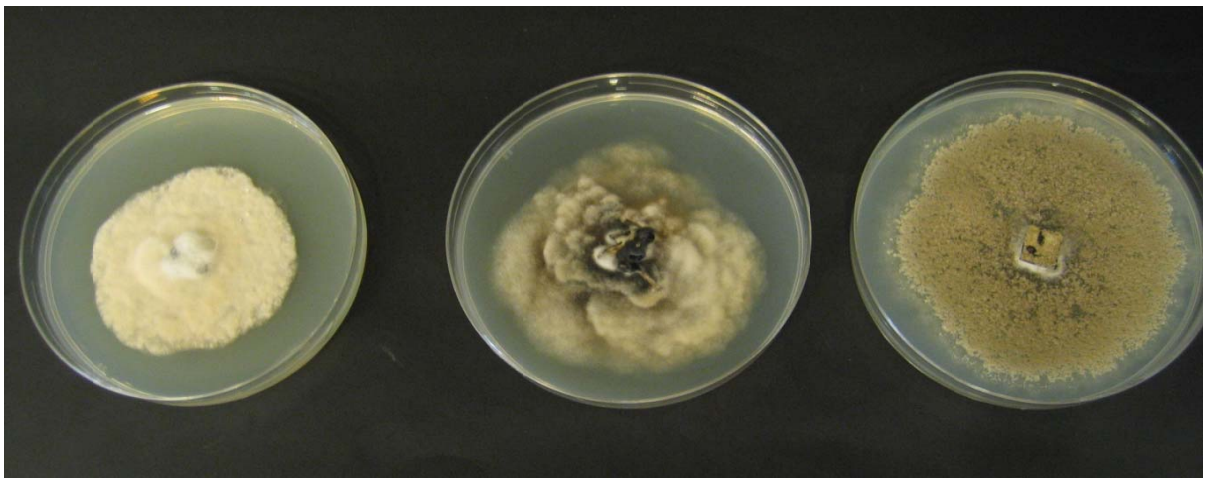


Figure 5: Species of *Monilinia* grown on potato-dextrose agar (PDA) at 25 ºC for 7 days in the dark. From left to right: *Monilinia fructigena*, *M. laxa* and *M. fructicola*.

Several molecular diagnostic methods have been developed to detect and identify *M. fructicola*. The first methods were based on the use of SSU rDNA group I intron (Fulton and Brown, 1997; Snyder and Jones, 1999). Subsequent studies showed that these methods were not reliable because some isolates of *M. fructicola* lack a group I intron in their nuclear rDNA small subunit (Fulton et al., 1999). Reliable new PCR primers and diagnostic protocols were developed by Côté et al. (2004), Gell et al. (2007), Hughes et al. (2000), Ioos and Frey (2000) (see Figure 6). These protocols distinguish *M. fructicola*, *M. fructigena* and *M. laxa* from each other. Other PCR primers and protocols for *M. fructicola* were published by Boehm et al. (2001), Förster and Adaskaveg (2000) and Ma et al. (2003a). However these methods discriminate *M. fructicola* from *M. laxa* but have not been validated for distinguishing *M. fructicola* from *M. fructigena*.

Real-time PCR methods have been developed by Luo et al. (2007) and van Brouwershaven et al. (2010). The first method is a SYBR Green assay, and has only been validated against *M. laxa*. The other method is a TaqMan assay validated against all four brown rot fungi of fruit crops.

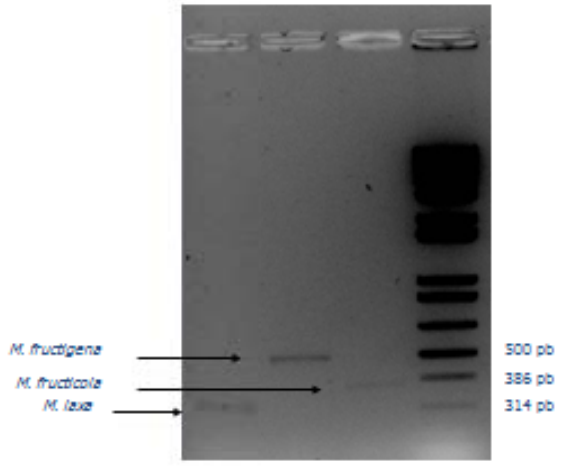


Figure 6: Polymerase chain reaction (PCR) products obtained after amplification of DNA extracted from isolates of *Monilinia laxa* (lane 1), *M. fructigena* (lane 2), and *M. fructicola* (lane 3) 1-kb plus ladder (Invitrogen, Life Technologies, Carlsbad, CA, USA) as molecular marker (M) are also shown in lane 4 (Gell et al., 2007).

3.2. Probability of entry

3.2.1. List of pathways

The Panel identified the following pathways for entry of *M. fructicola* from infested areas:

- plant material for propagation purposes of susceptible genera, especially rooted plants and to a lesser extent budwood;
- fruit (fresh or dried) of susceptible genera;
- natural means (insects, wind, etc.).

3.2.2. Pathway 1: plant material for propagation purposes of susceptible genera

The Panel considers that, in the absence of specific regulations covering the whole range of hosts of *M. fructicola*, host plants for planting may be imported into the EU at different growth stages, with leaves, blossoms and fruit present on them. Also dormant plants may be accompanied by remnants of flowers or fruit (e.g. mummified fruit or fragments of them). As all the above plant organs may play a role in the spread of the pathogen to new areas, they have been considered in the analysis of this pathway.

3.2.2.1. Association of the pest with the pathway at origin

There are no specific statistical data on imports of plants for planting of Rosaceae from outside the EU into the EU in EUROSTAT. The only data available concern import of trees and shrubs in general, from which it is impossible to know whether key rosaceous genera are included. However, from an analysis of Europhyt notifications (see Section 2.2.2.), the abundance of interceptions of plants of susceptible genera, intercepted because of various other reasons, provides evidence that there is movement on this specific pathway.

In addition, *M. fructicola* has already been detected on host plants for propagation purposes, especially rooted plants (Cline, 2005; De Cal and Melgarejo, 2000; Ogawa et al., 1995) and budwood (OEPP/EPPO, 1997).

Considering also the worldwide *M. fructicola* distribution (see Section 3.1.3.) and its biology (see Section 3.1.5.), in particular that:

- Dormant plants for planting may be latently infected. Latency of blossom and immature fruit infection are important features of the brown rot pathogen (Gell et al., 2009; Michailides et al., 2007) and attached fruit with latent infections may mummify and act as a primary inoculum source the following spring (Luo and Michailides, 2001; Villarino et al., 2010).
- Dried infected fruit (mummies), twig and branch cankers and peduncles, where *M. fructicola* can overwinter, may produce conidia that can infect blossoms and young shoots the following spring (Ellis, 2001).

The Panel considers that import of plants for planting of *Prunus*, *Malus*, *Pyrus*, *Cydonia* and other Rosaceae originated in infested areas presents the major risk for the introduction of *M. fructicola* into the EU. However, there is uncertainty due to the lack of data on the volume of host plant material for propagation purposes imported into the EU.

3.2.2.2. Survival during transport or storage

Although the Panel mostly found recommendations applied to transport and storage conditions of live plants at large or regarding hardwood seedlings, it is likely that the following may also apply to transport and storage of host plants of *M. fructicola*.

Optimum storage conditions vary by species with most nursery stock storing well at 33-35 °F (0.56-1.67 °C), with relative humidity above ~90 to 95% (Scianna and Logar, 2005).

According to Jacobs (2003), hardwood seedlings are most often stored at 33-40 °F (0.56-4.44 °C) following packing and prior to shipping or customer pickup and they are stored at a relative humidity greater than 80%. These storage conditions ensure that seedlings will remain moist and physiologically dormant prior to shipping for planting. Many nurseries have large coolers in which they store seedling bundles on racks. Sufficient space must be available between bundles to promote proper air circulation. This helps regulate temperature consistency and minimizes the chance for introduction of disease and mould. Seedlings continue to respire and expend stored carbohydrates while in cold storage. When storing seedlings for extended periods, freezer storage may provide a more effective means of minimizing any loss of seedling vigour (Englert et al., 1993). Jacobs (2003) states that in the USA, large orders are generally shipped in refrigerated trailers, while small orders that are not picked up at the nursery are often shipped without refrigeration. He suggests that when it is not possible to cold store seedlings during transport, seedlings should receive proper air circulation and remain free of direct sun, high temperatures, and drying winds at all times. Moreover, the same author recommends cold storage of seedlings also after pickup until planting.

Similar suggestions are given by Huber (2003), who highly recommends temperature range of 34-38 °F (1.11-2.22 °C), as warmer temperatures may induce bud break, causing eventual bud mortality. If no cooler is available an alternative method is outside storage, provided that plants are protected from freezing and warm temperatures.

According to Scianna et al. (2002), dormant plants should be shipped and stored under refrigerated (34-37 °F, i.e. 1.11-2.78 °C) and high humidity (90-95%) conditions. Plant material transported to the planting site in refrigerated storage and placed directly in on-site refrigerated storage may be held on-site for up to 14 days prior to transplanting. All bare-root material should have roots kept in moist packing material wrapped in polyethylene sheeting during transport. A plant grown in containers should have moist media (but not dripping wet) at all times. If actively growing, container plants should be transported and stored under conditions that favour active growth (45-75 °F, i.e.7.22-23.89 °C, sun light and adequate moisture). All plants should be fully protected from wind and sun desiccation during transport (tarps, protective boxes, caps etc.). On arrival at the planting site and prior to transplanting, plants should be temporarily stored in a cool, shaded (dark), wind-protected area. The mentioned paper (Scianna et al., 2002) includes, among the species for which the suggested conditions apply, also species of *Prunus*, *Crataegus* and other Rosaceae.

It is also recommended to warrant appropriate timing (coordination of shipping dates with picking up dates, etc.) in order to minimise the time of exposure of plants for planting to non-optimal conditions during transport and storage, to eliminate potential stress and injuries (CITES-UNEP, 1981; Huber, 2003; Scianna et al., 2002; Scianna and Logar, 2005).

The Panel has no information about the actual conditions applied during transport and storage of host plants of *M. fructicola* imported into EU. Nevertheless it assumes that, in order to ensure the quality standards, the conditions should not greatly differ from the above mentioned recommendations, which are based upon plant physiology.

Considering in addition the high tolerance of *M. fructicola* to environmental stresses (see Section 3.1.5.) the Panel considers that the transport and storage conditions that ensure the viability of plant material for propagation purposes of susceptible genera do not affect the survival of the pathogen.

3.2.2.3. Pest surviving the existing pest management procedures

Latent and quiescent infections may occur (Michailides et al., 2007, 2010; Mordue, 1979) and symptoms on host plants intended for planting are likely to be insignificant (OEPP/EPPO, 2009b) so latently infected (asymptomatic) or diseased plants may escape inspections.

Pruning to eliminate diseased plant parts, especially mummified fruit, can reduce inoculum sources but not latently infected quiescent infections (Melgarejo and De Cal, 2010; Villarino et al., 2010).

Pre-harvest fungicide sprays applied for the control of diseases caused on several host species by other *Monilinia* species or other fungi (e.g. powdery mildews), can suppress sporulation of *M. fructicola* on infected tissues (Kable, 1976; Wilcox, 1990). Among them there are systemic fungicides, such as dicarboximides, benzimidazoles, triazoles and protectant including captan, mancozeb, methiram, propineb, thiram, folpet, chlorotalonil and ziram (Melgarejo and De Cal, 2010).

Watson et al. (2002) observed reduction in canker sporulation in two successive crop years (31% in 1991 against 6.3% in 1992) and considered management practices applied in the previous year as a factor. In their study the orchard, from which infected twigs were collected in 1992, received preharvest applications of triforine and iprodione fungicides in 1991, whereas those orchards from which originated the twigs collected in 1991 had not received fungicide sprays in 1990. The same authors stated that environmental conditions might also have been involved. They concluded that the length of time that sporulation can be suppressed by fungicides, or the fungus is eliminated by fungicide treatment(s), is unknown.

Isolates resistant to benzimidazoles, dicarboximides and triazoles from stone fruit orchards in several parts of the world have been reported (Penrose et al., 1979 and 1985). In a survey on stone fruit orchards conducted in California (Yoshimura et al., 2004), different levels of resistance to benzimidazole fungicides were observed, including high levels. Highly resistant isolates had been reported in Michigan (Jones and Ehret, 1976), South Carolina (Zehr et al., 1999), New York (Szkolnik and Gilpatrick, 1977) and Australia (Whan, 1976). There are conflicting reports about the fitness of resistant vs. sensitive isolates. Some authors found that resistant isolates were equal to the sensitive isolates in pathogenicity and competitiveness (Jones and Ehret, 1976; Sanoamuang and Gaunt, 1995; Sonoda et al., 1983; Yoshimura et al., 2004). However differences in pathogenicity between sensitive and resistant isolates of *M. fructicola* have also been reported (Jones and Ehret, 1976; Sonoda and Ogawa, 1982; Sonoda et al., 1982). These studies indicate that the parasitic fitness of benzimidazole-resistant isolates of *M. fructicola* may vary depending on the crop or location.

According to Yoshimura et al. (2004), no resistance to iprodione or tebuconazole was detected in California, despite the fact that these fungicides had been used extensively for over a decade. The demethylation inhibiting (DMI) fungicide tebuconazole was first applied in stone fruit orchards in California in 1997. The authors observed no significant increase in the EC_{50} values between the historic and current populations, in substancial agreement with Wilcox and Burr (1994). However Zehr et al. (1999) reported that the EC_{50} values of *M. fructicola* isolates from South Carolina increased after 3 years of exposure to propiconazole, but the isolates with lower sensitivities were still controlled by the fungicide. Resistance to both benzimidazole and dicarboximide fungicides has been reported for isolates of *Botrytis cinerea* in several crops (Raposo et al., 2000; Yourman and Jeffers, 1999). However, in the study by Yoshimura et al. (2004), the thiophanate-methyl resistant isolates of *M. fructicola* did not show decreased sensitivity to iprodione. The results of this study also indicate that iprodione remained effective against benzimidazole resistant isolates. The authors suggest that alternate applications of iprodione and tebuconazole would be an appropriate resistance management strategy.

Biological agents, like *Epicoccum nigrum* and *Penicillium frequentans,* isolated from peach shoots (Melgarejo et al., 1986) have a high potential of controlling the disease caused by *Monilinia* spp. on

fruit, shoots and twigs, particularly when applied prior to harvest at blossoming, fruit pit hardening and postharvest (De Cal et al., 2009; Guijarro et al., 2008; Larena et al., 2005; Mari et al., 2007).

3.2.2.4. Transfer to a suitable host

Hosts of *M. fructicola* are widely grown in the risk assessment area in commercial orchards, nurseries and private gardens, as ornamental trees in parks and at roadsides both in rural and urban regions (see Section 3.1.4.).

M. fructicola overseasons as mycelium in infected plant parts (Byrde and Willetts, 1977; Biggs and Northover, 1985; Landgraf and Zehr, 1982). Primary inoculum produced in spring is in two forms: conidia and ascospores. Conidia are produced under favourable conditions from mycelium in the mummified fruit, fruit peduncles, cankers on twigs and branches, leaf scars and buds (Sanoamuang, 1992). Dispersal of *M. fructicola* conidia in pome and stone fruit orchards can occur by by natural means (see Sections 3.2.4.1. and 3.4.1.) and by human assistance (see Section 3.4.2.).

Based on the above, the Panel considers that *M. fructicola* has a high probability to transfer to a suitable host.

3.2.3. Pathway 2: Fruit (fresh and dried)

In addition to planting material, movement of fruit (fresh and dried) of *Prunus*, *Malus*, *Pyrus*, *Cydonia* and other Rosaceae constitutes an additional pathway of entry of the pathogen into new areas.

3.2.3.1. Association of the pest with the pathway at origin

Fresh fruit

Imports of fresh fruit of host plants constitute the greatest bulk of material on which the pathogen could be carried. The quantities of fresh stone fruit imported into the EU from non-European regions, where *M. fructicola* is known to occur, are given in Table 1.

Table 1: Imports of fresh stone fruit (meaning apricots, cherries, peaches, nectarines, plums and sloes) into the EU from regions where *Monilinia fructicola* is present (EUROSTAT, 2009).

Place of origin	**Quantities of imported fresh stone fruits into the EU in 2009 (tons)**	**Proportion of importing Member States on the whole EU 27**
Asia (China, India, Korean Rep., Japan, Taiwan, Yemen)	93.9	**5/27**
Africa (Nigeria; Zimbabwe)	-	
North America (Canada, Mexico, USA)	5220.5	**9/27**
Central America and Caribbean (Guatemala, Panama)	-	
South America (Argentina, Bolivia, Brazil, Ecuador, Paraguay, Peru, Uruguay, Venezuela)	5514.4	**11/27**
Oceania (Australia, New Caledonia, New Zealand)	903.7	**8/27**

(a): A more detailed table is available at Appendix C

Fresh fruit consignments of host plants are imported from non-EU countries into the EU 27 almost throughout the whole year (Appendix D). Host plants are susceptible to infection by *M. fructicola* from flowering to dormancy. Host plants at the susceptible stage may therefore be available in the pest risk assessment area during the import period.

Orchard sanitation to minimize inoculum sources, orchard monitoring, pre-harvest fungicide applications, prompt cooling immediately after harvest and post-harvest treatments are recommended for the management of brown rot in the areas present distribution of the pathogen (Bush et al., 2009; Ellis, 2008; Hong et al., 1997; Michailides and Morgan, 1997; Michailides et al., 2007). Cultural practices, such as removal of mummies from trees and the orchard floor, fruit thinning after pit hardening, removal of thinned fruit from the orchard floor, pruning of infected twigs and branches, co-ordination of fruit thinning and irrigation, disking the soil, etc., aim at removing as much infested plant material as possible to reduce the overwintering inocula, but they are not sufficient to control the disease, particularly in humid climates (Bush et al., 2009; Ellis, 2008; Hong et al., 1997; Michailides and Morgan, 1997; Michailides et al., 2007; Ogawa et al., 1995).

Pre-harvest treatments with protectant fungicides are also applied when (a) susceptible flower parts are exposed, (b) before or soon after the occurrence of periods of wetness and temperatures conducive to infection, and (c) during the three-week pre-harvest period (Bush et al., 2009; Ogawa et al., 1995) in order to protect flowers and fruit and reduce the amount of sporulation formed on the infected plant tissues. Current brown rot management strategies in orchards consist of 2-3 fungicide sprays around flowering followed by 1-2 sprays when fruit start to ripen (Zehr et al., 1999). Benomyl, thiophanate-methyl, vinclozolin, iprodione, bitertanol and triforine sprays have been reported to be very effective in controlling *M. fructicola* in the orchards (Brackmann et al., 1984; Harman and Beever, 1987; Montero et al., 1985; Takamura and Ochiai, 1989). However, the need to spray several times during the growing period has led to a build-up of strains resistant to certain fungicides, such as benzimidazoles and dicarboximides (Elmer and Gaunt, 1986 and 1993; Michailides et al., 1987; Penrose, 1990). Fungicides are not usually applied to immature fruit unless the environmental conditions are favourable for infection (high relative humidity, dew, etc.) or injury caused by insects, cold, hail, etc. has increased the susceptibility of the host. Post-harvest physical treatments, such as rapid cooling of the fruit immediately after harvest and artificial ripening at high temperatures (35 °C), may delay the development of brown rot symptoms (Ogawa et al., 1995), but they are unlikely to eliminate the prevalence of the pathogen in fresh fruit consignments. Several fungicides are also registered for post-harvest dipping of fruit in the areas of the pathogn's present distribution. Post-harvest fungicide dips, such as iprodione and procymidone, may reduce the inoculum (conidia) present on the fruit surface (Chastagner and Ogawa, 1976; Feliciano et al., 1992; Karabulut et al., 2010; Poole et al., 2001) but they are unlikely to affect the survival of the mycelium located inside the fruit.

Considering also the worldwide *M. fructicola* distribution (see Section 3.1.3.) and its biology (see Section 3.1.5.), in particular that:

- The pathogen may be carried on harvested fruit of susceptible host plants as (a) conidia adherent on the surface of healthy fruit (contaminants), (b) mycelium grown intercellullarly without any visible symptoms (latent infections), and (c) conidia produced within sporodochia on symptomatic (rotted) fruit (active infections).

- Fruit may become infected by *M. fructicola* at all stages of their development and, after harvest, during transit and storage (Agrios, 2005). As fruit ripen, its invasion by the fungus is very rapid resulting in fruit rot before or after harvest even when environmental conditions at harvest time are not conducive to infection (Adaskaveg et al., 2005). Infected fruit will continue to rot after harvest, whereas the mycelium may directly attack healthy fruit in contact with infected ones. Although the injury of the fruit may lead to an increase in infection, the fungus readily infects when no wound or fruit-to-fruit contact is present (Michailides and Morgan, 1997).

- Apparently healthy fruit at harvest can be contaminated with conidia at any time between harvest and consumption. However, not all latent infections induce fruit rot before harvest (Cruickshank and Wade, 1992). In most cases, infections remain latent even after harvest and act as sources for post-harvest fruit rot during cold storage (Byrde and Willetts, 1977).

The Panel considers that that *M. fructicola* is highly associated with the fresh fruit of susceptible genera originated in areas where the pathogen is known to occur.

Dried fruit

Stone fruit, particularly plums and apricots, are also traded worldwide as dried fruit for human consumption. In general, dried fruit undergo the following process steps: pre-drying treatments (e.g. size selection, peeling, colour preservation, culling, etc.), drying or dehydration using natural or artificial methods and post-dehydration treatments (e.g. inspection and packaging) (FoodPro, 2007). Initially the fresh fruit are sorted according to size, maturity and soundness. They are then washed to remove dust, dirt, plant parts, insects and other material that might contaminate or affect the colour or the flavour of the fruit. The final step in the pre-dehydration treatment is colour preservation, also known as sulphuring. During this step, fruit are treated with sulphur dioxide (SO_2), which has antioxidant and preservative effects. Sulphur dioxide also retards the browning of fruit, which occurs when the enzymes are not inactivated by a sufficiently high heat normally used in drying. Several drying methods are commercially available, with sun drying and atmospheric forced-air drying the most widely used methods for drying fruit. In the former method, which is limited to climates with hot sun and a dry atmosphere, fruit are spread on the ground, racks, trays or roofs and exposed to the sun until they dry. The second method uses heated ovens, where the fruit stay in tunnels with heated air and controlled RH for a certain period of time depending on the type of fruit. The drying conditions for plums, apricots, cherries and pears are shown in Table 2. Following drying, fruit undergo inspection and screening during which any foreign material and discoloured pieces are removed (FoodPro, 2007).

Table 2: Technical data for fruit drying in heated tunnels.

Fruit	Drying conditions			Dried product moisture (%)
	Load (kg/m2)	Temperature (°C)	Time (h)	
Plums	15	I. 40-50	6	18-20
	15	II. 75-80	14	18-20
Apricots (halves)	10	60-70	10-15	15-20
Cherries	10	55-70	6-8	12-15
Pears (halves and quarters)	15	65-70	15-22	18-20

Source: FAO, 2010 (http://www.fao.org/docrep/v5030e/v5030e0j.htm)

As mentioned above, *M. fructicola* may be present on harvested fruit of susceptible host plants as (a) conidia adherent to the surface of healthy fruit (contaminants), (b) mycelium grown intercellullarly with or without any visible symptoms (latent infections), and (c) conidia within sporodochia on symptomatic fruit (active infections).

Thermal death points of fungi are different for different fungal species as well as for different growth stages such as mycelium, spores or survival structures. Most fungi are sensitive to high temperatures. Thermal death points for spores of many fungi range from 40 to 60 °C for 10-min exposures. However, the effect of extreme temperatures depends on moisture content, metabolic activity and age of the fungal propagules or somatic tissue (Kader, 2002).

In the case of *M. fructicola* conidia, Bussel et al. (1971) showed that 96% of freshly harvested ungerminated *M. fructicola* conidia survived heating at 40 °C for 16 min. However, only 0.1% and 0.02% of those conidia survived exposure to 50 °C for 1 min and 16 min, respectively.

Conidia of *Monilinia* species can survive dry conditions, especially under relatively low temperatures and high relative humidity (Xu et al., 2001).

Germinating or germinated conidia of *M. fructicola* are able to withstand drying of a long duration. In a study carried out under laboratory conditions (Grindle and Good, 1961) germinating conidia

survived drying at 0% or 15% RH for at least 72 h. Those dried at 45-90% RH survived for shorter periods. At 30 °C no conidia survived drying for 12 h. Successively, Good and Zathureczky (1967) obtained data on the effect of drying on conidia with germ tubes of various lengths and subjected to two successive dryings. These experiments were carried out in the laboratory and on membranes exposed in the field on a platform, set within the canopy of a lilac bush similar in shape to a peach tree. Survival under laboratory condition after a 12 h single drying was 98-83%, and after a second 6-h drying was 61-76% (data on two samples of 139 and 42 conidia, respectively). In the field six samples (totallying 1,050 conidia) were tested: four showed 100% survival, the other two 98% and 96%. There was some increase in susceptibility to injury by drying as the germ tube became longer, although this increase was low at 25-26 °C and greater at 29 °C (the only temperatures tested). The conidia re-established growth by continued elongation of only the shortest germ tubes, or by producing a new tube.

According to the *in vitro* studies of Casals et al. (2010a), conidia of *M. fructicola* germinated over a wide range of temperatures (0-35 ºC) in PDA medium at a water activity (a_w) of 0.99, but no germination occurred at 38 ºC. However, when the water activity of the PDA medium was decreased to 0.90 a_w no germination occurred at 0, 5 or 35 ºC.

Mycelial growth and sporulation of *M. fructicola* are directly affected by the water content of the infected plant tissues (Corbin and Cruickshank, 1963; Hong and Michailides, 1999). According to Cook and Papendick (1978), the water potential of ripe peaches, nectarines and apricots is between -1 to -2 MPa. Koball et al. (1997) showed that the *in vitro* growth of *M. fructicola* mycelium decreased substantially as the osmotic potential of the PDA medium decreased from -1 to -6 MPa at 20 °C. According to Hong and Michailides (1999), *M. fructicola* mycelium survived water stress better at low temperatures than at high temperatures. *In vitro* studies have shown that *M. fructicola* mycelium did not grow in PDA amended with KCl at osmotic potential (Ψ) = -11 MPa at 20 and 25 °C, Ψ = -9 MPa (at 15 and 30 °C) or Ψ= -7 MPa (at 10 °C) after 6 h of incubation.

Studies carried out in California under simulated natural conditions have shown that when the water content of drying thinned plum fruit was reduced below 13.4%, very few thinned fruit produced *M. fructicola* conidia (Luo and Michailides, 2001).

Based on the above, the Panel considers that:

- Pre-dehydration treatments, such as culling and washing, applied to fresh fruit of susceptible hosts intended for drying will probably remove symptomatic fruit and most of the *M. fructicola* conidia present on the surface of healthy or symptomatic fruit.

- Treatment of fresh fruit prior to drying with sulphur dioxide, which has been reported to exhibit a direct fungicidal effect on *M. fructicola* (Miller et al., 1953), will further reduce or even eliminate the pathogen's inoculum present on the surface of the fruit.

- *M. fructicola* conidia and latent mycelium present in infested/infected fruit are unlikely to survive the long exposure either to the sun or to the high temperatures used in the drying ovens (see Table 2).

Moreover, because of the positive effect of processing on the soundness and preservation of dried fruits, the risk that unmarketable waste material is produced and discarded in proximity of susceptible host is likely to be very low or negligible.

Therefore, *M. fructicola* is unlikely to be associated with the dried fruit of susceptible hosts pathway and for this reason this pathway will not be analysed further.

3.2.3.2. Survival during transport or storage

Harvested fruit of susceptible hosts are usually cooled immediately to temperatures between 5 and 10 °C provided that packing will occur the next day (Crisosto and Kader, 2000). If packing is going to be delayed, then fruit is thoroughly cooled to near 0 °C. Storage and long-distance shipping of fruit usually take place at or below 0 °C (Crisosto and Kader, 2000).

M. fructicola overwinters in fruit as mycelium or apothecia with ascospores and therefore, cold storage of infected fruit during transport and storage is unlikely to have any effect on the survival of the pathogen. According to Zhong et al. (2008), conidia and mycelium of *M. fructicola* on mummified fruit and in infected branches survived cold winters (10-year average temperature in November, December and January 5.1, -3.3 and -4.2 °C, respectively) in suburban Beijing (China).

Based on the above, it may be concluded that in terms of duration and conditions of transport and storage, *M. fructicola* in the form of latent mycelium and/or conidia present in fruit of susceptible host plant genera, will not be affected by the transport and storage conditions. This is further supported by the fact that living stages of the pathogen continue to be intercepted on fruit consignments imported into the EU 27. More specifically, during the period 1995-2010, there have been 20 notifications from EU Member States of interceptions of *M. fructicola* on *Prunus* spp. fruit consignments imported into the EU from infested third countries (source: Europhyt; see Section 2.2.).

3.2.3.3. Pest surviving the existing pest management procedures

A combination of cultural practices and chemical control measures are commonly applied in the areas of the pathogen's present distribution for the management of *M. fructicola* (Michailides et al., 2007) (see Section 3.2.2.3.). Culling in the orchard will most probably remove symptomatic fruit at harvest but not fruit with latent infections (asymptomatic) or healthy fruit carrying on its surface conidia of *M. fructicola*. Moreover, other *Monilinia* species (i.e. *M. laxa, M. fructigena, M. polystroma*), closely related to *M. fructicola,* can cause similar symptoms on fruit (Chalkley, 2010).

Following harvest, fresh fruit are subjected to a number of physical (cooling, washing, drying, brushing) and chemical (fungicide dips) treatments in commercial packing houses before distribution. If packing is to be delayed, then harvested fruit are immediately cooled to near 0 °C (Crisosto and Kader, 2000). Although these temperatures may delay symptom development, they are unlikely to affect the survival of the pathogen (see also Section 3.2.3.2.). Post-harvest washing and brushing may remove some conidia present on the surface of the fruit. However mycelium located inside the fruit will not be affected by this process. Furthermore, grading and packing procedures are likely to result in culling of symptomatic fruit, but not of latently infected ones (asymptomatic).

Post-harvest treatments, such as dipping of fruit in fungicides (Chastagner and Ogawa, 1979; Feliciano et al., 1992; Karabulut et al., 2010; Poole et al., 2001) or fruit immersion in water at 60 °C for 60 s (Karabulut et al., 2010) may reduce the prevalence of the pathogen in fruit, but they are unlikely to eliminate it.

Visual inspection of fruit consignments can detect fruit showing brown rot symptoms but as three other *Monilinia* species also cause brown rot symptoms (see above), culturing is necessary to determine which of the four species is involved. Differentiation of the pathogen from the other related *Monilinia* species can only be made by laboratory examination. Moreover, latent infected fruit and fruit carrying conidia of the pathogen on their surface as contaminants will most probably go undetected at border inspection.

Based on the above, the Panel concludes that *M. fructicola* may survive the management strategies commonly applied to fresh fruit in the areas of its present distribution.

3.2.3.4. Transfer to a suitable host

Fresh fruit of host plants (plums, cherries, apricots, etc.) are destined for human consumption. Therefore it is expected that following their import, they will be widely distributed in the pest risk assessment area. As fresh fruit are usually eaten with the skin, it is expected that there will be limited amounts of waste material. However, the risk with fresh fruit imported from infested areas is associated with the discarded unmarketable whole fruit/skins derived from packinghouses, households, fresh fruit markets, etc.

Hosts of *M. fructicola* are widely grown in the pest risk assessment area in commercial orchards, nurseries and private gardens, as ornamental trees in parks and at roadsides both in rural and urban regions (see Section 3.1.4.).

M. fructicola survives in winter as mycelium on mummified fruit which can subsequently produce either conidia or a sclerotial mat from which apothecia with ascospores appear as the host blossoms in the following spring (Bryde and Willetts, 1977). Ascospores are forcibly ejected into the air and carried by air currents about the orchard and over longer distances (Holb, 2008b). Conidia of *M. fructicola* are disseminated by air currents, rain water and can also be transported by various insects and birds (see also Section 3.2.3.1.) (Agrios, 2005; Byrde and Willetts, 1977; Tate and Ogawa, 1975). Pauvert et al. (1969) found that splash dispersal is important for short range spread of *M. fructicola* conidia within a tree. Some of the insects are able not only to transport the conidia from infected thinned fruit to the surface of healthy fruit on the trees, but also to facilitate fruit infection by creating wounds (Poulos and Heuberger, 1952). According to Hong et al. (1997), a minimum of 3.5 to 11.7 million conidia of *M. fructicola* may be produced per fruit on the orchard floor. Conidia produced on mummified fruit on the orchard floor may also survive the winter and cause infection in spring (Bertram, 1916; Zhong et al., 2008). If infected fruit were to be deposited in the vicinity of host plants grown in commercial orchards, private gardens, parks, roadsides, etc., in urban and rural regions of the pest risk assessment area, the pathogen could be transferred by natural means (wind, rain, insects, birds, etc.) and be deposited on susceptible host tissues (e.g. blossoms, twigs, fruit) leading to infection (Luo et al., 2005). However, there are uncertainties concerning (i) the prevalence of *M. fructicola* on infected fresh fruit of host plants imported into the pest risk assessment area, and (ii) the frequency and quantity of infected fruit/peel being discarded in close proximity to susceptible host.

3.2.4. Other pathways

3.2.4.1. Natural means

Wind, water, insects, birds are responsible for the dispersal of *Monilinia* conidia in pome and stone fruit orchards (Byrde and Willetts, 1977; Lack, 1989; Pauvert et al., 1969).

Pauvert et al. (1969) found that splash dispersal is important for short range spread within a tree and Kable (1965a) discovered that airborne conidia ensure a wide dispersal of conidia within an orchard during the ripening period. Insect dissemination provides a continuance of the infection chain, even during dry weather in the pre-ripening and ripening period, while water splash contributes to the short distance dispersal of large numbers of conidia during infection periods, and is important in initiating epiphytotics. Long-range dispersal probably relies on vector-borne or airborne mechanisms (Byrde and Willetts, 1977).

Insects were shown to be able to transport conidia from one fruit to another (Croxall et al., 1951; Lack, 1989) and they were the major wounding agents in pome fruit orchards acting as prerequisite factors for infection (Xu et al., 2001). Insects (nitidulid beetles, vinegar flies and honeybees) can be important vectors of *M. fructicola* during fruit ripening by carrying and depositing conidia to injuries caused by oriental fruit moth, peach twig borers, Mediterranean fruit flies, etc. (Agrios, 2005; Ogawa et al., 1995; Tate and Ogawa, 1975).

Wind dispersal was the most studied means among the above mentioned ones. Dispersal of fungal spores by air currents is an important component of plant disease epidemiology and is of major concern in devising disease management strategies. Dispersal can be monitored directly through spore sampling techniques or, in some cases, indirectly through disease gradients (Aylor, 1999).

Concentration of *Monilinia* conidia in the air shows a seasonal pattern, which strictly depends on the life cycle of the fungus (see Section 3.1.5.). Brown rot is a polycyclic disease with many infection cycles during the vegetative period of the host plant, lasting approximately one week each (Melgarejo and De Cal, 2010). At the end of each cycle, the fungus produces asexual conidia on all the affected plant surfaces, including blighted flowers/twigs, cankers, mummies, rotted fruit attached to the trees or fallen on the orchard floor, and thinned fruit (Bannon et al., 2009; Holb and Scherm, 2007; Hong et al., 1997; Van Leeuwen et al., 2002b; Villarino et al., 2010). These conidia are then dispersed, most of them remain viable (Holb, 2008a; Van Leeuwen et al., 2000; Xu et al., 2001) and can start a new infection cycle under favourable environmental conditions (Biggs and Northover, 1988b; Corbin, 1963; Corbin and Cruishank, 1963; Michailides and Morgan, 1997; Phillips, 1984). Therefore the density of the airborne conidia strictly depends on the density of the inoculum sources and, obviously, on the sporulation rate of the inoculum sources. It was estimated that one infected mummy per m^2 of orchard floor can produce more than 40 airborne *Monilinia* conidia per m^3 air (Villarino et al., 2010). The maximum hourly concentration of *M. fructigena* conidia detected in an apple orchard was in the range 200–250 conidia/m^3 (Bannon et al., 2009) and that of *M. fructigena* in the range of 120-395 conidia/m^3 air per day (Holb, 2008a; van Leeuwen, 2000, respectively): lower than concentrations measured in stone fruit orchards. A maximum concentration of 5000 conidia/m^3 was measured in a peach orchard with approximately 5% of the fruit infected by *M. fructicola* (Kable, 1965a). A maximum concentration of 1260 conidia/m^3 was found in an apricot orchard affected by *M. laxa* (Corbin et al., 1968).

Bucksteeg (1939) showed that the aerial concentration of *Monilinia* conidia in a pome fruit orchard peaked during June and July. In apricot orchards affected by *M. laxa*, conidia were only detected regularly when approximately 1% of the fruit in the trees was sporulating and the aerial spore content rapidly increased 10–14 days before the harvest ripe stage (Corbin et al., 1968). Recent studies have shown that the concentration of *M. fructigena* conidia in the air of apple orchards increased continuously from the appearance of the first infected fruit until harvest and was correlated with fruit with sporulating lesions on the orchard floor (Holb, 2008b). The aerial conidia concentration of *M. fructigena* in apple orchards increased markedly from the time when the first diseased fruits appeared in the beginning of July (Bannon et al., 2009). Density of *M. fructigena* conidia in apple orchards markedly increased from the fruit ripening stage (van Leeuwen, 2000; van Leeuwen et al., 2000). In other studies, the maximum number of airborne conidia of *Monilinia* spp. has been recorded just after harvest (Villarino et al., 2010).

In addition to the seasonal pattern, distinct diurnal patterns in aerial conidia concentration related to environmental conditions have also been observed. Peak concentrations of *M. fructicola* / *M. laxa* conidia occurred during the afternoon when relatively low air humidity and high wind speed prevail (Corbin et al., 1968; Kable, 1965a). The diurnal pattern under natural day length conditions also depends on the fact that conidia production is triggered by light which may impose a diurnal pattern (Bannon et al., 2009). This is inconsistent with laboratory results, where small and inconsistent differences in conidia production were observed between continuous darkness and light/dark cycles (Sanderson and Jeffers, 2001; Van Leeuwen and van Kesteren, 1998). However, the diurnal effects are likely to be caused by factors operating on conidia dispersal rather than conidia production (Bannon et al., 2009).

Relationships between environmental factors and aerial conidia concentration of *Monilinia* spp. have been studied extensively (Corbin et al., 1968; Holb, 2008a; Kable, 1965a; Sanderson and Jeffers, 1992). Dehiscence of conidial chains in *Monilinia* is stimulated by a decrease in the ambient relative humidity (RH), but dehiscence and final capture of conidia may be separated in time (Byrde and Willetts, 1977). In an apricot orchard, fluctuations in numbers of *M. laxa* airborne conidia were

correlated with temperature, RH, and wind speed (Corbin et al., 1968). During the daytime hours until about 15.00, temperature and wind speed increased, while RH decreased; thereafter temperature declined, RH increased, but wind speed continued to increase until 17.00. Numbers of conidia in the air continued to increase until 18.30 and it was concluded that wind speed was probably the most influential weather variable. Wind speed was also found to be the most essential variable, followed by temperature and air humidity in stone fruit orchards infected by *M. fructicola* (Jenkins 1965; Kable 1965a). In *M. oxycocci*, the diurnal pattern of conidia release coincided with increasing temperature and wind speed, and decreasing RH (Sanderson and Jeffers, 1992). Rainfall amount reduced conidia catch on a number of specific days. Correlation of conidia numbers with wind speeds and mean hourly rainfall in different orchards were inconsistent or poor, respectively (Bannon et al., 2009). Concentration of *M. laxa* and *M. fructigena* conidia in the air in peach orchards in Spain was also affected by climatic factors, such as temperature, solar radiation, rainfall and wind speed (Gell et al., 2009). Holb (2008a) found significant positive correlations between hourly conidia density of *M. fructigena* in apple orchards and temperature, and negative correlations between hourly conidia density and RH, in agreement with other *Monilinia* studies (Corbin et al., 1968; Sanderson and Jeffers, 1992; van Leeuwen, 2000).

All the previously mentioned studies concern within-orchard concentrations of *Monilinia* conidia. No published studies concern between-orchard and long-range dispersal of conidia. Lacking experimental studies, density of spores that come from a distant source can be calculated by mathematical models. The Panel has used the Gaussian Plume Model (GPM), a simple atmospheric dispersal model, to estimate the maximum distance the *M. fructicola* conidia can travel under favourable conditions (Appendix E). Based on this model, it can be considered that in reasonable circumstances the spread of conidia of *M. fruticola* is possible up to 500 m in wind direction from any inoculum source.

Therefore, the Panel considers that it is very unlikely that *M. fructicola* can enter in the risk assessment area through wind-blown conidia from non-European countries.

3.2.5. Conclusions on probability of entry

Rating	Description
Very likely	• Plant material for propagation purposes of host genera may carry *M. fructicola* as latent mycelium and/or conidia, which are capable of surviving transport and storage conditions and existing pest management procedures. Entry of the pathogen on plant propagation material, particularly latently infected, is considered very likely. • Fruit of susceptible genera may also carry the pathogen in the form of latent mycelium and/or conidia. Entry of the pathogen on fresh fruit of susceptible genera originating in infested areas is very likely. • Entry of the pathogen by natural means (wind, rain, insects, birds, etc.) from infested European non-EU countries (e.g., Switzerland) is very likely.
Unlikely	• Fruit of host genera that have undergone drying process (dried fruit) are unlikely to carry viable propagules of the pathogen. In addition, the possibility that unmarketable dried fruit waste material is produced and discarded in proximity of susceptible hosts is very low or negligible. For these reasons the potential of the pathogen to enter in the risk assessment area on dried fruit is considered unlikely. • Entry of the pathogen by natural means (wind, rain, insects, birds, etc.) from infested non-European countries is unlikely because of the long distance.

3.2.6. Uncertainties

Uncertainty	Description
Low	In spite of the lack of data on: (i) the volume of host plant material for propagation purposes imported into the EU; (ii) the prevalence of *M. fructicola* on infected fresh fruit imported into the EU, (iii) frequency and quantity of fruit/peel discarded in near proximity of host plants, the uncertainty related to the likelihood of entry remains low, because the available information gives sufficient evidence on the risk for entry.

3.3. Probability of establishment

M. fructicola shares some features with *M. laxa* and *M. fructigena* which are widely established in European stone and pome fruit orchards. However, differences in ecological requirements and host plant preferences are reported from areas where these species co-exist. Therefore, similarities between these species do not imply that *M. fructicola* may establish in the same areas.

3.3.1. Reports of *M. fructicola* in Europe

M. fructicola has been already established in some European countries, including EU Member States (France, Germany, Hungary, Italy, Poland, Romania and Slovenia, Spain; see Section 3.1.3.1.) and in Switzerland.

