# Mucor Rot

*By Achour Amiri and Keith van den Broek, WSU Plant Pathology. Updated February 2020.*

Mucor rot is a common problem on pome fruits (apples and pears) in the Pacific Northwest and elsewhere, as well as on other commercial crops including stone fruits (cherry, peach, nectarine, prune, plum), raspberries, and citrus fruits. Although not as important as blue and gray mold the disease can be a challenge because none of the current postharvest fungicides are effective against Mucor. Good bin sanitation, harvest management and water-sanitation practices are critical to manage the disease.

## Causal Organism

Mucor rot is caused primarily by *Mucor piriformis* A. Fisch. 1982. Other *Mucor* species that may cause Mucor rot in pome fruits include *M. mucedo* Fresen., *M. racemosus* Fresen., and *M. strictus* Hagem. However. Only *M. piriformis* has been found to cause significant losses on many cultivars of apple and pear in cold storage.

## Symptoms

Mucor rot typically originates at puncture wounds in the cuticle, or at the stem or calyx end of the fruit. At early stages of infection, long, coarse white or gray mycelium with pin-shaped dark spore heads may appear at wound sites, splits, or fruit lenticels. Once infected, fruit will rapidly decay and liquefy even in cold storage or controlled atmosphere (CA), with complete decay in less than two months at 0°C (32 °F). The decayed tissue is generally light brown to golden in color and is very soft and juicy in texture. It can be readily separated from any healthy tissue and the skin can be very easily peeled from the infected flesh. When the fruit is ruptured, abundant sporangia-containing juice is released, and can spread to cause secondary infections. At early infection stages, Mucor rot symptoms can be sometimes confused with those of blue mold but Mucor has a distinct sweet odor (Table 1).

### Table 1. Comparative diagnostic aid between Mucor rot and blue mold

| Characteristics | Blue mold | Mucor rot |
|---|---|---|
| Texture | Soft, watery | Very soft, juicy |
| Color of decayed area | Light tan to dark brown | Light brown to brown |
| Mycelia and spores on fruit | Blue or blue-green spore masses, rare mycelia | Gray mycelium with dark sporangia |
| Color of internal flesh | Brown | Light brown to brown |
| Odor | Earthy, musty | Sweet |

**A:** Early mucor symptoms starting from a wound on Granny Smith. Note the white mycelium emerging.

**B**: Early stage infection of Mucor rot starting from a wounded area around the stem-end on d' Anjou pear.

**C**: Cross section of Mucor rot on a Fuji apple. Note juicy tissue easily separated from healthy tissue.

**D**: Cross section of Mucor rot on a Granny Smith apple. Note juicy-watery tissue and white sporangiophores emerging from the calyx-end.

**E:** Actively growing Mucor infection on Granny Smith apple under high humidity causing the emergence of fuzzy-white sporangiophores.

**F**: Advanced Mucor rot on a Fuji apple. Entire fruit is extremely soft and juicy. Notice dark sporangia on fruit surface.

**G**: Abundant fuzzy sporangiophores (mycelium) carrying black sporangia.

**H**: Advanced late-stage Mucor infection on Granny Smith.

**E**: Stem-end Mucor infection carrying sporangiophores and black sporangia on Bartlett pear.

**Figure 1.** Characteristic symptoms and signs of Mucor rot infections on pome fruits. Photo credit to Achour Amiri & Keith van den Broek (WSU-TFREC).

## Infection cycle of Mucor Rot

*Mucor piriformis* is a soilborne pathogen that survives as sporangiophores mainly in the top layer of the orchard soil, especially in organic matter such as fallen fruit and debris. Sporangiospore populations peak in the fall or winter depending on moisture, temperature and nutrient availability in the soil. Sporangia may survive on bins if not sanitized after each use. Infections occur primarily through contact of bins with infested soils, but can also be transmitted through spores spread by other vectors such as birds, rodents and insects, particularly vinegar flies and nitidulid beetles.

Fruits are most susceptible to infections during the final month before harvest, and late-harvested or over-mature fruits are more susceptible to Mucor and other decays. Infections mainly occur during harvest if fruit are harvest into non-cleaned bins, during drenching from bin to bin or in the dump- tank and flume water during packing. The pathogen is cold-tolerant as germination can occur between -1ºC (30ºF) and 24ºC, with 20ºC being optimal but not at temperatures above 26ºC (78ºF). Mucor rot progresses rapidly and completely decays the fruit in less than two months in cold storage.

## Control

Because Mucor is a type of fungi with completely different (biology, physiology, etiology) from the other fungi known to decay pome fruit, none of the current pre or postharvest fungicides are effective against Mucor rot. Therefore, good orchard and harvest management practices are key to managing this disease. Orchard sanitation includes removal of fallen mummified fruit, and treatment or removal of leaf litter and other debris from the orchard floor to help reduce inoculum levels in the soil in the upcoming season. Flail mowing after harvest can spread inoculum and should be avoided.

Prior to the start of the new storage season, it is important to clean and sanitize rooms (air, walls, floors) and bins at least once a season prior to storing a new crop. Sanitation of the packing-line from dump-tank all-the-way to the sorters needs to be done regularly during the packing season. Several sanitizers, i.e. chlorine and chlorine dioxide, hydrogen peroxide, organic aids, electrolyzed water and ozone, are available and all have different efficacies and uses (Bernat et al., 2018; Feliziani et al., 2016). Consult extension specialists or consultants in your area and the product labels to optimize sanitation. Recent cold or hot fogging technologies have shown good levels of efficacy in sanitizing larger facilities (entire rooms, lines, stack of bins) more efficiently.

During harvest, fruit bins should be positioned on the orchard floor to minimize contamination of the undersides of bins by infested soil or organic debris. Fruits that fall to the ground during harvest should not be put back in fruit bins. Undersides of bins should be brushed clean before stacking. Fruits harvested during dry weather are less susceptible to Mucor rot than those harvested in wet weather.
On the packing line, thorough rinsing of fruit can help remove spores and lower decay rates, but recycled rinse water can also spread spores to healthy fruit. Because humidity tends to be slightly higher in rooms with controlled atmosphere, even with low $O_2$ concentrations, Mucor rot incidence tends to be slightly lower in regular storage atmospheres.

## References

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*Use pesticides with care. Apply them only to plants, animals, or sites listed on the labels. When mixing and applying pesticides, follow all label precautions to protect yourself and others around you. It is a violation of the law to disregard label directions. If pesticides are spilled on skin or clothing, remove clothing and wash skin thoroughly. Store pesticides in their original containers and keep them out of the reach of children, pets, and livestock.*

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