Monilinia fructigena

Scientific Name
Monilinia fructigena Honey, 1945

Synonyms:
Acrosporum fructigenum, Monilia fructigena, Oidium fructigenum, Oidium wallrothii, Oospora candida, Oospora fructigena, Sclerotinia fructigena, Stromatinia fructigena, Torula fructigena

Preferred Common Name
Brown rot

Other Common Names
Apple brown rot, Asian/European brown rot of Rosaceae**,** brown fruit rot, fruit canker, fruit rot, Monilinia brown rot, spur blight, spur canker, twig blight, twig canker, wither tip

Type of Pest
Fungal pathogen

Taxonomic Position
Class: Leotiomycetes, **Order:** Helotiales, **Family:** Sclerotiniaceae

Reason for Inclusion in Manual
CAPS Target: AHP Prioritized Pest List – 2014

Background
Monilinia fructigena is an Ascomycete fungus. The primary morphological character that distinguishes members of the Ascomycota is the ascus (plural asci), a sac-like cell containing the ascospores cleaved from within by free cell formation after karyogamy and meiosis. Eight ascospores typically are formed within the ascus but this number may vary from one to over a thousand according to the species. Asci are typically formed in an ascocarp (*i.e.,* a perithecium, pseudothecium, apothecium, or cleistothecium). Ascomycetes may have two distinct reproductive phases, one sexual (teleomorph) involving the formation of the asci and ascospores, and the other asexual (anamorph), with spore/conidia production occurring at different times on the same mycelium. The genus *Monilinia* is in the family Sclerotiniaceae and is characterized by the production of conidial and stromatal anamorphs (asexual stage), apothecial ascomata, and ascospores (Byrde and Willetts, 1977). The genus *Monilia* is the anamorph.

Monilinia spp. are well-known pathogens causing brown rot of fruit trees in many fruit production regions of the world. Three species of *Monilinia*, *M. fructigena, M. fructicola*, and *M. laxa*, are particularly important with regard to fruit trees and ornamentals, because they cause serious blossom and twig blight and brown rot of fruits (Petroczy et al., 2012). In 2002, a new species (described solely based on the anamorph), *Monilia polystroma*, was distinguished from *M. fructigena* based on morphological and molecular characteristics of isolates from Japan (van Leeuwen et al., 2002). This work confirmed the earlier work of Fulton et al. (1999), which showed the isolates of *M. fructigena* from Japan, on the basis of ITS sequence data, were distinct from European isolates and could possibly be regarded as a separate species.

Monilinia fructigena and *M. laxa and* are the main agents of brown rot in Europe and are widespread. *M. fructicola* is widespread in the United States, North America, South America, South Africa, Australia, and occurs in at least six countries in Europe (Bosshard et al., 2006; Petroczy and Palkovics, 2006; Duchoslavova et al., 2007; Pellegrino et al., 2009; De Cal et al., 2009; Hilber-Bodmer et al., 2010; Hinrichs-Berger and Muller, 2010). *M. laxa* is also known to occur in the United States, primarily in the Pacific Northwest. *M. fructicola* is particularly problematic in the United States due to fungicide resistance and increased adaptability and variability due to the frequent occurrence of the sexual stage (Fulton and Brown, 1997). *Monilia polystroma* is not known to occur in the United States and to date has only been reported from China, Czech Republic, Hungary, Japan, Poland, Serbia, and Switzerland (van Leeuwen et al., 2002; Petroczy and Palkovics, 2009; Zhu and Guo, 2010; Hilber-Bodmer et al., 2012; Poniatowska et al., 2013; Vasic et al., 2013). The color of the pustules on infected plant tissue is buff for *Monilia polystroma* and *Monilinia fructigena* and grayish-brown for *M. fructicola* and *M. laxa* (Byrde and Willetts, 1977; van Leeuwen and van Kesteren, 1998).

Hu et al. (2011) discuss the existence of two additional *Monilinia* species in China. China is also known to have the four species discussed previously. *Monilia mumecola*, previously isolated from Japan from *Prunus mume* and causing brown rot of papaya in China, was found from peaches/nectarines in China. Yin et al. (2014) reported that *Prunus armeniaca* (apricot) is also a host of *M. mumecola.* A new species, *M. yunnanensis*, was also recently described by Hu et al. (2011) from peaches/nectarines in China.