Based on the replies to the EFSA questionnaire:

- in Belgium, Czech Republic, Denmark, Portugal, Slovak Republic, Latvia official surveys have been performed but the pathogen was never detected;
- Estonia, Finland and United Kingdom are declared free from the pathogen, but no surveys (or no recent surveys) have been done;

No information is available (neither from literature nor from questionnaires) for Bulgaria, Cyprus, Greece, Ireland, Lithuania, Luxembourg, Malta, Netherlands, and Sweden.

3.3.2. Availability of suitable hosts in the risk assessment area

M. fructicola has a wide host range manly within the family of Rosaceae (see Section 3.1.4.). Between the potential hosts, there are some of the principal species for fruit production in Europe, which are widely distributed in the risk assessment area, as indicated in the Table 3.

In addition to crop species, the risk assessment area hosts wild plants which can represent potential additional hosts for the pest: in Appendix B the full list from Flora Europaea shows in most of the cases also the countries where the species is present.

Table 3: EU 27 area (1000 ha) and harvested production (1000 t) of orchards of *Monilinia fructicola* host species (Eurostat, 2007).

	Year 2007	Apples, including cider apples	Pears, including perry pears	Peaches	Apricots	Cherries, including sour cherries	Plums	Nectarines	Almonds
Austria	Area	6.1	0.4	0.2	0.5	0.2	0.3	:	:
	Production	477.9	175.5	8.0	14.6	39.7	68.4	:	:
Belgium	Area	8.5	8.1	0.0	:	1.3	0.1	:	:
	Production	358.0	286.6	0.0	:	7.2	0.5	:	:

Bulgaria	Area	5.4	0.6	6.2	7.1	15.8	16.3	:	1.9
	Production	26.2	1.0	18.8	8.3	21.1	23.0	:	0.2
Cyprus	Area	1.1	0.2	0.5	0.3	0.2	0.5	0.3	5.0
	Production	8.6	1.1	2.5	1.9	0.6	0.9	1.6	0.7
Czech Republic	Area	9.9	0.7	1.2	1.8	3.2	1.8	:	:
	Production	115.8	3.6	3.6	5.4	11.4	5.9	:	:
Denmark	Area	:	:	:	:	:	:	:	:
	Production	:	:	:	:	:	:	:	:
Estonia	Area	1.1	:	:	:	0.0	0.1	:	:
	Production	2.1	:	:	:	0.0	0.0	:	:
Finland	Area	0.6	0.1	:	:	:	:	:	:
	Production	3.5	:	:	:	:	:	:	:
France	Area	53.4	7.9	8.1	14.2	11.1	18.9	6.9	1.3
	Production	2026.0	194.6	176.8	126.4	45.8	250.9	175.2	1.6
Germany	Area	31.7	2.1	0.0	0.0	8.9	5.1	:	:
	Production	1070.0	49.9	:	:	63.2	71.3	:	:
Greece	Area	12.2	4.0	36.9	5.3	8.2	0.8	5.7	14.5
	Production	262.3	52.4	737.2	87.2	52.0	2.1	99.5	36.4
Hungary	Area	43.5	3.1	8.0	6.1	15.7	8.5	:	0.2
	Production	170.9	11.8	40.8	21.7	49.1	30.8	:	0.2
Ireland	Area	:	:	:	:	:	:	:	:
	Production	:	:	:	:	:	:	:	:
Italy	Area	60.6	41.4	60.3	18.0	29.7	14.1	32.8	80.0
	Production	2224.1	855.4	1037.4	214.6	106.2	185.2	593.0	112.6
Latvia	Area	7.4	0.6	:	:	0.7	0.4	:	:
	Production	30.5	1.1	:	:	0.9	0.3	:	:
Lithuania	Area	12.7	1.1	:	:	1.2	1.2	:	:
	Production	35.7	1.6	:	:	0.8	0.6	:	:
Luxembourg	Area	1.0	0.1	:	:	0.1	0.8	:	:
	Production	4.1	1.2	:	:	0.2	0.6	:	:
Malta	Area	:	:	:	:	:	:	:	:
	Production	0.1	0.3	0.6	0.0	:	0.0	0.1	:
Netherlands	Area	9.4	7.3	0.0	:	0.7	0.3	:	:
	Production	391.0	260.0	:	:	:	:	:	:
Poland	Area	175.6	13.0	3.3	1.6	47.9	22.2	0.0	:
	Production	1040.0	30.7	3.6	1.1	127.8	53.5	0.0	:
Portugal	Area	20.5	12.9	5.8	0.6	6.3	2.0	:	38.1
	Production	247.2	141.2	53.1	5.0	9.4	19.8	:	11.8
Romania	Area	59.0	4.6	1.8	3.3	7.7	76.2	0.0	:
	Production	472.0	61.9	16.4	26.9	64.8	370.6	0.1	:
Slovakia	Area	3.2	0.1	0.7	0.2	0.3	0.6	:	:
	Produc	17.7	0.3	1.1	0.1	0.5	2.2	:	:

	tion								
Slovenia	Area	:	:	:	0.0	0.1	0.0	:	:
	Production	114.5	11.8	9.3	0.5	4.0	6.3	:	:
Spain	Area	36.1	31.9	54.9	18.3	24.1	20.1	25.7	563.8
	Production	721.2	551.8	846.9	89.0	75.7	201.4	374.2	187.7
Sweden	Area	1.4	:	:	:	:	:	:	:
	Production	21.0	:	:	:	:	:	:	:
United Kingdom	Area	15.0	1.5	:	:	0.4	0.9	:	:
	Production	242.8	20.6	:	:	1.2	13.8	:	:

3.3.3. Suitability of environment

Development of *M. fructicola* strictly depends on temperature and humidity. Conidia of *M. fructicola* germinate over a wide range of temperatures (0-35 ºC), but no germination occurs at 38 ºC (Casals et al., 2010a). Germination is very slow at 0-5 ºC and progressively faster, up to an optimum, between 15 and 25-30 ºC (Casals et al., 2010a; Weaver, 1950). At 100% relative humidity, conidia of *M. fructicola* are able to germinate on all plant surfaces, while at 80% relative humidity they can germinate only on floral stigmata (Weaver, 1950). Germination is very slow at 0.90 a_w and progressively faster, up to an optimum at 0.99 a_w (Casals et al., 2010a). A minimum of 3-4 h of wetness duration at 20-22 ºC is necessary for germination of *M. fructicola* conidia to take place (Wilcox, 1989). Infection can occur in a temperature range from 5 to 30 °C, with optimum at 20-25 °C, in the presence of high relative humidity or free water (Lichou et al., 2002; Weaver, 1950; Wilcox, 1989). Blossom blight in sour cherry inoculated with *M. fructicola* was proportional to the temperature and duration of the wetting period; disease incidence was nil without wetting and minimal with 3 h of wetting, regardless of temperature, but was 5, 7, 28, and 72% with 5 h of wetting at 8, 12, 16, and 20 °C, respectively (Wilcox, 1989). Both peach and sweet cherry had an increased incidence of fruit infection with increased wetness duration until 15-18 h over a temperature range of 15-30 °C (Biggs and Northover, 1988a). On *Prunus domestica*, optimal temperatures for blossom blight development were 22 to 26 °C; blossom blight linearly increased with wetness duration, and did not occur at <10 or >30 °C and less than 4 h of wetness (Luo et al., 2001b). The mycelium of *M. fructicola* grows rapidly on PDA at 20 to 25 °C (Weaver, 1950). *M. fructicola* did not grow in PDA at water potential < - 11 MPa (20 and 25 °C), -9 MPa (15 and 30 °C), or -7 MPa (10 °C) after 6-d incubation; it also did not grow at < - 11 MPa nor in PDA amended with sucrose at < - 13 MPa even after 60 d incubation at any temperatures tested. *M. fructicola* survived water stress better at low temperatures than at high temperatures (Hong and Michailides, 1999).

Asexual sporulation occurs on different inoculum sources (blighted blossoms, peduncles, abscission scars, and cankers) with higher frequency at 15 and 23 °C than at 4 or 11 °C. Twelve hours of wetting were sufficient at all temperatures studied (5 to 23 °C) for sporulation to occur, but the number of sources supporting sporulation increased with time of wetting up to 72 h (Watson et al., 2002).

Optimum temperature for production of apothecia of *M. fructicola* is 15-16 °C (Ezekiel, 1923; Harada, 1977; Holtz and Michailides, 1994). The period of ascospore discharge decreased as temperature increased from 10 to 25 °C. However, daily discharge increased as temperature increased from 10 to 15 °C and remained high at 20 and 25 °C. The greatest discharge occurred with apothecia at 15 °C, followed by those incubated at 20, 10, and 25 °C. The germination of ascospores of *M. fructicola* and the length of germ tubes increased as temperature increased from 7 to 15 °C; however, increasing temperatures above 15 °C did not increase either ascospore germination or length of germ tubes (Hong and Michailides, 1998a). High temperature (25 °C) does not affect ascospore germination, but damages ascocarps (Hong and Michailides, 1999).

Based on the previous information, it can be stated that development of *M. fructicola* can occur over a wide range of temperatures, when there is sufficient humidity.

The current distribution of the fungus confirms its ability to develop over a wide range of environmental conditions (see Section 3.1.3.2.). The distribution maps of *M. fructicola* based on the climate classification used by CABI (2007) (see Figure 6) show that the pathogen has a worldwide distribution, over different climatic zones.

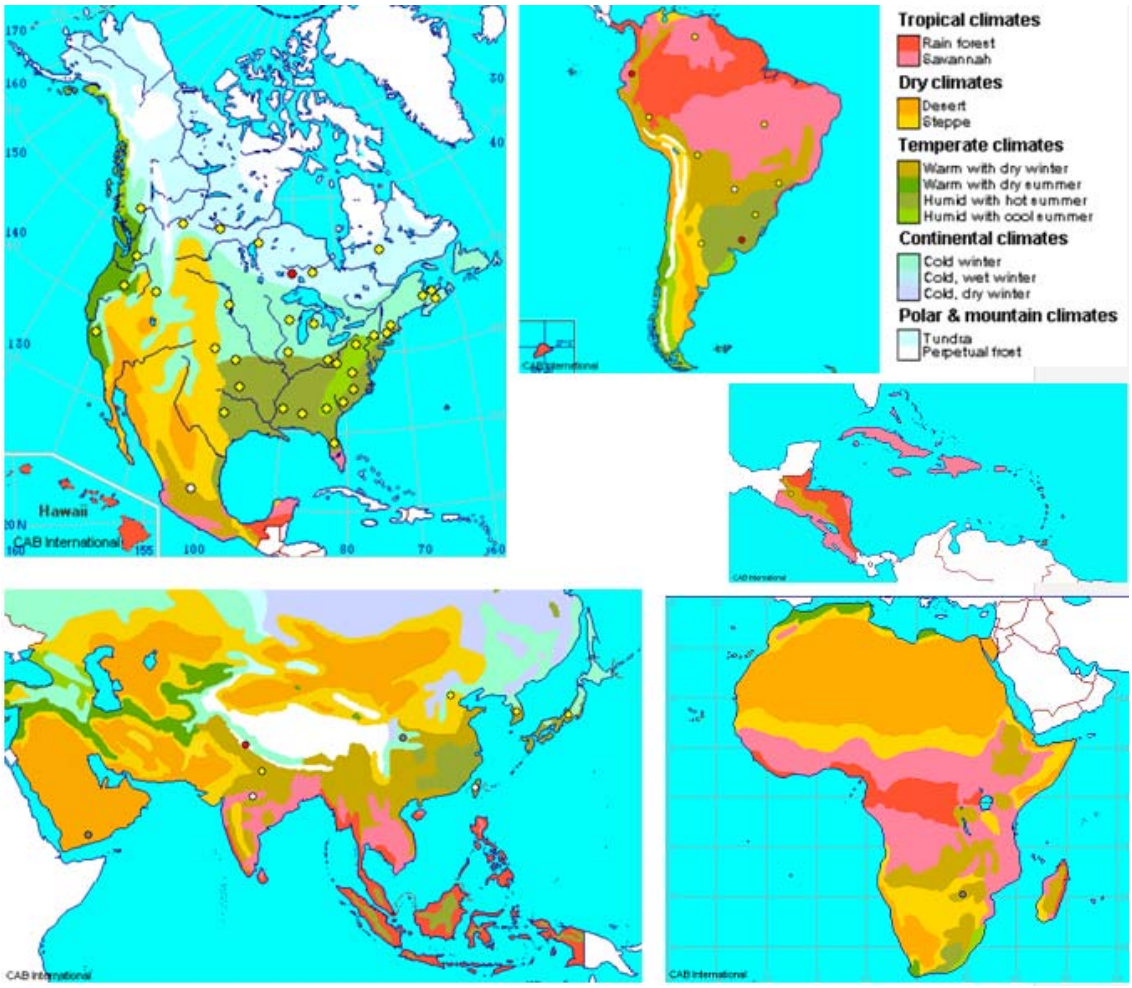


Figure 7: Distribution maps of *Monilinia fructicola* and climatic zones (from CABI, 2007); circles show the presence of the fungus.

In detail, 44% of the cases shown in Figure 7 belong to Temperate climates, mainly to "Humid with hot summer" (28%) and "Warm with dry winter" (16%); 30% of cases are in the Continental climates, with cold winter, and 7% in the Dry climates.

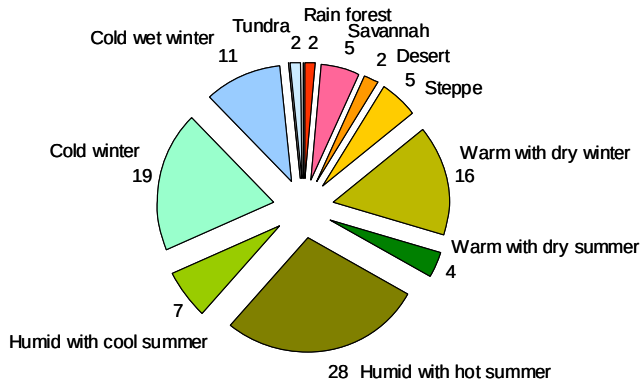


Figure 8: Percent distribution of the worldwide areas with *Monilinia fructicola* in relation to the different climatic zones (see Figure 6).

The climate of southern Europe (see Figure 8) is comparable with that of California (USA), where *M. fructicola* is widespread, while the climate of Central Europe is similar to that of Georgia, North and South Carolina, and Virginia (USA) were the fungus is also present (CABI/EPPO, 2010). Therefore, there is no reason to suppose that climatological conditions would restrict the establishment of *M. fructicola* in Europe.

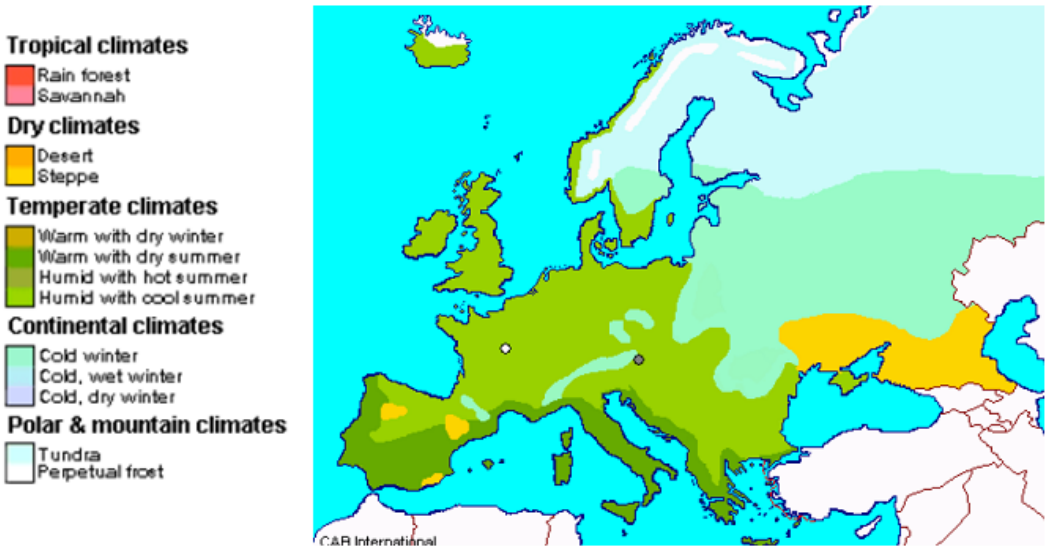


Figure 9: Climatic zones of Europe (CABI, 2007).

A further analysis on the suitability of the environment on the potential establishment of *M. fructicola* in the risk assessment area was carried out with ClimPest[5], a software elaborated by JRC which uses the general equation of Magarey et al., (2005) (Appendix E). This equation estimates the combined effect of air temperature and wetness duration on the infection establishment; the equation can be adapted to a particular pathogen by adjusting the equation parameters and particularly: the minimum duration of wetness at optimum temperature for infection to occur (*Wmin*); the maximum duration of wetness (*Wmax*); minimum, optimum and maximum temperature for infection (*Tmin*, *Topt*, *Tmax*, respectively); the duration of a dry period (i.e., wetness interruption) which results in a 50% reduction of infection compared to continuous wetness (*D50*). In ClimPest, Donatelli et al. (JRC, 2010)

[5] ClimPest (Model Framework for the assessment of EU climatic suitability for the establishment of organisms harmful to plants and plant products) is a project developed as a service level agreement by JRC for EFSA and will be concluded by April 2011. The final report will be published on EFSA website.

introduced a relative humidity threshold during the dry period (*AirRH*) which was not present in the original equation of Magarey.

To parameterise the equation, data on the duration of the lag phase of conidial germination from Casals et al. (2010a) were used. Data on spore germination were preferred to data on infection because the former are more consistent over the literature than the latter, which are strongly influenced by the host, the organ and the growth stage (see Sections 3.1.5. and 3.3.3.). Based on the goodness-of-fit of the Magarey's equation to the Casals's data the following parameter values were selected: *Wmin* = 2 h; *Wmax* = 30 h; *Tmin* = 4 °C; *Topt* = 28 °C; *Tmax* = 38 °C (see Figure 9). This parameterisation gave wrong fit only for the duration of the lag phase at 0 °C, but this inaccuracy should have low impact on the ClimPest output because that temperature level usually occurs in months when no susceptible host tissue is available.

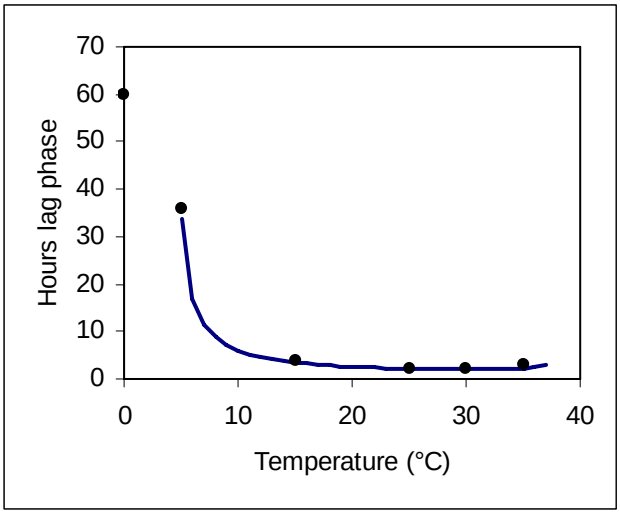


Figure 10: Comparison between the data of Casals et al. (2010a) on germination of *Monilinia fructicola* conidia and the parameterised Magarey's equation.

The parameter *D50* was arbitrarily set at 3 h. Germinated and germinating conidia of *M. fructicola* show a moderate resistance to dryness (Good and Zathureczky, 1967; Grindle and Good, 1961), but there are no sufficient data to precisely estimate the spore survival under natural conditions. In the case that conidia survive dry periods longer than 3 h in the orchard, the selected parameter value may lead to underestimate the potential for spores to germinate. To explore the sensitivity to this parameter, we calculated an additional run with a possible interruption of *D50* = 10 h (for only one year). Based on this analysis, it can be stated that the choice of *D50* has a minor effect (Appendix E).

Definition of the parameter *AirRH* was difficult. Data from Grindle and Good (1961) clearly demonstrates that the survival of *M. fructicola* is greater at low than at high relative humidity. For instance, germinated conidia survived drying at 15% relative humidity for at least 72 hs at all temperatures, while those dried at 45–90% relative humidity survived for shorter periods. Therefore, the *M. fructicola* conidia react to relative humidity at the opposite as supposed in the ClimPest software. To minimize this problem we set *AirRH* = 30% relative humidity but this inconsistency increases uncertainty of the ClimPest output.

In ClimPest, the Magarey's equation parameterised on germination of *M. fructicola* conidia was operated by using the "Real EU Oracle Weather" database of the JRC (2010) on a 25 × 25 km grid, between 2003 and 2007. Hourly weather data were simulated using algorithms from the CLIMA libraries (Donatelli et al., 2005) and the SWEB model for leaf wetness (Appendix E). Shortcomings in the ClimPest output due to this dataset are discussed in Appendix E.

The ClimPest output is a percentage of the hours (in a month or year) in which the conidia can start a successful germination period, i.e. a period in which weather conditions make germination possible. As previously mentioned, this percentage refers to the average weather conditions of the 25 × 25 km grid. The monthly maps generated by ClimPest for the 5-year period are shown in Figure 10. Distribution of susceptible host across Europe is not accounted for in these maps. In maps, a value of 30 in a cell means that the conidia can start a successful germination in 30% of the hours in that particular cell in that particular month.

Figure 10 shows that suitable conditions for germination of *M. fructicola* conidia occur in all the risk assessment area for long periods, with strong month by month variation (coefficient of variation, ds/average × 100, CV = 65%). In South Europe and western France, the weather conditions are conducive between February and May (which is roughly the period of blooming and fruit set), and then in October and November (which is the period of leaf fall). In central and North Europe, the weather is highly favourable between May and September. There are no areas in Europe where the fungus never encounters favourable conditions. Year by year variability has a lower impact, with CV = 5.5%.

Therefore, simulations made by ClimPest support the conclusion that climatological conditions would not restrict the establishment of *M. fructicola* in the risk assessment area.

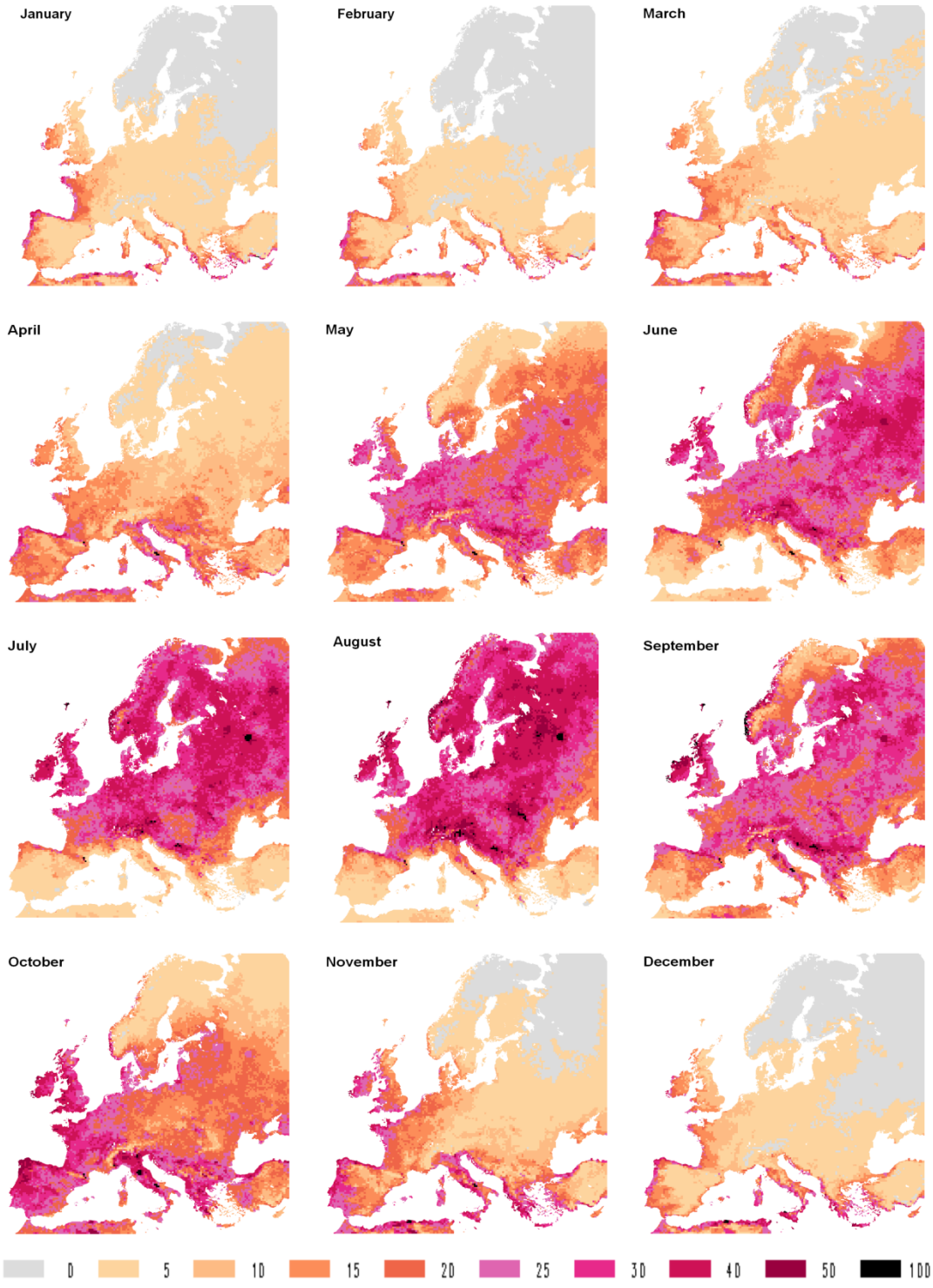


Figure 11: Percentages of hours in a month in which the conidia of *Monilinia fructicola* can start a successful germination period.

3.3.4. Potential endangered area

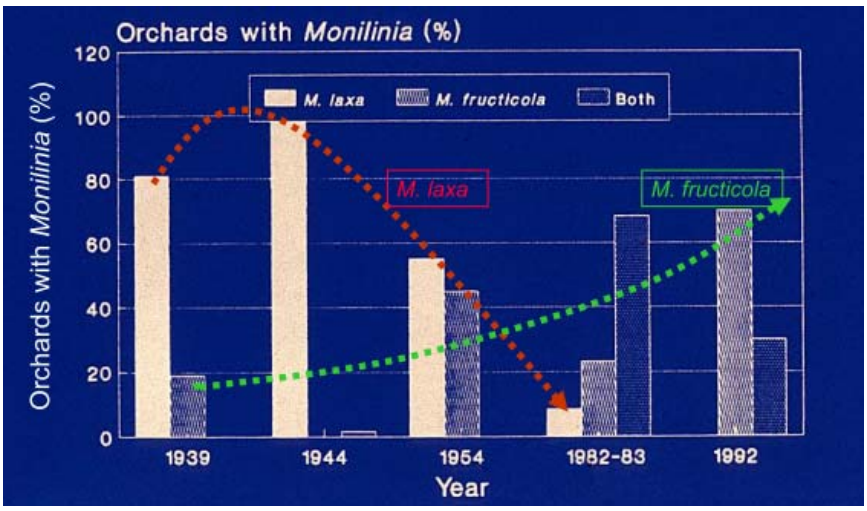
Based on the maps of Figure 10 generated by using ClimPest, the potential endangered area is the whole risk assessment area.

3.3.5. Competition from existing species in the risk assessment area

M. fructicola is mostly found on fruit whereas *M. laxa*, which is widespread in Europe, is mostly prevalent of blossoms and twigs/branches (Baur and Huber, 1941; Boesewinkel and Corbin, 1970; Ogawa et al., 1954 and 1975). In a survey conducted in the major stone fruit-growing areas of California (USA) where the two species have been present from long time, 72% of the isolates of *M. fructicola* derive from diseased fruit, while 83% of the isolates of *M. laxa* derive from blighted flowers and twigs (Ogawa et al., 1954). Similarly, in Australia *M. laxa* causes flower blight in peach and apricot, but rarely causes fruit rot (Penrose, 1998). An important aspect of the probability of successful establishment of *M. fructicola* is the potential of an initially small *M. fructicola* population establishing itself in orchards where *M. laxa* is present. A clear ecological disadvantage for *M. fructicola* compared with *M. laxa* is that abundant sporulation only starts when the temperature reaches 15-25 °C, whereas *M. laxa* sporulates also at 5-10 °C (Byrde and Willetts, 1977). The proportion of conidia of *M. fructicola* in the environment early in the season would thus be very low, minimising the probability of infection even though environmental conditions are favourable for infection. Later in the season, however, when conidia infect fruits, rapid lesion development and profuse sporulation will enhance dispersal and, ultimately, the establishment of the pathogen (van Leeuwen et al., 2001).

At the moment, *M. laxa* is the prevalent species isolated from brown rot stone fruit in European countries, also in Spain where *M. fructicola* has been reported to be present (Villarino, 2010). However, the distribution of each *Monilinia* spp. is expected to change in the future, with *M. fructicola* displacing the other two species due to its parasitic fitness: compared to *M. laxa* and *M. fructigena*, *M. fructicola* grows faster and sporulates more abundantly (De Cal and Melgarejo, 1999). The components of the parasitic fitness were studied for a group of isolates of each of the three *Monilinia* species in Spain, and have been correlated with the rate of infection in peaches (Villarino, 2010). *M. fructicola* has a greater fitness because of a higher percentage of conidia germination and longer germ tubes, which are all characteristics significantly related to virulence (Villarino, 2010; Villarino et al., 2010). These results suggest a future scenario where only *M. fructicola* and *M. laxa* will compete in the peach brown rot pathosystem, with *M. fructigena* showing a reduced virulence compared to other two species (Villarino, 2010; Villarino et al., 2010). Furthermore, *M. fructicola* has a teleomorphic stage (Holtz et al., 1998; Landgraft and Zehr, 1982) which increases the primary inoculum sources, and moreover *M. fructicola* produces more asexual conidia than *M. laxa* or *M. fructigena* (Ogawa et al., 1995) thus affecting the quantity of secondary inoculum in orchards.

A similar situation has been observed in the USA. In a survey of California stone fruit in the first half of the twentieth century, over 79% of a total of 250 isolates of *Monilinia* spp. were identified as *M. laxa*, while *M. fructicola* represented the remaining 21% (Hewitt and Leach, 1939). Similar results for the state of California had already been obtained by Ezekiel (1923). In early 1980s, both *M. fructicola* and *M. laxa* were widespread in plum and apricot growing areas (Michailides et al., 1987). Thus, *M. fructicola* had partly displaced *M. laxa* in those orchards (see Figure 11).



Source: http://cetehama.ucdavis.edu/files/23176.pdf

Figure 12: Changes in distribution of *Monilinia laxa* and *M. fructicola* in the USA

The situation in USA is partly different from that in Europe: in the USA only *M. fructicola* and *M. laxa* are present, while in Europe the three species (*M. laxa*, *M. fructigena* and *M. fructicola*) may all be present in the same growing areas. The above mentioned Spanish studies suggest that *M. fructicola* will partly displace *M. laxa* in Europe, and both species will displace almost totally *M. fructigena* in stone fruit (Villarino, 2010).

Based on the above information, it is very unlikely that establishment of *M, fructicola* in the risk assessment area will be prevented by competition with existing species.

3.3.6. Cultural practices and control measures

Current disease management practices in stone fruit orchards to control *Monilinia* spp. consist of both agronomic measures and repeated fungicide applications. These measures are described in Section 4.1.1. Despite these control measures, the *Monilinia* brown rot regularly threaten stone fruit orchards in the pest risk assessment area, even though with variable incidence and severity.

It is unlikely therefore that cultural practices and control measures currently applied in the risk assessment area for the management of other *Monilinia* species will prevent the establishment of *M. fructicola*.

3.3.7. Other characteristics of the pest affecting establishment

The reproductive strategy of *M. fructicola* is likely to aid establishment in the pest risk assessment area. *M. fructicola*, similarly to *M. laxa* and *M. fructigena*, overwinters in orchards as mycelium on mummified fruit, fruit peduncles, cankers on twigs and branches, leaf scars, and buds that under favourable conditions sporulate and produce infective conidia (Biggs and Northover, 1985; Byrde and Willets, 1977; Jehle, 1913; Kable, 1965b; Mix, 1930; Ogawa et al., 1985). *M. fructicola* can also overwinter in pseudosclerotial mummified fruit that produce apothecia from which ascospores are discharged in the spring (Biggs and Northover, 1985; Byrde and Willetts, 1977; Holtz et al., 1998). Apothecia are found in South Carolina and California (USA) (Holtz et al., 1998; Landgraf and Zehr, 1982), and also in South America (Uruguay) (Mondino et al., 1997), but infrequently in Australia (Jenkins, 1965; Kable, 1969). Apothecia of *M. fructigena* and *M. laxa* are rarely found in the field, and have not been produced in culture (Gell et al., 2009; Villarino et al., 2010). Apothecia of *M. fructicola* have not yet been found in the pest risk assessment area.

The presence of apothecia and ascospores of *M. fructicola* has several effects on establishment potential. First of all, apothecia increase the quantity of primary inoculum in the orchards and affect

the incidence and severity of the brown rot disease (Luo et al., 2001a). As a secondary effect, the presence of sexual recombination, increases the evolutionary potential and awards major diversity (Förster and Adaskaveg, 2000), thus increasing adaptability of *M. fructicola*.

Ability of *M. fructicola* to develop resistance to several fungicides is well documented (see Section 3.4.3.) and may increase the establishment potential in those areas where those fungicides are used.

3.3.8. Previous cases of introduction of *M. fructicola* into new areas

M. fructicola has a worldwide distribution (CABI/EPPO, 2010). The pathogen was first identified in 1883 in North America at Pennsylvania (USA) being named *Ciboria fructicola* G. Winter (Batra, 1991). Later it was reported in other parts of North America such as California in 1936 (Hewitt and Leach, 1939), Canada in 1976, and Mexico in 1999. Nowadays it is present in almost all the states of USA (CABI/EPPO, 2010). The pathogen has also been reported in Central America (Guatemala in 1976, and Panama in 1999), South America (Argentina, Bolivia, Brazil, Peru, and Venezuela, Ecuador, Paraguay, Uruguay), Asia (Japan, Korea Republic, Taiwan, Yemen, China, and India); Africa (Zimbabwe, and Nigeria), and Oceania (Australia, New Caledonia, and New Zealand). During the last century, none of the countries where *M. fructicola* has been established has eradicated the pathogen, except some European countries such as Austria (OEPP/EPPO, 2006) and Slovak Republic (Appendix I).

3.3.9. Conclusion on probability of establishment

Rating	Description
Very likely	• the host plants are widespread in the risk assessment area: more than 1 million of hectares are cropped with stone fruit (peach, nectarine, apricot, cherry, almond and plum) only in the main stone fruit-producing Member States (France, Greece, Italy, Portugal, and Spain); • the host plants are susceptible for a long period: from flowering to harvesting, as well as during leaf fall, when the conidia can penetrate the plant through leaf scars; • the environmental conditions are suitable in most parts of the risk assessment area and for most of the host growing season; • competition from other *Monilinia* species (*M. laxa* and *M. fructigena*) currently present in the risk assessment area can not prevent the establishment of *M. fructicola*, which has greater fitness and adaptability compared to the other two *Monilinia* species; sexual reproduction and occurrence of fungicide-resistant strains also increase its potential for establishment; • cultural practices and control measures currently applied in the pest risk assessment area are not able to prevent the establishment of *M. fructicola*; • no other obstacles to establishment occur. In addition, the pest has already been detected in several Member States in the risk assessment area (France, Germany, Hungary, Italy, Poland, Romania, Slovenia and Spain).

3.3.10. Uncertainties

Rating	Description
Low	Information and data are sufficient, consistent and not conflicting. No subjective judgement was introduced. Maps were drawn by using the ClimPest software to define the suitability of the environment and determine the potential endangered area. In this software, the general equation of Magarey was used to estimate the environmental suitability to *M. fructicola* for conidia germination; after appropriate parameterization, this equation fits adequately the published data on conidia germination. However, some parameters for running the Magarey's equation within ClimPest may introduce some uncertainty. The weather data-base used in ClimPest has been previously evaluated and published, and the correspondent forthcomings are known. Since the results obtained from ClimPest are in full agreement with those obtained by comparing the climatic zones of Europe with those of the third countries where the disease is established, the uncertainty of the conclusion can be considered low.

3.4. Probability of spread after establishment

Once introduced in a certain location, *M. fructicola* can spread by (i) natural means and (ii) human assistance.

3.4.1. Spread by natural means

M. fructicola does not depend on specific vectors for dispersal; both ascospores and conidia are readily dispersed by wind, water, insects, and birds (see Section 3.2.4.1.).

Dispersal of *Monilinia* conidia by natural means was described in Section 3.2.4.1., with emphasis on wind dispersal mechanisms which are more profusely studied than the other means. Since there is a lack of data on between orchard and long distance spread of the conidia of *Monilinia*, a modelling approach was used by applying the Gaussian Plume Model (GPM) (Appendix F). Based on this model, it can be considered that in reasonable circumstances the spread of conidia of *M. fruticola* is possible up to 500 m in wind direction from any inoculum source, i.e. an affected tree with sporulating lesions. Conidia of *Monilinia* should remain viable in the air currents for a long period of time, because they can survive dryness (Xu et al., 2001).

A confirmation of a possible spread of *M. fructicola* can be deduced from the data collected in California (USA). Hewitt and Leach (1939) reported that *M. laxa* was widespread in all stone fruit-growing areas, whereas *M. fructicola* was more localised in the peach-producing areas. A later survey in plum- and apricot-growing areas (in 1982 and 1983) showed that both *M. fructicola* and *M. laxa* were widespread (Michailides et al., 1987).

Therefore spread by natural means of *M. fructicola* in the risk assessment area is very likely.

3.4.2. Spread by human assistance

Humans can contribute to the spread of the pathogen, mainly by trading infected plant material (fresh fruit, propagating material Humans (travellers, tourists, agricultural workers, storage workers) can also unintentionally spread the conidia of the pathogen.

Characteristics of *M. fructicola* movement by trading infected fruit (with both latent and visible infections) and propagating material are discussed in Sections 3.2.2. and 3.2.3. Clear evidence of the spread of the pathogen within the pest risk assessment area is the finding of infected fruit coming from Italy and Spain in Hungary in 2005 (Petróczy and Palkovics, 2005 and 2006). Similarly, the pathogen was intercepted in Switzerland in fruit coming from France, in 2003–2005 (Bosshard et al., 2006).

In addition to the above mentioned main means of spread, visitors travelling from infested territories to non-infested ones may carry fresh fruit for consumption. Infected, rotten fruits are usually thrown away and – such as the pathogen sporulates abundantly over a wide range of conditions (see Section 3.1.5.) – conidia may be further dispersed by wind or may be carried away by adhering to shoes of humans or to machines. Rotten fruits may also be thrown into waste. In this case – unless the waste gets processed immediately – the conidia can still be dispersed.

Agricultural workers can also contribute to spreading of the infection. At harvest, the infected rotten fruits may be thrown down and left on the soil – or may already have fallen down and left there. This can happen in large orchards as well as in small gardens, or beside urban roads. If the fallen fruits are not immediately removed and disposed of or incorporated into the soil in case of large orchards, the conidia can be spread by wind or by the shoes of workers or by machines. In the case of mechanical harvest, the harvesting machines may become contaminated by the spores and may easily carry the infection into other orchards as well. If not cleaned properly, vehicles (trucks, wagons, etc.) used for transportation of fruits can also spread the conidia.

M. fructicola conidia usually appear on ripened fruits, often in storage, or even after sale. Brown rot caused by *M. fructicola* often manifests itself as a storage disease. Quality control in storehouses is very important in order to avoid further spreading of the disease from one fruit to another and – if an infected fruit is sold – to avoid spreading of the disease to other territories. The possibility of spreading in storage very much depends on the storage technology. Fruits stored in bulk can easily infect each other, while fruits stored in smaller boxes or separately may escape infection. Proper cleaning of storage rooms and containers or boxes can prevent further spreading of the disease, while at the same time forced aeration or air-conditioning may contribute to spreading. Human travellers or tourists may also carry plant propagating material of host plants from infested territories to non-infested areas. These can also spread the infection, though less efficiently than fruits.

Based on the previous information, spread of *M. fructicola* by human activities, particularly by trade pathways, within the risk assessment area is very likely. It is likely that such spread will occur rapidly and over longer distances compared to spread by natural means (van Leeuwen et al., 2001).

3.4.3. Containment of the pest within the risk assessment area

Containment of *M. fructicola* within the infected territories of the risk assessment area seems to be impossible, because there are no regulations limiting the trade within the EU. Introduction of special containment measures by National Plant Protection Organisations (NPPOs) to keep *M. fructicola* in the restricted areas after detection, would be desirable, but merely legislative trade limitations would not be effective because of the possibility of spread by natural means.

3.4.4. Conclusion on probability of spread

Rating	Description
Very likely	• has multiple ways to spread, which all occur in the risk assessment area, including natural means (particularly wind), trade of infected fruit and planting material, and other human activities; • no effective barriers to spread exist; • hosts are widely distributed in the risk assessment area and the environmental conditions are suitable in large parts of this area. The pathogen has been repeatedly found in infected fruit entering Hungary, Poland and Switzerland from other European countries; this clearly supports a high likelihood of spread.

3.4.5. Uncertainties

Uncertainty for spread	Description
Low	All the available information is consistent in demonstrating that the probability of spread within the risk assessment area is very likely. Interceptions of the pathogen in infected fruit trade within the risk assessment area support the conclusion.

3.5. Assessment of potential consequences

3.5.1. Pest effects within its current area of distribution

The impact of brown rot on stone fruit involves direct and indirect effects. Direct effects of brown rot include: blossom and twigs blight, fruit rot, and cankers on branches (De Cal and Melgarejo, 2000; Ogawa et al., 1995). Concerning fruit rot, *M. fructicola*, similarly to *M. laxa* and *M. fructigena*, can cause severe losses both before and after harvest. Twig cankers may girdle the branch leading to death or to weakness of the tree (Byrde and Willets, 1977).

Serious brown rot losses occur in years with favourable weather conditions for the development of the disease, especially in orchards of late-harvesting varieties (Ahmadi et al., 1999; Hong et al., 1997; Larena et al., 2005). Postharvest losses are more severe than pre-harvest losses, and routinely occur during storage and transport, in some cases even at the processing stage (Hong et al., 1997 and 1998). When conditions are favourable for disease development, postharvest losses may reach in some cases values of 80–90%, both in USA(Hong et al., 1997 and 1998) and in Europe, (Larena et al., 2005), nevertheless the European data includes also other *Monilinia* species.

