Pest risk assessment for the countries of the European Union (as PRA area) on *Monilinia fructicola*

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A pest risk assessment was performed according to the EPPO Standard PM 5/3 to determine the probability of introduction of *Monilinia fructicola* into the countries of the European Union (EU) and its potential economic impact. Data on the biology of the pathogen were combined with trade pathways and information on the use of commodities in order to quantify risk. On the basis of the EPPO Standard, we concluded that there is a serious risk that *M. fructicola* could become established in the EU, with significant economic losses as a result. This justifies the phytosanitary measures currently in place in the EU.

Introduction

Monilinia fructicola is a serious fungal pathogen of stone fruit crops in North and South America, Japan and Australia, and is listed on the EPPO A1 list of quarantine pests for Europe (CABI/EPPO, 1997) and in Annex I of EU Directive 2000/29 (EU, 2000). Two closely related species are indigenous in Europe, *Monilinia fructigena* and *Monilinia laxa*. The three species are commonly referred to as 'the brown rot fungi of fruit crops'. They cause blossom and twig blight and fruit rot in rosaceous crops. Recently, a collaborative effort was made to improve methods for the identification and rapid detection of *M. fructicola* in a project financed by the EU (van Leeuwen & van Kesteren, 1998; Corazza *et al.*, 1999). We consider that there is a need to assemble and update information on *M. fructicola* related to the probability of introduction of the pathogen into the territory of the EU. Introduction is defined as the entry of a pest resulting in its establishment (IPPC, 1999). We present a pest risk assessment on *M. fructicola* according to EPPO Standard PM 5/3 (OEPP/EPPO, 1997).

Stage 1. Initiation

Identification of pest and PRA area

Name: *Monilinia fructicola* (Winter) Honey
Synonyms: *Sclerotinia fructicola* (Winter) Rehm
Taxonomic position: Fungi, Ascomycota, Helotiales
Common names: brown rot fungus, brown rot disease (English); pourriture brune des fruits (French); Braunfäule der Früchte (German); podredumbre morena (Spanish).

The PRA area is defined as the countries of the European Union (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, Netherlands, Portugal, Spain, Sweden, UK).

Stage 2. Pest risk assessment

Section A. Qualitative criteria of a quarantine pest

Geographical criteria

The pathogen does not occur in the PRA area. It was found once in Egypt on apple fruits (Ali & Morsy, 1972). It is hard to verify this single record on the basis of the information given in the publication. The pathogen is known to occur in North and South America, the Far East (Korea, Taiwan, Japan), Australia, Yemen and Zimbabwe (CABI/EPPO, 1997). There are official records in South Africa dating back to the 1950s (IAPSC, 1985), but the South African NPPO declares that the pest is not now present. The situation is further complicated by reports from some European countries that a *Monilinia* sp. recently detected on stone fruits imported from South Africa is *M. fructicola* (Anonymous, 1996; OEPP/EPPO, 1999).

Potential for establishment

The brown rot fungi of fruit crops have a wide host range, comprising fruit and ornamental crops of the family *Rosaceae*. *M. fructicola* is reported to occur widely in stone fruit crops (peach, apricot, etc.). Vast cultivated areas of stone fruit are found in southern Europe, and an overview of areas and production is given in Table 1. Italy and Spain had the highest production of stone fruits within the EU in 1995/1996. Peach and nectarine are the most important crops. The climate of southern Europe is comparable with that of California (US), where *M. fructicola* is widespread (Schneider, 1996). There is no reason to suppose that climatological conditions would restrict the establishment of *M. fructicola* in Europe. *M. fructicola* does not depend on specific vectors for propagule dispersal. Conidia are readily dispersed by wind, water, all kind of vectors (insects, birds) and man (Kable, 1965a; Ogawa *et al.*, 1975).

Table 1 Area and production of stone fruit crops of EU countries in southern Europe in 1996*

	Peach/nectarine	Apricot	Cherry	Almond†	Plum
(× 1000 ha)					
France	32	18	16	NA	NA
Greece	45	5	10	25	1
Italy	107	16	29	95	14
Portugal	11	1	4	42	NA
Spain	75	24	28	765	20
(× 1000 ton)					
France	463	176	74	NA	270
Greece	935	47	42	NA	5
Italy	1743	126	145	93	189
Portugal	73	5	10	7.5	NA
Spain	892	194	76	227	145

NA, not available.
*Source: Eurostat, European Union, Brussels.
†Data from 1995.