Pest Description

In a study by van Leeuwen et al., (2002) using six different *M. fructigena* isolates from throughout Europe, mean colony growth rate was 5mm/day on potato dextrose agar (PDA) at 22°C (71.6°F) under a 12 hr. light/12 hr. dark cycle. Aerial mycelium rose 4-5 mm above the colony surface, and the color of sporogenous tissue was buff/pale luteous. Stromata formed on only four out of six test colonies 21 days after inoculation with a mean size of 0.4cm^2 and a range of 0-0.9cm^2. Macroconidia are globose, ovoid or limoniform, smooth measuring, on average,19 x 11.5 µm (distilled water) when grown on cherry agar (CHA) at 22°C (71.6^{o}F) and 21.5 µm x 13 µm on pear fruit at 15°C (59°F). The authors were unable to induce the formation of apothecia and thus only described the anamorphic stage.

Biology and Ecology

Casals et al. (2010) evaluated the effect of temperature (0 to 38°C; 32 to 100.4°F) and water activity (a_w: 0.87 to 0.99) on the percentage of conidial germination over time for *Monilinia fructigena*, *M. fructicola*, and *M. laxa*. The three species of *Monilinia* studied were able to germinate over a wide temperature range (0 to 35°C; 32 to 95°F) at 0.99 a_w , but no germination occurred at 38°C (100.4°F)for any of the tested isolates. The optimum temperature for germination occurred after four hours of incubation and was in the range 15 to 30°C (59 to 86°F) for the studied species. Isolates of *M. fructicola* and *M. fructigena* reached 85 to 99% germination after two hours of incubation at 25°C (77°F) at 0.99 a_w; while *M. laxa* needed four hours.

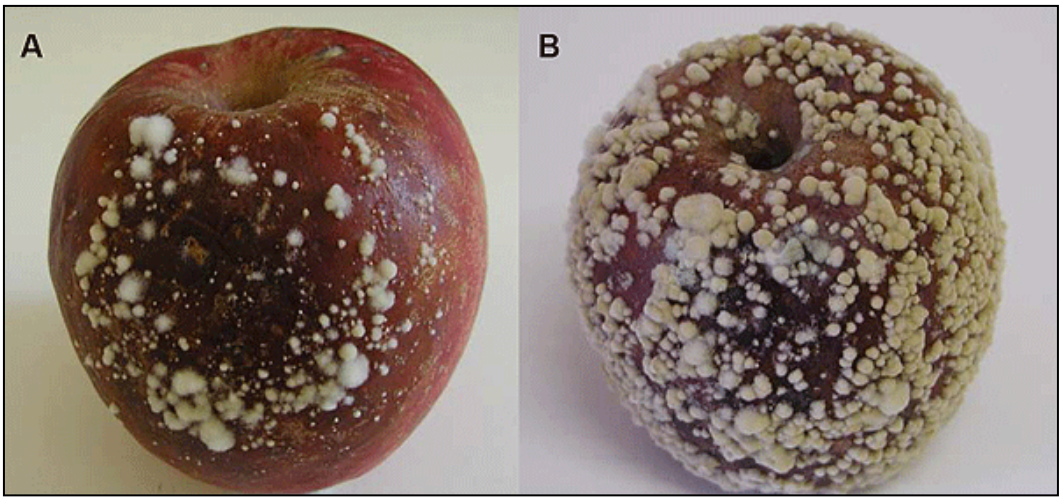

Figure 1. Apples naturally infected with *Monilinia fructigena* at; a) 5 days incubation and b) 14 days incubation. Photo courtesy of DAFF (Department of Agriculture, Fisheries, and Forestry-Australia).

Conidia of brown rot fungi, in general, overwinter in fruit mummies or cankerous lesions. These conidia serve as a primary inoculum source in the spring. Under unfavorable climatic conditions, infections can remain latent in immature fruit until conditions become favorable for disease development later in the season (Gell et al., 2008).

