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Rhizopus Soft Rot of Sweetpotato

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The sweetpotato is a very important local food in Hawai'i and a multimillion dollar export crop for the state. It was ranked as the 18th most valuable agricultural commodity in 2006, valued at more than $4.4 million. Countless backyard growers also produced sweetpotatoes for their own consumption or for sale at farmers' markets. It is a crop that is now grown on lands long occupied by sugarcane or pineapple.

Growers in Hawai'i produce a number of sweetpotato varieties with different skin and flesh colors. Perhaps the most important and widely grown variety, and one that is exported to the U.S. mainland, has purplish flesh inside the storage roots of the plant and is known as the Okinawan purple sweetpotato. Crops of this and other varieties can suffer from a range of pests, including a number of postharvest diseases of the fleshy roots caused by plant-pathogenic fungi.

Several significant, common postharvest diseases of similar appearance threaten to reduce Okinawan sweetpotato production and profits for Hawai'i growers, marketers, and exporters. These diseases are caused by fungi present in the soil or in the environment where sweetpotatoes are grown and processed. The pathogens that cause these diseases can occur alone or together and infect plants within the same areas of the sweetpotato field.

The major postharvest diseases of the Okinawan sweetpotatoes in Hawai'i include Ceratocystis black rot, Java black rot, Rhizopus soft rot, and scurf. Fungal pathogens cause most of the damage after the crops are harvested, handled, processed, shipped, and marketed.

This publication describes one of the most costly postharvest diseases of sweetpotatoes, Rhizopus soft rot. When the infection is restricted, it is called ring rot or collar rot. Symptoms on Okinawan sweetpotato are shown, and integrated practices designed to minimize sweetpotato losses to farmers and marketers are recommended. The symptoms of the disease are similar on other sweetpotato varieties grown in Hawai'i.

The host

Okinawan purple sweetpotato, *Ipomoea batatas* (L.) Lam. (synonym *Ipomoea fastigiata* Choisy), of the plant family Convolvulaceae, is a tuberous-rooted perennial

At a grocery store on Hawai'i, Okinawan purple sweetpotatoes show symptoms not only of Rhizopus rot but of Java black rot and scurf. It is common to see several postharvest diseases of sweetpotatoes in the same batch. The severity of these diseases can be reduced using the integrated management methods similar to those described in this publication for Rhizopus soft rot.

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native to the American tropics. The plant's aboveground growth is herbaceous, with stems that form a prostrate, slender, running vine. Lateral stems are usually not branched. The leaves, borne on long petioles, are palmately veined, angular or lobed, and green or purplish, depending on the variety.

The pathogen and infection

Rhizopus is a common pre- and/or postharvest pathogen of many fruits and vegetables worldwide, including jackfruit (*Artocarpus heterophyllus*). It is also a common cause of bread mold.

The fungi causing disease of sweetpotato worldwide include several *Rhizopus* species, *Rhizopus nigricans* = *Rhizopus stolonifer*, also known as the common bread mold, *Rhizopus* sp. and *Rhizopus oryzae*. This is a widespread, common and potentially costly fungal disease. It is most prevalent in temperate and subtropical growing regions but is also common in the warmer tropics. In Hawai'i, the disease can occur wherever sweetpotatoes are grown or processed.

Sites of infection are primarily wounded, necrotic storage root periderms (wounded sweetpotato "skins"). These sites are usually the broken tips of sweetpotatoes damaged during harvest, holes in the periderm caused by tools or insects such as weevils, or bruises or wounds created by overly rough handling of sweetpotatoes after harvest and during processing. Uncured sweetpotatoes are more prone to damage than are cured sweetpotatoes. Curing is a process that creates wound periderm, a scar-like tissue that seals wounds and reduces infections.

Other factors favoring disease development include unsanitary packing facilities and handling practices, warm and moist storage or marketing conditions, and dirty or pathogen-contaminated sweetpotato washing water.

Symptoms

Symtpoms may begin in any wounded or damaged area of the sweetpotato. The disease usually begins in the wound created where roots are broken from the plants during harvest. But symptoms may sometimes develop before harvest in fields with heavy or clayey soils after flooding or heavy, continuous rainfall. Diseased sweetpotatoes turn soft and moist, with stringy flesh. The infected tissue of Okinawan sweetpotatoes usually turns brownish to blackish quickly. The color of the diseased tissue may vary among sweetpotato cultivars. A pronounced, fermented odor is often present and may attract egg-laying fruit flies. The entire root usually rots completely within days after infection. The parenchyma (composing the pith, or innermost layer) may liquefy, whereas the periderm (skin) and root fibers remain relatively undegraded.