Potential economic importance

Moderate to high yield losses are caused by *M. fructicola* in the USA and Australia. In addition, the introduction of *M. fructicola* into one of the EU countries would have serious consequences for trade (both within the EU and with other countries). A detailed account of the economic importance is given in Section B.

Thus, *M. fructicola* satisfies the defining criteria for a quarantine pest with respect to the PRA area.

Section B. Quantitative evaluation

Probability of introduction: entry

We distinguished two pathways that the pest can be carried on: imported (stone) fruits and nursery stock.

Fruits. Imported fruits constitute the greatest bulk of material on which the pathogen could be carried. EU legislation (EU, 2000) requires that fruits of *Prunus* spp. imported from non-EU countries between 15 February and 30 September are accompanied by an official statement indicating that the fruits originate from a country/area which is free from *M. fructicola*, or that fruits are carefully checked and treated before transport in order to ensure that they are free from this fungus. The quantities of fresh stone fruits imported into the EU from regions where *M. fructicola* is known to occur are given in Table 2. It is clear that most of the imported fruits arrive in ports of western European countries (UK, Belgium, Netherlands), and a relatively small amount is imported directly by the main producers of stone fruits in southern Europe. North America (Canada, USA) as well as South Africa are the main exporting countries (Table 2).

The pathogen is clearly able to survive transit. Wormald (1954) reported that *M. fructicola* was found on more than one occasion on fruits imported into the UK from the USA. There have been recent detections on imported *Prunus* fruits

Table 2 Import of fresh stone fruits (apricot, cherry, peach/nectarine, plum and almond) in EU countries from regions where *M. fructicola* is endemic (in tons; data for 1998)*

	N. America	Argentina	South Africa	Australasia	Others†	Total
France	474	118	1278	88	0	1958
Greece	0	0	0	0	0	0
Italy	119	153	453	15	0	740
Portugal	0	0	93	0	17	110
Spain	37	323	1987	0	8	2355
Belgium/Luxemburg	164	595	6634	9	0	7402
Netherlands	14	387	6751	24	62	7238
UK	6546	64	13201	179	51	20041
Germany	142	26	1958	18	4	2148
Sweden	932	2	0	0	0	934
Finland	203	1	0	0	0	204
Denmark	74	0	0	0	0	74
Ireland	0	0	0	0	0	0
Austria	0	0	0	0	0	0

*Source: Eurostat Data Shop, Voorburg, The Netherlands.
†Zimbabwe, Brazil, Uruguay.

(Anonymous, 1996; OEPP/EPPO, 1999). Visual inspection readily shows the presence of the pathogen when sporulating on fruits, but culturing is necessary to determine which of the three *Monilinia* species is involved. When only lesions are visible, other fruit pathogens may also be involved (*Botrytis*, *Penicillium*). Currently, an ELISA-based detection kit is being optimized by the Central Science Laboratory (CSL) in York (UK) in order to identify *M. fructicola* quickly when it is detected on imported fruits (C. Lane, pers. comm.). This method, and others, were developed as part of an EU project aimed at the development of diagnostic methods and a rapid field kit for monitoring *Monilinia* brown rot of stone and pome fruit, especially *M. fructicola*. In the same project, *M. fructicola*-specific primers were developed by Fulton & Brown (1997) for *in situ* detection of *M. fructicola* on imported consignments. However, intraspecific genetic variation in *M. fructicola* renders these primers less appropriate (Fulton *et al.*, 1999; Förster & Adaskaveg, 2000). Sets of newly developed primers directed to other regions in the DNA of the fungus can probably serve as an adequate tool for quick detection of *M. fructicola* (Förster & Adaskaveg, 2000; (Ioos & Frey, 2000).

After entry, fruits are widely traded in the PRA area. Because the product is aimed for consumption, it has a relatively small chance of arriving in the vicinity of suitable hosts by comparison with nursery stock (see below). It is evident from Table 2 that most shipments arrive at entry points far from the main areas of stone fruit production in Europe. Moreover, the bulk of imports arrive in Europe during winter (November–March), when hardly any susceptible host tissue is available in orchards for infection. Despite this, infected fruits cannot be ruled out altogether as a pathway: the fungus will survive transit and easily goes unnoticed, while the volume of fruit imports is huge.