Figure 2. Apples infected with *Monilinia fructigena*. Photo courtesy Radek Sotalar – Czech. Republic.

Infection of *Monilinia fructigena* takes place via cracks and wounds in the fruit skin (Xu and Robinson, 2000) and also via fruit-to-fruit contact (Michailides and Morgan, 1997). Wind, water, insects, birds, and man are responsible for the dispersal of *Monilinia* conidia in pome and

stone fruit orchards (Byrde and Willetts, 1977; Bannon et al., 2009). Splash dispersal is important for short range spread within a tree (Bannon et al., 2009). Lack (1989) reported spread by insects. Kable (1965) discovered that airborne conidia ensured a wide dispersal of conidia within an orchard. Van Leeuwen et al. (2002b) observed that late infected fruits in one season can contribute to primary inoculum *of M. fructigena* in the next spring, and in early summer dropped fruit (such as fruit on the ground from very late thinning) can contribute to infection on the tree. Disease incidence can be controlled by avoiding fruit wounds caused by biotic (insects, birds, man) and abiotic (frost, hail) agents. A study by Spadoni et al. (2013), showed that hot water treatment is a promising method for controlling rot caused by *M. fructigena*, *M. fructicola*, and *M. laxa*.

Symptoms/Signs

Symptoms include stem cankers, twig and leaf blights, and brown fruit rots (Fig. 1 to 3).

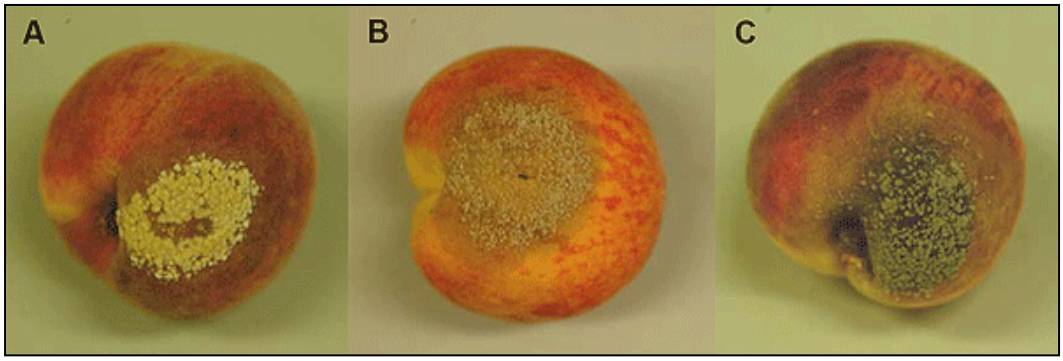

Figure 3. Peaches inoculated with a) *Monilinia fructigena*; b) *M. fructicola*; and c) *M. laxa*. Photo courtesy of DAFF (Department of Agriculture, Fisheries, and Forestry-Australia).

The primary and most frequent symptom is fruit rot (Fig. 1 to 3). Initial fruit lesions are brown, circular, and firm (Fig. 2). Eventually the whole fruit decays and turns brown. Tufts of mycelium and conidia (cream-white to buff colored) sprout from the skin of the infected fruit (Fig. 1, 3), often arranged in concentric rings (Fig. 2) (Byrde and Willetts, 1977). When the relative humidity is low and/or when the fruits are not ripe, no mycelium and very few or no conidial tufts develop. Rotted fruits may either fall to the ground or dry out on the tree, leaving a hard, shriveled ‘mummy’. Mummified fruit hang on branches of trees until spring or fall to the ground where they remain throughout the winter months, partly or completely buried beneath the soil or leaf litter (Byrde and Willetts, 1977). Infection of fruits can take place at any time during fruit development, but the disease is only severe in ripe or ripening fruits.

Pest Importance

Brown rot of stone fruits is an extremely destructive disease. The pathogens that cause brown rot of stone fruit also occur on apple and pear fruit trees. The disease may destroy or seriously reduce a crop by rotting mature fruit, either on the tree or after harvest.

Monilinia fructigena, a regulated pest in the United States, causes severe fruit rot of fruit trees. This pest causes loss of apple and stone fruits, both before and after harvest. Twigs and shoots can also be infected, albeit less frequently. Crops may be severely reduced or destroyed due to the infection.