It is difficult to find in the literature exact yield loss data specifically for *M. fructicola*. Losses in stone fruit vary between stone fruit species and years, and depend greatly on weather conditions around harvest time. In plum, *M. fructicola* is a principal causal agent of brown rot blossom blight and fruit rot in pre- and post-harvest (Ogawa et al., 1995). Northover and Cerkauskas (1994) estimated that total preharvest plum loss was 15-30%, despite a rigid spray programme. In nectarine orchards, Hong et al. (1997) recorded 8-10% fruit loss at harvest time as a result of *M. fructicola* attacks in 1995, whereas this was only 0.5% in 1996. Similar variation in yield loss is reported by other workers (Kable, 1969; Morschel, 1956). Willison (1937) and Biggs and Northover (1985) reported the occurrence of perennial cankers in peach in Canada, whereas Kable (1965b) did not find similar cankers in Australia. It is likely that the extent of damage to twigs and branches depends on environmental conditions.

3.5.2. Potential pest effects in the risk assessment area

To estimate the potential effect of *M. fructicola* in the pest risk assessment area, it is instructive to compare present yield losses in European orchards caused by *M. laxa* and *M. fructigena* with those reported in Section 3.5.1. for *M. fructicola*. In Europe, *M. laxa* is an important pathogen in peach, but damage is only serious in the flower and twig blight phase of the disease (Melgarejo et al., 1986; Sagasta, 1977). Although *M. fructicola* can cause wilting of flowers, Kable and Parker (1963) found that subsequent invasion of twigs in sour cherry was limited compared with *M. laxa*. Damage to twigs and branches by *M. laxa* in Europe is strongly related to favourable weather conditions (Madrigal et al., 1994; Sagasta, 1977). In Switzerland, Rüegg and Siegfried (1993) assessed fruit losses caused by *Monilinia* in three sweet cherry orchards treated with regular fungicide sprays, and found a low yield loss in two orchards (3-5%), and a moderate loss at the third site (15%). Xu et al. (2007) reported losses up to 33% rotted fruit mainly caused by *M. laxa* in sweet cherry in the UK. According to Byrde and Willetts (1977), *M. fructigena* can be expected to be less damaging than *M. fructicola* in stone fruits.

It is not very likely that *M. fructicola* will increase damage in the flower and twig blight phase of the disease in Europe compared to the present situation. However an increase in pre- and post-harvest fruit losses is possible once *M. fructicola* further spreads within the pest risk assessment area. Concerning the estimated yield reduction caused by the pathogen, information from Spain (Appendix I) suggests an impact, at least initially, moderate. It remains very difficult to estimate the extent of fruit rot specifically caused by *M. fructicola*, considering that mixed infections with other *Monilinia* species may occur on the same fruit in the European areas where the pathogen is present. Results from Villarino (2010) produce evidence that in the future *M. fructicola* has the potential for competing with *M. laxa* and *M. fructigena* in Europe (see Section 3.3.4.).

3.5.3. Control of *M. fructicola* in the risk assessment area without phytosanitary measures

In Europe, two to three fungicide sprays around flowering, followed by one to two sprays between the beginning of ripening and pre-harvest are applied (Rüegg et al., 1997; Zehr et al., 1999). Fungicide postharvest treatments is not a common practice in the risk assessment area (Mari et al., 2007; Villarino, 2010) and biocontrol agents and natural substances show some effect but are not commercially available. It is unlikely that any significant additional management measures would be required if *M. fructicola* became established in Europe.

Regular use of fungicides in spray programmes has led to the development of fungicide resistance in *Monilinia* species in the past. Benzimidazole-, dicarboximide- and triazole-resistant strains have been reported for *M. fructicola* in the USA, Australia and Korea (Gilpatrick, 1981; Jones and Ehret, 1976; Lim et al., 1998; Osorio et al., 1994; Penrose et al., 1979 and 1985). Zehr et al. (1999) have shown that *M. fructicola* can develop resistance also to the new demethylation inhibiting (DMI) fungicides. In Spain all isolates of *M. fructicola* tested against benzimidazole fungicides showed resistance compared to only a few isolates of *M. laxa* (Egüen et al., 2010). In the case of dicarboximide fungicides a few isolates of both species were resistant (Egüen et al., 2010; Gell, 2008). Fungicide resistance has been found also in *M. laxa* in the USA (Ogawa et al., 1984; Osorio et al., 1994), as well as in Europe (Egüen et al., 2010; Gell, 2008). Guizzardi et al. (1995) studied the sensitivity of isolates of *M. laxa* from Italian stone fruit orchards to benomyl and dicarboximides, and found that the pathogen could grow on agar containing even a hundred times the normal fungicide dose.

The presence of benzimidazole- and dicarboximide-resistant *M. fructicola* strains was documented in Spain (Egüen et al., 2010 and 2011; Villarino, 2010; Villarino et al., 2010) but not in Italy (Appendix I). Anti-resistance strategies are already used in the risk assessment area to minimise risks for the development of fungicide resistance in the other *Monilinia* species. Development of *M. fructicola* fungicide resistant strains might aggravate problems in disease control but it is difficult to foresee to what extent this might occur.

To avoid fruit losses, more attention will be paid to post-harvest fruit management, mainly to early detection, proper packaging, sanitation of packaging materials and means of transport and systematic management of waste. Post-harvest treatments like disinfection, heat treatments or fungicide treatments are not commonly applied in the risk assessment area.

3.5.4. Environmental consequences

No environmental consequences have been reported within the current area of distribution of *M. fructicola*. No negative environmental consequences are foreseen in the risk assessment area.

3.5.5. Conclusion on impact in the endangered areas

Conclusion	Description
Moderate	• incidence and severity of the brown rot diseases on flowers and twigs/branches are unlikely to increase compared to the current situation;

	• an increase in pre- and post-harvest fruit losses is possible once *M. fructicola* further spread within the risk assessment area, but it is difficult to estimate the extent of losses specifically caused by *M. fructicola*; • neither additional cultural measures nor increased fungicide treatments should be necessary for controlling the brown rot disease in the orchard following the introduction of *M. fructicola*; the post-harvest impact can be mitigated by inspections and immediate removal of diseased fruit after detection, and also by suitable packaging; • development of *M. fructicola* fungicide resistant strains might aggravate problems in disease control but it is difficult to foresee to what extent this might occur; • no negative environmental consequences are foreseen.

3.5.6. Uncertainties

Uncertainty	Description
Medium	Information and data on the pest effect in its current area of distribution are incomplete. Occurrence of fungal strains resistant to the available fungicides, which is the main threat related to the impact of *M. fructicola* in the risk assessment area, is based on an extrapolation of what occurred in the USA, but only few data are available for the risk assessment area, where the apothecia of the fungus (which is the main source of genetic variability) has not yet been observed.

3.6. Conclusion on risk assessment

Having given due consideration to the evidence, the Panel concludes that:

a. Entry of *M. fructicola* by means of plant propagation material, fresh fruits of susceptible genera and by natural means from infested European non-EU countries is very likely. It is very unlikely in case of dried fruit and natural means from infested non-European countries. In both cases the level of uncertainty is low.

b. Establishment of *M. fructicola* in the risk assessment area is very likely with a low level of uncertainty because of the avaialability of host plants with a long period of susceptibility and of suitable environmental conditions. Competition from other *Monilinia* species (*M. laxa* and *M. fructigena*) and currently applied cultural practices and control measures cannot prevent the establishment of the pest. In addition, the pest has already been detected in several Member States in the risk assessment area (France, Germany, Hungary, Italy, Poland, Romania, Slovenia and Spain).

c. Spread of *M. fructicola* within the risk assessment area is very likely with a low level of uncertainty because of its multiple ways to spread (natural and human assisted), to the wide distribution of host species in the risk assessment area and the absence of effective barriers.

d. Potential for yield reduction and negative effects on fruit production in orchards is estimated as moderate, with medium level of uncertainty mainly because of the incompleteness of data from the current area of distribution of the pest. Incidence and severity of the disease caused by the brown rot fungi, on flowers and twigs/branches are unlikely to increase compared to the situation in which only *M. fructigena* and *M. laxa* are present.

4. Management options

4.1. Identification of management options

4.1.1. Identification of management options for the fruit pathway

4.1.1.1. Options to reduce infestation in the growing crop

Control of the disease at production site is possible by the following options: (a) application of orchard cultural practices, (b) chemical control, (c) biological control, (d) use of resistance cultivars and (e) by surveillance for *M. fructicola* in the crop.

A. Cultural practices

Orchard sanitation will reduce inoculum levels and improve the effectiveness of fungicide sprays. Sanitation includes the removal and destruction of fruit mummies still attached to the tree and any cankered or dead twig as soon as they are found. Removing symptomatic fruit from the tree will also reduce initial inoculum. Collecting fallen fruit from the ground is less practical, but may be an option in small blocks or for organic growers. Although sanitation alone is not sufficient to control brown rot in most commercial orchards, it is a good Integrated Pest Management (IPM) control strategy. Fungicidal control may not be as good as desired when disease pressure is very high.

Some cherry varieties such as Lapins tend to produce large clusters of fruit. Brown rot may develop in these clusters more easily due to difficulty in obtaining good fungicide coverage and to slower drying of fruit in the middle of the clusters. When pruning, the removal of excessive branches facilitates air flow and reduces fruit cluster formation (Province of British Columbia, 2010).

Bagging of fruits four weeks before harvest could prevent infestation of pear fruits by brown rot (MAF Biosecurity New Zealand, 2009).

Proper coordination of fruit thinning and irrigation can significantly reduce the inoculum potential. An empirical recommendation is to time the orchard irrigation in such a way that the thinned fruit on the ground remains for at least two weeks without becoming wet.

High humidity as a result of rain events, irrigation, or presence of weeds can increase the chance of sporulation on *Monilinia*-infected thinned fruit. Weed control can reduce the moisture in orchards and also the chance for fruit infection. Disking the soil can be an effective method for the significant decrease in the density of apothecia and sporulated mummies. Orchard sanitation practices can contribute to the reduction of the disease level but they may be more costly and labor intensive than the commonly applied fungicide sprays (Michailides et al., 2007).

Treatment with micro-elements may also belong to cultural practices. The effect of Calcium foliar sprays was studied by Elmer et al. (2007) in New Zealand. Calcium content of the peach epidermis was significantly increased by at least 50% following Calcium sprays, compared to unsprayed fruit. Increasing the Calcium content of fruit significantly reduced the incidence and severity of *M. fructicola* infections in fruit disk assays. Pre-harvest Calcium applications also significantly reduced the number of brown rot infected fruit per tree at harvest and the incidence of postharvest rots. The integration of Calcium foliar sprays into current brown rot management practices has been widely adopted by stone fruit growers in New Zealand as a practical tool to reduce brown rot losses.

B. Chemical control

Chemical control of brown rot disease by the application of fungicides is widely used either in the pest risk assessment area, or in third countries.

The present practice of chemical control followed by the EU Member States is shown in Appendix J.

In the USA, according to one of the suggested spraying programmes, fungicides are applied at the following growth stages: blossom, immature fruit, ripening fruit, and mature fruit (in this programme, only fungicides that have a minimum pre-harvest interval of three or less days are recommended). The list of fungicides contains pyraclostrobin + boscalid, iprodione, fenbuconazole, propiconazole, fenhexamid, boscalid, captan, myclobutanil, chlorothalonil, thiophanate-methyl, *Bacillus subtilis* (suppression only) and/or triforine (Province of British Columbia, 2010).

Fungicides, which may also be applied to prevent diseases caused by other *Monilinia* species or by other fungi on several host species, can suppress sporulation of *M. fructicola* on infected tissues (Kable, 1976; Wilcox, 1990). Among them there are systemic fungicides effective against *M. laxa* and *M. fructicola*, such as dicarboximides, benzimidazoles, triazoles and protectants including captan, mancozeb, methiram, propineb, thiram, folpet, chlorotalonil, and ziram (Melgarejo and De Cal, 2010).

However chemical control of *M. fructicola* using fungicides is not without problems.

Isolates resistant to benzimidazoles, dicarboximides and triazoles from stone fruit orchards in several parts of the world, other than Europe, have been reported (Penrose et al., 1979 and 1985). Yoshimura et al. (2004) observed, in a survey on stone fruit orchards conducted in California, different levels of resistance to benzimidazole fungicides, including high levels. Highly resistant isolates had been reported in Michigan (Jones and Ehret, 1976), South Carolina (Zehr et al., 1999), New York (Szkolnik and Gilpatrick, 1977), and Australia (Whan, 1976). Ma et al. (2003b) found low and high levels of resistance to the benzimidazole fungicides benomyl and thiophanate-methyl in field isolates of *M. fructicola.*

Egüen et al. (2010 and 2011) found that some field isolates were resistant to methyl-tyophanate and iprodione. Weger et al. (2011) demostrated, for the first time in European isolates (from France, Switzerland, Italy and Spain) the presence of the E198A mutation conferring resistance to benzimidazole fungicides. As the mutation appears to be widely distributed, they anticipated that benzimidazole fungicides may be ineffective at controlling brown rot in countries with occurrence of *M. fructicola*.

Thiophanate-methyl, iprodione and tebuconazole applied against blossom blight caused by *M. fructicola* were found effective in trials carried out by Yoshimura et al. (2004). None of the tested isolates of *M. fructicola* were resistant to either iprodione or tebuconazole.

Management of demethylation inhibitor (DMI) fungicide (propiconazol) resistance in *M. fructicola* is a priority in peach orchards of the south eastern United States, but DMI fungicides are still an important component of anti-resistance strategies in view of the few effective alternatives. According to Holb and Schnabel (2007), the addition of elemental sulphur to a DMI fungicide is likely to be a relatively inexpensive means to improve brown rot control in peach production areas where reduced sensitivity to DMI fungicides is suspected. According to field testing of DMI fungicides, captan, QoI fungicides, and fenhexamid in experimental orchards in Georgia (Schnabel et al., 2004) indicated that the DMI fungicides were still among the most efficacious products for brown rot control, and that new products containing quinone outside inhibitor (QoI) fungicides may be viable disease control alternatives.

QoI fungicides azoxystrobin and pyraclostrobin and succinate dehydrogenase inhibitor (SdhI) fungicides boscalid, and a mixture of pyraclostrobin + boscalid are respiration inhibitors (RIs) used for preharvest control of brown rot of stone fruit. Both chemical classes are site-specific and prone to resistance development. In vivo and *in vitro* studies carried out between 2006 and 2008 indicate a shift toward reduced sensitivity in *M. fructicola* from the southeastern United States. No cross-resistance was observed between the QoI and the SdhI fungicides, which implies that alternation or tank mixtures of these two chemical classes can be used as a resistance management strategy (Amiri et al., 2010).

Varga (2008) studied the inhibiting effect of 30 widely used fungicides on a *M. fructicola* strain isolated in Hungary, in 1, 5, 10, 50 and 100 ppm concentrations of active ingredients. In these *in vitro* tests, active ingredients boscalid, boscalid + pyraclostrobin, chlorothalonil, ziprodinil, dichloran, difenokonazol, dithianone, fludioxonile, iprodione, mancozeb, captan, pyrimethanil, procimidone, tebuconazol, tiophanate methyl and vinclozolin inhibited the growth of the fungus, even in the lowest, 1 ppm concentration. Fenhexamide, folpet and propineb inhibited the fungus growth only from 10 ppm. Different forms of copper sulphate and copper hydroxide compounds inhibited the fungus from 50 or 100 ppm, zineb and cresoxymethyl from 100 ppm concentration, while copper-oleat, copperoxychloride and azoxystrobin did not have any inhibiting effect in these tests.

The results of studies on detached fruits, carried out by Holb and Schnabel (2008) show up to 12 h post-inoculation activity of lime – sulphur (LS) on *M. fructicola* in controlled environment studies and indicate that LS has potential for post-infection brown rot control in organic stone fruit production.

The effects of sulphur and copper sprayed in the orchard, on postharvest brown rot caused by *M. fructicola* were studied for six years in an apricot block at Clyde Research Centre, New Zealand. Four treatments of sulphur and/or copper were applied up to nine times between flowering and harvest. Brown rot levels were high in seasons with a high rainfall from November to January (harvest).

Sulphur with copper reduced brown rot levels in some peach cultivars. Some other, organically acceptable alternatives to sulphur (sodium bicarbonate, sodium bicarbonate plus Ultrafine oil, calcium hydroxide, LS) were also tested but none was more effective. However alternatives to sulphur were needed for use close to harvest to reduce both visible residues and the possible negative effect of sulphur on return bloom (McLaren and Fraser, 2000).

C. Biological control

In biocontrol trials of De Cal et al. (2009), application of an *Epicoccum nigrum* conidial formulation decreased the number of conidia of *Monilinia* spp. on fruit surfaces during the growing season to the same extent as fungicides. There is no available information about the biological control possibilities against blossom blight caused by *M. fructicola* in particular (Holb, 2008b).

D. Resistant cultivars

There are no data available on selection for host resistance against *M. fructicola* for the majority of hosts. No peach cultivar has been known to be highly resistant but according to studies of Feliciano et al. (1987) cv. Bolinha showed moderate resistance against the pathogen. According to the study of Biggs and Northover (1989) sweet cherry cultivars varied in relative susceptibility to brown rot from year to year, and their relative susceptibility to the fungus was correlated with cell wall thickness. If thicker epidermal cell walls were associated with delayed infection, then the selection of cultivars for thicker walls could result in increased host resistance to *Monilinia* spp.

E. Surveillance for M. fructicola *in the crop*

The IPPC Standard ISPM No 6 (FAO, 1997) describes the components of survey and monitoring systems for the purpose of pest detection and the supply of information for use in pest risk analyses, the establishment of pest free areas and, where appropriate, the preparation of pest lists. The implication is that NPPOs should be in a position to validate declarations of the absence or limited distribution of quarantine pests. There are two major types of surveillance systems: general surveillance and specific surveys. General surveillance is a process whereby information on particular pests which are of concern for an area is gathered from many sources, wherever it is available, and provided for use by the NPPO. Specific surveys are procedures by which NPPOs obtain information on pests of concern on specific sites in an area over a defined period of time. The verified information acquired may be used to determine the presence or distribution of pests in an area, or on a host or commodity, or their absence from an area (in the establishment and maintenance of pest free areas).

Surveillance for *M. fructicola* requires a specific survey. Specific surveys may be detection, delimiting or monitoring surveys. These are official surveys and should follow a plan which is approved by the NPPO. The survey plan should include: definition of the purpose (e.g. early detection, assurances for pest free areas, information for a commodity pest list) and the specification of the phytosanitary requirements to be met; identification of the target pest; identification of scope (e.g ; geographical area, production system, season); identification of timing (dates, frequency, duration); indication of the statistical basis, (e.g. level of confidence, number of samples, selection and number of sites, frequency of sampling, assumptions); description of survey methodology and quality management including an explanation of sampling procedures, diagnostic procedures and reporting procedures (FAO, 1997).

4.1.1.2. Postharvest options

Infection may occur before or after harvest, either through injuries or by direct penetration of the intact skin of fruit. Pre-harvest infections often lie dormant until after harvest where they may develop only as the fruit ripens.

Postharvest infections may be caused by: field boxes contaminated by soil or decaying produce or both; contaminated water used to wash produce before packing; decaying rejected produce left lying around packing houses; contaminating healthy produce in packages (FAO, 1989).

Post harvest options for reducing *M. fructicola* infestation include: (a) detection of *M. fructicola* – inspection of fruits, (b) treatments during storage (disinfection, fungicide treatment, heat treatment, biological control, (c) options for packaging and means of transport (disinfection) and (d) management of waste.

A. Detection of M. fructicola – *inspection of fruits*

Most important mean of control in packinghouses and storehouses is careful selection and removal of infected, decayed fruits in order to avoid further spreading of the inoculum. Before taking the fruits to storage, the infected, rotten fruits should be removed, because they can infect the healthy fruits during storage (Holb, 2006; Ogawa et al., 1995).

During the inspection procedure the guidelines of IPPC Standard ISPM No 23 (FAO, 2005) should be followed. Symptoms of the pathogen can be easily confused with those caused by other *Monilinia* species and the infection can also remain latent, manifesting later. Visual inspection should be followed by sampling and laboratory identification. Sampling should be carried out according to the guidelines of IPPC Standard ISPM No 31 Methodologies for sampling of consignments (FAO, 2008) take into consideration the size and type of consignment and purpose of sampling. For the laboratory identification method see Section 3.1.6.

B. Treatments during storage (disinfection, fungicide treatments, heat treatments, biological control)

Disinfection

There are several possibilities for treatment of fruits against postharvest brown rot disease. Treatments in packinghouses by chlorine water can be used effectively on fruit surface but they do not prevent the buildup of the pathogen (Kupferman, 1984). Peracetic acid (PAA) treatment of stone fruit (sweet cherry, apricot, peach and nectarine) reduced the incidence of brown rot caused by *M. laxa* and soft rot caused by *Rhizopus stolonifer*. The efficacy of the treatment depended on the length of time. Sodium bicarbonate, sodium propionate and potassium sorbate, substances generally regarded as safe, were also evaluated. On untreated fruit the incidence of brown rot ranged between 10.2 and 56% depending on the species and variety; a preventive treatment by dipping fruit for 1min in a PAA solution (125 mg l^{-1}) reduced rot incidence with an efficacy of 65–100%. Only on cv. Nero I sweet cherries, was brown rot significantly reduced by dipping for 2 min (Mari et al., 2007).

Fungicide treatments

Post-harvest application of fungicides is common on crops which are to be stored for a long period or those which undergo long periods of transport to distant markets. Fungicides are normally applied after the produce has been washed and drained. The use of fungicides after harvest is normally subject to more stringent regulation than would be applied to their use on growing crops. The range of chemicals available for post-harvest treatment of fresh produce is small, with strict limitations on both the concentrations used and the permitted levels of residues on treated produce at the retail or processing stage.

Post-harvest fungicide treatments are not used in Europe. However fungicides are used in Third countries (e.g. United States, Australia, etc.), where they use "low-risk" fungicides. Materials that were either derivatives of naturally occurring compounds (such as fludioxonil and pyraclostrobin or were discovered by random chemical synthesis and screening for biological activity (such as boscalid, fenhexamid and pyrimethanil were successfully used against brown rot and other fungal rots applied as postharvest treatments (Adaskaveg et al., 2005).

In experimental packing-line trials that closely simulated fungicide treatments under commercial conditions, efficacies of treatments by low-risk fungicides fenhexamid and fludioxonil on peach cv. Elegant Lady and nectarine cv. Red Diamond, were compared with those of iprodione. For the control of brown rot (*M. fructicola*), tebuconazole was the most effective treatment, with 1% decay incidence on peach (tebuconazole was not included in the nectarine trials) compared with 96.9% incidence in the control. For fenhexamid and fludioxonil, the incidence of brown rot ranged from 11.5 to 19.6%, compared with iprodione, where no decay developed on peach, and 24.4% incidence was found on the nectarine. The high efficacy of fenhexamid and fludioxonil against brown rot was substantiated by low effective concentrations necessary (≤0.063 mg l^{-1}) for 50% inhibition of mycelial growth *in vitro*. In general, fungicides applied 14 to 16 h after wound inoculation was significantly more effective than those applied before inoculation. These results indicate that the fungicides act mainly as protectants, because they do not penetrate deeply enough into the fruit to prevent decay from wounds that extend below the fruit epidermis (Forster et al., 2007).

Heat treatments

According to Casals et al. (2010b), postharvest curing of peach and nectarine fruit may be a suitable alternative to synthetic fungicides for postharvest brown rot control. Complete control of disease development was achieved in a trial, when four varieties of peach and nectarine fruit artificially inoculated with either *M. laxa* or *M. fructicola* were cured at 50 °C for 2 h and 95-99% RH. Curing at 50 °C for 2 h and 95-99% RH had a <0.05 lower firmness loss in comparison with uncured fruit. No adverse effects were observed on fruit acidity and colour index. Casals et al. (2010c) determined that the efficacy of curing decreases with the advancement of maturity of fruits and with length of infection time. When fruit with natural inoculum were surface sterilized prior to the curing treatment, complete brown rot control resulted.

In postharvest trials of Karabulut et al. (2010), immersion in water at 55 °C for 60 s or at 60 °C for 30 or 60 s significantly reduced both decay incidence and severity among the remaining wounds that developed the disease. Water temperatures of 65 °C or higher were phytotoxic and caused moderate to severe surface injuries. Immersion in water at 60 °C for 60 s was effective for plums and it reduced the incidence of brown rot from more than 80% to less than 2%. In nectarines, this treatment reduced decay incidence from 100 to less than 5% on fruit stored at 20 °C and from 73 to 28% on cold-stored fruit.

Biological control

In the trials of Smilanick et al. (1993) two antibiotic-producing bacteria, *Pseudomonas corrugata* and *P. cepacia*, significantly reduced postharvest decay on nectarines and peaches, when applied up to 12

h after inoculation. *P. corrugata* controlled decay with fewer colony-forming units (c.f.u.) than *P. cepacia*; < 10^4 c.f.u. per wound of *P. corrugata* controlled decay, whereas *P. cepacia* required ≥ 10^5 c.f.u. per wound. Both antagonists grew rapidly in wounds but not on the intact surface of fruit. Washed cells controlled decay but filter-sterilized culture fluids did not. Both bacteria controlled the decay of wound-inoculated peaches better than thiabendazole, and *P. corrugata* was only slightly inferior to triforine. In tests employing very high inoculum densities of *M. fructicola*, both species significantly reduced decay but were inferior to isolate B3 of *Bacillus subtilis*. *B. subtilis* B3 isolate is mentioned also by Holb (2006) as a used biocontrol agent against *M. fructicola*.

There are intensive studies concerning postharvest control with yeasts. According to Xu et al. (2008a), yeast treatments may be related to alleviating proteins carbonylation and mitigating pathogen-induced oxidative damage, which result in decrease of fruit decay and imply that antioxidant defense response may be involved in the mechanisms of microbial biocontrol agents against *M. fructicola* fungal pathogen. In other studies of Xu et al. (2008b) a promising alternative to the use of synthetic fungicides, the antagonistic yeast *Pichia membranaefaciens*, showed a potential effect on controlling post-harvest brown rot. To improve biocontrol efficacy of the yeast against fungal pathogens, the biocontrol efficacy of *P. membranaefaciens* combined with salicylic acid (SA) was found promising against brown rot in peach fruit caused by *M. fructicola*. Another study (Qin et al., 2006) suggests that integration with food additives like ammonium molibdate and sodium bicarbonate with yeast biocontrol agents has great potential for commercial management of postharvest diseases of fruit. The same way, an exogenous application of silicon (Si) in the form of sodium metasilicate reduced disease development caused by *Penicillium expansum* and *M. fructicola* in sweet cherry fruit at 20 °C. In the inhibition of fruit decay was correlated closely with Si concentrations. Silicon at concentrations of 1%, in combination with the biocontrol agent *Cryptococcus laurentii* yeast at 1 × 10^7cells ml^{-1}, provided synergistic effects against both diseases (Quin and Tian, 2005).

Studies carried out by Yang et al. (2010) showed that a combination of oligochitosan and silicon had a synergistic effect on the control of disease caused by *M. fructicola* in apple fruit at 25 °C.

Fumigation with volatile-producing biocontrol fungus *Muscodor albus* provided promising results against brown rot diseases in the trials of Mercier and Jimenez (2004) and Schnabel and Mercier (2006).

C. Options for packaging and means of transport

During harvest, packing and transport, fruits easily can be damaged. Most important in packinghouses and storehouses is to avoid mechanical injuries to the fruits during handling because this provides increasing possibilities for infections by pathogens. In a study carried out by Amorim et al. (2008) at a wholesale market in São Paulo (Brazil), mechanical injuries were the most frequent injuries, ranging from 8.7% (plum) to 44.5% (nectarine) of injured fruit. There was a significant positive correlation between the incidence of postharvest mechanical injuries and postharvest diseases. Incidence of postharvest diseases varied from 2.5% to 6.6%. *Cladosporium* rot (*Cladosporium* sp.) and brown rot (*M. fructicola*) were the most frequent diseases.

On infected fruits, especially if overripened, decay and sporulation may appear. Shipping cartons, boxes, containers and other means of packaging and transport should be either disposable, or should be disinfected. Water used for washing of fruits should also be disinfested in order to avoid spreading of spores and to maintain water quality. This is most commonly done by sodium hypochlorite.

Chlorine dioxid and non-chlorine materials like ozone, hydrogen peroxide, irradiation, bromine and iodine all have been tested in fresh produce operations, but these sanitizing agents have not become widely used (Rushing and Taylor, 2005).

D. Management of waste

Management of waste is very important in all phases of fruit growing and marketing. Remaining fresh fruits (unsold, uneaten, etc.) or disposed rotten fruits infected by *M. fructicola* are sources of infectious inoculum, serving as a pathway (see Section 3.2.3.).

EPPO Standard PM 3/66(2) provides guidelines for the management of plant health risks of biowaste of plant origin (OEPP/EPPO, 2008).

Fruit processing also produces waste – fruit peel/skin can also serve as source of inoculum. If there are no plans to utilise the waste, it should be buried, far from fruit growing area, fruit storages, packinghouses or processing sites.

There are many ways of handling solid fruit waste: composting, utilisation for industrial fermentation (vinegar, alcohol), for animal feed, biogas digestion, etc. Sanitation of unused waste can be solved by incineration as well.

4.1.1.3. Options for consignments

According to ISPM No 5 (FAO, 2009), a consignment is a quantity of plants, plant products and/or other articles being moved from one country to another and covered, when required, by a single phytosanitary certificate.

Options for risk reduction for consignments may include: (a) control of the movement of fruit from infested areas, (b) detection – inspection and testing, (c) phytosanitary measures after importation (limiting end use of consignments, quarantine treatments).

A. Control of the movement of fruit from infested areas

Control of the movement of fruit (host plants) is regulated by the legislation represented by the Council Directive 2000/29/EC[6].
The legislation - specific and non-specific for *M. fructicola* – (see Section 3.1.7.) can have an effect only on movement of fruit from non-EU countries.
In case of movement of fruits within the EU there is no legal basis to reject a consignment because of free trade within the Member States. Member States with infested orchards detected by regular surveys, should themselves limit the trade by quarantine containment or other limitations in the spirit of the Council Directive 2000/29/EC.

B. Detection – inspection and testing

Inspection can be used as a risk management procedure (FAO, 2005). Detection of the pest in the consignment requires pre- and post-entry inspection, sampling and laboratory identification. Inspection may miss the diseased fruits because of the lack of visual symptoms or possibility for confusing the symptoms with other pathogens. Sampling also may miss the diseased fruits – especially in cases of latent or mild infection. During inspection the guidelines of IPPC Standard ISPM No 23 should be followed (FAO, 2005).
Sampling should be carried out according to the guidelines of IPPC Standard ISPM No 31 Methodologies for sampling of consignments (FAO, 2008), taking into consideration the size and type of consignment and purpose of sampling. For the laboratory identification method see Section 3.1.6.

[6] Council Directive 2000/29/EC of 8 May 2000 on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community. OJ L 169, 10.7.2000, p. 1-148.

C. Phytosanitary measures after importation (limiting end-use of consignments, quarantine treatments)

When identification of the pest has been confirmed official actions should be taken to contain and to eradicate it. According to the EPPO Standard PM 9/10(1) (OEPP/EPPO, 2009c), these could include: investigation to determine the extent and source of outbreak and to assess the risk of spread; delimitation of the infested areas; demarcation of contaminated facilities and equipment; demarcation of infested or and probably infested plant material; containment measures to prevent further spread such as setting up buffer zone(s); testing of clonally-related or contact-related stocks; methods of disposal of infested or probably infested plants or plant parts, solid waste or liquid waste; cleansing and ⁄ or disinfection of machinery, storage facilities and other equipment; eradication measures for a specified period following an outbreak in the infested area such as cropping restrictions, measures regarding machinery and equipment, additional control measures on movement and additional surveys and use of plant protection products; monitoring of effectiveness of measures (OEPP/EPPO, 2009c). Limiting end-use of consignments means when the utilisation is limited, e.g. free marketing is not allowed, but immediate processing in canning factories or other limitations are applied. The measures applied by the NPPO depend on the time and severity of infection.

According to IPPC Standard ISPM No 9 (FAO, 1998), a programme for pest eradication may be developed by a NPPO either as an emergency measure to prevent establishment and/or spread of a pest following its recent entry (re-establish a pest free area), or - a measure to eliminate an established pest (establish a pest free area). The eradication process involves three main activities: surveillance, containment, and control measures.

Of the measures included in ISPM No 9 (FAO, 1998) the following can be applied in the case of *M. fructicola*: host destruction, disinfestation of equipment and facilities, pesticide treatments, the use of cultivars that suppress or eliminate pest populations, processing or consumption of infested crop (see Section 4.1.1.). In most cases, eradication will involve the use of more than one treatment option. The selection of treatment and/or control options may be limited by legislative restrictions or other factors. In such situations, exceptions for emergency or limited use may be available to the NPPO.

4.1.2. Identification of management options for plants for planting

4.1.2.1. Options to reduce infection in the growing crop

Infestation by *M. fructicola* can be reduced in the growing crop (i.e. nurseries) by the following options: (a) cultural practices, (b) chemical control, (c) biological control and (d) resistant cultivars.

A. Cultural practices

In the production sites of planting material of rosaceous fruit crops, one should try to avoid infection of planting material by *M. fructicola.* Firstly, nurseries should preferably be situated in areas/regions where this specific brown rot fungus is not known to occur. In countries where the pathogen is known to occur, specific areas could be designated for production of planting material (i.e. in regions with no/negligible fruit production of susceptible hosts). To minimise the probability of infection of young planting material, an option would be to sell the trees before blooming; this would require trading (very) young plants. Pruning of suspicious plant parts before delivery to customers would also be important (Melgarejo and De Cal, 2010).

B. Chemical control

The use of chemicals might be effective, especially to avoid flower infection in young trees (Schlagbauer and Holz, 1990; Wilcox, 1989). Flowers are one of the most important entry points of the pathogen, from out of which the pathogen can progress in twigs and stem (Byrde and Willetts, 1977; Luo et al., 2001b). Thus in nurseries, a main objective is to avoid flower infection by applying

chemicals in young trees/propagation material, so that infection of woody tissue is prevented. Care should be taken with the use of chemicals: several reports exist about occurrence of resistance in *M. fructicola* (see Sections 3.5.3. and 4.1.1.1.) Furthermore, an important aspect is that certain fungicides can suppress sporulation of *M. fructicola* on infected tissues, masking symptoms (see Section 3.2.2.3.) (Burnett et al., 2010; Kable, 1976; Wilcox, 1990).

C. Biological control

In peach orchards, De Cal et al. (2009) applied sprays with *Epicoccum nigrum* microbiological control agent during full flowering. The main objective of the use of these kinds of agents is mostly to increase the size of the indigenous population in trees, so that colonisation of fruit is promoted, resulting in less fruit infection by *Monilinia* spp. For this, biocontrol agents are less suitable to be used in controlling blossom blight, which is the most critical phase in case of plant propagation materials.

D. Resistant cultivars

According to studies of Feliciano et al. (1987), the peach cv. Bolinha shows a moderate resistance against *M. fructicola*. Studies on resistance of host plants against *Monilinia* spp. are always focused on resistance of fruit, related to e.g. cell wall thickness, epicuticular waxes, and levels of phenolic compounds. Again, in the phase of producing planting material, and the subsequent protection against infection of *Monilinia* spp. in the blossom phase, fruit resistance is of less significance.

4.1.2.2. Options for consignments

Options for consignments include: (a) control of movement of propagation material, (b) phytosanitary measures after importation (post-entry quarantine measures, demarcation of areas/production sites free from pathogen, quarantine treatments), and (c) certification of pre-entry testing of source planting material.

A. Control of movement of propagation material

According to the current legislation (Section 4.3.1.), host plants of *Chaenomeles* Lindl., *Crataegus* L., *Cydonia* Mill., *Eriobotrya* Lindl., *Malus* Mill., *Prunus* L. and *Pyrus* L., intended for planting, other than seeds, originating in non-European countries are allowed to be imported to the pest risk assessment area only from countries non-infested by *M. fructicola* or from areas recognised as being free from the pathogen and if no symptoms had been observed at the place of production since the beginning of the last complete cycle of vegetation. This legislation does not include all *M. fructicola* host plants (see Section 3.1.4.). The movement of propagation material is not regulated within the EU.

B. Phytosanitary measures after importation

Post-entry quarantine measures

As latent infections in planting material will not easily be detected at inspection, it might be wise to adopt a post-entry quarantine procedure in the country of destination. After importation, the material should be kept in post-entry quarantine.

To allow latent infection to develop in order to make a diagnosis, fruit should be previously treated with the herbicide paraquat (1,1´-dimethyl-4,4´-bipyridinium dichloride) or alternatively frozen at -20 ºC for 24 h (Michailides et al., 1996). After that, they are incubated under suitable conditions for seven days. Latent infection with *Monilinia* spp. is recorded following the appearance of brown rotted tissue showing sporulation on the fruit.

Demarcation of areas/production sites free from pathogen

When an orchard is infested by *M. fructicola*, spread of the pathogen by natural means takes place (see Section 3.2.4.1.). Demarcation zones free of the pathogen could then be those zones/areas where the pathogen has not been detected so far, and which are sufficiently distant from the nearest infested orchards/area. The "safe" distance to the nearest infested site could be estimated by rationalised estimations (Appendix F). In Slovenia, there is some experience with delimited areas surrounding infested orchards (Orešek et al., 2010). After the detection of *M. fructicola* in peach and nectarine orchards in 2009, in March 2010 a decision was issued on delimitation of infected areas in the region of Goriška (western Slovenia). The delimited area contains the foci of infection (some orchards), and a protected area 'encompassing the area of host-tree plantations or nurseries in a zone of at least 100 m and up to 10 km surrounding the foci' (Orešek et al., 2010). A management option would be to restrict export of planting material and fruits from host plants from out of the infested zones.

Quarantine treatments

If *M. fructicola* is detected on imported plants for planting, for example after a post-entry quarantine period, it should be eradicated. This can happen by host destruction (incineration) or chemical treatments. The facilities/equipment, in which the infested material was stored/placed, should be disinfested thoroughly by means of a chemical treatment before it is used again (FAO, 1998).

C. Certification of pre-entry testing of source planting material

Checking of plants for planting is done using a certification system. The certification system described in EPPO Standard PM 4/27(1) for *Malus, Pyrus* and *Cydonia* (OEPP/EPPO, 1999), in EPPO Standard PM 4/29(1) for cherries (OEPP/EPPO, 2001a) and in EPPO Standard PM 4/30(1) for almond, apricot, peach and plum (OEPP/EPPO, 2001b) does not require checking for *M. fructicola* or any other *Monilinia* spp., either for nuclear stock or propagation stock plants. This represents considerable risk for plants for planting to become infected. Nevertheless the NPPOs can take measures based on regular phytosanitary checks during the growing period of basic propagation material.

4.2. Evaluation of risk management options

In this paragraph, the management options described in Session 4.1. are evaluated by the Panel, based on their effectiveness and technical feasibility in reducing the level of risk for entry, establishment and spread of *M. fructicola*, and the magnitude of impacts, taking into consideration of uncertainty in each case. As a result of this evaluation the Panel considers that:

Cultural practices and chemical control applied in infested non-European countries (for fruit producing orchards and for plants for planting as well) can reduce the inoculum level and the disease pressure in the infested orchards but that may not influence the entry of the pathogen in the risk assessment area. The effectiveness of these measures when applied in orchards and nurseries in the risk assessment area, can reduce the possibility of establishment, spread and potential consequences with moderate effectiveness. According to the Panel, the technical feasibility of cultural practices and chemical control is high, because these measures are anyway applied against other *Monilinia* spp. The Panel considers, that the uncertainty is medium, because some information and data are missing, espacially on fungicide resistant strains.

Biological control or use of resistant cultivars have a very low effectiveness on preventing either the entry or the establishment, or on reducing the spread and the magnitude of impact. Very few resistant cultivars are available and biological control agents against *Monilinia* spp. are not used. This renders the technical feasibility negligible. Due to these facts, according to the Panel the uncertainty concerning resistant cultivars and biological control is low.

Inspection of fruits or plants for planting can have altogether low influence on entry and establishment. Visual inspection itself is not reliable, due to the presence of latent infections, which

are detectable only by laboratory methods, following the sampling. The technical feasability of visual inspection is considered high, but that of the laboratory detection is low, because of the necessity of intensive sampling and use of molecular methods. The uncertainty of inspection and detection altogether is considered low.

Monitoring and surveillance of the growing crop may lead to early detection of the pathogen and by that could limit further spread of the disease and reduce the magnitude of impact with moderate effectiveness. The technical feasibility of monitoring and surveillance is moderate. These methods are currently not used against other *Monilinia* spp., but can easily be implemented. The uncertainty is considered high, because surveillance and sampling may miss the pathogen.

Certification systems for plants for planting are an important element of management options. It could reduce the risk with high effectiveness. The presently applied certification system unfortunately does not require any checking for any of *Monilinia* spp. The feasibility is moderate. The system can be implemented with certain technical difficulties (e.g. establishment of pest-free stock orchards, surveillance, inspection, sampling and laboratory testing of propagation material, etc.). The uncertainty is medium, because of the diversity of the task.

Legislative control of movement of fruit or propagation material consignments from infected non-European countries into the pest risk assessment area is a highly effective measure on preventing the risk of entry of the pathogen. The feasibility is high, it can be easily implemented. The uncertainty is low, these measures can not be easily circumvented. At the same time the effectiveness of **legislative control of movement of** these **consignments from infected European countries** into the pest risk assessment area is considered only moderate on preventing the risk of entry and establishment of the pathogen, because from neighbouring infected countries the pathogen may enter into the pest risk assessment area also by natural means and it also can establish. The feasibility is high. The uncertainty is high, because many factors may disturb the effectiveness of these measures.

Limiting end-use of consignments means if utilisation of them is limited, e.g. free marketing is not allowed, but immediate processing in canning factories or other limitations are applied. According to the Panel the effectiveness of limiting end-use is moderate on preventing entry into the risk assessment area and the following establishment, because the fruit peel still can represent a risk. Implementation of this measure could have technical difficulties (e.g. availability, capacity and proximity of industrial processing facilities). The uncertainty is medium, because the fate of fruit peel is not always managed.

Postharvest inspection of fruit is moderate on spread and impact of *M. fructicola*. This measure can easily be implemented; technical feasibility of it is also moderate. The uncertainty is high, because the inspection and the following sampling may miss the pathogen.

Postharvest treatments by disinfection agents remove the pathogen only from the surface of fruits and do not prevent build-up of the decay. Fungicide treatments are not used in practice, mainly because of the possibility of residues. Heat treatments require very precise technical implementation, because the limits of effective and safe temperatures are narrow. Microbiological agents are not used for postharvest treatments in the EU against *M. fructicola.* Based on this evaluation, the Panel considers the effectiveness of postharvest treatments low and the technical feasibility also low. The uncertainty here is judged as low in all aspects.