Plants for planting. Import of plants for planting of *Prunus*, *Malus*, *Pyrus*, *Cydonia* and other *Rosaceae* presents the prime risk for the introduction of *M. fructicola* into the EU. The risk is not confined to visually affected plants: the fungus can survive in twig lesions, and these are usually hard to detect. It is therefore insufficient to restrict imports of plants for planting from non-European countries to dormant material (without leaves, flowers and fruits), as laid down in EU Directive 2000/29 (Annex III, para 9). Dormant plants for planting may still be latently infected. Such material planted in nurseries may develop symptoms later, and eventually offer the pathogen an excellent opportunity to infect other trees. For this reason, strict care should be taken with the import of plants for planting of rosaceous plants from countries where *M. fructicola* is present. Further, the EU only allows import of plants for planting of *Cydonia*, *Malus*, *Prunus* and *Pyrus* from Mediterranean countries, Australia, New Zealand, Canada and the continental states of the USA (Annexe III, para 18). A further restriction is that import is only allowed from countries known to be free from *M. fructicola* or areas recognized by the EU to be free from *M. fructicola* (Annex IV/A1, para 15). The formulation of the EU regulations does

Table 3 Import of trees and shrubs for the growing of edible fruits in EU countries from regions where *M. fructicola* is endemic (in tons; data for 1998)*

France	62	UK	12
Greece	0	Germany	0
Italy	0	Sweden	0
Portugal	0	Finland	2
Spain	672	Denmark	0
Belgium/Luxemburg	0	Ireland	0
Netherlands	23	Austria	0

*Source: Eurostat Data Shop, Voorburg, The Netherlands.

not make it quite clear which countries are allowed to export plants for planting of these genera to the EU. In the case of Australia, New Zealand, Canada and the USA, where the fungus is present, only the second possibility remains, i.e. dormant plants for planting of these genera are allowed, but only from areas in these countries that have been recognized by the EU to be free from the fungus. The pest status of different areas in those countries for *M. fructicola* is not clear at present.

There is no specific data on import of plants for planting of *Rosaceae* from outside the EU, only data on the import of trees and shrubs in general (Table 3). Thus, Spain imported a large volume of trees and shrubs from risk areas in 1998, but it is not clear whether this included any of the key rosaceous genera.

Establishment

Host plant preference, ecological niche. *M. fructicola* shares common features with *M. laxa*, which is widely established in European stone fruit orchards. However, differences in host plant preference and ecological niche are reported from areas where the two species co-exist. In the numerous publications which describe the occurrence of *M. fructicola* and *M. laxa* in the field, it is striking that *M. fructicola* is mostly found on fruits (Ogawa *et al.*, 1954; 1975; Boesewinkel & Corbin, 1970). In a survey in the major stone fruit-growing areas of California (USA), Ogawa *et al.* (1954) found that 72% of the isolations of *M. fructicola* came from diseased fruits. *M. laxa* appeared to be more of a flower and twig pathogen, 83% of the isolations of *M. laxa* coming from blighted flowers and twigs. This confirmed earlier findings by Huber & Baur (1941). Similarly, recent records from Australia state that *M. laxa* causes flower blight in peach and apricot, but rarely causes fruit rot (Penrose, 1998).

Among the many host plant species present in the PRA area, we expect that peach/nectarine and apricot will be most affected by the introduction of *M. fructicola*. Ogawa *et al.* (1954) found 92% of the collected samples in peach to be *M. fructicola*, in regions where *M. laxa* was dominantly present but caused no harm in peach orchards. Zehr (1982) also stated that *M. laxa* is less important on peaches than on other stone fruits in the USA. 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 (M.-Sagasta, 1977; Melgarejo *et al.*, 1986). An increase in pre- and post-harvest fruit losses in peach/nectarine and apricot is likely to occur once *M. fructicola* establishes itself in Europe. Moderate fruit losses in plum caused by *M. fructicola* have been reported from Ontario (CA) (Northover & Cerkauskas, 1994), but workers in Australia stated that the pathogen is less important in plum (Kable, 1969).