In general, *M. fructigena* is less damaging than *M. fructicola* or *M. laxa*. The severity of the disease varies from year to year depending upon environmental and storage conditions. *M. fructigena* is highly infectious and is reported to cause considerable losses in Europe during summer when warm temperatures are favorable to disease development (Scopes and Ledieu, 1983). The greatest losses are often observed in apples and plum fruits. Losses of between 7 and 36% have been reported in European apple orchards and between 0.2 and 1.5% in stored fruits (Jones and Aldwinckle, 1990; van Leeuwen et al., 2000). Latent infections can also occur, with symptoms only developing after fruit ripening.

Monilinia fructigena is listed as a harmful organism in the following countries: Argentina, Canada, Chile, Ecuador, Egypt, Jordan, New Zealand, Peru, Syria, and Taiwan (USDA-PCIT, 2013). If this pest were found in the United States, there are potential trade implications with these countries.

Known Hosts

Cydonia spp. (quince), *Malus* spp. (apple), *Prunus* spp. (stone fruit), and *Pyrus* spp. (pear) (van Leeuwen et al., 2002).

Other hosts:
Actinidia arguta (kiwi), *Amelanchier canadensis* (shadbush), *Amygdalus communis* (almond), *Armeniaca vulgaris* (apricot), *Azalea* spp. (azalea), *Berberis* spp. (barberry), *Capsicum* spp. (pepper), *Cerasus* spp. (cherry), *Chaenomeles* spp. (flowering quince), *Corylus* spp. (hazelnut), *Cotoneaster* spp. (cotoneaster), *Crataegus laevigata* (hawthorn), *Crataegus oxyacantha* (English hawthorn), *Diospyros* spp. (persimmon), *Elaeagnus macrophylla* (maruba-gumi), *Eriobotrya* spp. (loquat), *Ficus* spp. (fig), *Fragaria* spp. (strawberry), *Mespilus germanica* (medlar), *Psidium* spp. (guava), *Rhododendron* spp. (rhododendron), *Rosa* spp. (rose), *Rubus* spp. (blackberry), *Solanum lycopersicum* (tomato), *Sorbus* spp. (rowan), *Vaccinium* spp. (blueberry), *Vitis spp.* (grape) (Mackie & Kumar, 2005; Petroczy et al., 2005; Amiri et al., 2009; USDA-ARS, 2005; CABI, 2013; EPPO, 2013).

Known Vectors (or associated insects)

Insects play a role in the dispersal of *Monilinia fructigena* (Lack, 1989). According to this study, insects from the order Diptera and Hymenoptera played the largest role among insects in spreading this pest.

Known Distribution

Africa: Egypt and Morocco. **Asia:** Afghanistan, Belarus, China, India, Iran, Israel, Japan, Kazakhstan, Korea (North), Korea (South), Lebanon, Nepal, Russia, Taiwan,

Turkey, and Uzbekistan. **Europe:** Armenia, Austria, Azerbaijan, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Georgia, Greece, Hungary, Ireland, Italy (Including Sicily), Latvia, Lithuania, Luxembourg, Moldova, Montenegro, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, and United Kingdom (UK) (CABI, 2013; EPPO, 2013).

North America: *M. fructigena* was found in Beltsville, Maryland, United States, in 1979, but it was successfully eradicated (CABI, 2013; EPPO, 2013).

This pathogen was reported in Brazil, Chile, and Uruguay, but these reports proved to be erroneous (EPPO, 2013). There have also been unconfirmed reports in Canada (Ginns, 1986), Cuba (Arnold, 1986), and New Caledonia (Huguenin, 1986).

It is unclear at this time if this fungus is present in Mexico. There were two interceptions of *M. fructigena* on *Prunus persica* var. *nucipersica* and *Malus* sp. fruit imported from Mexico (Paul Larkins, personal communication; AQAS, 2013). These interceptions suggest that this pathogen may be present in Mexico even though it has not been officially confirmed there.