Sanitation measures (phytosanitary measures) of fruit or propagation material consignments have moderate effect on establishment and spread of the pathogen and on the magnitude of impact, depending on the choice of the method (e.g. eradication is highly effective, but other methods, like certain fungicide treatments or surface disinfection might be less effective). The technical feasibility is moderate. The uncertainty is high, depending on the choice of the method.

According to the Panel, suitable **packaging of harvested fruit, sanitation of packaging, storage facilities and means of transport** could save fresh fruits from injuries and infection and by that to

prevent spreading infestation and to reduce the magnitude of impact with high efficacy, but has only negligible effect on entry and establishment. Technical feasibility of packaging measures is considered by the Panel as high, because they are anyway used in practice. Uncertainty concerning means of packaging, transport and sanitation measures is considered by the Panel as medium, considering the high diversity of means of packaging, storage facilities and means of transport and their effect on different fruits.

The Panel notes that effectiveness of **management of fruit waste** at entry points can be high, but considering establishment and spread from infected areas to non-infested ones is moderate. The effect on potential consequences is considered low. Technical feasibility of waste control is considered high, it can easily be implemented. The uncertainty is medium, because different kinds of waste could occur on different places, or could not occur at all – depends on many factors.

4.3. Evaluation of existing legislation

4.3.1. Legislation specific for *M. fructicola*

M. fructicola presently is listed in Annex I., Part A., Section I. of Council Directive 2000/29/EC on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community at (c) Fungi 9. *Monilinia fructicola* (Winter) Honey. According to this classification *M. fructicola* is a harmful organism whose introduction into and spread within all Member States shall be banned, not known to occur in any part of the Community and relevant for the entire Community.

The Panel notes that the above classification is not in accordance with the present situation:

- With listing *M. fructicola* in Annex I., Part A., Section I. of Council Directive 2000/29/EC, because *M. fructicola* occurs in parts of the EU territory (see Section 3.1.3.).

- With listing *M. fructicola* in Annex II., Part A. Section I. of Council Directive 2000/29/EC of 8May 2000 – as a consequence of not being listed in Annex I. – because *M. fructicola* occurs on several host plants in parts of the EU territory (see Section 3.1.4.).

M. fructicola is also subject to Council Directive 2000/29/EC Annex IV, Part A, on special requirements which must be laid down by all Member States for the introduction and movement of plants, plant products and other objects into and within all Member States.

According to the Section I, Article 15 of the above regulation, an official statement is necessary for plants of *Chaenomeles* Lindl., *Crataegus* L., *Cydonia* Mill., *Eriobotrya* Lindl., *Malus* Mill., *Prunus* L. and *Pyrus* L., intended for planting, other than seeds, originating in non-European countries - without prejudice to the prohibitions applicable to the plants listed in Annex III(A)(9), (18) and Annex III(B)(1), where appropriate, that: — the plants originate in a country known to be free from *Monilinia fructicola* (Winter) Honey; or — the plants originate in an area recognised as being free from *Monilinia fructicola* (Winter) Honey and no symptoms of *Monilinia fructicola* (Winter) Honey have been observed at the place of production since the beginning of the last complete cycle of vegetation.

The Panel notes that the official statement of being originated in a country known to be free, or in an area recognized as being free from *M. fructicola* and where no symptoms have been observed since the beginning of the last complete cycle of vegetation, which is necessary for some host plants for planting, originated from non-European countries, listed in the Section I., Article 15 of the above regulation, is only partially contributing to reducing the risk of introduction of this pest into the EU territory, because:

- Not all host plants are listed. Hosts of *M. fructicola* include *Rubus* and *Vitis* that are not included in the above legislation (see Section 3.1.4.).

- Visual inspection at the production site during the last complete cycle of vegetation is insufficient to determine freedom of *M. fructicola*. Symptoms can be latent, confused with other *Monilinia* species and also mixed infections can occur.

According to Section I., Article 16 of the above regulation, from 15 February to 30 September, an official statement is necessary for fruits of *Prunus* L., originating in non-European countries, that — the fruits originate in a country known to free from *M. fructicola*; or — the fruits originate in an area recognised as being free from *M. fructicola*, or — the fruits have been subjected to appropriate inspection and treatment procedures prior to harvest and/or export to ensure freedom from *Monilinia* spp.

The Panel notes that that the official statement on introduction and movement of fruits of *Prunus* L. being originated in non-European countries known to free from *M. fructicola* or in an area recognised as being free from *M. fructicola*, or the fruits having been subjected to appropriate inspection and treatment procedures prior to harvest and/or export to ensure freedom from *Monilinia* spp., is only partially contributing to reducing the risk of introduction of this pest into the EU territory, because:

- *Prunus* is not the only genus affected (see Section 3.1.4.)

- Infected fruit can be imported from southern hemisphere before 15 February and after 30 September and stored (see also Appendices C and D). Therefore imported fruit presents a risk all year round.

- Inspection prior to harvest and/or export cannot ensure freedom from *M. fructicola* and treatment (pre or post harvest) can reduce but not eliminate *M. fructicola* (see Section 4.4.).

4.3.2. Other legislation, not specific to *M. fructicola*

The Panel considers that certain legislation specific to other pests (*Erwinia amylovora*, virus pathogens), indirectly can have an effect on introduction of *M. fructicola.*

A. Legislation on host plants

The Council Directive 2000/29/EC Annex III, Part A, (9) prohibits the introduction of plants of *Chaenomeles* Ldl., *Cydonia* Mill., *Crateagus* L., *Malus* Mill., *Prunus* L., *Pyrus* L., and *Rosa* L., intended for planting, other than dormant plants free from leaves, flowers and fruit – from non-European countries in all Member States.

The Council Directive 2000/29/EC Annex III, Part A, (18) prohibits the introduction of plants of *Cydonia* Mill., *Malus* Mill., *Prunus* L. and *Pyrus* L. and their hybrids, and *Fragaria* L., intended for planting, other than seeds, from non-European countries, other than Mediterranean countries, Australia, New Zealand, Canada, the continental states of the USA in all member states.

The Panel notes that, taking into consideration the present distribution of *M. fructicola* on host plants, the above regulations may have only a partial effect on the introduction of this pest into the EU, because not all host plants of *M. fructicola* are listed (see Section 3.1.4.)

B. Legislation for protected zones

The Council Directive 2000/29/EC Annex III, Part B, prohibits plants, plant products and other objects in certain protected zones. The regulation laid down in (1) is not meant for *M. fructicola* but *Erwinia amylovora,* partially may nevertheless concern marketing of *M. fructicola* host plants into certain regions of EU.

According to the above regulation, without prejudice to the prohibitions applicable to the plants listed in Annex IIIA (9), (9.1), (18), where appropriate, plants and live pollen for pollination of: *Amelanchier* Med., *Chaenomeles* Lindl., *Crataegus* L., *Cydonia* Mill., *Eriobotrya* Lindl., *Malus* Mill., *Mespilus* L., *Pyracantha* Roem., *Pyrus* L. and *Sorbus* L., other than fruit and seeds, originating in third countries other than Switzerland and other than those recognised as being free from *Erwinia amylovora* (Burr.) Winsl. et al. in accordance with the procedure laid down in Article 18(2), or in which pest free areas have been established in relation to *E. amylovora* in accordance with the relevant International Standard for Phytosanitary Measures and recognised as such in E, EE, F (Corsica), IRL, I (Abruzzo, Puglia, Basilicata, Calabria, Campania, Emilia-Romagna (provinces of Parma and Piacenza); Friuli-Venezia Giulia, Lazio, Liguria, Lombardia (except the province of Mantua), Marche, Molise, Piemonte, Sardinia, Sicily, Toscana, Umbria, Valle d'Aosta, Veneto (except the provinces of Rovigo and Venice, the communes Castelbaldo, Barbona, Boara Pisani, Masi, Piacenza d'Adige, S. Urbano, Vescovana in the province of Padova and the area situated to the south of highway A4 in the province of Verona), LV, LT, P, SI (except the regions Gorenjska, Koroška, Maribor and Notranjska), SK (except the communes of Blahová, Horné Mýto and Okoč (Dunajská Streda County), Hronovce and Hronské Kľačany (Levice County), Málinec (Poltár County), Hrhov (Rožňava County), Veľké Ripňany (Topoľčany County), Kazimír, Luhyňa, Malý Horeš, Svätuše and Zatín (Trebišov County), FI, UK (Northern Ireland, Isle of Man and Channel Islands).

The Panel notes that, in case the protected zones for *E. amylovora* listed in the above regulation are overlapping with areas in EU infested by *M. fructicola*, this regulation may have a limiting effect on entry of this pathogen in those protected zones (e.g. Emilia Romagna, Italy).

C. Legislation concerning inspection at the place of production

The Council Directive 2000/29/EC Annex V, Part A, plants, plant products and other objects which must be subject to a plant health inspection at the place of production if originating in the Community, before being moved within the Community: I. Plants, plant products and other objects which are potential carriers of harmful organisms of relevance for the entire Community and which must be accompanied by a plant passport; 1.1. Plants, intended for planting, other than seeds, of *Amelanchier* Med., *Chaenomeles* Lindl., *Cotoneaster* Ehrh., *Crataegus* L., *Cydonia* Mill., *Eriobotrya* Lindl., *Malus* Mill., *Mespilus* L., *Photinia davidiana* (Dcne.) Cardot, *Prunus* L., other than *Prunus laurocerasus* L.and *Prunus lusitanica* L., *Pyracantha* Roem., Pyrus L. and *Sorbus* L.

The Panel notes that the above regulation – that is not meant for the host plants of *M. fructicola*, but those of *E. amylovora* – with adequate modification and amendments may be applied to host plants of *M. fructicola* as well.

4.4. Conclusions on risk management options

In this paragraph, the management options described in Paragraph 4.1 are evaluated by the Panel, based on their effectiveness and technical feasibility in reducing the level of risk for entry, establishment and spread of *M. fructicola*, and the magnitude of impacts, taking into consideration of uncertainty in each case.

The Panel considers that **cultural practices and chemical control** applied in infested non-European countries (for fruit producing orchards and for plants for planting as well) can reduce the inoculum level and the disease pressure in the infested orchards but that may not influence the entry of the pathogen in the risk assessment area. The effectiveness of these measures when applied in orchards

and nurseries in the risk assessment area can reduce the possibility of establishment, spread and potential consequences with moderate effectiveness. According to the Panel, the technical feasibility of cultural practices and chemical control is high, because these measures are anyway applied against other *Monilinia* spp. The Panel considers that the uncertainty is medium, because information is lacking, and data are missing, especially on fungicide resistant strains.

The Panel considers the effectiveness of **biological control or use of resistant cultivars** are very low on preventing either the entry, or the establishment, or on reducing the spread and the magnitude of impact. Very few resistant cultivars are available and biological control agents against *Monilinia* spp. are not used. This renders the technical feasibility negligible. Due to these facts, according to the Panel, the uncertainty concerning resistant cultivars and biological control is low.

The Panel acknowledged that **inspection of fruits or plants for planting** can have altogether low influence on entry and establishment. Visual inspection itself is not reliable, due to the presence of latent infections, which are detectable only by laboratory methods, following the sampling. The technical feasability of visual inspection is considered high, but that of the laboratory detection is low, because of the necessity of intensive sampling and use of molecular measures. The uncertainty of inspection and detection altogether is considered low.

According to the Panel **monitoring and surveillance** of the growing crop may lead to early detection of the pathogen and by that could limit further spread of the disease and reduce the magnitude of impact with moderate effectiveness. The technical feasibility of monitoring and surveillance is moderate. These methods are currently not used against other *Monilinia* spp., but can easily be implemented. The uncertainty is considered high because surveillance and sampling may miss the pathogen.

The Panel considers **certification system** for plants for planting an important element of management options. It could reduce the risk with high effectiveness. The presently applied certification system unfortunately does not require any checking for any species of *Monilinia*. The feasibility is moderate. The system can be implemented with certain technical difficulties (e.g. establishment of pest-free stock orchards, surveillance, inspection, sampling and laboratory testing of propagation material, etc.). The uncertainty is medium, because of the diversity of the task.

According to the Panel **legislative control of movement of fruit or propagation material consignments from infected non-European countries** into the pest risk assessment area is a highly effective measure on preventing the risk of entry of the pathogen. The feasibility is high, it can be easily implemented. The uncertainty is low, these measures can not be easily circumvented.

At the same time the effectiveness of **legislative control of movement of these consignments from infected European countries** into the pest risk assessment area is considered only moderate on preventing the risk of entry and establishment of the pathogen, because from neighbouring infected countries the pathogen may enter into the pest risk assessment area also by natural means and it also can establish. The feasibility is high. The uncertainty is high, because many factors may disturb the effectiveness of these measures.

Limiting end-use of consignments, e.g. free marketing is not allowed, but immediate processing in canning factories or other limitations are applied to consignments. According to the Panel the effectiveness of limiting end-use is moderate on preventing entry into the risk assessment area and the following establishment, because the fruit peel still can represent a risk. Implementation of this measure could have technical difficulties (e.g. availability, capacity and proximity of industrial processing facilities). The uncertainty is medium, because the fate of fruit peel is not always managed.

The Panel considers that the effectiveness of **postharvest inspection** of fruit is moderate on spread and impact of *M. fructicola*. This measure can easily be implemented, technical feasibility of it is also

moderate. The uncertainty is high, because the inspection and the following sampling may miss the pathogen.

Postharvest treatments by disinfection agents remove the pathogen only from the surface of fruits and do not prevent build-up of the decay. Fungicide treatments are not used in practice, mainly because of the possibility of residues. Heat treatments require very precise technical implementation, because the limits of effective and safe temperatures are narrow. Microbiological agents are not used for postharvest treatments in the EU against *M. fructicola.* Based on this evaluation, the Panel considers the effectiveness of postharvest treatments low and the technical feasibility also low. The uncertainty here is judged as low in all aspects.

According to the Panel, **sanitation measures (phytosanitary measures) of fruit or propagation material consignments** have moderate effect on establishment and spread of the pathogen and on the magnitude of impact, depending on the choice of the method (e.g. eradication is highly effective, but other methods, like certain fungicide treatments or surface disinfection might be less effective). The technical feasibility is moderate. The uncertainty is high, depending on the choice of the method.

According to the Panel, suitable **packaging of harvested fruit, sanitation of packaging, storage facilities and means of transport** could save fresh fruits from injuries and infection and by that to prevent spreading infestation and to reduce the magnitude of impact with high efficacy, but has only negligible effect on entry and establishment. Technical feasibility of packaging measures is considered by the Panel as high, because they are anyway used in practice. Uncertainty concerning means of packaging, transport and sanitation measures is considered by the Panel as medium, considering the high diversity of means of packaging, storage facilities and means of transport and their effect on different fruits.

The Panel notes, that effectiveness of **management of fruit waste** at entry points can be high, but considering establishment and spread from infested areas to non-infested ones is moderate. The effect on potential consequences is considered low. Technical feasibility of waste control is considered high, it can easily be implemented. The uncertainty is medium, because different kinds of waste could occur on different places –or could not occur at all– depending on many factors.

Measure	Effectiveness	Technical feasibility	Uncertainty	Where it applies
Cultural practices and chemical control	*Negligible* applied in the infested non-European countries (for fruit producing orchards and for plants for planting as well) may not influence the entry of the pathogen in the risk assessment area.	*High* because control measures against other *Monilinia* spp. are anyway applied.	*Medium* some information and data are missing, especially on fungicide resistant strains.	*Entry*

	Moderate when applied in the risk assessment area for reducing the possibility of establishment, spread and potential consequences in orchards and nurseries			*Establishment / spread /impact*
Biological control and resistant cultivars	*Very low*	*Negligible* because no biological control agents are available on market and resistant cultivars are not commonly grown	*Low*	*Entry / establishment / spread /impact*
Inspection of fruit or plants for planting	*Low* because visual inspection is not reliable due to the presence of latent infections, which are detectable only by laboratory detection.	*High* for visual inspection *Low* for laboratory detection of latent infections because of intensive sampling and use of molecular methods.	*Low*	*Entry / establishment*
Monitoring and surveillance of growing crop	*Moderate* may lead to early detection and by that could limit further spread of the disease and reduce the magnitude of impact with moderate effectiveness.	*Moderate* these measures are not currently used against other *Monilinia* spp., but can easily be implemented.	*High* surveillance and sampling may miss the pathogen.	*Spread /impact*
Certification systems for plants for planting	*High*	*Moderate* it can be implemented with technical difficulties (e.g. establishment of pest-free stock orchards, inspections,	*Medium*	*Entry / establishment / spread /impact*

		surveillance etc.).		
Control of movement of fruit or propagation material consignments by legislation from infested non-European countries	*High* on preventing entry of the pathogen into the risk assessment area.	*High*	*Low*	*Entry*
Control of movement of fruit or propagation material consignments by legislation from infested European countries	*Moderate* on preventing entry of the pathogen into the risk assessment area, mainly because of natural means of entry.	*High*	*High* it depends on many factors.	*Entry / establishment*
Limiting end use of consignments	*Moderate* because the fruit peel still represents a risk.	*Moderate* because implementation may have technical difficulties (e.g. availability, capacity and proximity of industrial processing facilities).	*Medium* because the fate of fruit peel is not always managed.	*Entry / establishment*
Postharvest inspection of fruit	*Moderate* in packinghouses, storehouses and markets in the risk assessment area	*Moderate* it can easily be implemented.	*High* inspection and sampling may miss the pathogen.	*Spread /impact*
Postharvest treatment of fruit	*Low*	*Low* postharvest treatment methods are not commonly used.	*Low*	*Entry / establishment / spread / impact*
Sanitation measures (phytosanitary measures) of fruit or propagation	*Moderate* depends on the choice of treatment – altogether it can be	*Moderate*	*Medium* depending on chosen methods	*Establishment / spread /impact*

material consignments	considered as moderate			
Management of fruit waste	*High* at the entry points	*High* it can easily be implemented.	*Medium* because different kind of waste could occur on very many different places or could not occur at all – depends on too many factors	*Entry*
	Moderate for establishment and spread from infested areas to non-infested ones			*Establishment / spread*
	Low effect on the impact			*Impact*
Packaging of fruit, sanitation of packaging, storage facilities and means of transport	*Negligible* for entry and establishment in the risk assessment area	*High* because suitable packaging is usually anyway used – especially for stone fruits.	*Medium* because there is very high diversity of packaging, storage facilities, means of transport and sanitation methods.	*Entry / establishment*
	High for spread of the pathogen and on the magnitude of impact.			*Spread /impact*

CONCLUSIONS AND RECOMMENDATIONS

Having given due consideration to the evidence, the Panel concludes that:

a. Entry of *M. fructicola* by means of plant propagation material, fresh fruits of susceptible genera and by natural means from infested European non-EU countries is very likely. It is very unlikely in case of dried fruit and natural means from infested non-European countries. In both cases the level of uncertainty is low.

b. Establishment of *M. fructicola* in the risk assessment area is very likely with a low level of uncertainty because of the avaialability of host plants with a long period of susceptibility and of suitable environmental conditions. Competition from other *Monilinia* species (*M. laxa* and *M. fructigena*) and currently applied cultural practices and control measures cannot prevent the establishment of the pest. In addition, the pest has already been detected in several Member States in the risk assessment area (France, Germany, Hungary, Italy, Poland, Romania, Slovenia and Spain).

c. Spread of *M. fructicola* within the risk assessment area is very likely with a low level of uncertainty because of its multiple ways to spread (natural and human assisted), to the wide distribution of host species in the risk assessment area and the absence of effective barriers.

d. Potential for yield reduction and negative effects on fruit production in orchards is estimated as moderate, with medium level of uncertainty mainly because of the incompleteness of data from the current area of distribution of the pest. Incidence and severity of the disease caused by the brown rot fungi, on flowers and twigs/branches are unlikely to increase compared to the situation in which only *M. fructigena* and *M. laxa* are present.

The Panel identified the following risk management options as highly effective in reducing:

a. The likelihood of entry of *M. fructicola*: (i) certification systems for plants for planting, (ii) control of movement of fruit or propagation material consignments by legislation from infested non-European countries and (iii) management of fruit waste

b. The likelihood of establishment of *M. fructicola*: (i) certification systems for plants for planting

c. The likelihood of spread and impact of *M. fructicola*: (i) certification systems for plants for planting and (ii) packaging of fruit, sanitation of packaging, storage facilities and means of transport

The Panel identified the following risk management options as moderately effectives in reducing:

a. The likelihood of entry of *M. fructicola*: (i) control of movement of fruit or propagation material consignments by legislation from infested European countries and (ii) limiting end use of consignments

b. The likelihood of establishment of *M. fructicola*: (i) cultural practices and chemical control, (ii) control of movement of fruit or propagation material consignments by legislation from infested European countries, (iii) limiting end use of consignments, (iv) sanitation measures (phytosanitary measures) of fruit or propagation material consignments, and (v) management of fruit waste.

c. The likelihood of spread of *M. fructicola*: (i) cultural practices and chemical control, (ii) monitoring and surveillance of growing crop, (iii) postharvest inspection of fruit, (iv) sanitation measures (phytosanitary measures) of fruit or propagation material consignments, and (v) management of fruit waste

d. The impact of of *M. fructicola*: (i) cultural practices and chemical control, (ii) monitoring and surveillance of growing crop, (iii) postharvest inspection of fruit, and (iv) sanitation measures (phytosanitary measures) of fruit or propagation material consignments

Other available measures (postharvest treatment of fruit, visual inspection of fruit or plants for planting in orchard, biological control and resistant cultivars) have been considered by the Panel scarcely effective in reducing the risk to plant health posed by this organism.

Regarding the evaluation of the effectiveness of the special requirements linked to *M. fructicola* presently listed in Annex IV, Part A, Section I of Council Directive 2000/29/EC, the Panel recommends considering the following aspects:

1) *M. fructicola* is listed in Annex I, Part A, Section I, as a harmful organism not known to occur in any part of the Community and relevant for the entire Community while it occurs on several host plants in parts of the EU territory.

2) The special requirements linked to listing *M. fructicola* in Annex IV, Part A, Section I of Council Directive 2000/29/EC only partially contribute to reducing the risk of introduction of this pest into the EU territory, more specifically:

   - In Art. 15 (i) the listed species (*Chaenomeles* Lindl., *Crataegus* L., *Cydonia* Mill., *Eriobotrya* Lindl., *Malus* Mill., *Prunus* L. and *Pyrus* L.) constitute only part of the range of the potential host plants of *M. fructicola* and (ii) the observation of symptoms (visual inspection) at the production site during the last complete cycle of vegetation is insufficient to determine freedom from *M. fructicola*.

   - In Art. 16 (i) fruit *Prunus* L. genus is not the only one potential fruit pathway, (ii) the limitation from 15 February to 30 September doesn't take into consideration that infected fruit can be imported from southern hemisphere before 15 February and after 30 September and stored, therefore imported fruit presents a risk all year round; (iii) inspection prior to harvest and/or export cannot ensure freedom from *M. fructicola*; (iv) treatment procedures prior to harvest (pre or post harvest) and/or export can reduce but not eliminate *M. fructicola*.

The Panel considers that other legislation, not specific for *M. fructicola*, but concerning – mainly – *Erwinia amylovora*, may also contribute to reduce the risk because of the partial overlapping of host plants.

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APPENDICES

A. RATINGS AND DESCRIPTORS

In order to follow the principle of transparency as described under Session 3.1. of the Guidance document on the harmonised framework for risk assessment (EFSA, 2010) – *"…Transparency requires that the scoring system to be used is described in advance. This includes the number of ratings, the description of each rating…. the Panel recognises the need for further development…"*– the Plant Health Panel has developed specifically for this opinion rating descriptors to provide clear justification when a rating is given.

1. Ratings used in the conclusion of the pest risk assessment

In this opinion of EFSA's Plant Health Panel for the risk assessment of *M. fructicola* and the evaluation of the effectiveness of the management options, a rating system of five levels with their respective descriptors has been used to formulate separately the conclusions on entry, establishment, spread and impact, as described in the following tables.

1.1. Rating of probability of entry

Rating for entry	**Descriptors for *Monilinia fructicola***
Very unlikely	The likelihood of entry would be very low because the pest: • is not or only occasionally associated with the pathway at the origin; and/or • may not survive during transport or storage; and/or • cannot survive the current pest management procedures existing in the risk assessment area; and/or • may not transfer to a suitable host in the risk assessment area.
Unlikely	The likelihood of entry would be low because the pest: • is rarely associated with the pathway at the origin; and/or • survives at very low rate during transport or storage; and/or • is strongly affected by the current pest management procedures existing in the risk assessment area; and/or • has considerable limitations for transfer to a suitable host in the risk assessment area.
Moderately likely	The likelihood of entry would be moderate because the pest: • is frequently associated with the pathway at the origin; and/or • survives at low rate during transport or storage; and/or • is affected by the current pest management procedures existing in the risk assessment area; and/or • has some limitations for transfer to a suitable host in the risk assessment area.
Likely	The likelihood of entry would be high because the pest: • is regularly associated with the pathway at the origin;

	and/or • mostly survives during transport or storage; and/or • is partially affected by the current pest management procedures existing in the risk assessment area; and/or • has very few limitations for transfer to a suitable host in the risk assessment area.
Very likely	The likelihood of entry would be very high because the pest: • is usually associated with the pathway at the origin; and/or • survives during transport or storage; and/or • is not affected by the current pest management procedures existing in the risk assessment area; and/or • has no limitations for transfer to a suitable host in the risk assessment area.

1.2. Rating of probability of establishment

Rating for establishment	**Descriptors for *Monilinia fructicola***
Very unlikely	The likelihood of establishment would be very low because even though the host plants are present in the risk assessment area, the environmental conditions are unsuitable and/or the host is susceptible for a very short time during the year; other considerable obstacles to establishment occur.
Unlikely	The likelihood of establishment would be low because even though the host plants are present in the risk assessment area, the environmental conditions are mostly unsuitable and/or the host is susceptible for a very short time during the year; other obstacles to establishment occur.
Moderately likely	The likelihood of establishment would be moderate because even though the host plants are present in the risk assessment area, the environmental conditions are frequently unsuitable and/or the host is susceptible for short time; other obstacles to establishment may occur.
Likely	The likelihood of establishment would be high because the host plants are present in the risk assessment area, they are susceptible for long time during the year, and the environmental conditions are frequently suitable; no other obstacles to establishment occur.
Very likely	The likelihood of establishment would be very high because the host plants are present in the risk assessment area, they are susceptible for long time during the year, and the environmental conditions are suitable for most of the host growing season; no other obstacles to establishment occur. Alternatively, the pest has already been established in the risk assessment area.

1.3. Rating of probability of spread

Rating for spread	**Descriptors for *Monilinia fructicola***
Very unlikely	The likelihood of spread would be very low because the pest: • has only one, specific way to spread (e.g., a specific vector) which is not present in the risk assessment area, and/or • highly effective barriers to spread exist, and/or • the host is not or occasionally present in the area of possible spread, and/or • the environmental conditions for infection are unsuitable in the area of possible spread.
Unlikely	The likelihood of spread would be low because the pest: • has one to few, specific ways to spread (e.g., specific vectors) and their occurrence in the risk assessment area is occasional, and/or • effective barriers to spread exist, and/or • the host is not frequently present in the area of possible spread, and/or • the environmental conditions for infection are mostly unsuitable in the area of possible spread.
Moderately likely	The likelihood of spread would be moderate because the pest: • has few, specific ways to spread (e.g., specific vectors) and their occurrence in the risk assessment area is limited, and/or • effective barriers to spread exist, and/or • the host is moderately present in the area of possible spread, and/or • the environmental conditions for infection are frequently unsuitable in the area of possible spread.
Likely	The likelihood of spread would be high because the pest: • has some, unspecific ways to spread, which occur in the risk assessment area, and/or • no effective barriers to spread exist, and/or • the host is usually present in the area of possible spread, and/or • the environmental conditions for infection are frequently suitable in the area of possible spread.
Very likely	The likelihood of spread would be very high because the pest: • has multiple, unspecific ways to spread, which all occur in the risk assessment area, and/or • no effective barriers to spread exist, and/or • the host is widely present in the area of possible spread, and/or • the environmental conditions for infection are mostly suitable in the area of possible spread.

1.4. Rating of magnitude of the potential consequences

Rating of potential consequences	Descriptors for *Monilinia fructicola*
Minimal	Fruit production and tree longevity in orchards, and commercial production of plants for planting in nurseries, are not distinguishable from normal variation; no additional control measures are required.
Minor	Fruit production is not or occasionally reduced, tree longevity is not threatened, and commercial production of plants for planting in nurseries is not or occasionally affected; additional control measures are not necessary.
Moderate	Fruit production is rarely reduced, tree longevity is not threatened, and commercial production of plants for planting in nurseries is rarely affected; additional control measures are sometime necessary.
Major	Fruit production is frequently reduced, tree longevity is sometime threatened, and commercial production of plants for planting in nurseries is frequently affected; additional control measures are frequently necessary.
Massive	Fruit production is regularly reduced, tree longevity is frequently threatened, and commercial production of plants for planting in nurseries is regularly affected; additional control measures are always necessary.

2. Ratings used for the evaluation of the management options

The Panel developed the following ratings with their corresponding descriptors for evaluating the effectiveness of the risk management options to reduce the level of risk.

2.1. Rating of the effectiveness of risk management options

Rating	Descriptors for *Monilinia fructicola*
Negligible	The management has no practical effect in reducing the probability of entry or establishment or spread, or the potential consequences.
Very low	The management options make it possible to reduce the probability of entry or establishment or spread, or the potential consequences, to a very low level.
Low	The management options make it possible to reduce the probability of entry or establishment or spread, or the potential consequences, to a low level.
Moderate	The management options make it possible to reduce the probability of entry or establishment or spread, or the potential consequences, to a moderate level.
High	The management options make it possible to highly reduce the probability of entry or establishment or spread, or the potential consequences.

2.2. Rating of the technical feasibility of risk management options

Rating	Descriptors for *Monilinia fructicola*
Negligible	The management options are not in use in the risk assessment area, and the many technical difficulties they have (e.g., changing or abandoning the current practices, implement new practices and or measures) make their implementation into the practice impossible.
Very low	The management options are not in use in the risk assessment area, and the many technical difficulties they have (e.g., changing or abandoning the current practices, implement new practices and or measures) make their implementation into the practice very difficult or nearly impossible.
Low	The management options are not in use in the risk assessment area, and they can be implemented (e.g., changing or abandoning the current practices, implement new practices and or measures) with several technical difficulties.
Moderate	The management options are not in use in the risk assessment area, but they can be implemented into the practice (e.g., changing or abandoning the current practices, implement new practices and or measures) with some technical difficulties.
High	The management options are already in use in the risk assessment area as a part of the current crop management actions and / or of the existing phytosanitary measures. If the management options are not in use, they can be easily implemented in the practice.

3. Ratings used for describing the level of uncertainty

For the risk assessment chapter – entry, establishment, spread and impact – as well as for the evaluation of the effectiveness of the management options, the level of uncertainties has been rated separately in coherence with the descriptors that have been defined specifically by the Panel in this opinion for *M. fructicola*.

Rating	Descriptors for *Monilinia fructicola*
Low	No or few information or data are missing, incomplete, inconsistent or conflicting. No subjective judgement is introduced. No unpublished data are used. Where models are used: • input data are clearly described and contain only minor measurement errors; and/or • model assumptions, structure, methods, algorithms, and limitations are clearly described; and/or • output is clearly described with sensitivity and uncertainty analysis.
Medium	Some information or data are missing, incomplete, inconsistent or conflicting. Subjective judgement is introduced with supporting evidence. Unpublished data are sometimes used. Whether models are used: • input data are not clearly described and/or contain measurement errors; and/or • model assumptions, structure, methods, algorithms, and limitations are not clearly described; and/or • output is not clearly described and neither sensitivity nor uncertainty analysis is available.

High	Most part of information or data are missing, incomplete, inconsistent or conflicting. Subjective judgement may be introduced without supporting evidence. Unpublished data are frequently used. Whether models are used: • input data are not described and/or contain measurement errors; and/or • model assumptions, structure, methods, algorithms, and limitations are not described; and/or • output is not described and neither sensitivity nor uncertainty analysis is available.

B. HOST SPECIES IN EUROPE

List of the potential hosts of *Monilinia fructicola* in Europe according to Flora Europaea

Species	Synonyms	Distribution
Chaenomeles japonica (Thunb.) Spach		
Chaenomeles speciosa (Sweet) Nakai	*Cydonia japonica* auct., non (Thunb.) Pers.	
Crataegus aegeica Pojark.	*Crataegus monogyna* Jacq. subsp. *aegeica* (Pojark.) Franco	E. Aegean; Karpathos to Thasos
Crataegus albanica Pojark.	*Crataegus taurica* Pojark.	
Crataegus altaica (Loudon) Lange		Rs(E)
Crataegus ambigua C.A.Mey. ex A.K.Becker	*Crataegus helenolae* Grynj & Klokov, *Crataegus volgensis* Pojark.	Rs(C,W,E)
Crataegus azarolus L.	*Mespilus azarolus* (L.) All.	Cr [Ga Hs It ?Ju Si]
Crataegus azarolus L. subsp. *Azarolus*		
Crataegus azarolus L. subsp. *azarolus* var. *azarolus*		
Crataegus azarolus L. subsp. *azarolus* var. *aronia* L.		Cr
Crataegus azarolus L. subsp. *ruscinonesis* (Gren. & Blanc) Nyman	*Crataegus* × *ruscinonensis* Gren. & Blanc	
Crataegus calycina Peterm.	*Crataegus monogyna* auct., non Jacq.	Au Be Bu Cz Da Fe Ga Ge Hu Ju No Po Rm Rs(B,C,W,E) Su Endemic
Crataegus calycina Peterm. subsp. *Calycina*	*Crataegus monogyna* Jacq. subsp. *calycina* (Peterm.) Soó, *Crataegus raavadensis* Raunk.	N.W. & C. Europe, extending to E. Romania Endemic
Crataegus calycina Peterm. subsp. *curvisepala* (Lindm.) Franco	*Crataegus monogyna* Jacq. subsp. *intermedia* (Fuss) Jáv., *Crataegus curvisepala* Lindm., *Crataegus kyrtostyla* sensu Pojark., *Crataegus pseudokyrtostyla* Klokov, *Crataegus subrotunda* Klokov, *Crataegus tanaitica* Klokov	E.C. Europe, extending to S. Russia & W. Bulgaria; S. Sweden & S. Finland Endemic
Crataegus *calycina* subsp. *curvisepala* × *monogyna subsp. leiomonogyna*	*Crataegus fallacina* Klokov	
Crataegus coccinea L.		
Crataegus coccinea auct. plur., non L.	*Crataegus intricata* Lange	[Rm]
Crataegus coccinea sensu Dostál, non L.	*Crataegus microphylla* K.Koch, *Crataegus stankovii* Kossych	Rs(K)
Crataegus crus-galli L.	*Mespilus crus-galli* (L.) Du Roi	[?Co Cz ?Ga]
Crataegus destefani Lojac.	*Crataegus* × *polyacantha* Jan	
Crataegus dipyrena Pojark.		Rs(K)
Crataegus eremitagensis Raunk.	Crataegus *laevigata subsp. laevigata* × *monogyna subsp. nordica*	
Crataegus fallacina Klokov	Crataegus *calycina subsp. curvisepala* × *monogyna subsp. Leiomonogyna*	
Crataegus heldreichii Boiss.	*Mespilus heldreichii* (Boiss.) Asch. & Graebn.	Al Cr Gr Endemic

Crataegus heterodonta Pojark.	*Crataegus* × *kyrtostyla* Fingerh.	
Crataegus karadaghensis Pojark.		Rs(K) Endemic
Crataegus klokovii Ivaschin		Rs(C,W)
Crataegus laciniata Ucria	*Mespilus orientalis* (M.Bieb.) Poir., non Mill., *Crataegus orientalis* Pall. ex M.Bieb., *Crataegus tanacetifolia* auct., *Crataegus orientalis* Pall. ex M.Bieb. var. *orientalis*	Al Bu Cr Gr Hs Ju Rs(W,K) Si [Ga]
Crataegus laciniata Ucria subsp. *laciniata*		Al Bu Cr Gr Hs Ju Rs(W,K) Si [Ga]
Crataegus laciniata Ucria subsp. *pojarkovae* (Kossych) Franco	*Crataegus pojarkovae* Kossych	Rs(K) Endemic
Crataegus *laciniata* × *monogyna subsp. azarella*	*Crataegus insegnae* (Tineo ex Guss.) Bertol., *Crataegus oxyacantha* L., nom. ambig. subsp. *inzengae* (Bertol.) Fiori	
Crataegus laevigata (Poir.) DC.	*Crataegus oxyacanthoides* Thuill., *Crataegus oxyacantha* auct.	Au Be Br Cz Da Ga Ge He Ho Hs Hu It Po ?Rm ?Rs(B) ?Rs(W) Su [No] Endemic
Crataegus laevigata (Poir.) DC. subsp. *laevigata*		
Crataegus laevigata (Poir.) DC. subsp. *palmstruchii* (Lindm.) Franco	*Crataegus palmstruchii* Lindm., *Crataegus oxyacantha* L., nom. ambig. subsp. *palmstruchii* (Lindm.) Hrabe$Ktova	Commoner in E. part of range Endemic
Crataegus leiomonogyna Klokov	*Crataegus monogyna* Jacq. subsp. *leiomonogyna* (Klokov) Franco, *Crataegus praearmata* Klokov	Rs(W,K) Endemic
Crataegus macrocarpa Hegetschw.	*Crataegus ovalis* Kit., *Crataegus oxyacantha* L., nom. ambig. subsp. *macrocarpa* (Hegetschw.) Nyman, *Crataegus palmstruchii* sensu Dostál, non Lindm.	Au Cz Ga Ge He It Endemic
Crataegus mollis (Torr. & A.Gray) Scheele		
Crataegus monogyna Jacq.	*Crataegus oxyacantha* L., nom. ambig.	Al Au Be Bl Br Bu Co Cr Cz Da Fe Ga Ge Gr Hb He Ho Hs Hu It Ju Lu No Po Rm Rs(C,W,K) Sa Si Su Tu
Crataegus monogyna Jacq. subsp. *monogyna*	*Crataegus ceratocarpa* Kossych, *Mespilus monogyna* (Jacq.) All., *Crataegus oxyacantha* L., nom. ambig. subsp. *Oxyacantha*, *Mespilus oxyacantha* (L.) Crantz, *Crataegus transalpina* A.Kern.	From France to S. Ukraine
Crataegus monogyna Jacq. subsp. *azarella* (Griseb.) Franco	*Crataegus alutacea* Klokov, *Crataegus azarella* Griseb., *Crataegus boissieri* Willk., *Crataegus lasiocarpa* Lange, *Crataegus lipskyi* Klokov, *Crataegus panachaica* C.K.Schneid., *Crataegus popovii* Chrshan., *Crataegus triloba* auct., non (Poir.) Pers.	S.E. Europe, Sicilia, S. & E. Italy & S. & E. Spain Endemic
Crataegus monogyna Jacq. subsp. *brevispina* (Kunze) Franco	*Crataegus brevispina* Kunze, *Crataegus granatensis* Boiss., *Crataegus laciniata* sensu Willk., non Ucria, *Crataegus maura* auct. hisp., non L.f.	Bl Hs Lu
Crataegus monogyna Jacq.		N. & C. Europe

subsp. *nordica* Franco		Endemic
Crataegus nigra Waldst. & Kit.	*Mespilus nigra* (Waldst. & Kit.) Willd.	Al Cz Hu Ju ?Rm Endemic
Crataegus oxyacantha auct. balcan.	*Crataegus*× *polyacantha* Ja	
Crataegus pallasii Griseb.	*Crataegus beckerana* Pojark., *Crataegus stevenii* Pojark., *Crataegus stevenana* sensu Stankov & Taliev	Rs(K,E)
Crataegus pentagyna Waldst. & Kit. ex Willd.	*Crataegus melanocarpa* M.Bieb., *Mespilus pentagyna* (Willd.) K.Koch	Al Bu Cz Hu Ju ?Rm Rs(W,K,E) ?Tu
Crataegus plagiosepala Pojark.		Po
Crataegus praearmata Klokov	*Crataegus monogyna* Jacq. subsp. *leiomonogyna* (Klokov) Franco	
Crataegus pycnoloba Boiss. & Heldr.	*Crataegus triloba* (Poir.) Pers.	Gr Endemic
Crataegus pyracantha (L.) Medik.	*Pyracantha coccinea* M.Roem.	
Crataegus sanguinea Pall.	*Mespilus sanguinea* (Pall.) Spach	Rs(C,E) [Au ?Ga]
Crataegus sanguinea Pall. var. *sanguinea*		
Crataegus sanguinea Pall. var. *chlorocarpa* (K.Koch) C.K.Schneid.		
Crataegus schraderana Ledeb.	*Crataegus flabellata* auct., non (Spach) G.Kirchn., *Crataegus orientalis* Pall. ex M.Bieb. var. *sanguinea* Loudon, *Crataegus orientalis* Pall. ex M.Bieb. var. *tournefortii* (Griseb.) C.K.Schneid., *Crataegus sanguinea* Schrad., non Pall., *Crataegus tournefortii* Griseb.	Gr Rs(K)
Crataegus sphaenophylla Pojark.		Rs(K) Endemic
Crataegus stankovii Kossych	*Crataegus microphylla* K.Koch	
Cydonia oblonga Mill.	*Cydonia vulgaris* Pers.	[Al Au Bu Co Cz Ga Ge Gr He Hs Hu It Ju Lu Rm Rs(K) Sa Si Tu]
Eriobotrya japonica (Thunb.) Lindl.		
Malus communis Poir.		
Malus communis Poir. subsp. *pumila* auct., non (Mill.) Gams	*Malus dasyphylla* Borkh., *Malus pumila* Mill. var. *paradisiaca* auct., non (L.) C.K.Schneid.	Al Au Bu Gr Hu Ju Rm Endemic
Malus domestica Borkh.	*Pyrus malus* L., *Malus pumila* Mill. var. *domestica* (Borkh.) C.K.Schneid., *Malus sylvestris* Mill. subsp. *mitis* (Wallr.) Mansf.	[Al Au Az Be Bl Br Bu Co Cr Cz Da Fe Ga Ge Gr Hb He Ho Hs Hu It Ju Lu No Po Rm Rs(B,C,W,K,E) Sa Si Su Tu]
Malus florentina (Zuccagni) C.K.Schneid.	*Sorbus florentina* (Zuccagni) K.Koch, × *Malosorbus florentina* (Zuccagni) Browicz, *Crataegus florentina* Zuccagni	Al Gr It Ju Endemic
Malus praecox (Pall.) Borkh.	*Malus pumila* Mill. var. *praecox* (Pall.) C.K.Schneid.	Rs(C,W,E) Endemic
Malus pumila Mill.	*Malus pumila* Mill. var. *paradisiaca* (L.) C.K.Schneid.	
Malus pumila Mill. var. *pumila*		
Malus pumila Mill. var. *domestica* (Borkh.)	*Malus domestica* Borkh.	