Tufts of the plant pathogen *Rhizopus* emerge from openings in a rotting sweetpotato. Fungal "whiskers," typically darkly colored, fuzzy-looking tufts, are diagnostic for Rhizopus soft rot disease. The tufts are composed of fungal mycelia, sporangiophores, and sporangia.

As decay progresses, mycelia and whisker-like tufts of sporangiophores and darkly pigmented sporangiospores (spores) grow out through cracks, breaks, wounds, bruises, holes, or natural openings in the sweetpotato periderm.

Disease cycle

Dispersal: *Rhizopus* spores are ubiquitous and continually present in the air around us. The fungus can survive in crop debris in the soil, in fruits and vegetables, and to some extent on contaminated equipment.

Infection: *Rhizopus* spp. require wounds and necrotic tissue for infection of sweetpotato storage roots. When either airborne spores or infested soil comes into contact with a wound, the spores germinate, producing hyphae that enter the root.

Disease and symptom development: Pectolytic and other enzymes produced by *Rhizopus* quickly cause host discoloration and liquefy host tissues.

Pathogen reproduction and survival: The pathogen usually reproduces asexually in Hawai'i without the overwintering sexual stage seen in temperate zones. It is an efficient saprophyte, surviving on the dead tissues of its plant hosts or on rotting sweetpotatoes in fields, in

At left, these Okinawan purple sweetpotatoes are discolored from Rhizopus rot. The interior turns light to dark brown and becomes soft; the parenchyma typically liquefies in a few days if the sweetpotatoes are not cooled or refrigerated. The rot can expand rapidly within the storage roots: the photo above shows the same samples seen above left but taken two days later.

packinghouses, in field soils, and on partly decomposed, stored products such as old bread.

Environment and other factors

Several variables influence infection and disease development of Rhizopus soft rot.

Effects of air temperature: The optimum temperature for growth of *R. nigricans* in culture is 82°F (28°C), but the optimum temperature for the production of pectolytic enzymes and infection of sweetpotatoes is 68°F (20°C).

Effects of relative humidity: At 73°F (23°C), the optimum relative humidity for the initiation of soft rot is in the range of 75–84%. Few infections occur at 93–99% relative humidity, but once an infection has been established the pathogen continues to grow at relative humidity levels of 50–100%.

Effect of wound periderm: Wound periderm can exclude *Rhizopus* spp. from the storage roots. Proper curing conditions create sufficient wound periderm (special tissue formed around wounds by plants; inhibits entry of microorganisms) to reduce Rhizopus soft rot significantly.

Storage of sweetpotatoes: Sweetpotatoes stored for long periods of time after harvest are more susceptible to soft rot disease.

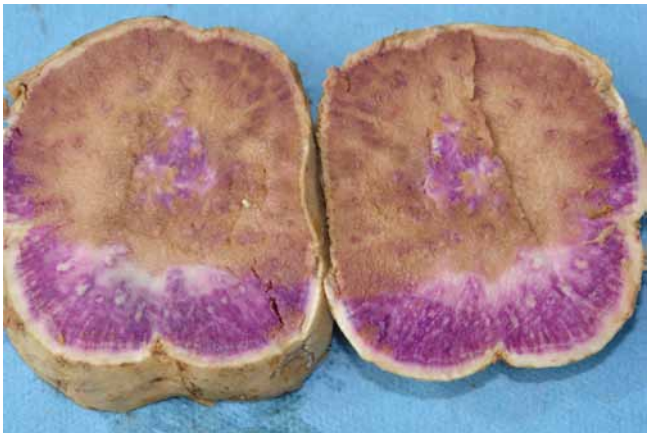
Integrated management of Rhizopus rot

Contact between infective spores of *Rhizopus* spp. and sweetpotatoes is almost inevitable because of the ubiquitous and airborne nature of the pathogens. The most effective ways to prevent disease before packing are to reduce wounding to sweetpotatoes after harvest and to sufficiently cure them.