Isolates of *Monilinia fructigena* from other areas of East Asia should be examined to determine whether some isolates actually belong to *Monilia polystroma* (van Leeuwen et al., 2002).

Pathway

Monilinia fructigena has been intercepted 33 times at U.S. entryways since 1984 (AQAS, 2013). Of those interceptions, 32 of them were found on contaminated fruit and the other on infected seed. All of the fruit was either *Malus sp*. or *Prunus* sp. In general, interceptions of *Malus* sp. or *Prunus* sp. propagative material are common. For example, there were 186 interceptions of *Malus* sp. propagative material and 56 interceptions of *Prunus* sp. propagative material from host country China in the past ten years. During the same timeframe there were 1,216 interceptions of *Malus* sp. and 203 interceptions of *Prunus* sp. (propagative material) from European countries. *M. fructigena* is located in at least 29 different European countries.

In addition to Europe and China, *M. fructigena* is found in at least 21 other countries. It is also possibly in Mexico (Paul Larkins, personal communication). This fungus also has many other known hosts in addition to *Malus* sp. and *Prunus* sp. (CABI, 2013). A wide host range coupled with a broad diversity of known hosts lead to the creation of many possible pathways into the United States.

Potential Distribution within the United States

There is a high potential for distribution of *Monilinia fructigena* in the United States if it becomes established. According to a recent host analysis developed by USDA-APHIS-PPQ-CPHST for *Monilia polystroma,* a pest whose known hosts are also known hosts of *M. fructigena*, the eastern half of the continental United States has a moderate to high

level of risk of establishment. Thisanalysis was based solely on the presence of susceptible hosts. Most areas of the western United States have a low risk; while portions of California, Washington, and Oregon have a moderate risk.

Since *M. fructigena* has many more known hosts than *M. polystroma*, the potential for distribution of *M. fructigena* in the United States is likely higher.

Survey

CAPS-Approved Method*: Visual survey is the approved survey method for *Monilinia fructigena .* For visual survey, collect symptomatic plant material.

*For the most up-to-date methods for survey and identification, see Approved Methods on the CAPS Resource and Collaboration Site, at http://caps.ceris.purdue.edu/.

Literature-Based Methods: Survey for *Monilinia fructigena* consists of visual inspection for symptoms, tissue sampling, and pathogen isolation.

Key Diagnostics/Identification

CAPS-Approved Method*: Morphological. Identification of brown rot fungi is commonly based on morphology and colony characteristics. This is the CAPS-Approved method until molecular methods can be validated for regulatory use.

Identification of the three main *Monilinia* species *(fructigena, fruticola*, and *laxa*) is commonly based on morphology and colony characteristics. Identification is possible by combining cultural characteristics, such as growth rate, growth pattern and color, with morphological data, such as conidial dimensions and the length of the germ tube (van Leeuwen and van Kesteren, 1998; De Cal and Melgarejo, 1999; van Leeuwen et al., 2002). Most of these characters are quantitative and overlap, so the identification has to be conducted under standardized conditions and starting from pure cultures. Lane (2003) also provides information for distinguishing the three main *Monilinia* spp. based on cultural characteristics (*M. fructigena*, *M. fructicola*, and *M. laxa*). *M. fructigena* can be distinguished from *Monilia polystroma* based on morphological and molecular characteristics of isolates (van Leeuwen et al., 2002).

Hu et al. (2011) discuss two additional *Monilinia* spp. in China: *Monilia mumecola* and *Monilinia yunnanensis*.

*For the most up-to-date methods for survey and identification, see Approved Methods on the CAPS Resource and Collaboration Site, at http://caps.ceris.purdue.edu/.

Literature-Based Methods:

Culture/Isolation: For isolation, the standard procedure is to place pieces of infected material (with or without surface sterilization) on slightly acid agar medium (pH 4-4.5) (EPPO, 2009). Isolation of *Monilinia* spp. from stone fruit and pome fruit surfaces is difficult, however, due to the presence of several fast-growing fungal species such as *Rhizopus*, *Alternaria*, and *Penicillium* spp. It is also possible to have mixed *Monilinia*

infections. Phillips and Harvey (1975) tested a medium containing pentachloronitrobenzene (PCNB), canned strained peaches, neomycin, streptomycin, agar, and distilled water and found that though it was not totally selective that it could be used to estimate spore density of *Monilinia* spp. on the surface of fruit. Amiri et al. (2009) developed a new selective medium (acidified potato dextrose agar (PDA) with fosetyl-Al) for recovery and of enumeration of *Monilinia* spp. from stone fruit.