C.K.Schneid.		
Malus sylvestris Mill.	*Malus acerba* Mérat, *Malus communis* Poir. subsp. *sylvestris* (Mill.) Gams, *Pyrus acerba* (Mérat) DC.	Al Au Be Br Bu Co Cz Da Fe Ga Ge Gr Hb He Ho Hs Hu It Ju Lu No Po Rm Rs(B,C,W,K,E) Si Su Tu
Malus sylvestris Mill. subsp. *sylvestris*		Al Au Be Br Bu Co Cz Da Fe Ga Ge Gr Hb He Ho Hs Hu It Ju Lu No Po Rm Rs(B,C,W,K,E) Si Su Tu
Malus trilobata (Labill.) C.K.Schneid.	*Sorbus trilobata* (Labill.) Heynh., *Eriolobus trilobatus* (Labill.) Heynh	Gr [*Bu]
Prunus acida Ehrh.		
Prunus amygdalus Batsch	*Prunus dulcis* (Mill.) D.A.Webb	
Prunus armeniaca L.	*Armeniaca vulgaris* Lam.	[Al Au Az Bl Bu Co Cr Cz Ga Ge Gr He Hs Hu It Ju Rm Rs(W,K,E) Sa Si Tu]
Prunus avium L.	*Cerasus avium* (L.) Moench	Al Au Be Br Bu ?Co Cz Da Ga Ge Gr Hb He Ho Hs Hu It Ju Lu No Po Rm Rs(C,W,K) Sa Su Tu [Bl]
Prunus brigantina Vill.	*Prunus brigantiaca* Vill. , *Prunus chamaecerasus* Jacq.	Ga It Endemic
Prunus cerasifera Ehrh.	*Padus racemosa* (Lam.) C.K.Schneid., *Prunus myrobalana* (L.) Loisel., *Padus racemosa* (Lam.) C.K.Schneid. subsp. *Racemosa*, *Prunus divaricata* Ledeb.	Al Bu Gr Ju Rs(K) Tu [Au Br Da Ga Ge Hu It Rm]
Prunus cerasus L.	*Cerasus austera* (L.) Borkh., *Cerasus vulgaris* Mill., *Cerasus acida* (Ehrh.) Borkh., *Prunus acida* Ehrh., *Cerasus collina* Lej. & Courtois	[Al Au Br Bu Cz Da Fe Ga Ge Gr Hb He Ho Hs Hu It Ju Lu No Po Rm Rs(B,C,W) Su]
Prunus cocomilia Ten.	*Prunus pseudoarmeniaca* Heldr. & Sart. ex Boiss.	Al Gr It Ju Si
Prunus communis Huds.	*Prunus domestica* L.	Al Au Be Bl Br Bu Co Cz Da Fe Ga Ge Gr Hb He Ho Hs Hu It Ju Lu No Po Rm Rs(B,C,W,K,E) Sa Si Su Tu
Prunus domestica L. subsp. *domestica*	*Prunus domestica* L. subsp. *oeconomica* (Borkh.) C.K.Schneid., *Prunus oeconomica* Borkh.	
Prunus domestica L. subsp. *insititia* (L.) C.K.Schneid.	*Prunus insititia* L., *Prunus italica* Borkh., *Prunus domestica* L. subsp. *italica* (Borkh.) Hegi	
Prunus dulcis (Mill.) D.A.Webb	*Prunus communis* (L.) Arcang., non Huds., *Amygdalus communis* L., *Amygdalus dulcis* Mill., *Prunus amygdalus* Batsch	[Al Au Bl Bu Co Cr Cz Ga Ge Gr He Hu It Ju Lu Rm Rs(W,K,E) Sa Si Tu]
Prunus fruticans Weihe		
Prunus fruticosa Pall.	*Cerasus fruticosa* (Pall.) Woronow	Au Bu Cz Ge Hu It Po Rm Rs(C,W,E)
Prunus laurocerasus L.	*Laurocerasus officinalis* M.Roem., *Cerasus laurocerasus* (L.) Loisel.	Bu Ju Tu [Br Co Ga Hb Lu]
Prunus lusitanica L.		Az Ga Hs Lu
Prunus lusitanica L. subsp. *lusitanica*	*Laurocerasus lusitanica* (L.) M.Roem., *Cerasus lusitanica* (L.) Loisel.	Ga Hs Lu
Prunus lusitanica L. subsp. *azorica* (Mouill.) Franco		Az
Prunus mahaleb L.	*Cerasus mahaleb* (L.) Mill.	Al Au Be Bu Co Cz Ga Ge Gr He Hs Hu It Ju Lu Rm Rs(W,K) Si [No Su]

Prunus nana (L.) Stokes, non Du Roi	*Prunus tenella* Batsch, *Amygdalus nana* L.	Au Bu Cz Hu Ju Rm Rs(C,W,K,E) [Ga]
Prunus padus L.	*Padus avium* Mill	Au Be Br Bu Cz Da Fe Ga Ge Hb He Ho Hs It Ju Lu No Po Rm Rs(N,B,C,W,K,E) Su
Prunus padus L. subsp. *padus*	*Padus racemosa* (Lam.) C.K.Schneid. subsp. *typica* (C.K.Schneid.) Dostál, *Cerasus padus* (L.) Delarbre	Au Be Br Bu Cz Da Fe Ga Ge Hb He Ho Hs It Ju Lu No Po Rm Rs(N,B,C,W,K,E) Su
Prunus padus L. subsp. *borealis* Cajander	*Padus petraea* (Tausch) M.Roem., *Prunus padus* L. subsp. *petraea* (Tausch) Domin, *Cerasus schuebeleri* N.I.Orlova, *Padus racemosa* (Lam.) C.K.Schneid. subsp. *petraea* (Tausch) Dostál	N. & W. Fennoscandia; C. Europe from the Vosges to the Carpathians & S.E.Alps
Prunus persica (L.) Batsch	*Persica vulgaris* Mill., *Amygdalus persica* L.	[Al Au Bl Bu Co Cr Cz Ga Ge Gr He Hs Hu It Ju Lu Rm Rs(W,K,E) Sa Si Tu]
Prunus persica (L.) Batsch var. *Persica*		
Prunus persica (L.) Batsch var. *nucipersica* (Borkh.) C.K.Schneid.		
Prunus prostrata Labill.	*Cerasus prostrata* (Labill.) Ser.	Al Co Cr Gr Hs Ju Sa
Prunus ramburii Boiss.		Endemic
Prunus serotina Ehrh.	*Padus serotina* (Ehrh.) Borkh., *Cerasus serotina* (Ehrh.) Loisel., non (Roth) Poit. & Turpin	[Au Cz Da Ga Ge Ho Hu Ju Po Rm Su]
Prunus spinosa L.		Al Au Be Bl Br Bu Co Cz Da Fe Ga Ge Gr Hb He Ho Hs Hu It Ju Lu No Po Rm Rs(B,C,W,K,E) Sa Si Su Tu
Prunus virginiana L.	*Padus virginiana* (L.) M.Roem., *Padus rubra* Mill.	[Cz Ga]
Prunus webbii (Spach) Vierh.	*Amygdalus webbii* Spach	Al Bu Cr Gr It Ju
Prunus × *gondouinii* (Poit. & Turpin) Rehder		
Pyrus amygdaliformis Vill.	*Pyrus nivalis* sensu Lindl., non Jacq., *Pyrus parviflora* Desf.	Al Bu Co Cr Ga Gr Hs It Ju Sa Si Tu
Pyrus aria (L.) Ehrh.	*Sorbus aria* (L.) Crantz subsp. *aria*	
Pyrus aucuparia (L.) Gaertn.	*Sorbus aucuparia* L.	
Pyrus aucuparia (L.) Gaertn. subsp. *aucuparia*	*Sorbus aucuparia* L. subsp. *aucuparia*	
Pyrus aucuparia (L.) Gaertn. subsp. *praemorsa* (Guss.) Arcang.	*Sorbus aucuparia* L. subsp. *praemorsa* (Guss.) Nyman	
Pyrus austriaca A.Kern.		Endemic
Pyrus bourgaeana Decne.	*Pyrus communis* auct. iber., non L., *Pyrus communis* L. subsp. *communis* var. *mariana* Willk.	Hs Lu
Pyrus caucasica Fed.		Gr Rs(K) ?Tu
Pyrus chamaemespilus (L.) Lindl.	*Sorbus chamaemespilus* (L.) Crantz	
Pyrus communis L.	*Pyrus communis* L. subsp. *communis* var. *sativa* (DC.) Gams	
Pyrus communis L. subsp. *communis*		
Pyrus communis L. subsp. *communis* var. *communis*		
Pyrus communis auct., non L.	*Pyrus pyraster* Burgsd., *Pyrus communis* L. subsp. *achras* (Wallr.) Asch. & Graebn.,	

	Pyrus communis L. subsp. *communis* var. *achras* Wallr.	
Pyrus communis L. subsp. *nivalis* (Jacq.) Gams	*Pyrus nivalis* Jacq.	Au Bu Cz Ga He Hu It Ju Rm Endemic
Pyrus communis L. subsp. *salvifolia* (DC.) Gams	*Pyrus salvifolia* DC.	
Pyrus cordata Desv.		Br Ga Hs Lu Endemic
Pyrus cordata auct. balcan., non Desv.	*Sorbus chamaemespilus* (L.) Crantz	
Pyrus domestica (L.) Ehrh.	*Sorbus domestica*	
Pyrus elaeagrifolia Pall.		Al Bu Gr Ju Rm Rs(K) Tu
Pyrus intermedia Ehrh.	*Sorbus intermedia* (Ehrh.) Pers.	
Pyrus magyarica Terpó		Hu Endemic
Pyrus mecsekensis Terpó		Hu
Pyrus pinnatifida Sm.	*Sorbus hybrida* L.	
Pyrus pyrainus Raf.		Si
Pyrus pyraster Burgsd.	*Pyrus communis* L. subsp. *achras* (Wallr.) Asch. & Graebn., *Pyrus communis* L. subsp. *communis* var. *achras* Wallr., *Pyrus communis* auct., non L.	Al Au Be ?Br Bu Cz ?Da Ga Ge Gr He Hs Hu It Ju Lu Po Rm Rs(C,W,E) Si
Pyrus rossica A.D.Danilov		Rs(C) Endemic
Pyrus salicifolia Pall.		Rs(K) Tu
Pyrus salvifolia DC.		Au Be Ga Gr Hu Ju Po Rm Rs(K) Endemic
Pyrus syriaca Boiss.		[Hu]
Pyrus torminalis (L.) Ehrh.	*Sorbus torminalis* (L.) Crantz	
Rubus fruticosus L.		
Vitis aestivalis Michx.		
Vitis berlandieri Planch.		
Vitis coignetiae Pulliat ex Planch.		
Vitis cordifolia Lam.		
Vitis inconstans Miq.	*Parthenocissus tricuspidata* (Siebold & Zucc.) Planch.	
Vitis labrusca L.		
Vitis riparia Michx.	*Vitis vulpina* L.	
Vitis rotundifolia Michx.	*Vitis vulpina* auct., non L., *Muscadinia rotundifolia* (Michx.) Small	
Vitis rupestris Scheele		
Vitis sylvestris C.C.Gmel.	*Vitis vinifera* L. subsp. *sylvestris* (C.C.Gmel.) Hegi	S.E. & S.C. Europe, extending locally to Corse & W. Germany
Vitis thunbergii Siebold & Zucc.		
Vitis vinifera L.		Al Au Bu Co Cz Ga Ge Gr He Hu It Ju Rm Rs(W,K) Sa Si Tu [Az Be Bl Cr Hs Lu Po Rs(E)]
Vitis vinifera L. subsp. *vinifera*	*Vitis vinifera* L. subsp. *sativa* Hegi	

Source: Flora Europaea (Royal Botanic Garden Edinburgh) Database http://rbg-web2.rbge.org.uk/FE/fe.html

Qualifiers

The following qualifiers can be applied to each of the geographical indicators:

Qualifier	Meaning
[...]	Not native
*	Status doubtful; possibly native
?	Occurrence doubtful
%	Extinct

Geographical codes

The geographical distribution of each taxon is indicated by a series of two letter codes. The following table lists the codes and their associated geographical region, Click on one of the codes below to move to that entry in the table.

[Al] [Au] [Az] [Be] [Bl] [Br] [Bu] [Co] [Cr] [Cz] [Da] [Fa] [Fe] [Ga] [Ge] [Gr] [Hb] [He] [Ho] [Hs] [Hu] [Is] [It] [Ju] [Lu] [No] [Po] [Rm] [Rs] [Sa] [Sb] [Si] [Su] [Tu]

Two letter code	Geographical region	Two letter code	Geographical region
Al	Albania	He	Switzerland (*Helvetia*)
Au	Austria with Liechtenstein	Ho	Netherlands (*Hollandia*)
Az	Açores	Hs	Spain (*Hispania*) with Gibraltar and Andora; excluding Islas Baleares
Be	Belgium	Hu	Hungary
Bl	Islas Baleares	Is	Iceland (*Islandia*)
Br	Britain, including Orkney, Zetland and Isle of Man; excluding Channel Islands and Northern Ireland	It	Italy, including the Arcipelago Toscano; excluding Sardegna and Sicilia
Bu	Bulgaria	Ju	Jugoslavia
Co	Corse	Lu	Portugal (*Lusitania*)
Cr	Kriti (*Creta*) with Karpathos, Kasos and Gavdhos	No	Norway
Cz	Czechoslovakia	Po	Poland
Da	Denmark	Rm	Romania
Fa	Færöer	Rs	Territories of the former U.S.S.R.
Fe	Finland (*Fennia*), including Ahvenanmaa (Åland Islands)	Sa	Sardegna
Ga	France (*Gallia*), with the Channel Islands (Îles Normandes) and Monaco; excluding Corse	Sb	Svalbard, comprising Spitsbergen, Björnöya (Bear Island) and Jan Mayen
Ge	Germany	Si	Sicilia, with Pantelleria, Isole Pelagie, Isole Lipari and Ustica; also the Malta archipelago
Gr	Greece, excluding those islands included under Kriti (*supra*) and those which are outside Europe as defined for *Flora Europaea*	Su	Sweden (*Suecia*), including Öland and Gotland
Hb	Ireland (*Hibernia*); both the Republic of Ireland and Northern Ireland	Tu	Turkey (European part), including Gökçeada (Imroz)

Extended abbreviations for Russian sub-divisions

The territories of the former U.S.S.R. have been sub-divided using the floristic divisions of Komarov's *Flora U.R.S.S.* These sub-divisions have been assigned abbreviations using extensions of the 'Rs' two letter code. The following table details the extended abbreviations.

Extended abbreviation	Geographical region
Rs(N)	*Northern Division*: Arctic Europe, Karelo-Lapland, Dvina-Pecora
Rs(B)	*Baltic Division*: Estonia, Latvia, Lithuania, Kaliningradskaja Oblast'
Rs(C)	*Central Division*: Ladoga-Ilmen, Upper Volga, Volga-Kama, Upper Dnepr, Volga-Don, Ural
Rs(W)	*South-western Division*:Moldavia, Middle Dnepr, Black Sea, Upper Dnestr
Rs(K)	*Krym* (*Crimea*)
Rs(E)	*South-eastern Division*: Lower Don, Lower Volga, Transvolga

Areas not explicitly coded are White Russia (Bjelorussija) which is entirely in Rs(C). Ukraine, which is largely in Rs(W), but small parts are in Rs(C), Rs(E) and Rs(K). The European part of Kazakhstan which is in Rs(E).

C. IMPORTS OF STONE FRUITS

Table on imports of fresh stone fruit (meaning apricots, sour cherries *Prunus cerasus*, cherries, peaches and nectarines, plums and sloes) to EU countries from regions where *M. fructicola* is present (in tons; data from 2009, EUROSTAT)

	Asia (China, India, Korean Rep., Japan, Taiwan, Yemen)	Africa (Nigeria; Zimbabwe)	North America (Canada, Mexico, USA)	Central America and Caribbean (Guatemala, Panama)	South America (Argentina, Bolivia, Brazil, Ecuador, Paraguay, Peru, Uruguay, Venezuela)	Oceania (Australia, New Caledonia, New Zealand)	Total
Austria	-	-	-	-	-	-	-
Belgium	0.1	-	372.6	-	1247.7	28.1	1648.5
Bulgaria	-	-	-	-	-	-	-
Cyprus	-	-	-	-	2.4	-	2.4
Czech Rep. (CS->1992)	-	-	-	-	-	-	-
Denmark	-	-	-	-	-	-	-
Estonia	-	-	-	-	-	-	-
Finland	-	-	-	-	-	-	-
France	-	-	402.2	-	193.6	54.9	650.7
Germany (incl DD from 1991)	83.4	-	369.3	-	56.5	64.3	573.5
Greece	-	-	-	-	0.6	4.6	5.2
Hungary	-	-	-	-	-	-	-
Ireland	3	-	21.4	-	-	-	21.7
Italy	-	-	83.8	-	309.2	12.2	405.2
Latvia	-	-	-	-	-	-	-
Lithuania	-	-	-	-	-	-	-
Luxembourg	-	-	-	-	-	-	-
Malta	-	-	-	-	-	-	-
Netherlands	10	-	472.3	-	1403.7	16.4	1902.4
Poland	-	-	-	-	-	-	-
Portugal	-	-	-	-	17.8	-	17.8
Romania	-	-	-	-	-	-	-
Slovakia	-	-	-	-	-	-	-
Slovenia	-	-	-	-	-	-	-
Spain	-	-	75.5	-	960.3	2.3	1038.1
Sweden	1	-	21.5	-	19	-	40.6
United Kingdom	-	-	3401.9	-	1303.6	720.9	5426.4
Total	93.9	-	5220.5	-	5514.4	903.7	

D. SEASONALITY OF THE IMPORTS

Imports of potential host plants (indicated with EUROSTAT descriptors), month by month, into the EU Member States from regions where *M. fructicola* is present (data from 2009, EUROSTAT)

2009		January	February	March	April	May	June	July	August	September	October	November	December
Asia	China	fresh apples, fresh pears and quinces	Edible fruit or nut trees, fresh apples, fresh pears and quinces	Edible fruit or nut trees, fresh apples, fresh pears and quinces	Edible fruit or nut trees, fresh apples, fresh pears and quinces	Edible fruit or nut trees, fresh apples, fresh pears and quinces	Edible fruit or nut trees, fresh apples, fresh pears and quinces, fresh apricots, fresh plums and sloes	fresh apples, fresh plums and sloes	fresh apples, fresh pears and quinces, fresh apricots, fresh cherries	fresh pears and quinces	fresh apples, fresh pears and quinces, fresh apricots, fresh plums and sloes	fresh apples, fresh pears and quinces, fresh apricots	Edible fruit or nut trees, fresh apples, fresh pears and quinces, fresh cherries, fresh peaches (including nectarines)
	India	fresh cherries						Edible fruit or nut trees					Edible fruit or nut trees, fresh cherries
	Korean Rep.	fresh pears and quinces	Edible fruit or nut trees, fresh apples, fresh pears and quinces	fresh apples, fresh pears and quinces	fresh pears and quinces	fresh pears and quinces	fresh pears and quinces	Edible fruit or nut trees		fresh apples, fresh pears and quinces	fresh apples, fresh pears and quinces, fresh pears and quinces	fresh pears and quinces	fresh apples, fresh pears and quinces
	Japan										fresh pears and quinces		
	Taiwan	fresh plums and sloes											
	Yemen												

Africa	**Nigeria**												
	Zimbabwe												
North America	**Canada**	fresh apples	fresh apples	fresh apples	Edible fruit or nut trees, fresh apples	Edible fruit or nut trees, fresh apples		fresh cherries	fresh cherries	fresh cherries	fresh apples	fresh apples, fresh cherries	fresh apples
	Mexico			Edible fruit or nut trees	Edible fruit or nut trees, fresh peaches (including nectarines)	Edible fruit or nut trees, fresh peaches (including nectarines)							
	USA	Edible fruit or nut trees, fresh apples, fresh pears and quinces, fresh peaches (including nectarines)	Edible fruit or nut trees, fresh apples, fresh pears and quinces	Edible fruit or nut trees, fresh apples, fresh pears and quinces	Edible fruit or nut trees, fresh apples, fresh apricots, fresh cherries, fresh peaches (including nectarines)	Edible fruit or nut trees, fresh apples, fresh apricots, fresh cherries, fresh peaches (including nectarines), fresh plums and sloes	Edible fruit or nut trees, fresh apples, fresh apricots, fresh cherries, fresh peaches (including nectarines), fresh plums and sloes	Edible fruit or nut trees, fresh apples, fresh cherries	Edible fruit or nut trees, fresh apples, fresh pears and quinces, fresh cherries, fresh peaches (including nectarines)	Edible fruit or nut trees, fresh apples, fresh pears and quinces, fresh cherries, fresh peaches (including nectarines), fresh plums and sloes	Edible fruit or nut trees, fresh apples, fresh pears and quinces, fresh cherries, fresh peaches (including nectarines), fresh plums and sloes	Edible fruit or nut trees, fresh apples, fresh pears and quinces, fresh peaches (including nectarines)	Edible fruit or nut trees, fresh apples, fresh pears and quinces
Central America and Caribbean	**Guatemala**			Edible fruit or nut trees									

	Panama												
South America	**Argentina**	fresh pears and quinces, fresh apricots fresh cherries, fresh peaches (including nectarines), fresh plums and sloes	fresh apples, fresh pears and quinces, fresh cherries, fresh peaches (including nectarines), fresh plums and sloes	fresh apples, fresh pears and quinces fresh cherries, fresh peaches (including nectarines), fresh plums and sloes	fresh apples, fresh pears and quinces, fresh peaches (including nectarines), fresh plums and sloes	fresh apples, fresh pears and quinces, fresh plums and sloes	Edible fruit or nut trees, fresh apples, fresh pears and quinces, fresh plums and sloes	fresh apples, fresh pears and quinces, fresh plums and sloes	fresh apples, fresh pears and quinces	fresh apples, fresh pears and quinces	fresh pears and quinces	fresh cherries, fresh peaches (including nectarines)	fresh cherries, fresh peaches (including nectarines), fresh plums and sloes
	Bolivia												
	Brazil		fresh apples	fresh apples	Edible fruit or nut trees, fresh apples	fresh apples	fresh apples	fresh apples	fresh apples	fresh apples		fresh apples, fresh cherries	
	Ecuador												
	Paraguay												
	Peru												

	Uruguay	fresh apples	fresh apples, fresh pears and quinces	fresh apples, fresh pears and quinces	fresh apples, fresh pears and quinces	fresh apples	fresh apples	fresh apples		fresh apples			
	Venezuela												
Oceania	**Australia**	fresh apricots, fresh cherries, fresh peaches (including nectarines)	fresh apricots, fresh cherries, fresh peaches (including nectarines)	fresh cherries, fresh peaches (including nectarines)	fresh pears and quinces, fresh peaches (including nectarines), fresh plums and sloes	fresh apples, fresh pears and quinces, fresh plums and sloes	fresh pears and quinces, fresh cherries	fresh cherries	fresh pears and quinces, fresh cherries	fresh apples,	fresh apples, fresh apricots, fresh peaches (including nectarines)	fresh apricots, fresh cherries, fresh peaches (including nectarines)	fresh apricots, fresh cherries, fresh peaches (including nectarines)
	New Caledonia												
	New Zealand	fresh apricots, fresh cherries	fresh apricots, fresh cherries	Edible fruit or nut trees, fresh apples, fresh pears and quinces, fresh apricots, fresh cherries	Edible fruit or nut trees, fresh apples, fresh pears and quinces	fresh apples, fresh pears and quinces	Edible fruit or nut trees, fresh apples, fresh pears and quinces	Edible fruit or nut trees, fresh apples, fresh pears and quinces	Edible fruit or nut trees, fresh apples	fresh apples	fresh apples	fresh apples	

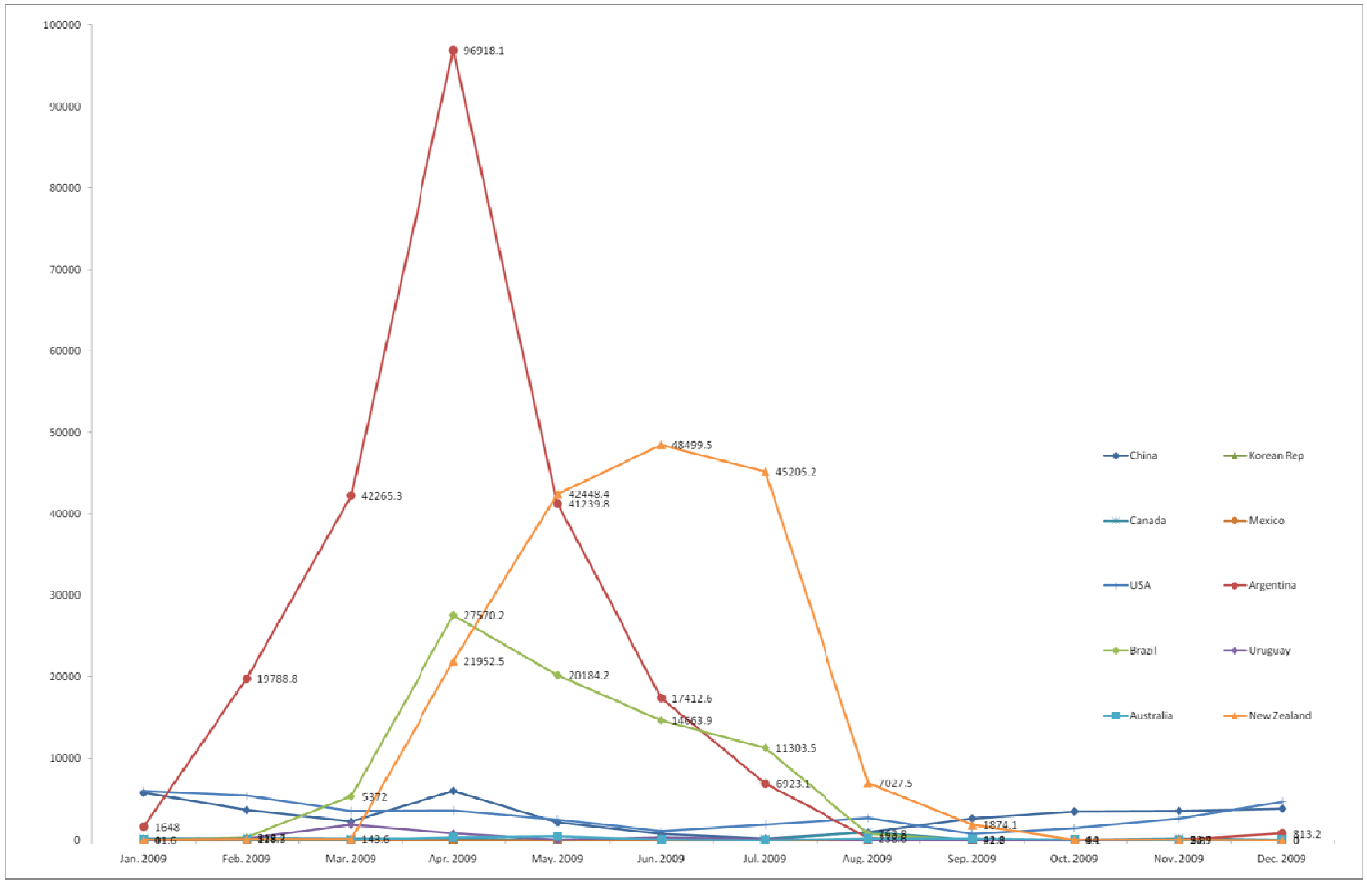


Figure 1: Imports of fresh fruit of potential host plants (meaning apples, pears, apricots, cherries, peaches and nectarines, plums and sloes) into the EU Member States from regions where *Monilinia fructicola* is present (in tons; data from EUROSTAT, 2009).

E. DESCRIPTION OF THE SIMPLE GENERIC INFECTION MODEL FOR FOLIAR FUNGAL PLANT PATHOGENS OF MAGAREY ET AL. (2005)

The generic infection model of Magarey et al. (2005) is used to identify hours with climatic conditions of temperature and leaf wetness, which allow a potential infection of a host plant with *Monilinia fructicola.*

The model calculates the surface wetness duration requirement W(T) at temperature T

$$W(T) = \min\left[\frac{W_{min}}{f(T)}, W_{max}\right]$$

with W_{min}, the minimum value of wetness duration requirement for the critical disease threshold at any temperature, and W_{max}, the upper boundary on the value of $W(T)$. This wetness duration is necessary to achieve a critical disease intensity at a given temperature T.

The dependence on the Temperature is based upon a temperature response function (Wang and Engel, 1998; Yin et al., 1995)

$$f(T) = \left(\frac{T_{max} - T}{T_{max} - T_{opt}}\right)\left(\frac{T - T_{min}}{T_{opt} - T_{min}}\right)^{\left(T_{opt} - T_{min}\right)/\left(T_{max} - T_{opt}\right)}$$

where T_{min} is the minimum temperature for infection, T_{max} is the maximum temperature for infection, T_{opt} is the optimum temperature for infection.

The period of continuous leaf wetness might be interrupted by a short duration D_{50} of dryness

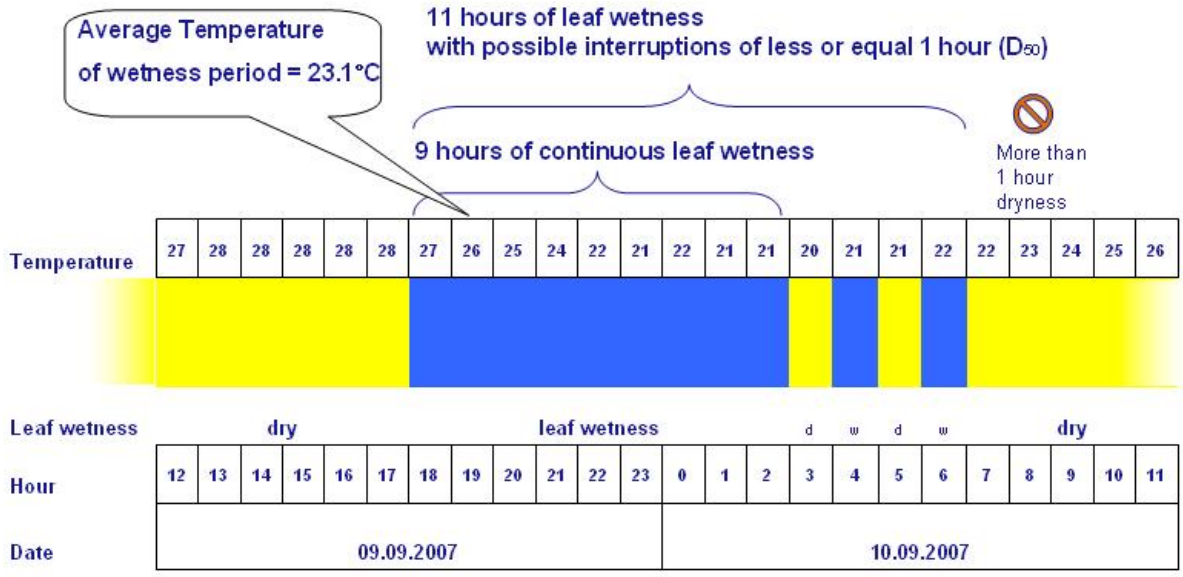


Figure 1: Calculation of wetness duration from hourly data

D_{50} is the duration of a dry period at relative humidity <95% that will result in a 50% reduction in disease compared with a continuous wetness period (Magarey et al., 2005).

For the model definition six parameters are necessary: T_{min}, T_{max}, T_{opt}, W_{min}, W_{max}, D_{50}. A calculation uses additional hourly information on temperature and leaf wetness.

1. Data Sources

The model parameter were fitted to empirical results on spore germination by Casals et al. (2010) (Section 1.1), while the "Real EU Oracle Weather" database of the JRC (2010) was used to obtain climatic information about Europe on a 25 × 25 km² grid (Section 1.2.).

Several intermediate steps were done to perform the final generic infection model. Missing hourly information on some variables was simulated from daily data. Missing air relative humidity was estimated and used to calculate the leaf wetness with the SWEB model (Section 1.2.).

Final output of the model is the temporal rate of potential infection of host plants with *M. fructicola*. This is the percentage of hours, for which the conditions are suitable for an infection.

1.1. Model parameters

Casals et al. (2010) reported following hours of lag phase for infection with *M. fructicola*.

Table 1: Hours of lag phase for germination of *Monilinia fructicola* (for aw = 0.99 and 0.97, Casals et al., 2010)

Temperature [°C]	Duration lag phase [h]		Average [h]	Fitted model [h]
	Water activity (aw [-])			
	0.99	0.97		
0	48	72	60.0	excl.
5	24	48	36.0	29.2
15	4	4	4.0	3.1
25	2	2	2.0	2.0
30	2	2	2.0	2.0
35	2	4	3.0	2.6

We fitted data to the average duration of the lag phase by water activity of 0.99 and 0.97, corresponding leaf wetness. The minimal temperature requirement was set to 4 °C, T_{max} = 38 °C, T_{opt} = 28 °C, W_{min} = 2 h. The maximal requirement was bounded by W_{max} = 30 h.

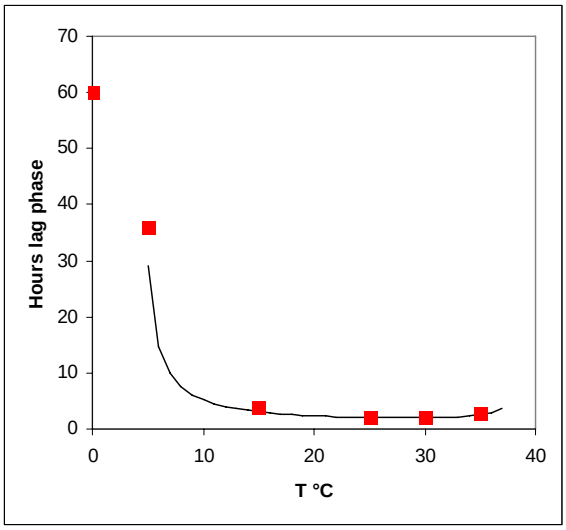


Figure 2: Average duration of lag phase of spore germination reported by Casals et al. (2010) and fitted temperature response function.

A comparison of these parameters with the proposal of Magarey shows some minor deviations.

Table 2: Parameter for the generic infection model for *Monilinia fructicola* from different authors

Parameter	Magarey et al., 2005	ClimPest, 2010	Fitted to measurements of Casals et al., 2010	Unit
Tmin	10	10	4	°C
Tmax	35	35	38	°C
Topt	20	20	28	°C
Wmin	10	10	2	h
Wmax	16	16	30	h
D50	no value	3	3 (and 10)	h
$AirRH_{Threshold}$	not in the model	30%	30%	

Magarey et al. (2005) gave no information on possible values of D_{50}. They generally propose 1-2 h for sensitive and 4-20 h for moderate sensitive fungi to dryness periods. We used a value of 3 h for our calculations.

Donatelli et al. (JRC, 2010) introduced a minimal air relative humidity in their implementation of the Magarey model. This threshold is set to 30%.

1.2. Climatic data

1.2.1. Generation of grid-based daily meteorological data (JRC, 2010)

The EU Real Weather database of the Joint Research Centre (EFSA, 2008; JRC, 2010), IEP/Agr4Cast provides daily weather data for Europe on a grid of 25 × 25 km² for the years 1990 to 2009. It is part of the Crop Growth Monitoring System (CGMs, http://mars.jrc.ec.europa.eu/mars/About-us/AGRI4CAST/Crop-yield-forecast/The-Crop-Growth-Monitoring-System-CGMS). The dataset contains information on minimal and maximal daily temperature, mean daily vapour pressure, mean daily wind speed at 10 m, mean daily rainfall, Penman potential evaporation and transpiration from a crop canopy, daily global radiation and snow depth. Because the European weather stations are irregularly distributed within the European countries the grid-based data are interpolated from neighbouring stations in a consistent way. The grid-based values describe the average situation of the area in one grid cell and reflect not always the situation at the midpoint. The altitude is the average of the altitude of the area with agricultural activities. Missing data on station level, like evaporation, were estimated by using the available measured meteorological parameters. Interpolations were done by simple averaging the values of most suitable neighbouring stations and correcting for differences in the altitude. Rainfall and snowfall data were taken from the most suitable neighbouring station. The technical description can be found by van der Groot and Orlandi (2003). Figure 3 shows the location of actual weather stations and the 25 × 25 km² grid.

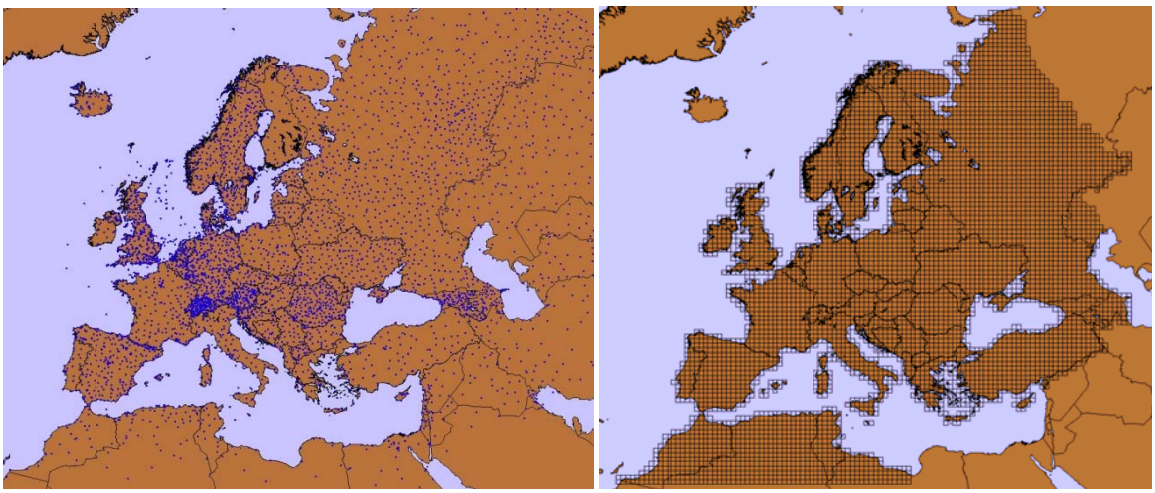


Figure 3: The network of weather stations and the grid derived using several interpolation procedures (EFSA, 2008).

1.2.2. Generation of hourly meteorological data (Donatelli et al., 2005)

Because the potential infection model of Magarey et al. (2005) needs hourly data on temperature and leaf wetness, the database was enriched by simulated hourly data. Algorithm from the CLIMA libraries (Donatelli et al., 2005) were used to simulate hourly data for air temperature, reference evapotranspiration, solar radiation, precipitation and wind speed. The algorithms are documented on the APES project page (www.apesimulator.org/help.aspx). Simulated are hourly air temperature, hourly wind speed, hourly net radiation, hourly slope of the vapour pressure curve, latent heat of vaporization, hourly rain, hourly atmospheric density, hourly relative air humidity, hourly saturation vapour pressure, hourly specific heat of air (EFSA, 2008).

1.2.3. Simulation of leaf wetness

The final estimation step to complete the database is the estimation of leaf wetness. Donatelli discusses in EFSA (2008) several alternatives to compute hourly leaf wetness from other meteorological variables. We use the Surface Wetness Energy Balance (SWEB) model by Magarey et al., 2006. This mechanistic model represents the inner process related to leaf wetness and consists of five modules: wind speed at the height of the canopy, fraction of net radiation intercepted by the canopy for the simulation of dew fall, fraction of rain intercepted by the canopy and the condensation of water as dew and their contributions to leaf wetness, latent heat flux density from the canopy and so the negative term for the water balance of the canopy and the actual wet area of the canopy and estimates if there is leaf wetness. Finally the leaf wetness is expressed as qualitative term, describing the dry or wet conditions during the hour.

A first application of this model was done for citrus black spot (*Guignardia citricarpa* Kiely) in EFSA (2008). A comparison of simulated data with real measurements of leaf wetness in citrus orchards can be found there.

1.3. Computation using the BioMA application

All computations of the potential infection model were done using the BioMA application version 0.1.1.0 of JRC (2010), available in internet: http://agsys.cra-cin.it/tools. The expected delivery of the final application is by April 2011.

The application allows access to the grid-based EU Real weather database for the years 1990 to 2009, the simulated hourly data including leaf wetness and an implementation (ClimPest) of the potential infection model by Magarey et al. (2005). The definition of parameters of the SWEB model was used

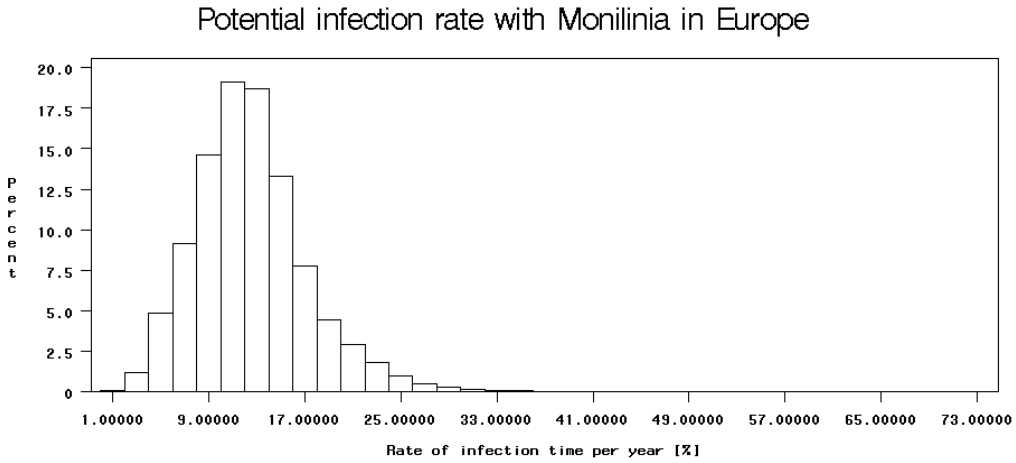
as given in the BioMA application and discussed in EFSA (2008). The application defines also a threshold of the relative humidity (RH_{thres} = 30%) in the potential infection model, which was not possible to decrease. Finally the actual version does only allow us to access the data of the years 2003 to 2007. In a revised version the computations might be extended to the full range of 20 years.

The outcome variable is the potential infection rate for a specific month and year in a specific grid cell. This means the number of hours with suitable conditions for a potential infection of a crop by a pathogen. The parameters of the Magarey model are given by the software or adjustable by the user.

2. Results

We calculated the potential infection rate of *M. fructicola* for all months of the years 2003 to 2007.

As overall mean of all locations and years the potential infection rate is 12.5% of the time with high regional variation. For 95% of the location the infection rate is higher than 5.7%, for 75% higher than 9.4%, for 50% higher than 12.1% (Median), for 25% higher than 15.0% and for 5% higher than 21.2% of the time.