It is not very likely that *M. fructicola* will enhance damage in the flower and twig blight phase of the disease. Although *M. fructicola* causes wilting of flowers, Kable & Parker (1963) found that subsequent invasion of twigs in sour cherry was limited compared with *M. laxa*. In peach, the severity of twig blight caused by *M. fructicola* seems to vary per region. Willison (1937) and Biggs & Northover (1985) reported the occurrence of perennial cankers in peach in Canada, whereas Kable (1965b) did not find these in Australia. It is likely that the extent of damage to twigs and branches depends on environmental conditions. This is supported by data from Europe related to *M. laxa* (M.-Sagasta, 1977; Madrigal *et al.*, 1994).

Survival and establishment. Survival mechanisms play an important role in determining whether, after initial entry, a pathogen becomes established. *M. fructicola* survives as mycelium in mummified fruits, on which new conidial pustules appear in spring. Kable (1965b) mentioned the fruit peduncle as an important overwintering site in peach. *M. fructicola* can also survive in twigs and branches, and subsequently produce conidia on these plant surfaces in spring (Jehle, 1913; Mix, 1930; Biggs & Northover, 1985). In addition, apothecia of *M. fructicola* are regularly found in the field, although not in all regions. Apothecia are found in South Carolina and California (US) (Landgraf & Zehr, 1982; Holtz *et al.*, 1998), and also in South America (Uruguay; P. Mondino, pers. comm.), but infrequently in Australia (Jenkins, 1965; Kable, 1969). In contrast, the sexual cycle plays no role in the life cycle of the two *Monilinia* species occurring in Europe. Sexual reproduction generates more genetic variation in populations, and this may have quickened the development of fungicide resistance in *M. fructicola*.

Current disease management practice in stone fruits to control *Monilinia* consists of two or three fungicide sprays around flowering (BBCH60), followed by one or two sprays when fruits start to ripen (BBCH81) (Rüegg *et al.*, 1997; Zehr *et al.*, 1999). In the past, regular use of benomyl and dicarboximides in spray programmes has led to the development of fungicide resistance in *M. fructicola* in the USA, Australia and Korea (Jones & Ehret, 1976; Penrose *et al.*, 1979; Osorio *et al.*, 1994; Lim *et al.*, 1998). The establishment of fungicide-resistant *M. fructicola* strains in Europe might aggravate problems in disease control due to lowered efficiency of spray programmes. Fungicide resistance has been found in *M. laxa* in the USA (Ogawa *et al.*, 1984; Osorio *et al.*, 1994), as well as in Europe. Guizzardi *et al.* (1995) studied the sensitivity of *M. laxa* isolates from Italian stone fruit orchards to benomyl and dicarboximides, and found cultures which grew on agar containing even a hundred times the normal fungicide dose. Zehr *et al.* (1999) have shown that *M. fructicola* can develop resistance to the new demethylation-inhibiting (DMI) fungicides. If *M. fructicola* develops resistance more quickly than *M. laxa*, this would make resistance management more difficult.

An important aspect of the probability of successful establishment is the potential of an initially (very) 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 sporulation only starts in spring when the temperature reaches 15–25 °C, whereas *M. laxa* sporulates at 5–10 °C (Byrde & Willetts, 1977). The proportion of *M. fructicola* conidia in the environment early in the season would thus be very low, minimizing the probability of successful infection of host tissue. Later in the season, however, when *M. fructicola* conidia infect fruits, rapid lesion development and profuse sporulation will enhance dispersal and, ultimately, the establishment of the pathogen.

During the last century, *M. fructicola* has become established in new areas where it was formerly considered absent. Among these areas are Japan, Zimbabwe, southern Africa and Yemen (Terui & Harada, 1966; CABI/EPPO, 1998). No information is available about eradication measures taken after the pathogen was first detected in these countries. However, Batra (1979) has shown in the USA that it is possible to eradicate an exotic *Monilinia* species from a restricted area. *M. fructigena* was found on pear cv. Kieffer in an experimental orchard in Beltsville in 1974/1975. This orchard was subsequently destroyed and, since then, there have been no reports of the occurrence of *M. fructigena* in the USA.