Molecular: Several molecular methods have been developed to distinguish *Monilinia* species. Fulton and Brown (1997) and Snyder and Jones (1999) established a PCR-based method of targeting to distinguish *M. fructigena* from *M. fructicola* and *M. laxa* based on the group I intron in the gene for the ribosomal subunit. Subsequent studies, however, showed that these methods were not reliable because some isolates of *M. fructicola* lack a group I intron in their nuclear rDNA small subunit (Förster and Adaskaveg, 2000; Fulton et al., 1999; Hughes et al., 2000; Cote et al., 2004b). Other PCR primers and protocols for *M. fructicola* were published by Förster and Adaskaveg (2000), Boehm et al. (2001), and Ma et al. (2003). However these methods discriminate *M. fructicola* from *M. laxa* but have not been validated for distinguishing *M. fructicola* from *M. fructigena*. Fluorescent AFLP fingerprinting and inter-simple sequence repeat analysis has been used to examine the genetic diversity of *M. fructicola* (Fan et al., 2010; Gril et al., 2010).

Ma et al. (2005) developed a pair of PCR primers specific to *M. laxa* on the basis of the differences in the DNA sequence of the intron 6 of *β*-tubulin gene from *M. laxa*, *M. fructicola* and other fungal species.

Ioos and Frey (2000) designed species-specific primer pairs for *Monilinia fructigena*, *M. fructicola*, and *M. laxa* based on the ribosomal internal transcribed spacer (ITS) region. This method, while testing for all three *Monilinia* species, produces PCR amplicons of the same size (356 bp), so three separate PCR reactions have to be performed in order to identify the species. Hughes et al. (2000) also developed species-specific primers for *Monilinia fructigena*, *M. fructicola*, and *M. laxa.* An internal control based universal PCR protocol was developed for *Monilinia* spp., and species-specific primers were designed by using SCAR makers (Gell et al., 2007). Miessner and Stamler (2010) and Hily et al. (2010) developed a primer/primers based on difference in the intron-exon of the cytochrome b gene to distinguish *Monilinia fructigena*, *M. fructicola*, and *M. laxa.* Cote et al. (2004) developed a multiplex PCR that can distinguish *Monilinia fructigena*, *M. fructicola*, *M. laxa*, and *Monilia polystroma* on inoculated and naturally infected apple and stone fruit. This PCR method uses a common reverse primer (MO 368-5) and three species specific forward primers (MO 368-8R, MO 368-10R, and Laxa – R2) to differentiate the three *Monilinia* species. In this assay, a 402-bp PCR product for *M. fructigena*, a 535-bp product for *M. fructicola*, and a 351-bp product for *M. laxa* are produced. Furthermore, another specific 425-bp PCR product was amplified, enabling the identification of isolates of *Monilia polystroma*. Malvarez et al. (2001) were able to use the Cote et al. (2004) primers (prior to their publication) to identify species of *Monilinia* in Uruguay. Upon comparing the *M. fructigena* and *M. polystroma* sequences with the genomic sequence of unknown function previously described by Cote et al.

(2004). Petroczy et al. (2012) revealed insertions and substitutions in the *M. polystroma* sequences. Repetitive sequence motifs were identified, which can be used for differentiation between *M. fructigena* and *M. polystroma.*

According to EPPO (2009), the PCR method of Hughes et al. (2000), Ioos and Frey (2000), and Cote et al. (2004) have been shown not to give cross-reaction with *Monilia polystroma*.