Rate in percent [%] of time with suitable conditions to initiate a potential infection.

Figure 4: Average rate of potential infection with *Monilinia fructicola* of the years 2003 – 2007.

There is only minor variation between the different years. We conclude that an actual period of five years is sufficient to calculate average results which don't reflect specific situations of individual years.

Table 3: Regional distribution of potential infection rate for the area of simulation (see Figure 5)

Year	**Rate of potential infection with *Monilinia fructicola* [%]**						
	Mean	Lower quantiles					
		95% above	75% above	50% (Med)	25% above	5% above	max
2003-2007	12.5	5.7	9.4	12.1	15.0	21.2	73.7
2003	11.6	5.5	9.0	11.2	13.6	18.7	37.5
2004	13.3	5.6	10.3	13.1	15.7	21.7	42.5
2005	12.1	5.8	9.0	11.5	14.5	21.0	68.5
2006	12.8	5.7	9.7	12.5	15.5	21.2	73.4
2007	13.0	5.6	9.6	12.3	15.4	22.5	73.7

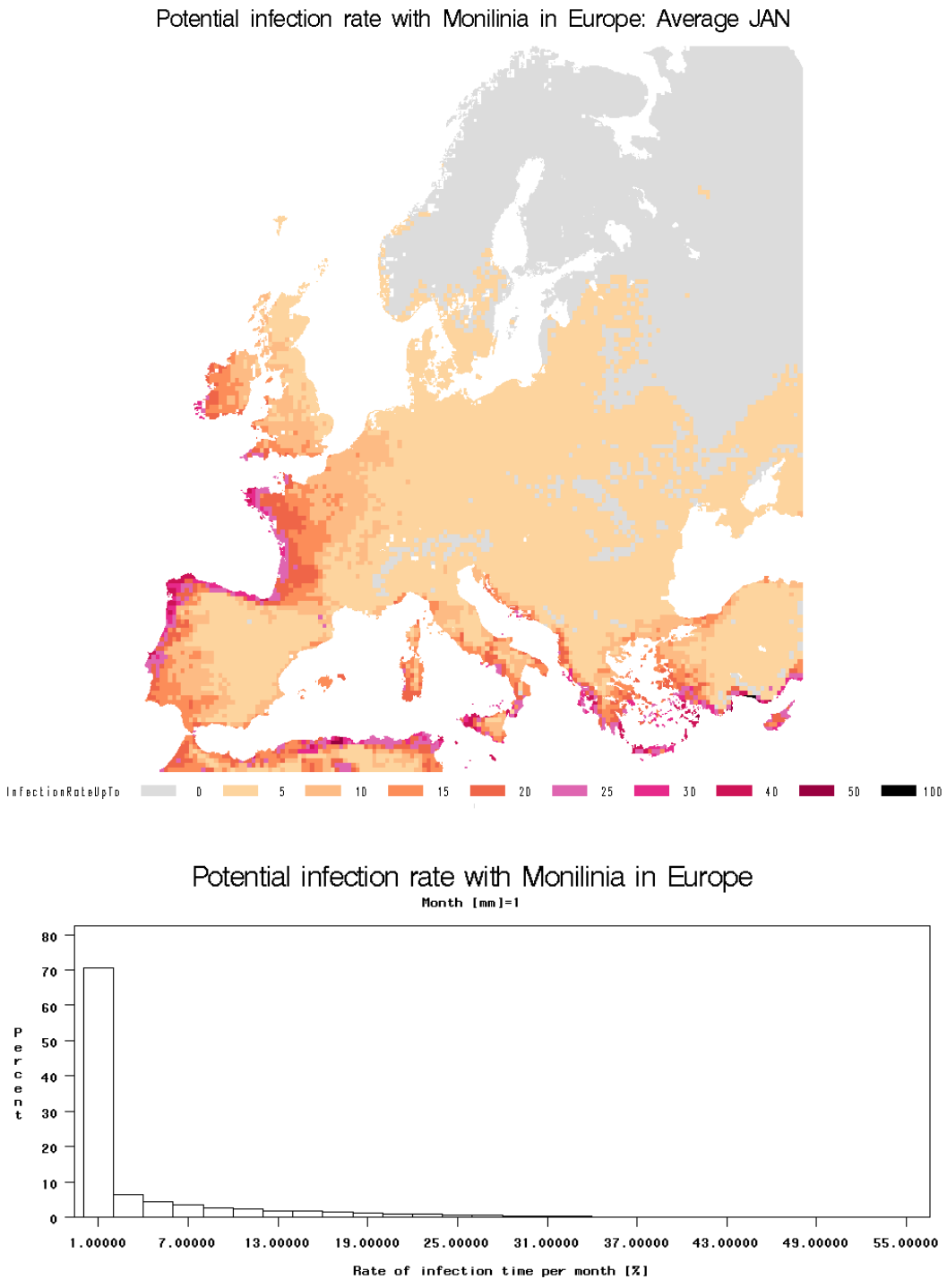
But within one year the area of highest infections swashes like a wave from the south-west in January to the north-east in July and back to the south-west.

Table 4: Regional distribution of potential infection rate for the area of simulation (see Figure 5) in the cycle of a year

Month	**Average rate of potential infection with *Monilinia fructicola* [%] for the years 2003-2007**						
	Mean	Lower quantiles					
		95% above	75% above	50% (Med)	25% above	5% above	max
Year	12.5	5.7	9.4	12.1	15.0	21.2	73.7
Jan	3.3	0.0	0.0	0.2	3.1	18.1	54.1
Feb	2.9	0.0	0.0	0.1	3.0	16.5	43.8
Mar	4.3	0.0	0.0	1.6	6.8	17.2	39.2
Apr	7.8	0.0	1.7	6.4	12.4	20.8	55.8
May	16.3	3.3	11.4	16.5	21.6	27.7	66.4
Jun	19.6	3.7	13.2	20.9	26.0	33.1	61.7
Jul	21.7	1.1	14.3	24.8	30.0	36.1	62.0
Aug	24.0	2.1	16.1	26.5	32.5	40.1	66.0
Sep	21.0	6.6	15.6	21.4	26.0	34.3	69.7
Oct	16.6	1.7	9.5	16.3	22.6	33.9	76.1
Nov	8.0	0.0	0.1	3.6	13.6	28.1	55.3
Dec	4.3	0.0	0.0	0.4	4.5	22.8	60.4

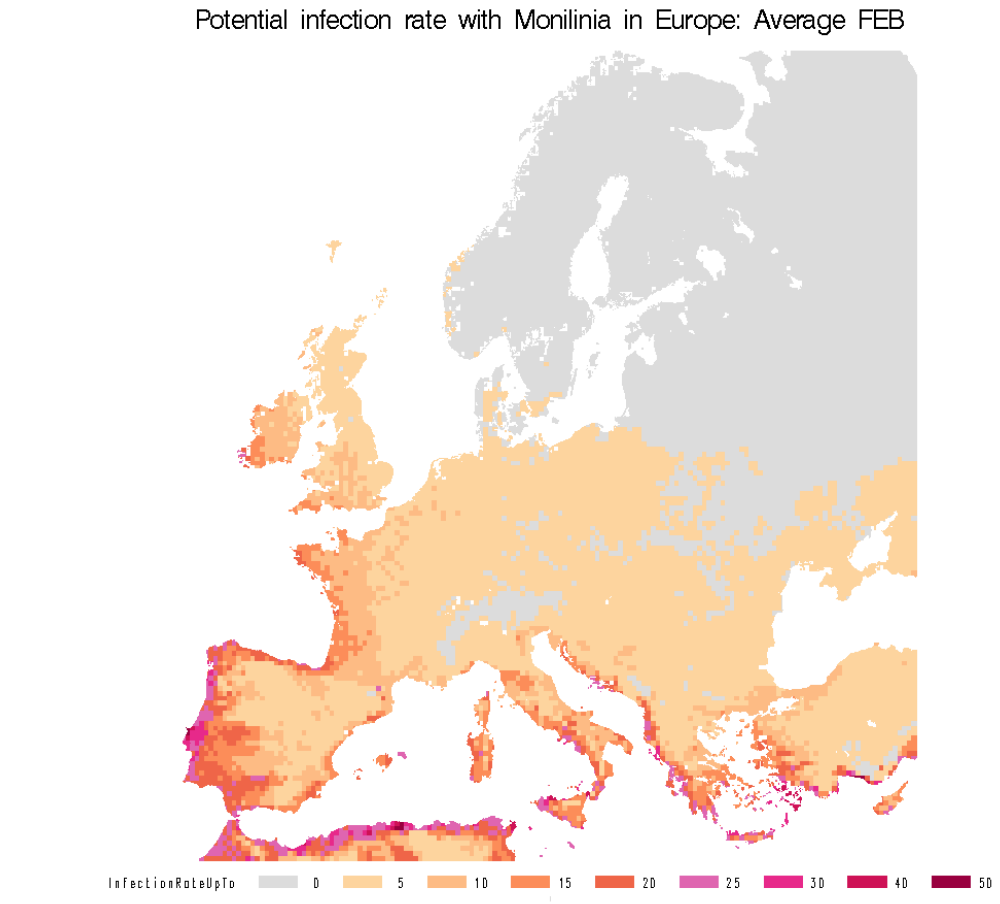
The month of higher infection rates are May to October. But there are large regional differences. For central and north-eastern Europe mayor potential infection time is May to September, while for south-western Europe the summer is not suitable. The mayor infection time here is two split into April-May and September-November.

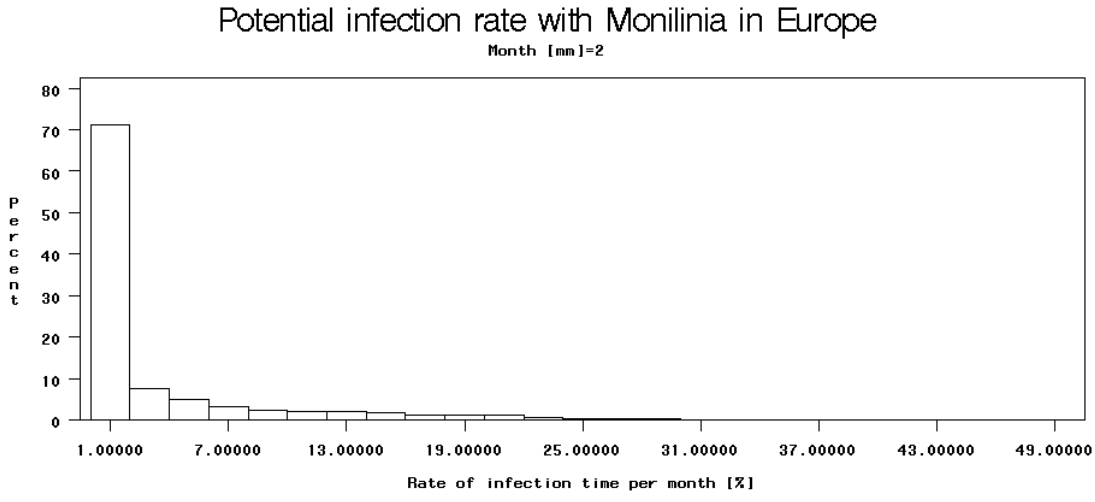
2.1. Potential infection rate with *Monilinia fructicola* – month by month



Rate in percent [%] of time with suitable conditions to initiate a potential infection. Colours see axis.

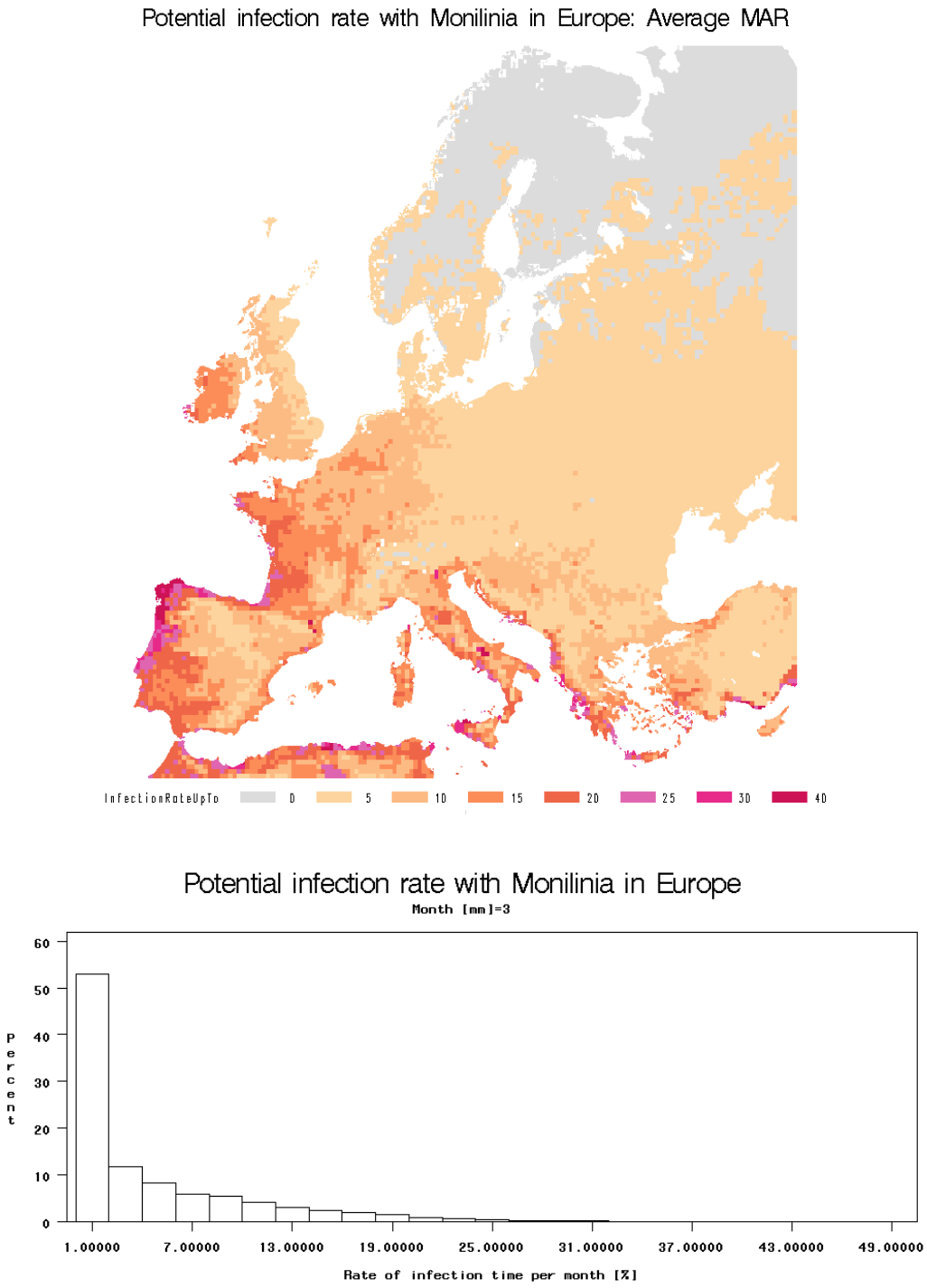
Figure 5: Monthly rate of potential infection with *Monilinia fructicola* for January, average of climatic conditions of the years 2003 – 2007.





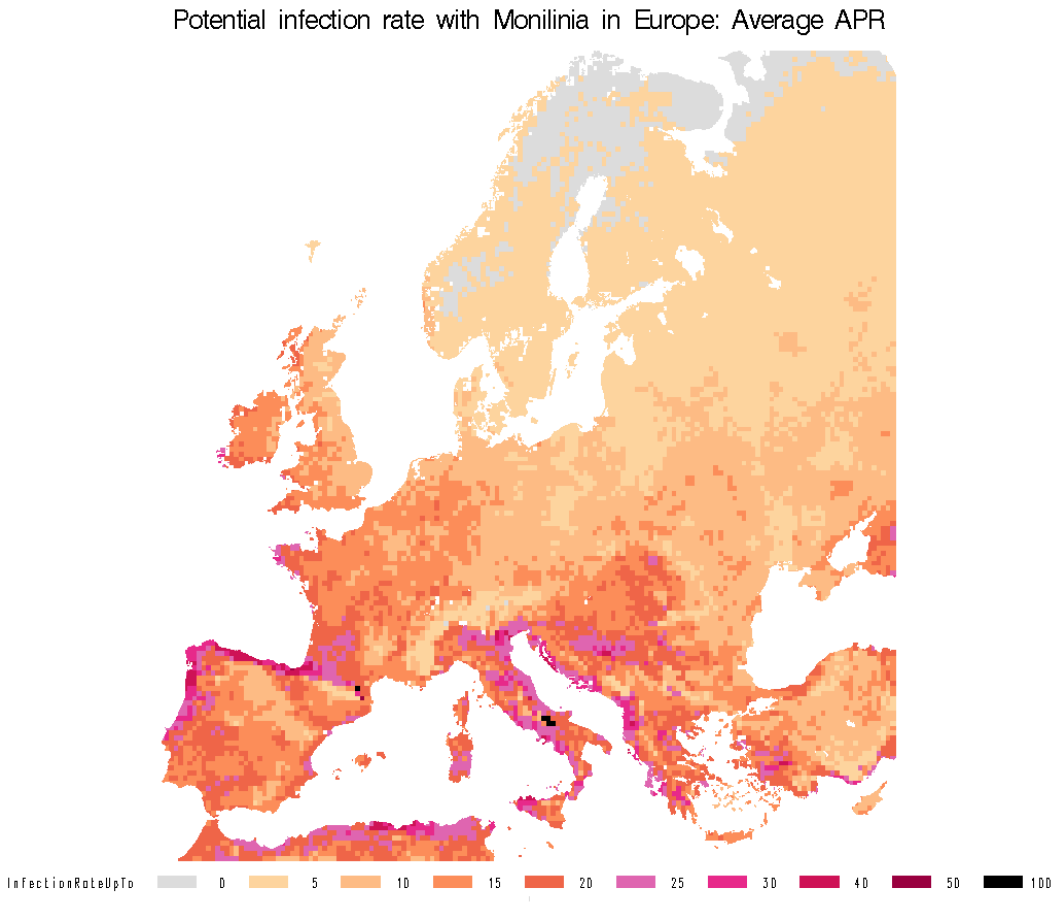
Rate in percent [%] of time with suitable conditions to initiate a potential infection. Colours see axis.

Figure 6: Monthly rate of potential infection with *Monilinia fructicola* for February, average of climatic conditions of the years 2003 – 2007.



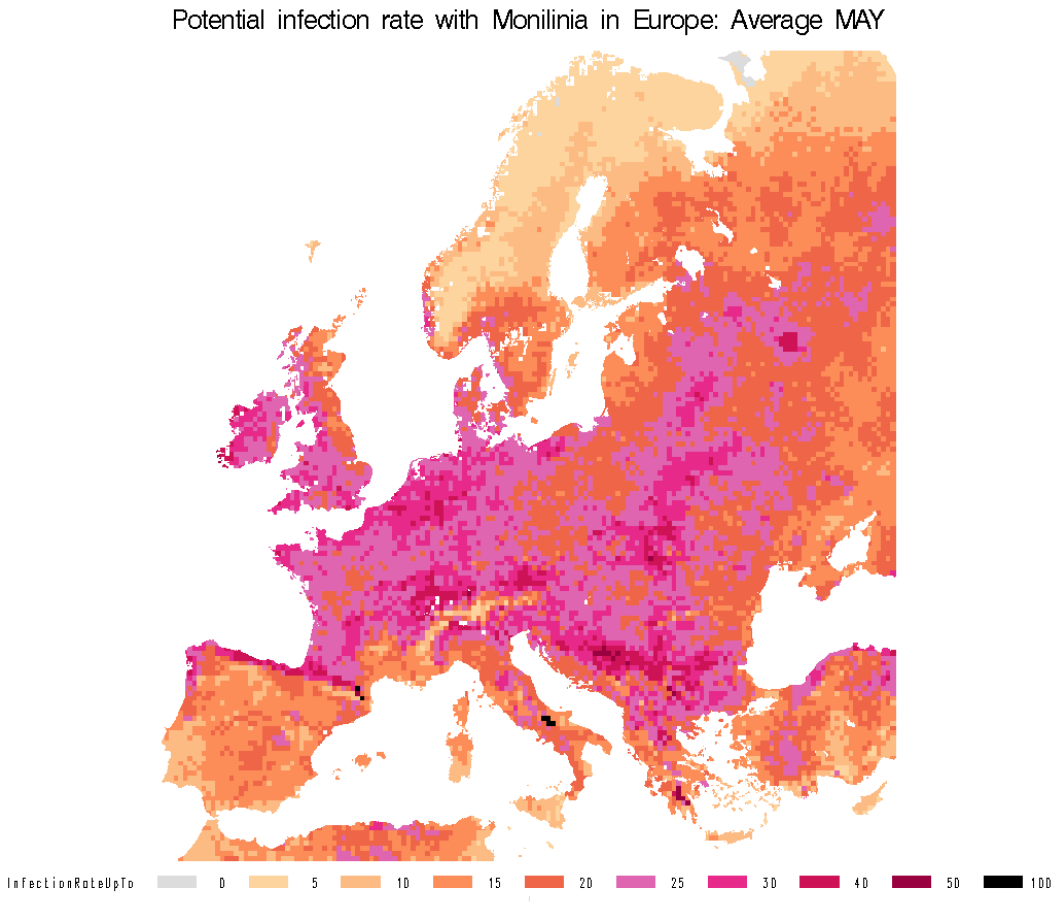
Rate in percent [%] of time with suitable conditions to initiate a potential infection. Colours see axis.

Figure 7: Monthly rate of potential infection with *Monilinia fructicola* for March, average of climatic conditions of the years 2003 – 2007.



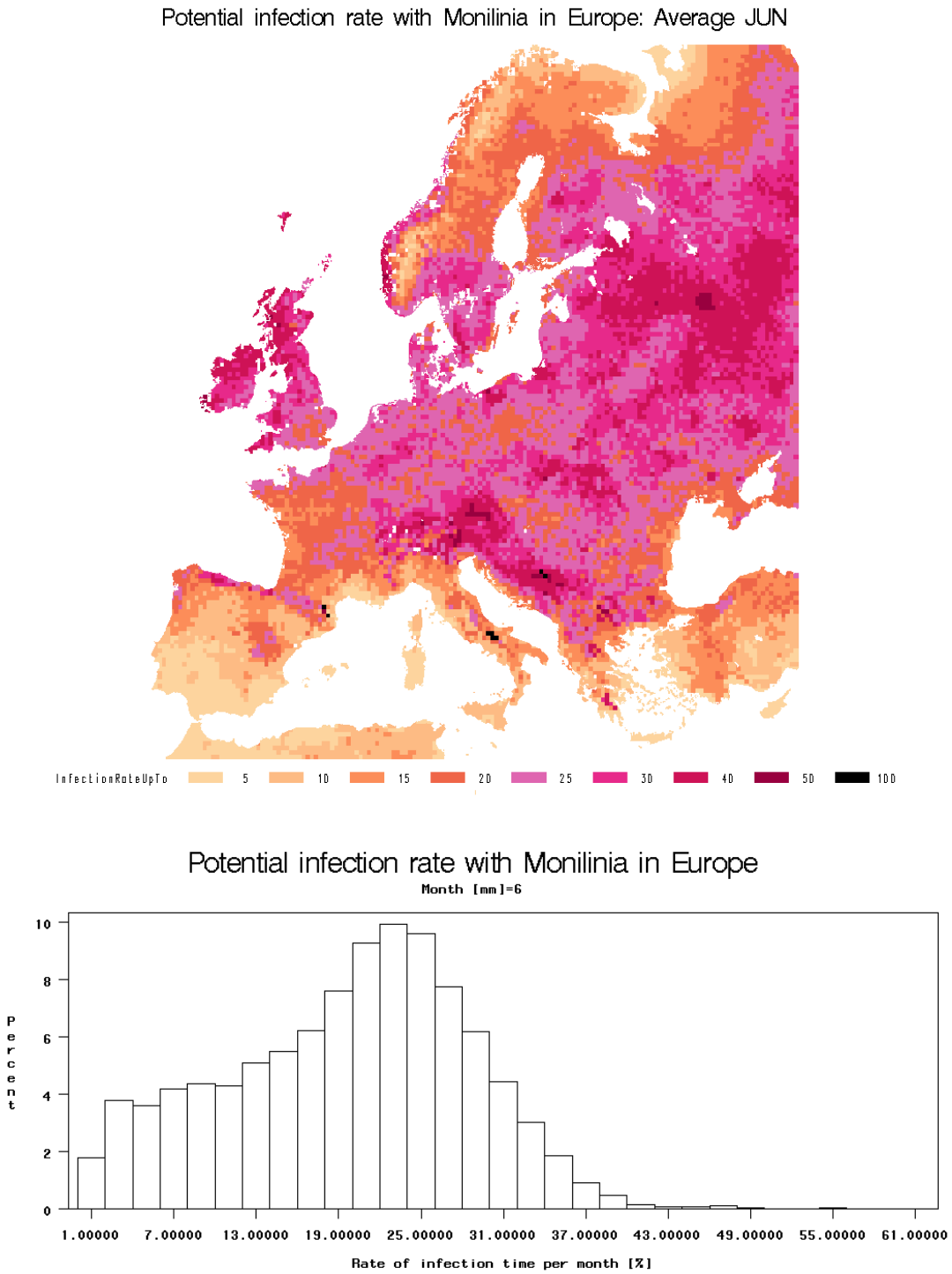
Rate in percent [%] of time with suitable conditions to initiate a potential infection. Colours see axis.

Figure 8: Monthly rate of potential infection with *Monilinia fructicola* for April, average of climatic conditions of the years 2003 – 2007.



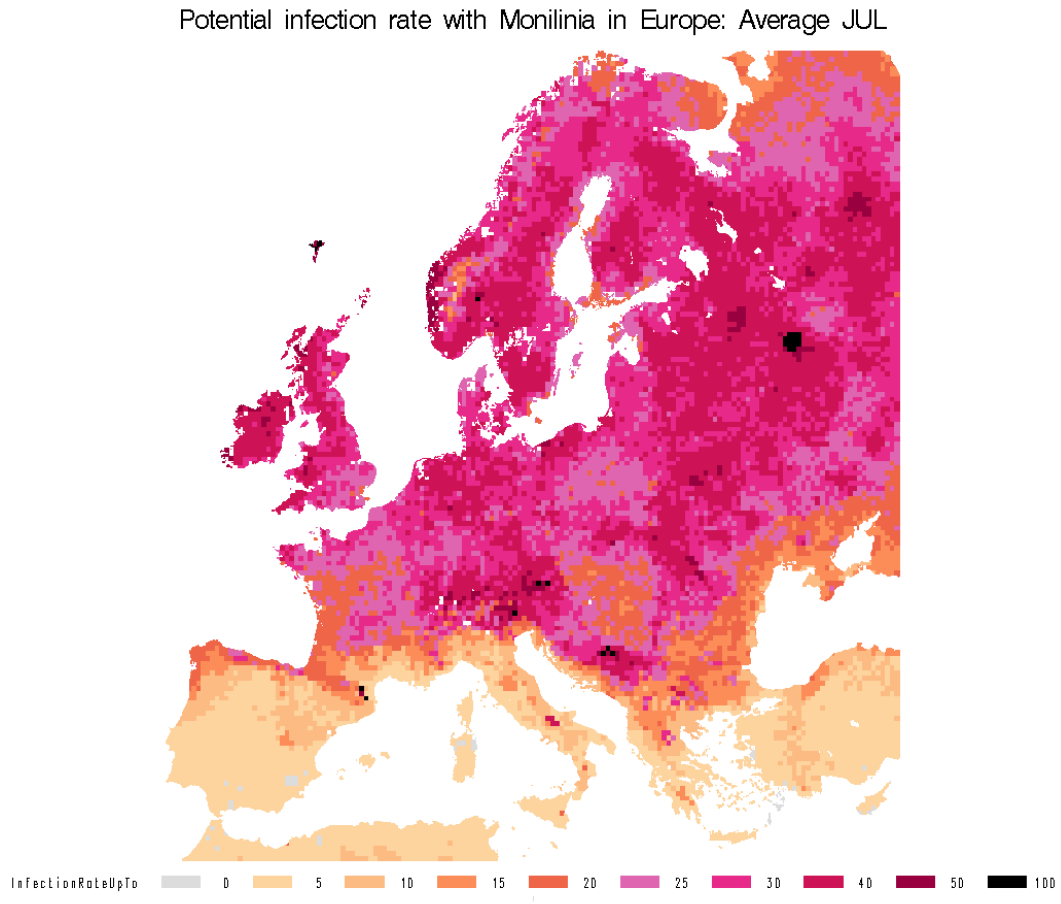
Rate in percent [%] of time with suitable conditions to initiate a potential infection. Colours see axis.

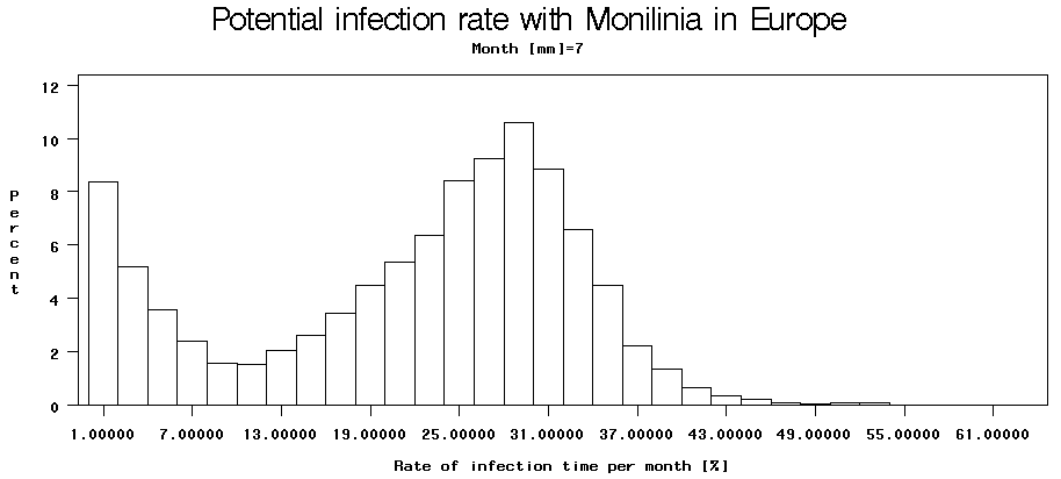
Figure 9: Monthly rate of potential infection with *Monilinia fructicola* for May, average of climatic conditions of the years 2003 – 2007.



Rate in percent [%] of time with suitable conditions to initiate a potential infection. Colours see axis.

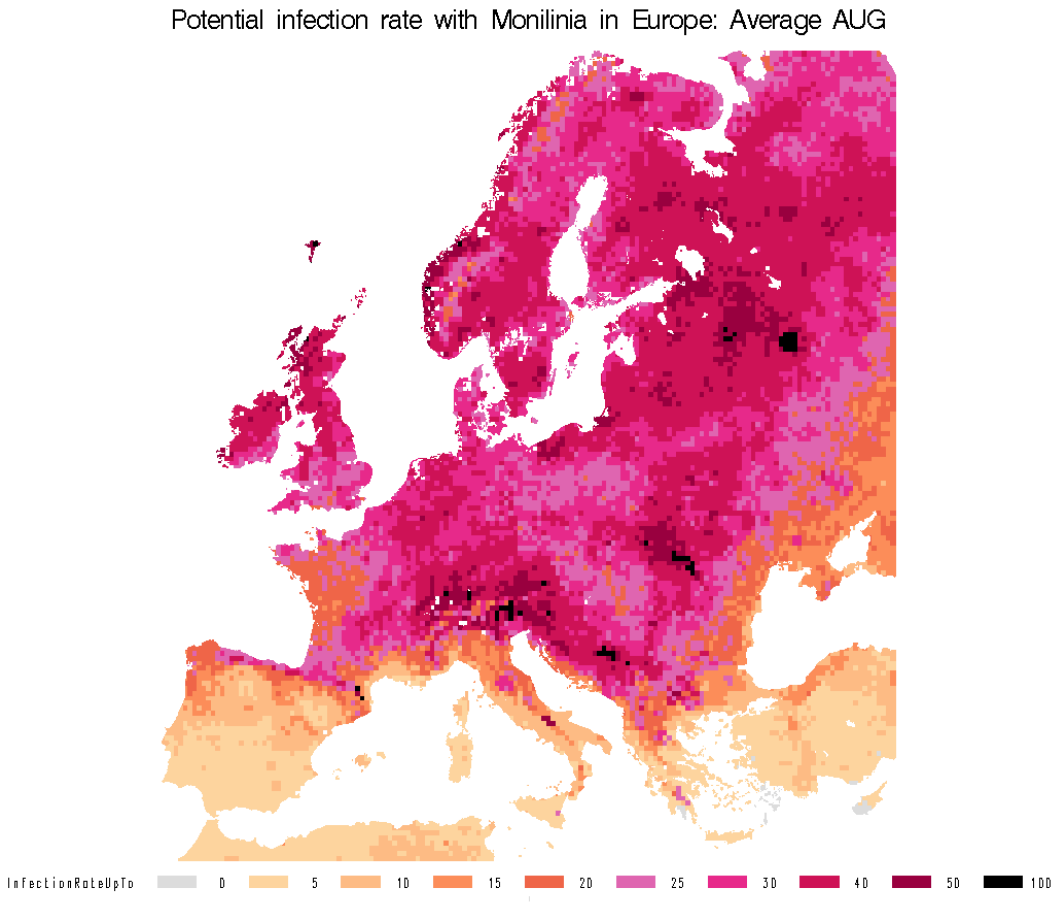
Figure 10: Monthly rate of potential infection with *Monilinia fructicola* for June, average of climatic conditions of the years 2003 – 2007.





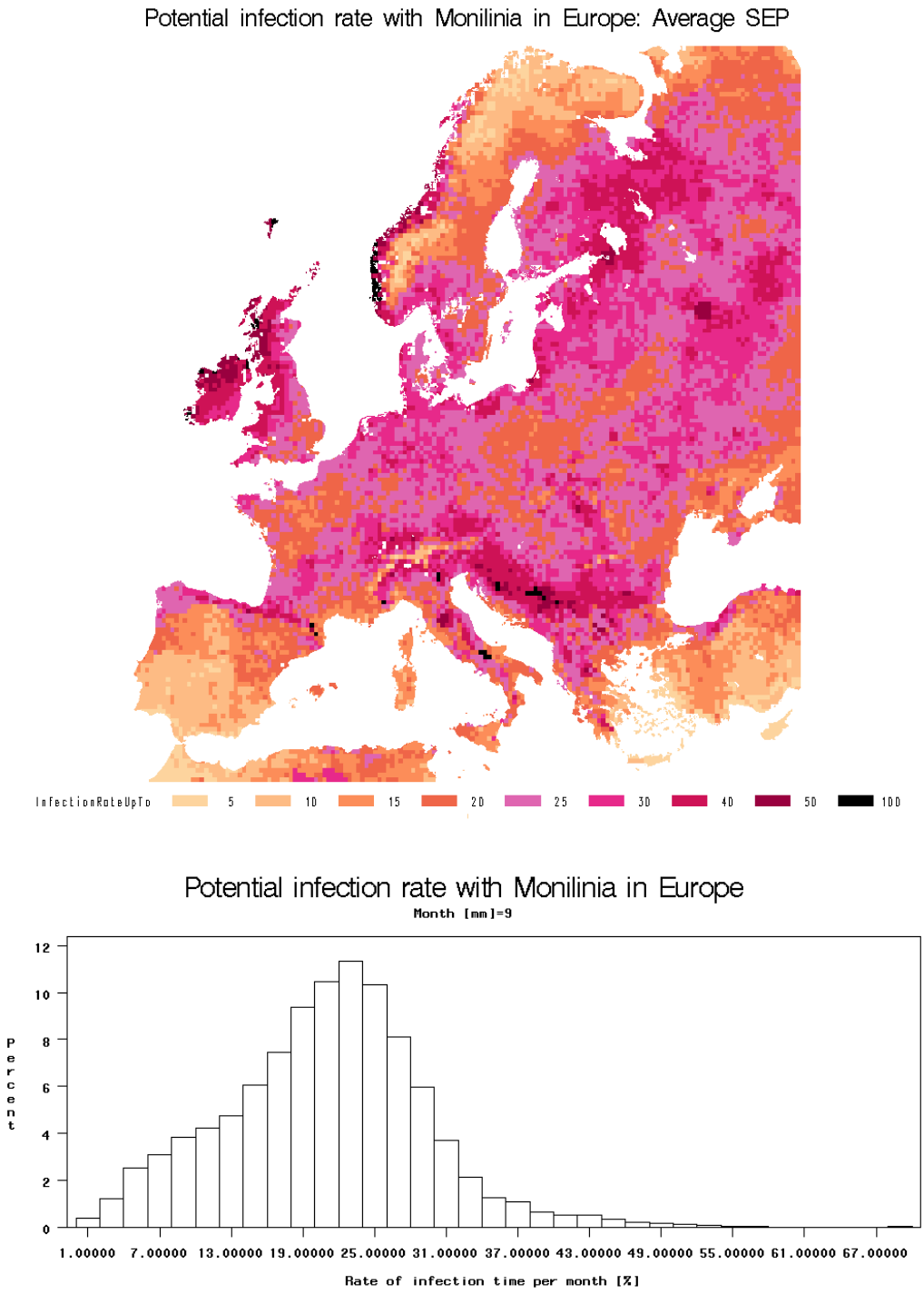
Rate in percent [%] of time with suitable conditions to initiate a potential infection. Colours see axis.

Figure 11: Monthly rate of potential infection with *Monilinia fructicola* for July, average of climatic conditions of the years 2003 – 2007.



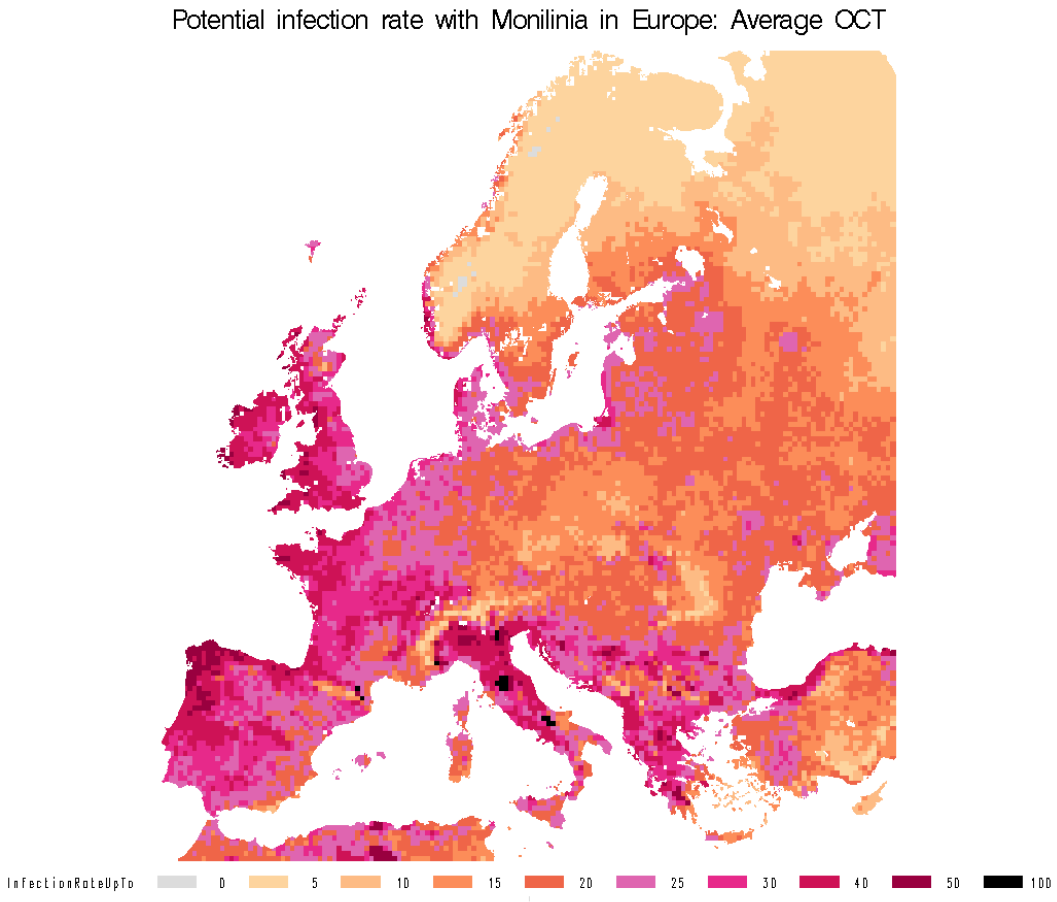
Rate in percent [%] of time with suitable conditions to initiate a potential infection. Colours see axis.

Figure 12: Monthly rate of potential infection with *Monilinia fructicola* for August, average of climatic conditions of the years 2003 – 2007.



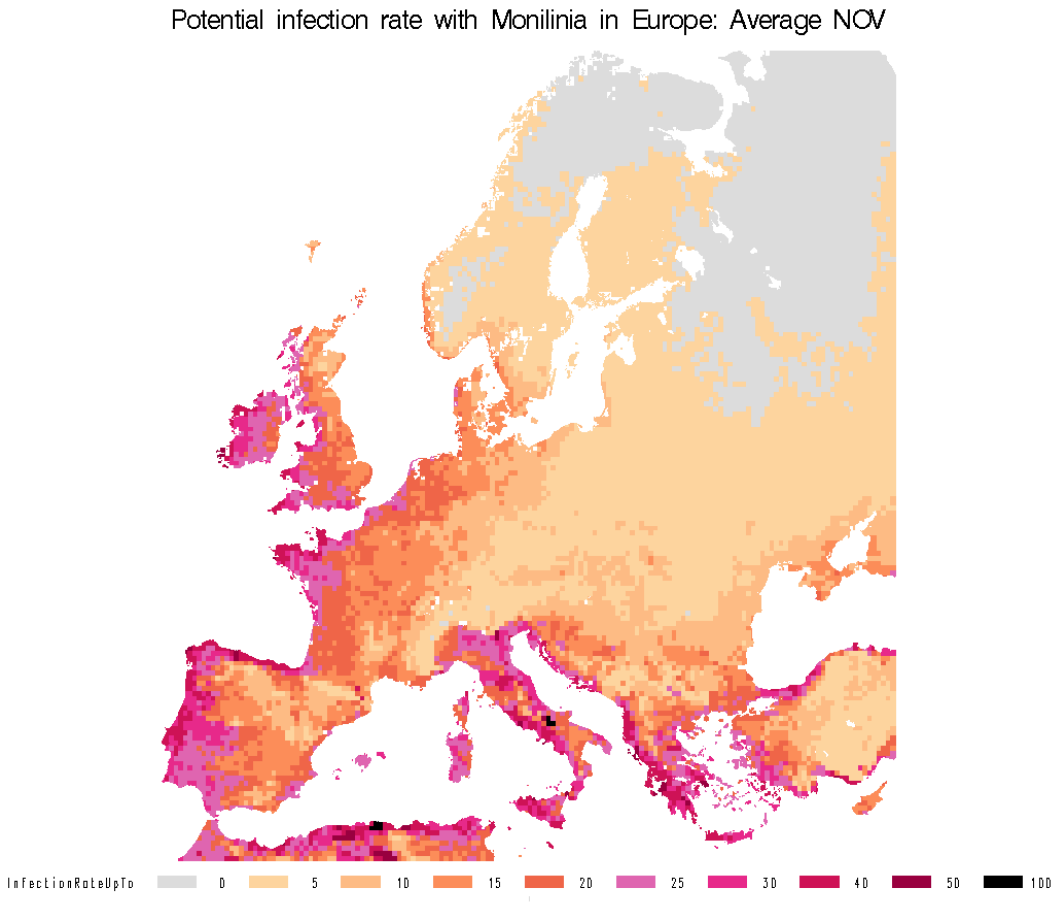
Rate in percent [%] of time with suitable conditions to initiate a potential infection. Colours see axis.