Economic impact assessment

It is difficult to find exact yield loss data for *M. fructicola* in the literature. Losses in stone fruits vary between years and depend greatly on weather conditions around harvest time. In plum, Northover & Cerkauskas (1994) estimated that total preharvest fruit 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* in 1995, whereas this was only 0.5% in 1996. Similar variation in yield loss is reported by other workers (Morschel, 1956; Kable, 1969). It is instructive to compare present yield losses in European orchards caused by *M. laxa*/*M. fructigena* with those reported for *M. fructicola*. Usually, *M. fructigena* causes as much fruit rot as *M. laxa* in European stone fruit orchards. In Switzerland, Rüegg & 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%). No other quantitative assessments of yield loss could be found for Europe.

According to Byrde & Willetts (1977), *M. fructigena* is less damaging than *M. fructicola* in stone fruits. Thus, it is likely that the introduction of *M. fructicola* will result in higher fruit losses in stone fruit orchards in Europe.

The endangered area within the EU is concentrated in the south (Table 1), and it is not only direct losses which should be considered. It is likely that phytosanitary measures will need to be taken to avoid further spread of the pathogen from a region where it is initially detected (see below). Export markets may be seriously affected. For countries such as Spain or Italy, where intra-EU export trade in peaches and nectarines amounted to 239 and 291 million EUR, respectively, in 1998 (Anonymous, 1999), introduction and spread would be disastrous.

It is hard to predict the extent of subsequent spread of *M. fructicola* once introduced in a certain location. Certainly, if export of fruits and nursery stock is not restricted from a contaminated area or strong regulations are not applied, the pathogen may be expected to spread quickly to other fruit-growing areas within the EU. Although the pathogen can be dispersed over large distances by natural means (wind, insects, birds), it is likely that such spread will occur only slowly compared with spread by trade pathways. Thus, containment measures would be desirable after the detection of *M. fructicola* in a restricted part of the PRA area. An indication of how quickly *M. fructicola* spreads can be deduced from surveys worked out in California (US). Hewitt & Leach (1939) reported that *M. laxa* was widespread in all stone fruit-growing areas, whereas *M. fructicola* was more localized in the peach-producing areas. A survey in prune- and apricot-growing areas during 1982 and 1983 showed that both *M. fructicola* and *M. laxa* were widespread (Michailides *et al.*, 1987). Thus, *M. fructicola* had partly displaced *M. laxa* in those crops, probably encouraged by disease management practice: more than 50% of the prune and apricot orchards harboured *M. fructicola* isolates resistant to benomyl, whereas all *M. laxa* isolates found were sensitive to benomyl. In Europe, a similar situation might develop over time.

Final evaluation

The pest risk assessment given above is based on reliable sources from the literature and statistical databases. Our conclusions may be summarized as follows. *M. fructicola* is present in many fruit-producing regions of the world, where it causes considerable economic losses, but it does not yet occur in Europe. The pathways for introduction are primarily infected plants for planting (dormant material may be latently infected) and, in the second instance, infected fruits. Although there is little risk that infected fruits arrive directly in nurseries, they may be thrown away in private gardens and could possibly infect fruit trees in such gardens. Ultimately, nurseries may also become infected. This risk, although in itself not as large as that arising from imports of latently infected nursery stock, may yet be serious because of the huge volume of fruit imports. Once introduced into Europe, the fungus is almost certain to become established as climatic conditions in the EU are favourable. Once *M. fructicola* establishes itself in EU countries, crop losses are expected to increase markedly especially in peach, nectarine and apricot. The costs of control will increase, and control measures may become less efficient because of the development of fungicide resistance. Export markets may also be affected. The categorization of *M. fructicola* as a quarantine pests for the European Union is thus clearly supported.

Imported fruits form an important pathway by which the pathogen can enter EU countries. Chances of establishment are highest when fruits are imported during the growing season in the EU countries, and EU legislation has anticipated this by demanding an official document that fruits originate from countries free from *M. fructicola* or from areas recognized as being free from this pathogen, or that the consignment has been carefully checked and treated, in the period from 15 February to 30 September (EU, 2000). In recent years, *Monilinia* isolates identified as *M. fructicola* have been detected in *Prunus* fruits from South Africa (Anonymous, 1996; OEPP/EPPO, 1999). Although this country is officially declared free from *M. fructicola*, the voluminous imports from this country (Table 2) raise questions about the actual risk. In general, extension of the period during which fruit imports are to be inspected for the presence of the fungus to the entire year would seem reasonable.