- Minimize injuries and wounding of sweetpotatoes before, during and after harvest. *Rhizopus*, a fungal

Rhizopus rot can progress rapidly. In this Okinawan purple sweetpotato, rot and discoloration turned a healthy root into an inedible product within 24 hours at 70°F (21°C). The skin and parenchyma of this sweetpotato was riddled with holes created by sweetpotato weevils.

This is the severed tip of the diseased sweetpotato shown above, less than 24 hours later at 70°F. The typical fuzzy tufts of *Rhizopus* sporangia and sporangiophores extrude like whiskers through openings and wounds in the sweetpotato surface. This is the diagnostic sign for this disease.



Rotted, discolored cross-sections of sweetpotato with Rhizopus rot. The rot progressed to this point in less than 24 hours at 70°F.

The same sweetpotato slices shown above, less than 24 hours later. The sections are completely covered with the typical, fuzzy-looking, black *Rhizopus* sporangia and white sporangiophores and mycelium.

Another view of the fungal structures of *Rhizopus* on one of the Okinawan sweetpotato slices shown above. The black sporangiospores are easily dispersed by wind or air currents.

Rhizopus rot often begins at the tip of a sweetpotato where it is detached from the vine at harvest, or in wounds or bruises associated with handling and processing. Other sweetpotato diseases can produce the same general symptom, so further diagnostic work is needed to accurately identify the cause.

Holes made by sweetpotato weevils (shown here with darkly colored abdomens) can allow the pathogen to enter and rot the sweetpotato storage roots.

Rhizopus rot often begins at the tips of sweetpotatoes or in wounds associated with harvesting and handling. Other sweet potato diseases (e.g., Java black rot) can produce the same general symptom initially, and therefore further diagnostic work is needed to accurately identify the cause of the problem.

pathogen, is an opportunist that requires wounds or openings in sweetpotatoes to cause disease. Before harvest, control populations of damaging insects like weevils that create holes in the epidermis of fleshy roots. Reduce the surface area of wounds created during harvest when the sweetpotatoes are removed from the vine, by breaking them off at a narrow point at the root tip. Avoid bruising sweetpotatoes by rough handling during harvest and transport the warehouse.

- Cure sweetpotatoes immediately after harvest to encourage the formation of wound periderm. Then refrigerate or store them at a cool temperature before washing and processing. To cure the potatoes, store them at 85–96°F (30–35°C) and 85–95% relative humidity for 5–10 days, remove and cool at approximately 60°F (16°C). Many sweetpotato growers in Hawai‘i do not cure their crop. This can result in high levels of postharvest disease and crop loss.
- Carefully handle the tubers during transport and storage. Minimize injury, and wash them with clean water. When sweetpotatoes are removed from storage, wash, sort, and pack them quickly for market. Slow handling is a weak point in disease control programs. Sweetpotatoes should not be cured again after washing and packing but should be held as close to 60°F (16°C) as possible until they are consumed. Use protectant fungicides where available.
- Rotate crops. Do not plant successive crops of sweetpotatoes on the same land. Intercrop with less susceptible crops or with cover crops to reduce fungal inoculum levels in the fields.
- Clean up crop debris in fields after harvest. Do not allow off-grade sweetpotato storage roots to rot in the fields.

- Use clean water and keep the packinghouse area clean.
- In grocery stores or in markets, avoid lengthy storage period before sale. Avoid marketing diseased sweet potatoes in plastic bags without aeration. Refrigeration predisposes sweet potatoes to this disease.
- Cultivar selection. There are no resistant sweetpotato cultivars. All cultivars of sweetpotato are susceptible in varying degrees. However, the varieties may differ in their reaction to handling (some do not injure as readily).
- Manage weevil populations to reduce holes in the sweetpotatoes for the fungal pathogens to enter.
- Avoid planting sweetpotatoes in poorly drained, heavy soils, and avoid very high-rainfall areas.
- Use fungicides where appropriate before sending sweetpotatoes to market. Wounds created after fungicide is applied may not be protected. One product registered in Hawai'i is Botran 75W Fungicide (active ingredient, dicloran (75%); formulation, wettable powder; apply as postharvest application to non-stored commodity).
- Recognize similar sweetpotato diseases. Java black rot produces similar disease symptoms initially but different symptoms and signs as the disease develops.

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