Figure 13: Monthly rate of potential infection with *Monilinia fructicola* for September, average of climatic conditions of the years 2003 – 2007.



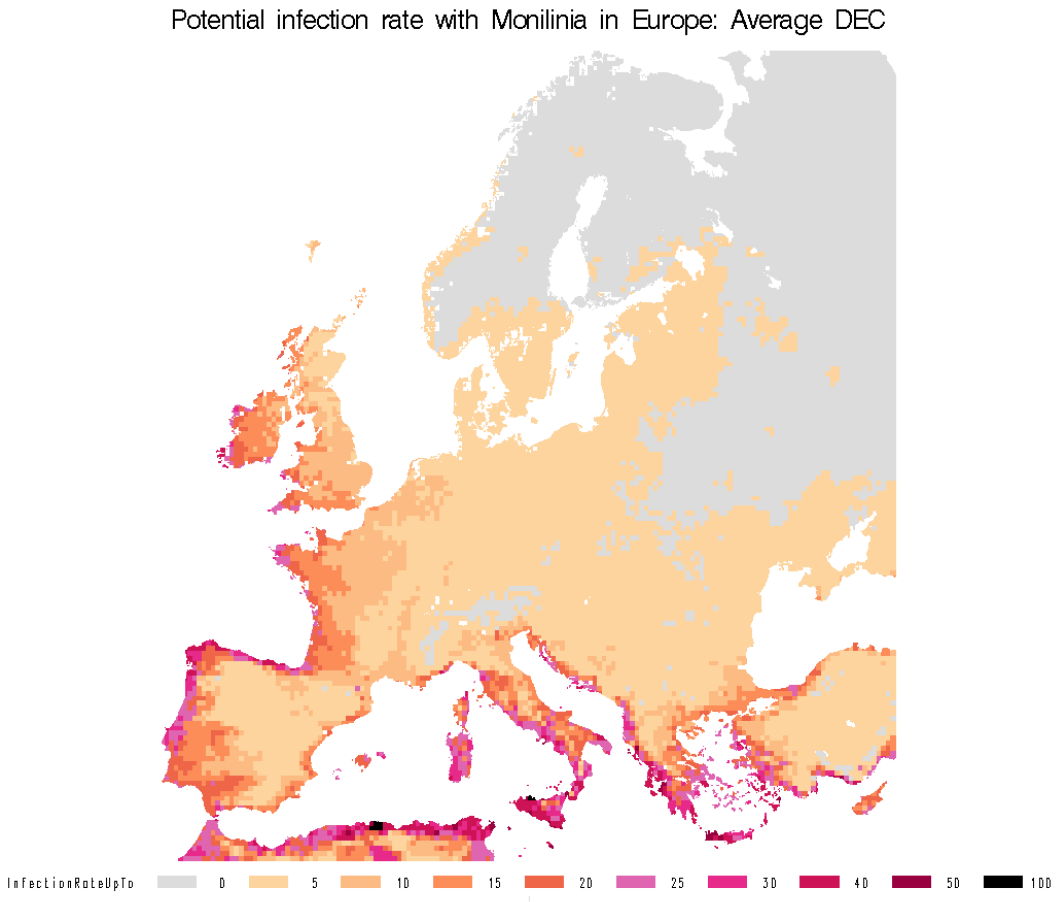
Rate in percent [%] of time with suitable conditions to initiate a potential infection. Colours see axis.

Figure 14: Monthly rate of potential infection with *Monilinia fructicola* for October, average of climatic conditions of the years 2003 – 2007.



Rate in percent [%] of time with suitable conditions to initiate a potential infection. Colours see axis.

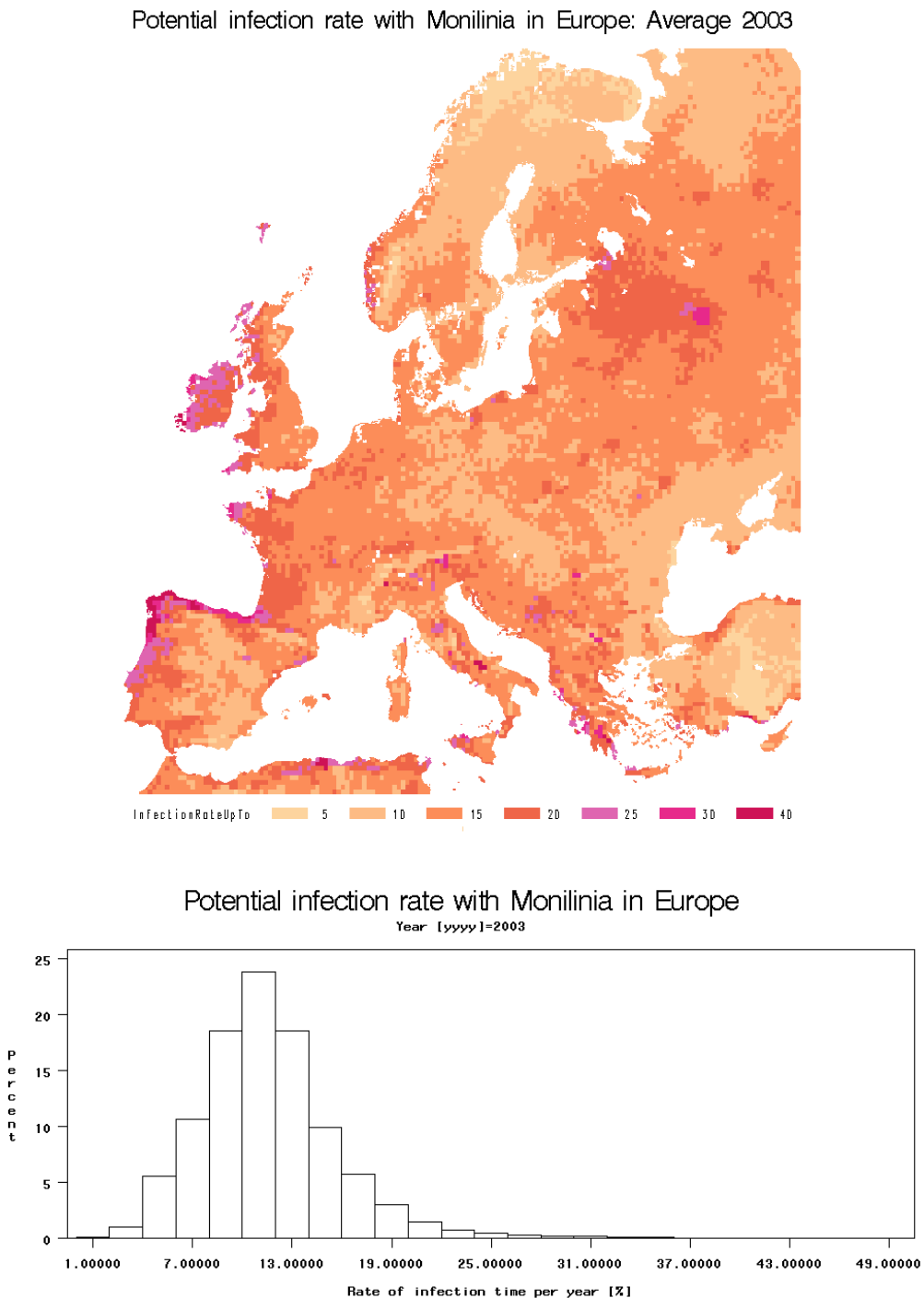
Figure 15: Monthly rate of potential infection with *Monilinia fructicola* for November, average of climatic conditions of the years 2003 – 2007.



Rate in percent [%] of time with suitable conditions to initiate a potential infection. Colours see axis.

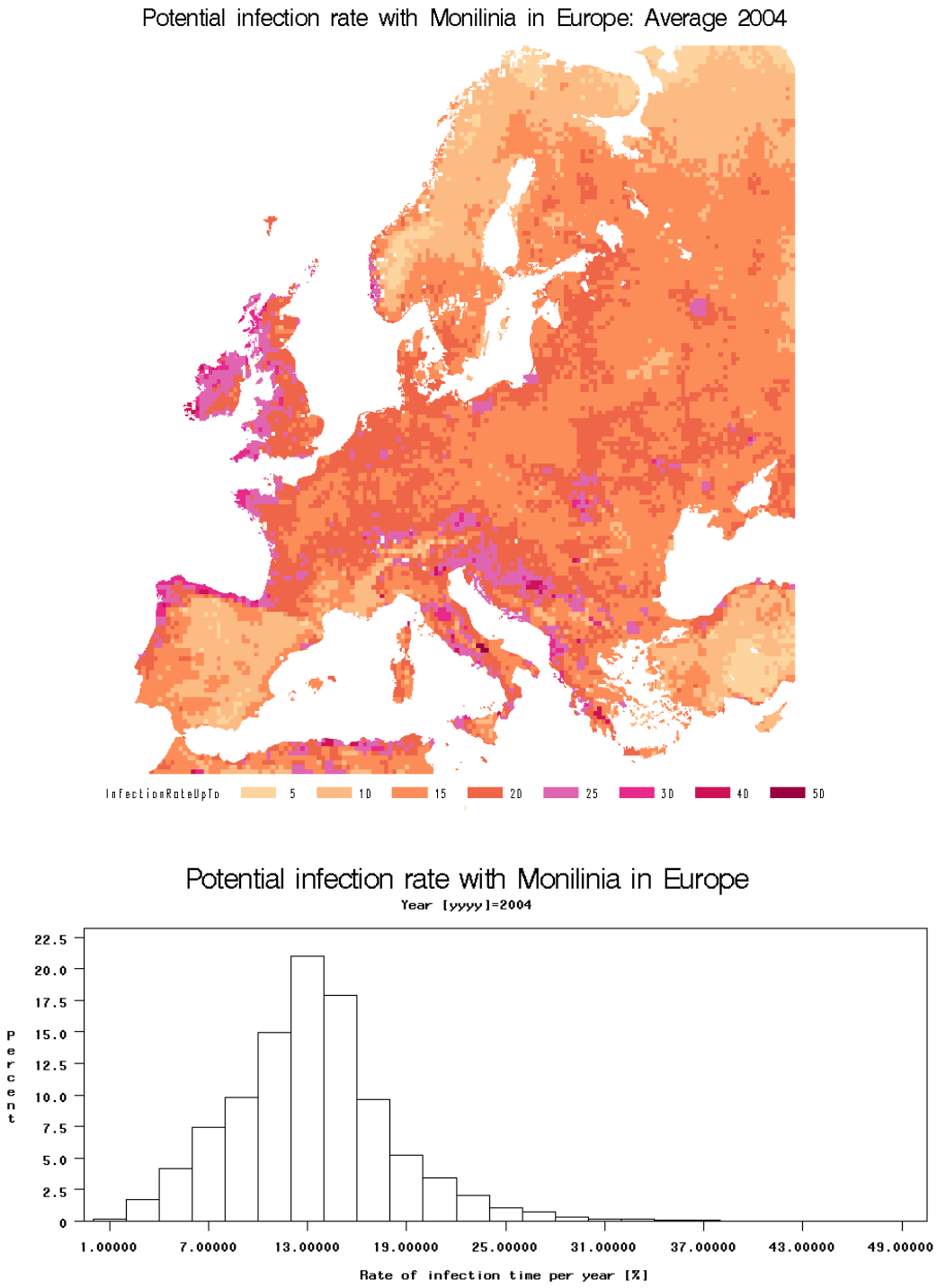
Figure 16: Monthly rate of potential infection with *Monilinia fructicola* for December, average of climatic conditions of the years 2003 – 2007.

2.2. Potential infection rate with *Monilinia fructicola* – yearly variation



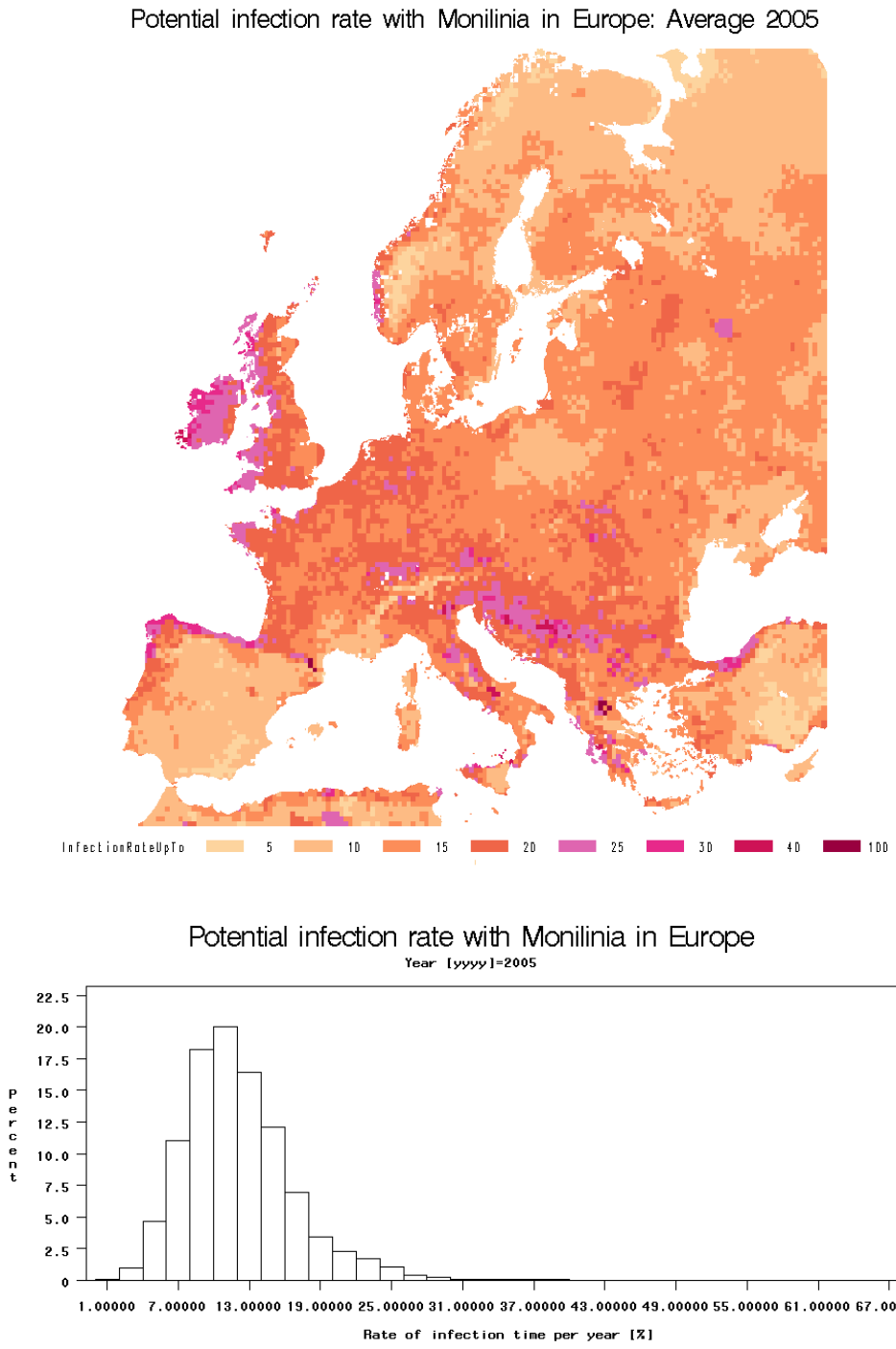
Rate in percent [%] of time with suitable conditions to initiate a potential infection. Colours see axis.

Figure 17: Average rate of potential infection with *Monilinia fructicola* in 2003.



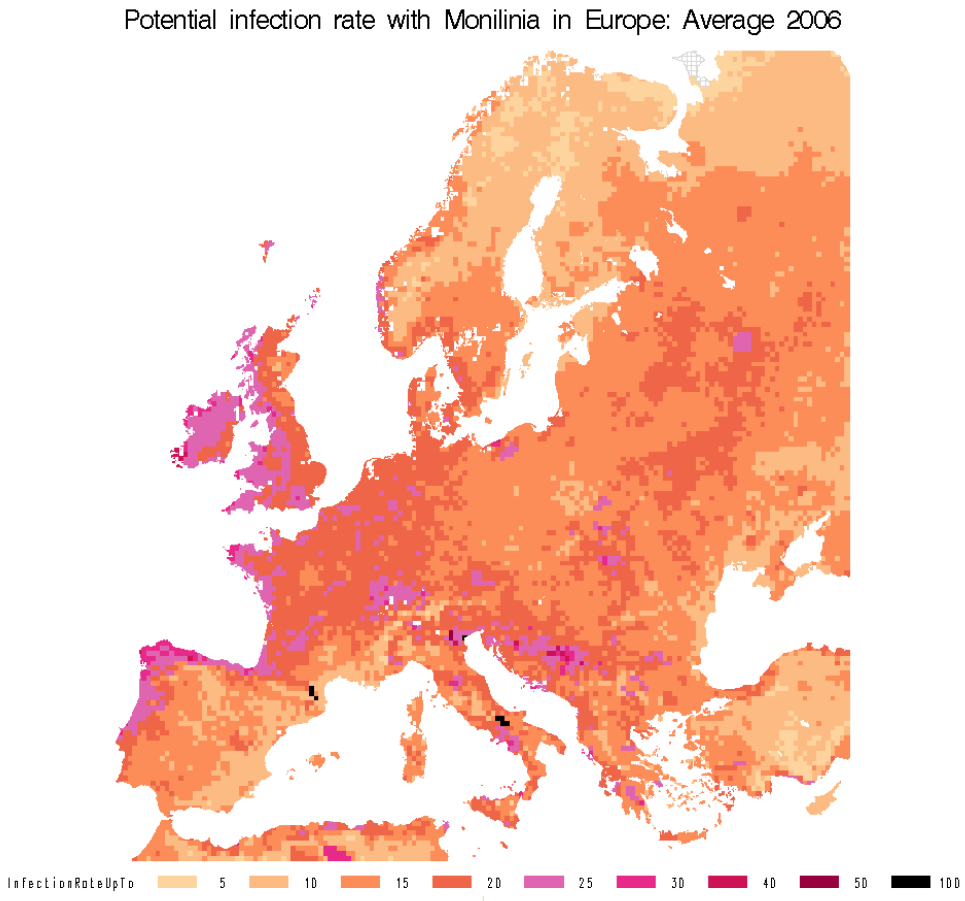
Rate in percent [%] of time with suitable conditions to initiate a potential infection. Colours see axis.

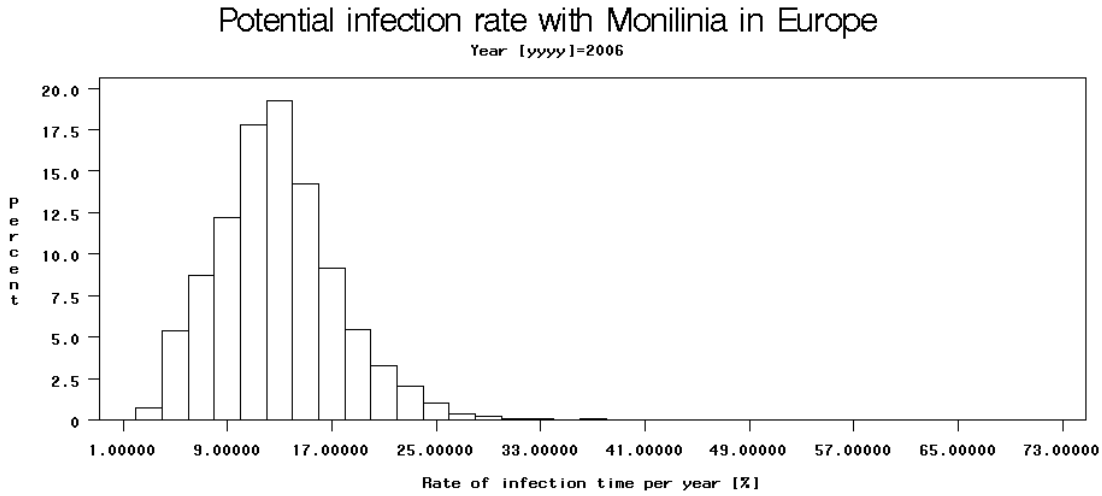
Figure 18: Average rate of potential infection with *Monilinia fructicola* in 2004.



Rate in percent [%] of time with suitable conditions to initiate a potential infection. Colours see axis.

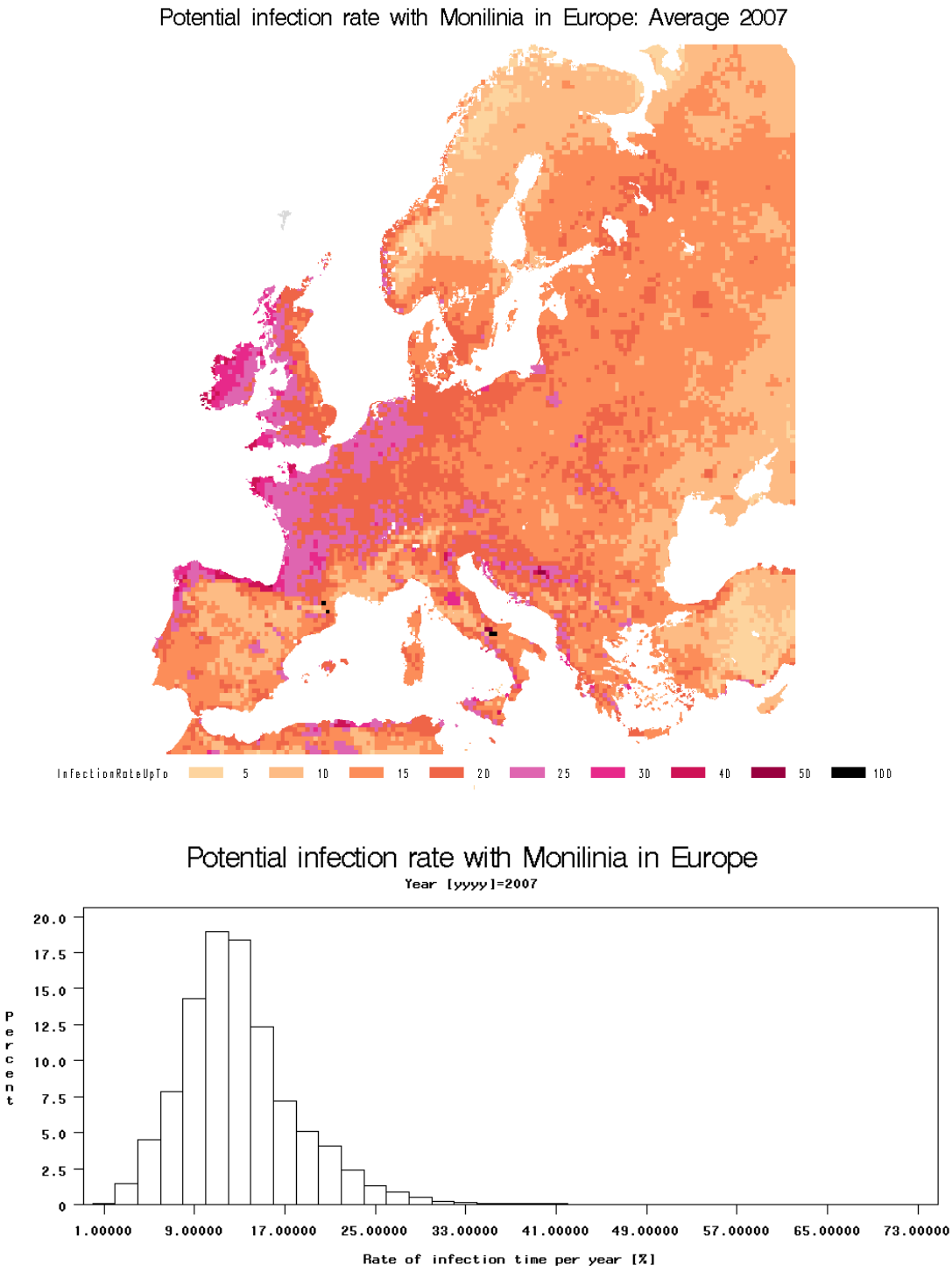
Figure 19: Average rate of potential infection with *Monilinia fructicola* in 2005.





Rate in percent [%] of time with suitable conditions to initiate a potential infection. Colours see axis.

Figure 20: Average rate of potential infection with *Monilinia fructicola* in 2006.



Rate in percent [%] of time with suitable conditions to initiate a potential infection. Colours see axis.

Figure 21: Average rate of potential infection with *Monilinia fructicola* in 2007.

2.3. Discussion

The potential infection model of Magarey et al. (2005) gives the possibility to explain regional and temporal differences of infection with *M. fructicola* in Europe. But the model has some shortcomings which should be discussed:

- The simulation is independent from the appearance of suitable host plants. Because stone fruit trees are widespread in agricultural orchards and private gardens in whole Europe this shortcoming is of minor importance. The time of higher infection rates corresponds also widely with the vegetation period of stone fruit trees: March to September in northern Europe, March to October in Central Europe and February to October in Southern Europe.

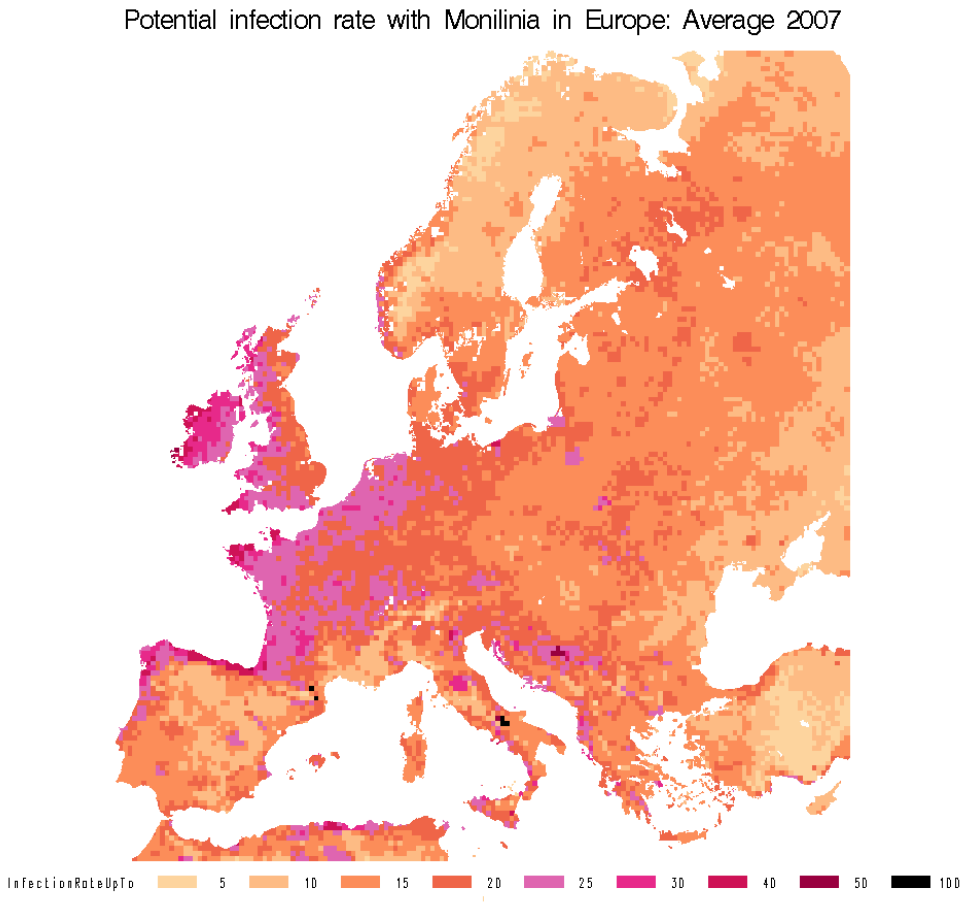
- The simulation calculates the potential infection rate on a regional scale of 25 × 25 km². This means that the results take not into account micro climatic conditions in a specific orchard or on specific geographical sites, like valleys or similar. The interpretation of the rate is therefore more usable for comparison to other locations or to other periods of the year than absolute to describe the actual rate on one site in one specific month.

There is still some uncertainty in the choice of the correct parameters to run the model. The most uncertain parameter is the possible duration of an interruption of the wetness period D_{50}. To explore the sensitivity to this parameter, we calculated an additional run with a possible interruption of D_{50} = 10 h for the year 2007.

The rate of potential infection increases in the year 2007 from 13.0% to 13.3%, but the effect of the choice of the D_{50} parameter on the rate of potential infection is minor. The simulations discussed in Section 2.2 can be seen as reasonable lower estimates of possible infection rates.

Table 5: Regional distribution of potential infection rate for the area of simulation (see Figure 5) for different parameters for possible interruptions D_{50}

D_{50}	**Average rate of potential infection with *Monilinia fructicola* [%] for the year 2007**						
	Mean	Lower quantiles					
		95% above	75% above	50% (Med)	25% above	5% above	max
3 h	13.0	5.6	9.6	12.3	15.4	22.5	73.7
10 h	13.3	5.8	9.8	12.5	15.8	23.1	73.7



Rate in percent [%] of time with suitable conditions to initiate a potential infection. Colours see axis.

Figure 22: Average rate of potential infection with *Monilinia fructicola* in 2007 with D_{50}=10h.

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F. THE GAUSSIAN PLUME MODEL APPLIED TO *MONILINIA FRUCTICOLA*

The Gaussian plume model (GPM) describes dispersal over distances up to kilometres from a source of gasses or particles downwind from a point source. In this model, particle concentrations at a given point depend on the distance from the source, the number of released particles, the wind direction and speed, the amount of mixing in the atmosphere as affected by weather conditions, and the effects of the vegetation on the wind flow (Pasquill, 1974).

The GPM has been used to model the dispersal of pollutant gases (Hinrichsen, 1984; Rao et al., 1979) and it is widely used for this purpose (Lyons and Scott, 1990). It is also used to study the spread of pollen (Di Giovanni et al., 1989), various human pathogens including *Bacillus anthracis* (Hogan, 2006), and for spores of plant pathogens (Aylor, 1990; de Jong, 1988; Pasquill, 1974; Spijkerboer et al., 2002). The GPM is considered as a valuable tool in predictions of the atmospheric transport of fungal spores in risk assessments (Spijkerboer et al., 2002).

In this opinion, the GPM was used to estimate the maximum distance the *M. fructicola* conidia can travel under favourable conditions.

Model description

The spore concentrations C at location (x, y, z) downwind from a source is calculated by equation [1]:

$$[1]\quad C_{x,y,z} = \frac{QE_v}{2\pi u} \cdot \frac{exp\left(-y^2/2\sigma_y^2\right)}{\sigma_y} \cdot \frac{1}{\sigma_z}\left\{exp\left[-\frac{(H-z)^2}{2\sigma_z^2}\right] + R \cdot exp\left[-\frac{(H+z-2d)^2}{2\sigma_z^2}\right]\right\}$$

where:
C (m^{-3}) = spore concentration
x (m) = downwind distance from source
y (m) = horizontal distance from the plume centre
z (m) = height above the surface
Q (s^{-1}) = source strength
E_v (−) = vertical escape fraction of spores
π (−) = mathematical constant (=3.14)
u ($m\ s^{-1}$) = mean horizontal wind speed at 10 m height
σ_y (m) = standard deviation of spore concentration in crosswind direction
σ_z (m) = standard deviation of spore concentration in vertical direction
H (m) = height at which spores are released
R (−) = reflection coefficient
d (m) = displacement height

In equation [1], x, y and z (m) are the coordinates that define the geographic location of the spore source; in this opinion, the source is an orchard were *M. fructicola* was established and there are sporulating lesions. The coordinate system is Cartesian and depends on the location of the source and the wind direction. The source is located in the origin of the Cartesian system at release height H (m) above the soil surface. Its coordinates are (0,0,H). The positive x-axis (i.e., the plume axis) lies in the direction of the mean wind. The z coordinate is the height above the soil surface (m). The y-axis lies in the crosswind direction (see Figure 1).

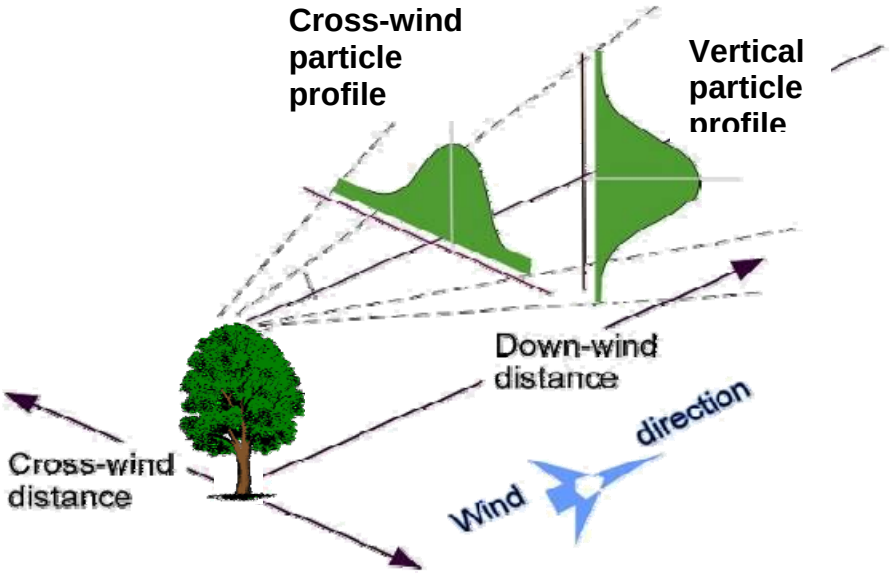

Figure 1: Schematic representation of the coordinate system of the GPM

The first factor of equation [1] describes the number of spores released from the affected orchard and the wind speed. The source strength Q (s^{-1}) is the rate of spore release at the inoculum source. The parameter u (m s^{-1}) is the mean wind speed at 10 m above the soil surface. The vertical escape fraction of spores, i.e., the fraction of spores which escape from the tree canopy, E_v, was derived from de Jong et al. (2002a); Ev increases with increasing mean wind speed, u, and decreases with increasing orchard leaf area index, LAI (−) (leaf area/ground area) based on the following equation:

[2] $$E_v = exp\left(-f\frac{LAI}{\sqrt{u}}\right)$$

where:
f = dimensionless (−) empirical constant.

The second factor of equation [1] describes the height of the plume which is assumed to have a Gaussian crosswind shape with standard deviation σ_y (m) with the peak on the x-axis.

The third factor of equation [1] describes the width of the plume as a Gaussian curve with standard deviation σ_z (m) and a peak at height H (m) and the effect of the surface, assuming that a fraction of R of the plume is reflected at the earth's surface after the first contact. The displacement height d (m) lifts the height at which the plume is reflected over a distance d above the soil. The value of d is calculated following Legg et al. (1981); therefore: $d = 0.78 / h$, where h (m) is the crop height.

The standard deviations σ_y and σ_z determine the height and width of the plume. These parameters depend on the downwind distance from the source (x, m) and on the amount of mixing (turbulence) in the atmosphere. The parameters σ_y and σ_z are calculated with the following empirical functions (Spijkerboer et al., 2000).

[3] $$\sigma_z = K(z_0)ax^b$$

[4] $\sigma_y = K(z_0)10^p x^q$

where:
a, b, p and q = dimensionless (−) empirical constants
$K(z0)$ is a dimensionless (−) correction factor for effects of surface roughness. calculated as:

[5] $K(z_0) = (10z_0)^{0.53x^{-0.22}}$

where:
z_0 (m) = roughness length (a characteristic of the surface cover).

The parameters a, b, p and q of equations [2] and [3] describe the amount of mixing of the atmosphere based on an empirical classification in six stability classes (A to F), where class A is the most unstable atmosphere and F the most stable one (de Jong, 1988). The parameters a, b, p and q have different values, as in Table 1.

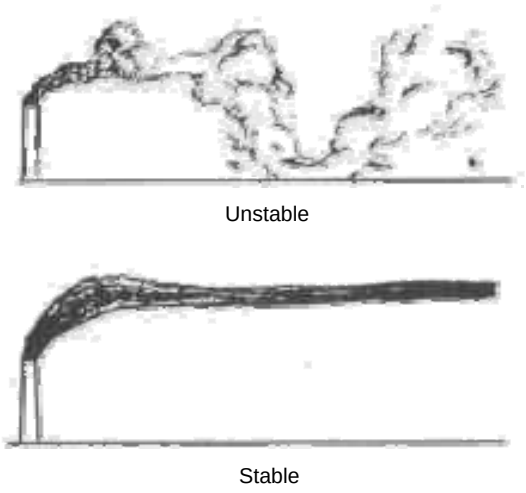

Figure 2: Schematic depiction of plum patterns in unstable and stable atmosphere.

Table 1: Values of stability parameters in the equations [2] and [3] (from de Jong, 1988)

Stability Class / **Parameter**	**A**	**B**	**C**	**D**	**E**	**F**
A	0.28	0.23	0.22	0.20	0.15	0.12
B	0.90	0.85	0.80	0.76	0.73	0.67
P	-0.27819	-0.43063	-0.67985	-0.89279	-1.00877	-1.1879
Q	0.865	0.866	0.897	0.905	0.902	0.902

The roughness length, z_0, represents the height at which the wind speed is = 0. The value of z_0 should be derived from wind speed measurements for each type of vegetation. In this opinion, the formula used by Spijkerboer et al. (2000) to calculate z_0 from the crop height h (m).

Model assumptions

In general, the GPM makes several simplifying assumptions: 1) the source of the particles is a point; 2) weather conditions do not vary over time or location; 3) the released particle behaves as a gas (that have the same density of the air); 4) the particles does not settle out of the air or otherwise decay (such as might occur due to chemical reactions with air or sunlight); 5) the terrain is flat (Hogan, 2006). These assumptions have been considered reasonable for the dispersal of *Bacillus anthracis* spores (Meselson et al., 1994). In this opinion: assumption 1) seems reasonable because *M. fructicola* is usually established in single orchards; assumption 2) does not affect the model results because the GPM runs under optimum conditions for dispersal, with stability class F of the atmosphere and mean horizontal wind speed at 10 m height $u = 3$ m s^{-1} (see Model parameteristion); assumption 3) should be not influential because of the small size of the *M. fructicola* conidia (14.5-16 × 9.5-11 µm) (OEPP/EPPO, 1997); assumption 4) introduces uncertainty in the opinion, even though *M. fructicola* conidia are able to survive dryness (Xu et al., 2001); assumption 5) means that the results from using the GPM in this opinion can not be applied to situations where hills or mountains separate two orchards.

Model parameterisation

The model was applied as deterministic and probabilistic. The following parameters were defined for the application of the two model types. Parameterisation of the deterministic model was developed in such a way to consider the reasonable worst case, i.e., maximum distance the spore can travel in wind direction. The probabilistic scenario was chosen in such a way to analyse the influence of the different model parameters on the model output.

Spore concentration, C. We evaluate only the spore density only in wind direction at the ground surface, i.e., $C(x)$, with:

$y = 0$ m

$z = 0$ m

Strength of inoculum source, Q. We do not have precise data on both amount and dynamic of *M. fructicola* spores released from infected trees. For this reason, we set $Q = 100$ and then we express our spore concentrations C downwind from the source as a percent of the spores released at the source.

Spores escaping the source, E_v. For calculating E_v, following de Jong et al. (2002b), we set the empirical constant f of equation [2] at:

$f = 0.934$

Leaf area index of stone fruit trees, *LAI*. The leaf area index is the ratio of total leaf surface and ground area of a crop. For stone fruit trees the leaf area index is assumed as $LAI = 5$. To model variation we assume a uniform distribution from 3 to 6.

LAI = UNIFORM[3, 6]

Wind speed at 10 m above soil, u. In the scenario, a minimal weed speed of $u = 3$ m s^{-1} was chosen. To model the wind speed variation we assume a uniform distribution from 3 to 7 m s^{-1} (source: European Wind Speed Map, www.windatlas.dk/Europe/About.html):

u = UNIFORM[3, 7]

Height of the spore source, *H*. The spore releasing source is located in the half height of the stone fruit tree (i.e., $c = 0.5$). In the probabilistic model, we allow a uniform variation in the upper two thirds of the tree; therefore:

$$c = \text{UNIFORM}[0.333, 1]$$

with:

$$H = c \cdot h$$

Height of the crop, *h*. The height of the stone fruit tree is set to 3 m. To model the variation we assume a triangular distribution with a minimum of 2 m, a modus of 3 m, and a maximum of 4 m:

$$h = \text{TRIANGULAR}[2\text{m} \mid 3\text{m} \mid 4\text{m}]$$

Reflection coefficient, *R*. In the deterministic scenario R = 1, which is 100% reflection. To model the variation, we assume a uniform distribution from 50% to 100%:

$$R = \text{UNIFORM}[0.5, 1]$$

Distance at which the plume is reflected, *d*. Legg et al. (1981) estimated the zero-plane displacement for potatoes and found $r = 0.78$ as appropriate ratio to the actual height of the crop. We have no information regarding stone fruit trees and then we take this value as constant:

$$d = r \cdot h$$

Roughness length of surface cover, z_0. Legg et al. (1981) estimated the roughness length for potatoes and found $g = 0.041$ as appropriate ratio to the actual height of the crop. We have no information regarding stone fruit trees and take this value as constant:

$$z_0 = g \cdot h$$

Stability class of the atmosphere, *SC*. To estimate the reasonable wide spread the most stable class (SC=F) was assumed. To model the variation we took a discrete uniform distribution on all six classes.

$$\text{SC} = \text{UNIFORM}\{\text{A, B, C, D, E, F}\}$$

Simulations

All computations were done with the simulation software @RISK version 3.5, using 10000 simulation runs. The sensitivity of the outcome variable C was judged using standardized regression coefficients.