Entry of the pathogen on plants for planting would increase the chances of establishment of the pathogen considerably, as spread takes place easily in tree nurseries. Strict import regulations have been adopted by the EU. However, if material from infested countries (Australia, New Zealand, Canada, the continental states of the USA) actually enters the EU, the requirement for plants for planting to be dormant will not cover the risk adequately.

The fungus has been detected rather rarely on imported consignments in recent years, and this could be because restrictions on imported produce work out so well. However, it might as well be that the intensity of sampling is low and the quality of the inspection regime is suboptimal. Well-defined instructions with respect to the recognition of disease symptoms for the inspectors working at dock sites and harbours are crucial. Anyhow, despite considerable trade, *M. fructicola* is still absent in European fruit orchards. Nevertheless, if the pathogen is introduced in European orchards in future, we believe that eradication or containment measures provide the best means to minimize the economic impact for the EU as a whole.

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Evaluation du risque phytosanitaire pour les pays de l'Union européenne (comme zone PRA) sur *Monilinia fructicola*

Une evaluation du risque phytosanitaire a été réalisée en conformité avec la Norme OEPP PM 5/3 pour déterminer la probabilité d'introduction de *Monilinia fructicola* dans les pays de l'Union européenne (UE), ainsi que son impact économique potentiel. Des données sur la biologie du pathogène ont été combinées à des filières commerciales et à des informations sur l'utilisation des marchandises, afin de quantifier le risque. L'utilisation de la Norme OEPP nous a permis de conclure qu'il existe un fort risque que *M. fructicola* s'établisse dans l'UE et y provoque des pertes économiques importantes. Ce risque justifie les mesures phytosanitaires déjà prises au sein de l'UE.

Оценка фитосанитарного риска (PRA), который представляет *Monilinia fructicola* для стран Евросоюза (в качестве ареала АФР)

Для определения вероятности интродукции *Monilinia fructicola* в страны Евросоюза и потенциального экономического ущерба проводилась оценка фитосанитарного риска в соответствии со стандартом ЕОЗР PM 5/3. В целях количественной оценки такого риска данные по биологии патогена были сопоставлены с торговыми путями его проникновения и информацией об использовании товаров. С помощью стандарта ЕОЗР авторы пришли к заключению, что существует серьезная опасность того, что *Monilinia fructicola* может акклиматизироваться в ЕС, что приведет к существенным экономическим потерям. Это служит обоснованием для тех фитосанитарных мер, которые в настоящее время принимаются в Евросоюзе.

References

Ali MDH & Morsy AA (1972) A note on two rots of apple fruits new to Egypt. *Egyptian Journal of Phytopathology* **4**, 91–92.

Anonymous (1996) *Europhyt, Reported Interceptions*. European Union, Brussels, Belgium.

Anonymous (1999) *Statistical Data EU*. Eurostat Data Shop, Voorburg, The Netherlands.

Batra LR (1979) First authenticated North American record of *Monilinia fructigena*, with notes on related species. *Mycotaxon* **8**, 476–484.

Biggs AR & Northover J (1985) Inoculum sources for *Monilinia fructicola* in Ontario peach orchards. *Canadian Journal of Plant Pathology* **7**, 302–307.

Boesewinkel HJ & Corbin JB (1970) A new record of brown rot, *Sclerotinia* (*Monilinia*) *laxa*, in New Zealand. *Plant Disease Reporter* **54**, 504–506.

Byrde RJW & Willetts HJ (1977) *The Brown Rot Fungi of Fruit. Their Biology and Control*. Pergamon Press. Oxford, UK.

CABI/EPPO (1997) *Quarantine Pests for Europe*, 2nd edn. CAB International, Wallingford, UK.

CABI/EPPO (1998) *Distribution Maps of Quarantine Pests for Europe*. CABI, Wallingford, UK.

Corazza L, Cook RT, Lane CR, van Kesteren HA, Melgarejo P, Brown A & Nazare Pereira AM (1999) *Development of Diagnostic Methods and a Rapid Field Kit for monitoring* Monilinia *Brown Rot of Stone and Pome Fruit, especially* M. fructicola. EU-FAIR 95-0725 report, Fourth Framework Programme. EU, Brussels, Belgium.