Real-time PCR methods have been developed by Luo et al. (2007) and van Brouwershaven et al. (2010). The Luo et al. (2007) method, which is based on the Ma et al. (2003) primer for *M. fructicola*, is a SYBR Green assay and has been tested only against *M. fructicola*, *M. laxa*, *Botrytis cinerea*, *Botryosphaeria dothidea*, and *Alternaria alternata*. The van Brouwershaven (2010) method is a Taq man assay and has been validated against *Monilinia fructigena*, *M, laxa*, *M. fructicola,* and *Monilia polystroma*; a FAM-labeled probe will detect *M. fructicola* while a VIC-labeled probe will detect *M. fructigena*, *M. laxa*, and *Monilia polystroma* as a group. Since the United States currently has both *M. fructicola* and *M. laxa,* at present these real-time methods may be of limited utility for the detection of exotic *Monilinia* or *Monilia* species.

Seven different PCR methods were tested by Hu et al. (2011) to differentiate *Monilinia* spp. None of the six molecular tools alone were able to distinguish all five *Monilinia* species (*M. fructigena, M. fructicola, M. laxa, M. yunnaensis, and M. mumecola*) (Ioos and Frey 2000; Ma et al. 2003, 2005; Cote et al., 2004; Gell et al., 2007; Miessner and Stammler, 2010; Hily et al., 2010). Note: The authors didn't test *Monilia polystroma*.

M. fructigena, M. fructicola, and *M. laxa* were reliably differentiated by the methods of Ioos and Frey (2000), Miessner and Stammler (2010), and Hily et al. (2010). However, neither of these methods was able to distinguish *M. fructigena* from *M. yannanensis*. Likewise, the methods developed by Ioos and Frey (2010), Ma et al. (2003, 2005) did not distinguish between *M. mumecola* and *M. laxa*. The method developed by Hily et al. (2010) did not distinguish *M. mumecola* from *M. fructicola*. Additionally, the methods of Miessner and Stammler (2010) and Hily et al. (2010) did not distinguish between *M. yunnanensis* and *M. laxa*.

Hu et al. recently (2011) developed an additional multiplex PCR to distinguish *M. fructicola* from *M. mumecola*, *M. yunnanensis* in China. Additional work needed to see if these primers distinguish *M. fructigena, Monilinia laxa*, and *Monilia polystroma*, because the authors did not find these species in China and did not present any specific data for these species.

Easily Confused Pests

Monilinia fructigena can easily be confused with other brown rot fungi, particularly *M. fructicola*, M. *laxa, and Monilia polystroma*. *Monilia mumecola* is another brown rot fungi of stone fruit that could be confused with *M. fructigena*. *Monilia polystroma* was originally classified as *Monilinia fructigena*. *M. laxa* is considered to be more a pathogen of blossoms and twigs than of fruit and primarily occurs on *Prunus* spp. *M.*

fructigena is mainly a fruit pathogen and primarily occurs on apple, pear, and other pome fruit trees, although it is also found on *Prunus* spp. (USDA ARS, 2005). *M. fructicola* is a pathogen of blossoms, twigs, and fruits and mainly affects stone fruits but can occur on apples, pears, and other pome fruits (USDA ARS, 2005). The color of the pustules on infected plant tissue is buff for *M. fructigena* and grayish-brown for *M. fructicola* and *M. laxa* (van Leeuwen and van Kesteren, 1998).

Monilinia fructigena is quite similar to *Monilia polystroma* but differences do exist. For example, *Monilia polystroma* forms a large number of dark/black colored stromata in agar culture (van Leeuwen et al., 2002). *Monilinia fructigena* has the largest macroconidia where the conidia of *Monilia polystroma* are slightly smaller. Colonies of *Monilinia fructigena* are similar to those of *Monilia polystroma*, but black stromatal plates occur on *M. polystroma* colonies after incubation for 10 to 13 days, and *Monilia polystroma* isolates grow faster than *M. fructigena* isolates under the same conditions (van Leeuwen et al., 2002).

Other fungi can cause rots with similar symptoms to *Monilia polystroma* (*Penicillium* spp., *Mucor* spp.). Avoid collecting fruits with blue, green, or yellow colored molds or fruit that are 'leaking' fluid.

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Draft log

2014 Updates: Updated Pest Importance section (Hot water treatment segment). Added information about apricot as a new host for *M. mumecola*.

July, 2016: Updated mapping information