The comparison of the deterministic model with the probabilistic one shows that the former model gives an upper estimation of the spore concentration than the average of the latter model starting from 20 m in downwind direction from the source (see Table 1). For both models, the highest conidia concentration is at 20 to 30 m in direction of wind. No spores are present at 10 km from the source. Very few conidia can be found farther than 500 m from the source (see Figure 1). No more than 0.01% of the conidia released at the source can be found far than 500 m (see Figure 2).

Table 2: Concentration of *Monilinia fruticola* conidia at different distances from the source, as simulated by the Gaussian Plum Model in deterministic and probabilistic versions. Conidial concentrations are expressed as a percentage of the conidia released at the source.

Distance in wind direction (m from the source)	Deterministic reasonable worst case model	Probabilistic Model			
		Mean	Standard deviation	5th Percentile	95th Percentile
10	0.0228	0.0992	0.0917	0.0026	0.2788
15	0.0868	0.0949	0.0797	0.0178	0.2505
20	0.1039	0.0847	0.0698	0.0167	0.2200
30	0.1016	0.0656	0.0563	0.0097	0.1764
50	0.0789	0.0415	0.0406	0.0042	0.1229
75	0.0571	0.0264	0.0286	0.0021	0.0856
100	0.0427	0.0184	0.0211	0.0013	0.0647
150	0.0265	0.0106	0.0129	0.0006	0.0402
200	0.0182	0.0070	0.0088	0.0004	0.0274
300	0.0103	0.0038	0.005	0.0002	0.0155
500	0.0049	0.0017	0.0023	0.0001	0.0073
750	0.0026	0.0009	0.0013	0.0000	0.0040
1000	0.0017	0.0006	0.0008	0.0000	0.0025
1500	0.0009	0.0003	0.0004	0.0000	0.0014
2000	0.0006	0.0002	0.0003	0.0000	0.0009
3000	0.0003	0.0001	0.0001	0.0000	0.0005
5000	0.0001	0.0000	0.0001	0.0000	0.0002
7500	0.0001	0.0000	0	0.0000	0.0001
10000	0.0000	0.0000	0	0.0000	0.0001

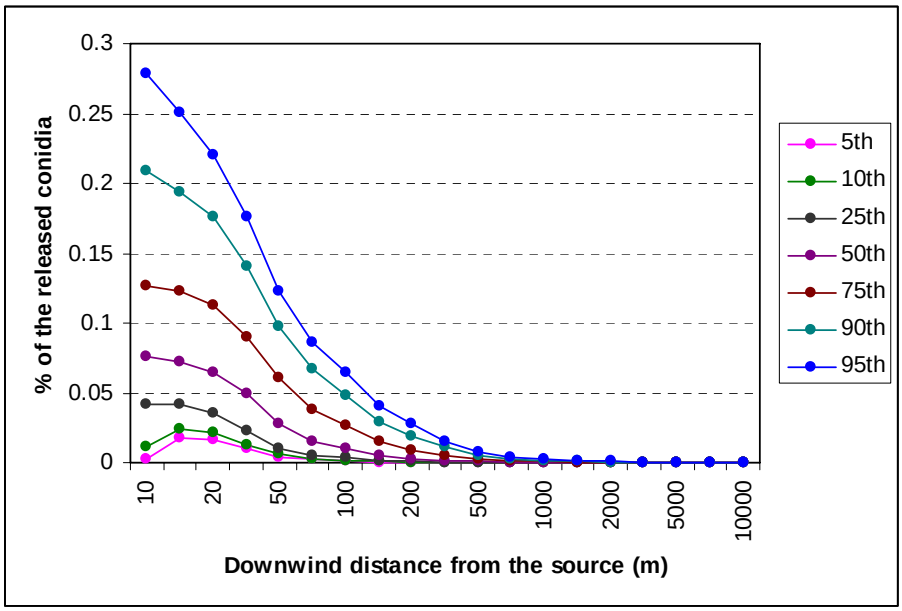

Figure 3: Distribution of conidia of *Monilinia fruticola* at different distances in wind direction calculated with the probabilistic model.

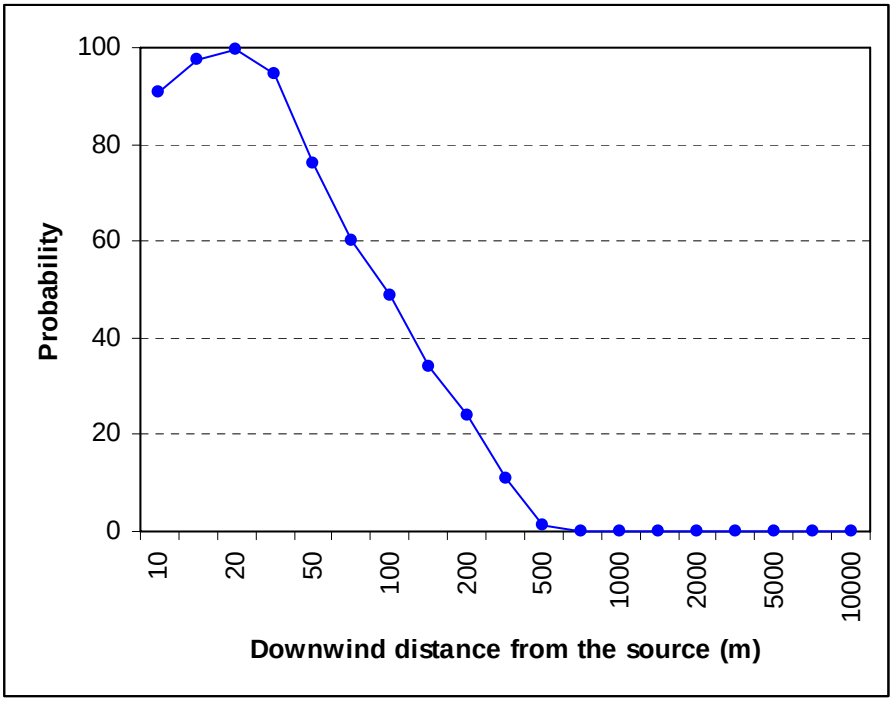

Figure 4: Probability (%) that more than 0.01% of the conidia of *Monilinia fruticola* released at the source are present at different distances in wind direction, as calculated with the probabilistic model.

The sensitivity analysis of the probabilistic model shows that most variation in the conidia concentration is caused by the different stability classes of the atmosphere (85.9% of total variation) while minor parts came from the varying LAI (13.4%). Variation in crop height, reflection, wind speed and the height of the source account for a few part of variability. This result demonstrates that the model output are robust enough when the worst case is considered for the stability of the atmosphere, which is stable atmosphere.

The effect of some other parameters was not considered in the probabilistic model, like the zero-plane displacement or the roughness of the surface. These parameters depend from the characteristics of the site where the spore source is located and may vary with locations. A more realistic scenario can be developed only referring to a particular site where *M. fructicola* is already established.

Table 3: Sensitivity of the GPM for conidia concentration of *Monilinia fructicola* (at 100 m from the source in wind direction) to some model parameters.

Model parameter		**Regression coefficients (R^2=0.749)**	**% of total variation**
Stability class of the atmosphere	*SC*	0.802	85.9
Leaf area index	*LAI*	-0.317	13.4
Height of the crop (m)	*h*	-0.075	0.8
Reflection coefficient	*R*	0.067	0.6
Mean horizontal wind speed at 10 m height (m s^{-1})	*u*	-0.025	0.1
Height of the inoculum source (fraction of *h*)	*c*	-0.009	0.0

In conclusion, it can be considered that in reasonable circumstances the spread of *M. fruticola* conidia is possible up to 500 m in wind direction from any inoculum source, i.e., an affected tree with sporulating lesions.

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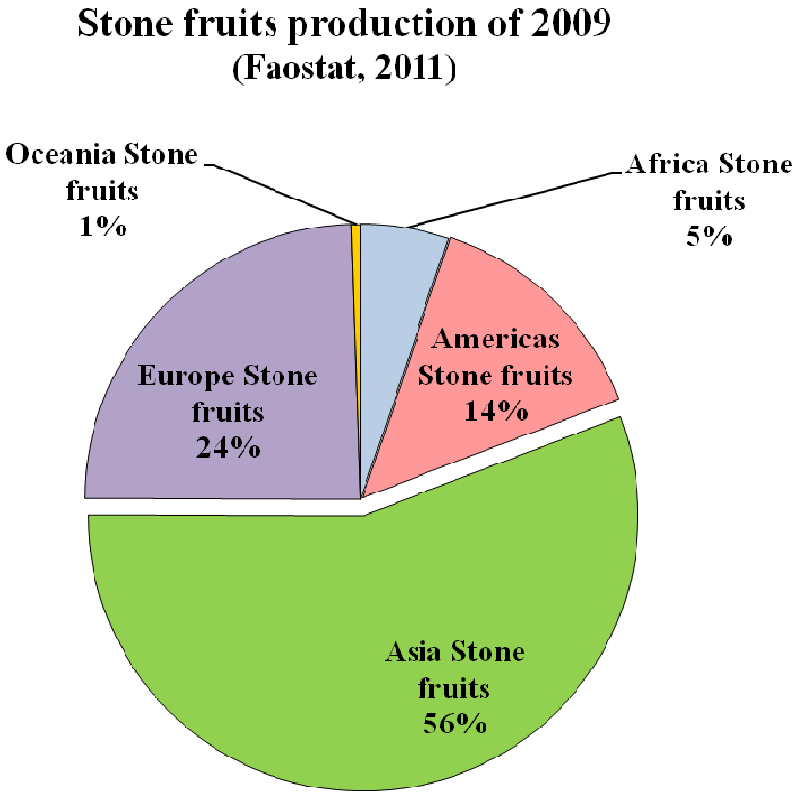
G. STONE FRUIT PRODUCTION



country		Item	year 2008		2009	
	World (Total)	Almonds, with shell	2420189	A	2311682	A
		Apricots	3758936	A	3831823	A
		Cherries	1802231	A	2150107	A
		Peaches and nectarines	18428913	A	18579393	A
		Plums and sloes	10217435	A	10679206	A
	Africa (Total)	Almonds, with shell	205773	A	213605	A
		Apricots	480753	A	514326	A
		Cherries	13489	A	16825	A
		Peaches and nectarines	888034	A	936368	A
		Plums and sloes	265886	A	281071	A
	Americas (Total)	Almonds, with shell	1421060	A	1173760	A
		Apricots	120530	A	108299	A
		Cherries	301082	A	473624	A
		Peaches and nectarines	2489341	A	2381862	A

		Plums and sloes	1018836	A	1091528	A
	Asia (Total)	Almonds, with shell	433549	A	458171	A
		Apricots	2332806	A	2302330	A
		Cherries	771100	A	892241	A
		Peaches and nectarines	10663096	A	10864914	A
		Plums and sloes	6332279	A	6479892	A
	Europe (Total)	Almonds, with shell	340807	A	447189	A
		Apricots	804020	A	889695	A
		Cherries	704930	A	751790	A
		Peaches and nectarines	4249326	A	4270861	A
		Plums and sloes	2574993	A	2808152	A
	European Union (Total)	Almonds, with shell	338654	A	444016	A
		Apricots	623268	A	667148	A
		Cherries	489753	A	546840	A
		Peaches and nectarines	4092234	A	4100109	A
		Plums and sloes	1351205	A	1489794	A
	Oceania (Total)	Almonds, with shell	19000	A	18957	A
		Apricots	20827	A	17173	A
		Cherries	11630	A	15627	A
		Peaches and nectarines	139116	A	125388	A
		Plums and sloes	25441	A	18563	A

A = May include official, semi-official or estimated data
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Aggregates are the sum of available data. Aggregates in 2009 include estimated data. For some item aggregates, conversion factors are applied to values when calculating totals. Please see item Metadata for the factors.

H. BLANK EFSA QUESTIONNAIRE FORM

Request for information on *Monilinia fructicola* in the EU Member States (EU27)

Please indicate the EU Member State you represent: .....

1. Do you perform surveys for *Monilinia fructicola*? YES ☐ NO ☐

If yes

- Please give the total number of administrative units (regions/counties/departments/provinces/federal states etc.) in your country, according to the organization of surveys: .....

  (e.g. 12 provinces in The Netherlands, 9 federal states in Austria, etc.)

- Please describe the survey method (random or targeted sites, number of inspections etc.) and diagnostic method(s) used:

  .....
  .....
  .....

2. Are there administrative units within your country where, based on surveys, the pest is **known NOT to occur?**
   YES ☐ NO ☐

- If yes, please list the administrative units where the pest is known NOT to occur and the year when the last survey was performed in the region

Administrative unit(s)	Year of last survey	Administrative unit(s)	Year of last survey

3. If *Monilinia fructicola* has been detected, please indicate the country status: ☐

   widespread (W); localized (L); occasionally present (O); reported in the past, but no longer present (D); eradicated (E); under eradication (U) intercepted on plants/produce (I)

Please provide further details of occurrence/findings in the table below:

Administrative Unit	Year of confirmed findings[1]	Distribution in the administrative unit[2]	Place of occurrence (nurseries / orchards / gardens &urban sites / storehouses / markets / at border stations with third countries / etc[3]	Host plant species[4]

[1] List the regions/departments/provinces/federal states, etc. where the pest has occurred and the year of detection for all findings
[2] Indicate the current distribution of the pest in each administrative unit using the following codes: widespread (W); localized (L); occasionally present (O); reported in the past, but no longer present (D); eradicated (E); under eradication (U); intercepted only on plants/produce (I)
[3] Indicate for each administrative unit if the pest occurs (or occurred in the past) using the following codes: nurseries (N),orchards (O), gardens and urban sites (GU), storehouses (S), markets (M) / border stations with third countries (B), or other (please name).
[4] Indicate on which host plant species the pest has been detected in your country (or individual administrative units of your country)

1

4. If *Monilinia fructicola* has been detected in your country, please indicate the official measures applied in order to prevent spread of the pest from infested to non-infested areas? Please provide any information to indicate the effectiveness of the measures undertaken.

   .....
   .....
   .....
   .....

5. In areas where *Monilinia fructicola* is recorded as present more detailed information on location, incidence, recorded damage etc. is sought. Please indicate additional contacts where appropriate:

Location where the pathogen has been detected	In nurseries / orchards/ gardens & urban sites	Year(s) of detection	Damage Estimate e.g % Yield reduction	Incidence (frequency or % positive samples)

[1]Indicate where surveys are performed using the following codes: nurseries (N), orchards (O), gardens and urban sites (GU), storehouses (S), markets (M), or other (please name)

Name:

Signature:

PLEASE RETURN THE COMPLETED QUESTIONNAIRE TO SARA.TRAMONTINI@EFSA.EUROPA.EU BY 7th JAN 2011

THANK YOU!

It is intended that the information provided (Q 1-4) will be included as an Annex in the opinion of the Panel on Plant Health which will be published on the EFSA website. You will have a further opportunity for review of the prepared Annex prior to publication. Use and disclosure of location data kindly provided to assist in determining current distribution of *Monilinia fructicola* in the EU will respect the "Rules on use, disclosure and re-use of data on pest findings" recently agreed at SCPH on 25th November.

2

I. RESULTS OF THE QUESTIONNAIRE

Country	Do you perform surveys for *Monilinia fructicola*?	Administrative units where the pest is known NOT to occur	If *Monilinia fructicola* has been detected, please indicate the country status	official measures applied
Belgium	YES 10 provinces 2002 monitoring survey after French findings: visual inspections + PCR analysis for suspected samples. 2006: 43 inspections and 18 samples 2007: 18 inspections on 41 parcels and 20 samples 2008: 43 inspections on 83 parcels and 18 samples 2009: 34 inspections and 16 samples 2010: 43 inspections and 25 samples Confirmed status "Absent, confirmed by survey" Available a detailed description of the detection method	YES entire country	Absent, confirmed by survey	
Czech Republic	YES 14 regions 2009: 468 phytosanitary inspections and 82 analysed samples. 2010: 445 phytosanitary inspections and 43 analysed samples.	YES List of the administrative units where the pest is known NOT to occur in		

	Surveys in orchards, nurseries, public green sites, forestry sites, garden centres. Diagnostic methods: cultivation methods according to PM 7/18(2) – evaluation after 10 days, PCR method Cote et al., 2004, PCR method Ioos, Frey 2000.	2010: entire country		
Denmark	YES 1 2006-2008 survey on orchards with samples of symptomatic trees. Since 2006 all fruit tree nurseries inspected twice a year. Samples tested with incubation on nutrient agar and microscopy; PCR not used.	YES Whole country		
Estonia	*Monilinia fructicola* has never been found in Estonia, also no surveys have been performed.			
Finland	NO	Whole Finland is considered as an area where *Monilinia fructicola* is not known to occur. No findings have been made.		
Hungary	YES 19 counties	YES 4 in 2010:	L	Applied measures: Place the area under

	2007: 214 inspections 2008: 251 inspections 2009: 114 inspections 2010: 75 inspections Diagnostic methods: - the PM 7/18 (2) EPPO Standard - the method described by Coté et al.	Baranya County, Békés County, Fejér County, Hajdú-Bihar County	**Administrative Unit**	**Year of confirmed findings**	**Distribution in the administrative unit**	**Place of occurrence (nurseries / orchards / gardens &urban sites / storehouses / markets / at border stations with third countries / etc.**	**Host plant species**	quarantine, sculling of the fruits, destruction of infected plant parts, permission for sales only the part of the crop free from the disease, mandatory spraying programme Use of surveys The number of findings has fairly decreased from 2007 to 2010, indicating the effectiveness of the measures undertaken
			Bács-Kiskun County	2007	(3 findings)	orchards, gardens &urban sites	*Prunus cerasus, P. armeniaca, Pyrus communis*	
			Borsod-Abaúj-Zemplén County	2007	(3 findings)	orchards	*Prunus avium, P. armeniaca, P. domestica*	
			Csongrád County	2007	(2 findings)	gardens & urban sites	*Prunus avium, P. cerasus*	
			Győr-Moson-Sopron County	2007	(2 findings)	gardens & urban sites	*Prunus avium*	
			Heves County	2007	(2 findings)	gardens & urban sites	*Prunus cerasus, P. domestica*	
			Komárom-Esztergom County	2007	(1 finding)	orchards	*Prunus avium*	
			Nógrád County	2007	(1 findings)	gardens & urban sites	*Prunus domestica*	
			Főváros és Pest County	2007	(14 findings)	orchards, gardens &urban sites	*Prunus avium, P. cerasus, P. armeniaca, P. persica, P. domestica*	
			Somogy County	2007	(1 finding)	gardens & urban sites	*Prunus armeniaca*	
			Szabolcs-Szatmár-	2007	(3 findings)	orchards,	*Prunus*	

			Bereg County			gardens &urban sites	*cerasus*, *Malus domestica*	
			Jász-Nagykun-Szolnok County	2007	(13 findings)	orchards	*Prunus avium*, *P. domestica*	
			Tolna County	2007	(1 finding)	orchards	*Prunus armeniaca*	
			Veszprém County	2007	(1 finding)	orchards	*Prunus avium*	
			Zala County	2007	(10 findings)	orchards, gardens &urban sites	*Prunus avium*, *P. cerasus*	
			Imported	2007	(11 findings)	markets	*Prunus persica*	
			Bács-Kiskun County	2008	(2 findings)	gardens &urban sites	*Prunus avium*, *P. domestica*	
			Főváros és Pest County	2008	(1 finding)	orchards	*Prunus domestica*	
			Imported	2008	(1 finding)	markets	*Prunus domestica*	
			Vas County	2009	(1 finding)	gardens &urban sites	*Prunus persica*	
			Bács-Kiskun County	2010	(3 findings)	orchards	*Prunus domestica*, *P. persica*	
			Borsod-Abaúj-Zemplén County	2010	(1 finding)	orchards, gardens &urban sites	*Prunus domestica*	
			Heves County	2010	(1 finding)	gardens &urban sites	*Prunus domestica*	
			Jász-Nagykun-Szolnok County	2010	(1 finding)	orchards	*Prunus avium*	
Italy	YES 19 regions + 2 autonomous provinces Surveys only In Emilia-Romagna, from 2004, organized in cooperation with the extension service agents employed by	NO						During winter periods, mummies should be collected and destroyed, while in the vegetative season, treatments as indicated

	the regional producing associations. All of the agents were alerted about the introduction risk and were invited to take samples, above all, in stone fruits orchards. Up to last year, the number of samples ranged from about ten to about 50 each year. Following the detection of *M. fructicola* on mummies in the last winter, in 2010, 296 samples were taken and 52 tested positive to *M. fructicola* (in 41 farms). In nurseries, verbal instructions were given to the inspectors to collect eventual suspect *Monilia* samples from the plants during the official inspections. Diagnostic method: direct isolation on a growing media (PDA), followed by PCR (EPPO protocol PM 7/18) on growing colonies. Sometimes the PCR was employed directly on infected tissues. Some samples were tested in Bologna University to verify the presence of an eventual fungicide resistance, but all were negative.		**Administrative Unit**	**Year of confirmed findings**	**Distribution in the administrative unit**	**Place of occurrence (nurseries / orchards / gardens &urban sites / storehouses / markets / at border stations with third countries / etc.**	**Host plant species**	in the IPM protocols should be performed, infected shoots should be pruned and destroyed and infected fruits should be collected, taken away from the orchard and destroyed Important: 2010 growing season was really suitable to fungal diseases (very wet) and during the investigations on the positive cases, it was found that, sometimes, the suggested treatments were sprayed in a wrong period.
			Piemonte	2009	(L) in stone fruit growing area	Orchards	*Prunus persica* var.*nectarina*	
			Emilia-Romagna	2010	(L) in stonefruit growing area (Bologna, Ravenna and Forlì-Cesena provinces)	Orchards	*Prunus persica* var.*nectarina*, *P. persica*, *P. domestica* and *P. salicina*	
			Veneto	2010	Intercepted by Member States on marketed fruits	Orchards	*Prunus persica* var.*nectarina*	

<table>
<tr><td></td><td></td><td></td><td>The damage rate observed in the infected orchards varies from few fruits up to more than 60 % of infected fruits. But Monilia fructicola has always been detected together to one or both of the other Monilia species, so it is really difficult to estimate the actual damage caused by the single pathogen.</td><td></td></tr>
<tr><td>Latvia</td><td>NO
7 regions

not specific survey but visual inspections in nurseries and orchards.

There are two samples tested in 2010 on Monilinia fructicola: it was not found.</td><td>NO</td><td></td><td></td></tr>
<tr><td>Poland</td><td>YES
16 provinces

Visual inspections of Monilinia fructicola on Malus sp., Prunus sp. and Pyrus sp.
2008: 1478 checks
2009: 1136 checks
2010: 1936 checks (+ 180 samples: minimum of 6 samples/province)

Until 2009 most of the controls were in nurseries and propagation material and samples were taken for lab testing only in case of occurrence.
Since 2010 controls and samples are in orchards too.</td><td>YES

8 provinces in 2010: Greater Poland, Opole, Podlaskie, Pomeranian, Silesian, Subcarpathian, Świętokrzyskie, Warmian-Masurian</td><td>L + U
<table>
<tr><th>Administrative Unit</th><th>Year of confirmed findings</th><th>Distribution in the administrative unit</th><th>Place of occurrence (nurseries / orchards / gardens &urban sites / storehouses / markets / at border stations with third countries / etc.</th><th>Host plant species</th></tr>
<tr><td>Łódź</td><td>2010</td><td>L + E</td><td>Research orchards</td><td>Prunus domestica</td></tr>
<tr><td>Kuyavian-Pomeranian</td><td>2011</td><td>L + U</td><td>orchards</td><td>Prunus domestica</td></tr>
<tr><td>Lublin</td><td>2011</td><td>L + U</td><td>orchards</td><td>Prunus domestica</td></tr>
<tr><td>Opole</td><td>2011</td><td>L + U</td><td>orchards</td><td>Prunus domestica</td></tr>
</table></td><td>First detection in September 2010: all trees on the plot were removed and burned.

January 2011: second outbreak confirmed in 12 orchards from 7 provinces, on apple, plum and pear fruits. Places of production will be placed under quarantine.</td></tr>
</table>

	Diagnostic method: EPPO Diagnostic Protocol PM7/18(2) – plate method and conventional PCR. In 12 cases of positive samples, additional sequencing techniques were used.		Lower Silesian	2011	L + U	orchards	*Malus domestica*	
			Kuyavian-Pomeranian	2011	L + U	orchards	*Malus domestica*	
			Lesser Poland	2011	L + U	orchards	*Malus domestica*	
			Masovian	2011	L + U	orchards	*Malus domestica*	
			Opole	2011	L + U	orchards	*Malus domestica*	
			West Pomeranian	2011	L + U	orchards	*Malus domestica*	
			Lesser Poland	2011	L + U	orchards	*Pyrus domestica*	
Portugal	YES 5 continental regions 2 autonomous regions (Azores and Madeira) Inspections are mainly in orchards of Prunus sp, during fruit growing, sampling fruits and stems...are perform and send to laboratory. About 20 trees are sampled. Diagnostic method is based in placing symptomless plant material in humidity chamber for fungus development and isolation in culture media. The isolated fungus are analysed by PCR multiplex.	YES List of the administrative units where the pest is known NOT to occur in 2009: entire country						-
Romania	YES 42 counties Survey method: from 2004 by visual inspection, with samples taken at	YES List of the administrative units where the pest is	O In Arad and Ilfov in 2010: findings in orchards on *Prunus persica* and *Prunus domestica*					Applied measures: - removal and distruction of mummified fruit ; - immediate removal

<table>
<tr>
<td></td>
<td>observing symptoms;

Analysed samples: 162 in 2004, 316 in 2005, 337 in 2006, 227 in 2007, 272 in 2008, 310 in 2009, 224 in 2010 (of which 12 were positive).

Diagnostic methods: PM 7/18(2) EPPO Standard for Monilinia fructicola - conventional PCR method Ioos R & Frey 2000.</td>
<td>known NOT to occur in 2010: 40 counties</td>
<td></td>
<td>of infected plants from the orchards;
- chemical treatments in autumn and winter;
- foliar chemical treatments during the growing season;
- increasing of the number of inspections.</td>
</tr>
<tr>
<td>Slovak Republic</td>
<td>YES
35 regional phytosanitary services

We have targeted surveys in fruit orchards and shops; observation is performed two times per year.

Diagnostic methods:
Morphological identification - cultivation on agar media, microscopy and molecular method -
PCR (EPPO diagnostic protocol PM 7/18 (2) for Monilinia fructicola).</td>
<td>YES
The Slovak republic is free from Monilinia fructicola.
2010</td>
<td>I + E
<table>
<tr><th>Administrative Unit</th><th>Year of confirmed findings</th><th>Distribution in the administrative unit</th><th>Place of occurrence (nurseries / orchards / gardens &urban sites / storehouses / markets / at border stations with third countries / etc.</th><th>Host plant species</th></tr>
<tr><td>Dunajská Streda</td><td>2006</td><td>I</td><td>markets *</td><td>Persica vulgaris subsp. laevis</td></tr>
<tr><td>Lučenec</td><td>2007</td><td>I</td><td>markets *</td><td>Prunus persica</td></tr>
<tr><td>Lučenec</td><td>2008</td><td>I</td><td>markets *</td><td>Prunus persica</td></tr>
<tr><td>Spišský Štiavnik</td><td>2008</td><td>E</td><td>garden - eradicated</td><td>Prunus domestica</td></tr>
<tr><td>Lučenec</td><td>2009</td><td>I</td><td>markets *</td><td>Prunus persica</td></tr>
<tr><td>Lučenec</td><td>2010</td><td>I</td><td>markets *</td><td>Prunus persica</td></tr>
<tr><td>Humenné</td><td>2010</td><td>I</td><td>markets *</td><td>Prunus persica</td></tr>
</table></td>
<td>Official measures:
- the eradication of trees and fruits
- surroundings trees is needed to treat by plant protection products
- the regular sustain and renew cut
- liquidation of symptomatic branches and fruits

Measures were effective.</td>
</tr>
</table>

			Zvolen	2010	I	markets *	*Persica vulgaris subsp. laevis*	
			Nitra	2010	I	markets *	*Persica vulgaris subsp. laevis*	
			Lučenec	2010	I	markets *	*Prunus persica*	
			*in all cases it was the import from EU countries (Spain, Italy, Greece)					
Slovenia	YES 2 administrative regions 3 ecological regions Surveys from 2002 to 2004. Delimited survey in 2010 only where 2009 outbreak was detected (West Slovenia). In delimited area all orchards of Prunus plants were inspected during the season twice. In addition in all areas symptomatic fruits of Prunus were collected from orchards and tested for *Monilinia*. For Official control of plants for planting (2 plant health checks/year) and voluntary certification are in place. Diagnostic method: EPPO protocol. When inspecting plant material with no mycelium and fructification of the fungus present, we first isolate the fungus on agar medium, look at colony characteristics and then perform PCR. From infected fruits and mummies with well developed fructifications of the fungus we perform direct PCR. Two PCR methods are routinely used: the	YES The whole East and Central Slovenia, while in West Slovenia only Obalno-kraška and Notranjsko-kraška (2010)	L In Nova Gorica (West Slovenia) in 2009 and 2010: localized findings in intensive orchards of *Prunus persica.* More detailed: 2009: few plants in 7 locations of Goriška 2010: 1 plant in 1 location of Goriška Vogrsko + 1 plant in 1 location of Goriška Bilje					Undertaken measures: physical eradication of infested plants

<table>
<tr><td></td><td>method of Hughes et al. (2000) and Cote et al. (2004).</td><td></td><td></td><td></td></tr>
<tr><td>Spain</td><td>YES
17 regions

The visual and sampling surveys are done on the main hosts: Prunus sp (peaches, almonds, apricots, cherries and plums), apples and pears. on nurseries and on agricultural fields.

Annually it is established in the number of surveys required.
The nurseries are selected according to the Regional authorities.
In the agricultural lands, the plots are selected at a random way and taking into account risk areas and farms.

Diagnostic method:
When Monilinia sp. is found in the culture, then samples are carried out to the laboratories, where molecular identification with PCR technique established by EPPO protocol.
Also, isolation of mycelium, culture on Petri dishes</td><td>YES
List of the administrative units where the pest is known NOT to occur in 2010: Cantabria, Andalucía, Valencia, Aragón (Zaragoza, Jalón), Murcia, Cataluña (Gerona, Tarragona), Castilla la Mancha (Albacete, Ciudad Real, Cuenca, Toledo y Guadalajara), Islas Baleares, Galicia (Pontevedra), Navarra</td><td>L
<table><tr><th>Administrative Unit</th><th>Year of confirmed findings</th><th>Distribution in the administrative unit</th><th>Place of occurrence (nurseries / orchards / gardens &urban sites / storehouses / markets / at border stations with third countries / etc.</th><th>Host plant species</th></tr><tr><td>Huesca (Aragón)</td><td>2005</td><td>L</td><td>orchards</td><td>Peach tree</td></tr><tr><td>Zaragoza y Teruel (Aragón)</td><td>2010</td><td>L</td><td>orchards</td><td>Peach and plum tree</td></tr><tr><td>Lleida (Cataluña)</td><td>2008</td><td>L</td><td>orchards</td><td>Peach tree</td></tr><tr><td>Lleida (Cataluña)</td><td>2010</td><td>L</td><td>orchards</td><td>Peach tree</td></tr><tr><td>Extremadura (Extremadura)</td><td>2010</td><td>W</td><td>orchards</td><td>Peach, plum and nectarine tree</td></tr></table>Information on location, incidence, damage estimate:</td><td>A combination of treatments with fungicides products in autumn, winter and before harvesting + cultural practices</td></tr>
</table>

			Location where the pathogen has been detected/	**In nurseries / orchards/ gardens & urban sites/**	**Year(s) of detection**	**Damage Estimate e.g % Yield reduction/**	**Incidence (frequency or % positive samples)/**	
			ARAGÓN				100 % samples	
			Zaragoza	M	2005	<1% *	2/4 orchards, 15/23 samples	
			Castillonroy (Huesca)	O	2005		4/17 orchards, 5/85 samples	
			Albelda (Huesca)	O	2006		5/16 orchards, 8/78 samples	
			Binaced (Huesca)	O	2006		2/2 orchards, 4/7 samples	
			Monzón (Huesca)	O	2006		8/15 orchards, 18/80 samples	
			Zaidín (Huesca)	O	2006		2/6 orchards, 5/28 samples	
			Fraga (Huesca)	O	2006		2/4 orchards, 10/32 samples	
			Caspe (Zaragoza)	O	2010		1/4 orchards, 1/20 samples	
			Sástago (Zaragoza)	O	2010		3/6 orchards, 7/41 samples	
			Maella (Zaragoza)	O	2010	*		
			CATALUÑA					
			Ivars de Noguera (Lérida)	O	2008	<1% *	16,6%**	
			Alfarrás (Lérida)	O	2008		28,88%**	
			Alcarrás (Lérida)	O	2010			
			Seròs (Lérida)	O	2010			
			Corbins (Lérida)	O	2010			
			Soses (Lérida)	O	2010			
			Benavent de Segrià (Lérida)	O	2010			
			La Portella (Lérida)	O	2010			
			EXTREMADURA					

			Extremadura	O	2010	Losses by rotting up to 10% in contaminated lots.	12%	
			* Respecting the damages that the infestation produces only has been detected infestations in fields, and not in storages and fruit enterprises. The damages are very low, under 1% according the above chapter. ** In Catalonia, in 2008 it was analyzed in the Laboratory an amount of 78 symptomatic samples, in which 13 of them were positive to *Monilinia fructicola*. In 2010 the amount of analyzed samples were 45, in which 13 of them were positive to *Monilinia fructicola.*					
Sweden	YES Limited survey: 2004-2005. All tested samples of *Prunus* domestica and *Pyrus communis* were negative. Survey continued in 2006 without findings. Suspect samples have been analysed.							
United Kingdom	NO After EU survey in 2002 none since have been formally undertaken in the UK. Over the last ten years, 122 samples from either fruit or young trees of Malus, Pyrus and Prunus have been found infected with *M. fructigena* (100 samples) or *M. laxa* (22 samples) but none with *M. fructicola*.	YES Entire country	I					Destruction or re-export of intercepted infected material from Third countries or EU.

	Prior to this, back to 1984, no records of *Monilinia fructicola* were recorded in UK tested material according to official records.			

J. RESULTS OF THE QUESTIONNAIRE: APPLIED MANAGEMENT OPTIONS

Table 6: Applied management options (info from Member States)

	Risk management options for prevention of pest establishment and spread within Europe	Risk management options for prevention and reduction of infestation in the crop	Risk management options post-harvest (surveillance, detection, control methods, eradication, etc.)
Belgium	Surveys: 2002 monitoring survey after French findings: visual inspections + PCR analysis for suspected samples. 2006: 43 inspections and 18 samples 2007: 18 inspections on 41 parcels and 20 samples 2008: 43 inspections on 83 parcels and 18 samples 2009: 34 inspections and 16 samples 2010: 43 inspections and 25 samples Confirmed status "Absent, confirmed by survey" Detection method: adapted from the French protocol (ML/03/15 version b (2006)) as described in PM7/18 appendix 1 from EPPO protocol. More specifically: one conventional PCR for the screening + another PCR targeting another region of the genome, for confirmation.		See what indicated on surveys and detection method in the column on establishment and spread.
Czech Republic	Surveys: 2009: 468 phytosanitary inspections and 82 analysed samples. 2010: 445 phytosanitary inspections and 43 analysed samples.		See what indicated on surveys and detection method in the column on establishment and spread.

	Surveys in orchards, nurseries, public green sites, forestry sites, garden centres. Detection methods: cultivation methods according to PM 7/18(2) – evaluation after 10 days, PCR method Cote et al., 2004, PCR method Ioos, Frey 2000.		
Denmark	Surveys: 2006-2008 survey on orchards with samples of symptomatic trees. Since 2006 all fruit tree nurseries inspected twice a year. Detection methods: Samples tested with incubation on nutrient agar and microscopy; PCR not used.		See what indicated on surveys and detection method in the column on establishment and spread.
Hungary	Surveys: The numbers of inspections per year were the followings: 214 in 2007, 251 in 2008, 114 in 2009 and 75 in 2010. Detection methods: PM 7/18 (2) EPPO Standard and the method described by Coté et al. (Coté M-J, Tardiff M-C and Meldrum AJ (2004): Identification of *Monilinia fructigena*, *M. fructicola*, *M. laxa*, and *Monilia polystroma* on inoculated and naturally infected fruit using multiplex PCR. Plant Disease, 88, 1219–1225.)	Only the prevention of infections is effective, based on 1)Wash-off spraying at the beginning and the end of the season 2)Preventive control of insects with chewing mouth parts 3)Fungicide(s) targeting *Monilinia* shall be applied within 12 hours after hails and storms Application: – With abundant spray volume to ensure complete cover of fruits (1000-2000 l/ha) – The effect of fungicides with systemic and translaminar mode of action should be improved with products of contact mode of action and with surfactants List of active substances for use against *Monilinia* + scheme for *Monilinia* management + specific programs for each stone fruit crop	See what indicated on surveys and detection method in the column on establishment and spread. In case of detection: Place the area under quarantine, sculling of the fruits, destruction of infected plant parts, permission for sales only the part of the crop free from the disease, mandatory spraying programme (See what indicated on prevention and reduction of infestation) The number of findings has fairly decreased from 2007 to 2010, indicating the effectiveness of the measures undertaken.

Italy (only Emilia-Romagna Region)	Surveys only In Emilia-Romagna, from 2004, organized in cooperation with the extension service agents employed by the regional producing associations. All of the agents were alerted about the introduction risk and were invited to take samples, above all, in stone fruits orchards. Up to last year, the number of samples ranged from about ten to about 50 each year. Following the detection of *M. fructicola* on mummies in the last winter, in 2010, 296 samples were taken and 52 tested positive to *M. fructicola* (in 41 farms). In nurseries, verbal instructions were given to the inspectors to collect eventual suspect *Monilia* samples from the plants during the official inspections. Diagnostic method: direct isolation on a growing media (PDA), followed by PCR (EPPO protocol PM 7/18) on growing colonies. Sometimes the PCR was employed directly on infected tissues. Some samples were tested in Bologna University to verify the presence of an eventual fungicide resistance, but all were negative.	During winter periods, mummies should be collected and destroyed, while in the vegetative season, treatments as indicated in the IPM protocols should be performed, infected shoots should be pruned and destroyed and infected fruits should be collected, taken away from the orchard and destroyed.	See what indicated on surveys and detection method in the column on establishment and spread.
Poland	Surveys: Visual inspections of *Monilinia fructicola* on *Malus* sp., *Prunus* sp. and *Pyrus* sp. 2008: 1478 checks 2009: 1136 checks 2010: 1936 checks (+ 180 samples: minimum of 6 samples/province)	2011: Places of production were affected fruits were found (12 orchards from 7 province) will be placed under quarantine.	See what indicated on surveys and detection method in the column on establishment and spread. 2010: All trees from the plot where affected fruits were found were removed and burned.

	Until 2009 most of the controls were in nurseries and propagation material and samples were taken for lab testing only in case of occurrence. Since 2010 controls and samples are in orchards too. Diagnostic method: EPPO Diagnostic Protocol PM7/18(2) – plate method and conventional PCR. In 12 cases of positive samples, additional sequencing techniques were used.		
Portugal	Inspections are mainly in orchards of *Prunus* sp, during fruit growing, sampling fruits and stems. Diagnostic methods: symptomless plant material in humidity chamber for fungus development and isolation in culture media.The isolated fungus are analysed by PCR multiplex.		See what indicated on surveys and detection method in the column on establishment and spread.
Romania	Survey method: from 2004 by visual inspection, with samples taken at observing symptoms; Analysed samples: 162 in 2004, 316 in 2005, 337 in 2006, 227 in 2007, 272 in 2008, 310 in 2009, 224 in 2010 (of which 12 were positive). Diagnostic methods: PM 7/18(2) EPPO Standard for *Monilinia fructicola* - conventional PCR method Ioos R &Frey 2000.		See what indicated on surveys and detection method in the column on establishment and spread. In case of occurrence: • the mummified fruit are removed and destructed; • infected plants are removed immediately from the orchards; • chemical treatments in autumn and winter; • foliar chemical treatments during the growing season
Slovak Republic	Surveys: Targeted surveys in fruit orchards and shops;	regular sustain and renew cut	See what indicated on surveys and detection method in the column on establishment and

	observation performed two times per year. Diagnostic methods: Morphological identification – cultivation on agar media, microscopy and molecular method – PCR (EPPO diagnostic protocol PM 7/18 (2) for *Monilinia fructicola*) .		spread. In presence of an outbreak: • eradication of affected trees and fruits • treatment with plant protection products of the surroundings trees • liquidation of symptomatic branches and fruits
Slovenia	Surveys from 2002. Diagnostic method: EPPO Diagnostic Protocol. PCR with the two methods of Hughes et al. (2000) and Cote et al. (2004). Voluntary certification		Physical eradication of infested plants
Spain	Surveys: On the main hosts: peaches, almonds, apricots, cherries, plums, apples and pears. On nurseries and on agricultural fields. Visual and sampling methods. Random or targeted areas and number of surveys: annually it is established in the number of surveys required. The nurseries are selected according to the Regional authorities. In the agricultural lands, the plots are selected at a random way and taking into account risk areas and farms Diagnostic method: Molecular identification with PCR technique established by EPPO protocol and isolation of mycelium, culture on Petri dishes.	Measures to farmers in the affected areas: <u>In autumn</u> • Since leave fall: Treatments with fungicides products (cupric products) <u>In winter:</u> • Preventive health measures in order to delete *Monilinia* • Withdrawal and destruction of the mummified fruits still present at that moment in the plantations, as the top of the trees as in the soil. • Cutting and burning of the Wood branches and organs that have chancres as possible illnesses symptoms. This measure is interesting in general to any illnesses of wood and it is convenience in *Monilinia* case in order to reduce any source of the illnesses. • Since January to March, protection of the plantations with fungicides treatments until petal falls.	Measures in nurseries: intensification of the inspection and surveillance of the production and trade of planting material by the Regional Administration.

	Additional preventive measures are undertaken by the local authorities to inform farmers and provide them with technical support agaist the pest (promotion of research projects, informative brochures, conferences and meetings).	• In general, recommendations of containment of nitrogen fertilizer and harsh pruning because they are elements that can favour the illnesses. Before harvesting: • Protection of the plantations with specific fungicides products for *Monilinia* the four weeks before harvest. This directions become to ones harsher when there are suitable conditions to the development of *Monilinia*, for example the productions of injuries in fruits or the present of rainfalls just before harvest.	
Sweden	Surveys: from 2004 to 2006.		Surveys: from 2004 to 2006.
United Kingdom	Surveys: Only the European survey of 2002. Samples are tested for the pathogen on suspicion basis or for unknown fungal problems. Diagnostic method: Morphological identification – cultivation on agar media, microscopy and molecular method – PCR (EPPO diagnostic protocol PM 7/18 (2) for *Monilinia fructicola*). Destruction or re-export of intercepted infected material from Third countries or EU.		See what indicated on surveys and detection method in the column on establishment and spread.