EU (2000) EU Directive 2000/29, Annex IV. Official Journal of the European Communities. **L129**, 1–112.

Förster H & Adaskaveg JE (2000) Early brown rot infections in sweet cherry fruit are detected by *Monilinia*-specific DNA primers. *Phytopathology* **90**, 171–178.

Fulton CE & Brown AE (1997) Use of SSU rDNA group-I intron to distinguish *Monilinia fructicola* from *M. laxa* and *M. fructigena*. *FEMS Microbiology Letters* **157**, 307–312.

Fulton CE, van Leeuwen GCM & Brown AE (1999) Genetic variation among and within *Monilinia* species causing brown rot of stone and pome fruits. *European Journal of Plant Pathology* **105**, 495–500.

Guizzardi M, Caccioni DRL & Pratella GC (1995) Resistance monitoring of *Monilinia laxa* (Aderh. et Ruhl.) Honey to benzimidazoles and dicarboximides in postharvest stage. *Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz* **102**, 86–90.

Hewitt WB & Leach LD (1939) Brown-rot Sclerotinias occurring in California and their distribution on stone fruits. *Phytopathology* **29**, 337–351.

Holtz BA, Michailides TJ & Hong CX (1998) Development of apothecia from stone fruit infected and stromatized by *Monilinia fructicola* in California. *Plant Disease* **82**, 1375–1380.

Hong CX, Holtz BA, Morgan DP & Michailides TJ (1997) Significance of thinned fruit as a source of the secondary inoculum of *Monilinia fructicola* in California nectarine orchards. *Plant Disease* **81**, 519–524.

Huber GA & Baur K (1941) Brown rot on stone fruits in Western Washington. *Phytopathology* **31**, 718–731.

IAPSC (1985) *Monilinia fructicola. Distribution Maps of Major Crop Pests and Diseases in Africa*, no. 306. IAPSC, Yaoundé, Cameroon.

Ioos R & Frey P (2000) Genomic variation within *Monilinia laxa*, *M. fructigena* and *M. fructicola* and application to species identification by PCR. *European Journal of Plant Pathology* **106**, 373–378.

IPPC (1999) *International standards for Phytosanitary Measures no. 5: Glossary of Phytosanitary terms*. FAO, Rome.

Jehle RA (1913) The brown rot canker of the peach. *Phytopathology* **3**, 105–111.

Jenkins PT (1965) *Sclerotinia laxa*: a cause of brown rot of stone fruits not previously recorded in Australia. *Australian Journal of Agricultural Research* **16**, 141–144.

Jones AL & Ehret GR (1976) Isolation and characterization of benomyl-tolerant strains of *Monilinia fructicola*. *Plant Disease Reporter* **60**, 765–769.

Kable PF (1965a) Air dispersal of conidia of *Monilinia fructicola* in peach orchards. *Australian Journal of Experimental Agriculture and Animal Husbandry* **5**, 166–171.

Kable PF (1965b) The fruit peduncle as an important overwintering site of *Monilinia fructicola* in the Murrumbidgee Irrigation Areas. *Australian Journal of Experimental Agriculture and Animal Husbandry* **5**, 172–175.

Kable PF (1969) Brown rot of stone fruits on the Murrumbidgee irrigation areas. I. Aetiology of the disease in canning peaches. *Australian Journal of Agricultural Research* **20**, 301–316.

Kable PF & Parker KG (1963) The occurrence of the imperfect stage of *Monilinia laxa* on *Prunus cerasus* var. *austera* in New York state. *Plant Disease Reporter* **47**, 1104.

Landgraf FA & Zehr EI (1982) Inoculum sources for *Monilinia fructicola* in South Carolina peach orchards. *Phytopathology* **72**, 185–190.

van Leeuwen GCM & van Kesteren HA (1998) Delineation of the three brown rot fungi of fruit crops (*Monilinia* spp.) on the basis of quantitative characteristics. *Canadian Journal of Botany* **76**, 2042–2050.

Lim TH, Chang TH & Cha B (1998) Incidence of benzimidazole- and dicarboximide resistant isolates of *Monilinia fructicola* from overwintering mummies and peduncles on peach trees. *Korean Journal of Plant Pathology* **14**, 367–370.

Madrigal C, Pascual S & Melgarejo P (1994) Biological control of peach twig blight (*Monilinia laxa*) with *Epicoccum nigrum*. *Plant Pathology* **43**, 554–561.

Melgarejo P, Carrillo R & M.-Sagasta E (1986) Potential for biological control of *Monilinia laxa* in peach twigs. *Crop Protection* **5**, 422–426.

Michailides TJ, Ogawa JM & Opgenorth DC (1987) Shift of *Monilinia* spp. and distribution of isolates sensitive and resistant to benomyl in California prune and apricot orchards. *Plant Disease* **71**, 893–896.

Mix AJ (1930) A blight of flowering almond, *Prunus glandulosa* Thunb. *Phytopathology* **20**, 265.

Morschel JRG (1956) Brown rot of stone fruits in New South Wales. II: Some observations and trials on the Murrumbidgee irrigation areas. *NSW Department of Agriculture contribution, no.* 383.

M.-Sagasta E (1977) *Monilia* disease. *Bulletin OEPP/EPPO Bulletin* **7**, 105–116.

Northover J & Cerkauskas RF (1994) Detection and significance of symptomless latent infections of *Monilinia fructicola* in plums. *Canadian Journal of Plant Pathology* **16**, 30–36.

OEPP/EPPO (1997) EPPO Standards PM 3/5 Guidelines on pest risk analysis. Pest risk assessment scheme. *Bulletin OEPP/EPPO Bulletin* **27**, 281–292.

OEPP/EPPO (1999) *Reporting Service*, no. 4–5. EPPO Secretariat, Paris, France.

Ogawa JM, English WH & Wilson EE (1954) Survey for brown rot of stone fruits in California. *Plant Disease Reporter* **38**, 254–257.

Ogawa JM, Manji BT & Schreader WR (1975) *Monilinia* life cycle on sweet cherries and its control by overhead sprinkler fungicide applications. *Plant Disease Reporter* **59**, 876–880.

Ogawa JM, Manji BT, Bostock RM, Canez VM & Bose EA (1984) Detection and characterization of benomyl-resistant *Monilinia laxa* on apricots. *Plant Disease* **68**, 29–31.

Osorio JM, Adaskaveg JE & Ogawa JM (1994) Inhibition of mycelial growth of *Monilinia* species and suppression and control of brown rot blossom blight of almond with iprodione and E-0858. *Plant Disease* **78**, 712–716.

Penrose LJ (1998) Disease control in stone fruits in Australia. *Pesticide Outlook* **9** (2), 13–17.

Penrose LJ, Davis KC & Koffmann W (1979) The distribution of benomyl-tolerant *Sclerotinia fructicola* in stone fruit orchards in New South Wales and comparative studies with susceptible isolates. *Australian Journal of Agricultural Research* **30**, 307–319.

Rüegg J & Siegfried W (1993) (Integrated fruit production: news on blossom and fruit Monilia). *Schweizerische Zeitschrift für Obst- und Weinbau* **129**, 620–624 (in German).

Rüegg J, Lauber HP, Siegfried W, Viret O & Hilber U (1997) Experiences with anilinopyrimidines in Switzerland. *Pesticide Outlook* **8**, 28–33.

Schneider SH (ed.) (1996) *Encyclopedia of Climate and Weather.* Oxford University Press. Oxford, UK.

Terui M & Harada Y (1966) On the brown rot fungus *Monilinia fructicola* of fruit trees in Japan. *Annals of the Phytopathological Society of Japan* **32**, 291–294.

Willison RS (1937) Peach canker investigations. III. Further notes on incidence, contributing factors, and related phenomena. *Canadian Journal of Research* **15**, 324–339.

Wormald H (1954) *The Brown Rot Disease of Fruit Trees.* Technical Bulletin no. 3. Ministry of Agriculture, Fisheries and Food, London, UK.

Zehr EI (1982) Control of brown rot in peach orchards. *Plant Disease* **66**, 1101–1105.

Zehr EI, Luszcz LA, Olien WC, Newall WC & Toler JE (1999) Reduced sensitivity in *Monilinia fructicola* to propiconazole following prolonged exposure in peach orchards. *Plant Disease* **83**, 913–916.