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Mango anthracnose (*Colletotrichum gloeosporiodes*)

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Dry weather during mango (*Mangifera indica* L.) flowering seasons in Hawai'i can stimulate the formation of an enormous amount of mango blossoms and indicates a potentially productive bearing season ahead for mango growers. However, abundance of mango flowering has happened before and yet the yields or fruit quality were very disappointing, especially in wet areas of mango cultivation. What are the explanations for this?

First, most flowers in a mango panicle are male flowers that do not yield fruit. The number of fruits produced depends in part upon the number of hermaphrodite flowers in the panicles, a number which varies among mango cultivars.

Second, where mango flowering coincides with or is followed by wet weather, a devastating disease known as anthracnose can become established on panicles, virtually destroying them. Or, should the panicles make it through the season without being destroyed by anthracnose, the fruits produced may still be seriously affected by the disease when they are young, and symptoms appear especially during and after ripening of the infected, mature fruit. (Compounding this situation is the disease, mango powdery mildew, which is covered by another CTAHR Plant Disease publication, PD-46.)

The mango tree produces a delicious fruit that is widely consumed in Hawai'i and throughout the world. It is an important export crop in countries or locations where quarantine pests and diseases can be controlled satisfactorily. In Hawai'i, mangos are commonly eaten raw, dried when ripe, or pickled in condiments. Demand for local mangos is very high in Hawai'i when the fruit is in season; good mango crops fetch premium prices in the marketplace. Yet Hawai'i's mango production could be significantly greater if anthracnose was not such a major problem. Worldwide, mango anthracnose is the most important and destructive disease of mango, although in drier areas in Hawai'i, mango powdery mildew is probably the more harmful of the two diseases.

All photos by S. Nelson (unless noted otherwise)

The host

Mango is in the plant family Anacardiaceae; related plants in this family include cashew (*Anacardium occidentale*), pistachio (*Pistacia vera*), and poison ivy (*Toxicodendron radicans*). Hundreds of mango cultivars are known worldwide. Sometimes called "the king of fruits," mango grows throughout the tropics and subtropics and is regarded as one of the world's most important fruit crops.

Mango is a perennial, branching, evergreen tree approximately 30–40 feet tall. Its fruit is a large, fleshy drupe containing a laterally compressed stone housing the seed. Mango cultivars vary considerably in fruit size, color, shape, flavor, texture, and taste.

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The pathogen and disease symptoms

The ubiquitous fungus *Colletotrichum gloeosporioides* Penz and Sacc. is the anamorph stage (asexual stage of the pathogenic fungus). *C. gloeosporiodes* is responsible for many diseases, also referred to as "anthracnose," on many tropical fruits including banana, avocado, papaya, coffee, passion fruit, and others.

According to Ploetz (1999), "characterizations of worldwide populations of *C. gloeosporiodes* indicate that strains from mango comprise a genetically and pathologically distinct population of this species. The mango population of the pathogen always predominated on mango, was not found on other tropical fruit crops, and had a restricted host range insofar as individuals from the population were highly virulent only on mango." In other words, populations of the pathogen are essentially host-specific.

On mango, anthracnose symptoms occur on leaves, twigs, petioles, flower clusters (panicles), and fruits. On leaves, lesions start as small, angular, brown to black spots that can enlarge to form extensive dead areas. The lesions may drop out of leaves during dry weather. The first symptoms on panicles are small black or dark-brown spots, which can enlarge, coalesce, and kill the flowers before fruits are produced, greatly reducing yield. Petioles, twigs, and stems are also susceptible and develop the typical black, expanding lesions found on fruits, leaves and flowers.

Ripe fruits affected by anthracnose develop sunken, prominent, dark brown to black decay spots before or after picking. Fruits may drop from trees prematurely. The fruit spots can and usually do coalesce and can eventually penetrate deep into the fruit, resulting in extensive fruit rotting. Most green fruit infections remain latent and largely invisible until ripening. Thus fruits that appear healthy at harvest can develop significant anthracnose symptoms rapidly upon ripening. A second symptom type on fruits consists of a "tear stain" symptom, in which are linear necrotic regions on the fruit that may or may not be associated with superficial cracking of the epidermis, lending an "alligator skin" effect and even causing fruits to develop wide, deep cracks in the epidermis that extend into the pulp.

Lesions on stems and fruits may produce conspicuous, pinkish-orange spore masses under wet conditions.

Wet, humid, warm weather conditions favor anthracnose infections in the field. Warm, humid temperatures favor postharvest anthracnose development.

Table 1. Commercial mango production in Hawai'i (2005).

Number of farms	100
Acreage in crop	295
Acreage harvested	190
Total number of trees	13,900
Number of bearing trees	8900
Utilized production	530,000 pounds
Farm price	$1.11 per pound
Value of sales	$586,000

Source: Hawai'i Agricultural Statistics Service (2005); data are based on mango farms participating in HASS' annual survey and do not reflect harvests from populations of naturalized mango trees or those cultivated by backyard growers.

Disease cycle

Dissemination: spores (conidia) of the pathogen are dispersed passively by splashing rain or irrigation water.

Inoculation: spores land on infection sites (panicles, leaves, branch terminals).

Infection and pathogen development: on immature fruits and young tissues, spores germinate and penetrate through the cuticle and epidermis to ramify through the tissues. On mature fruits, infections penetrate the cuticle, but remain quiescent until ripening of the climateric fruits begins.

Symptom and disease development: black, sunken, rapidly expanding lesions develop on affected organs

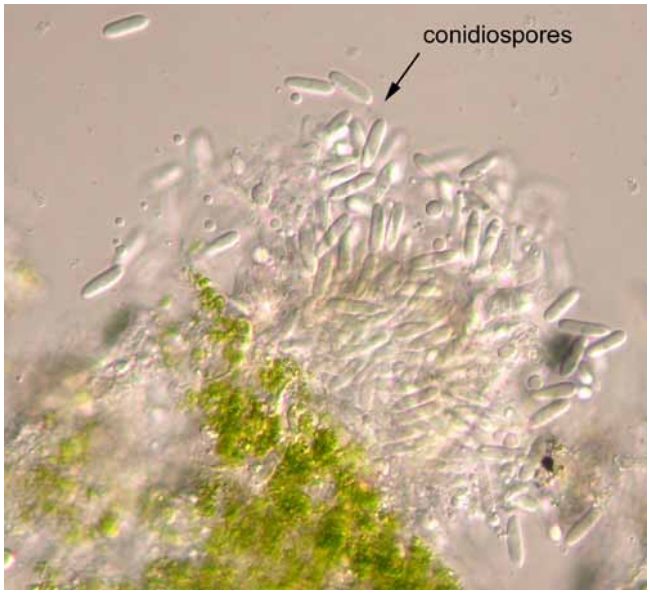
Pathogen reproduction: sticky masses of conidia are produced in fruiting bodies (acervuli) on symptomatic tissue, especially during moist (rainy, humid) conditions. Many cycles of disease can occur as the fungus continues to multiply during the season.

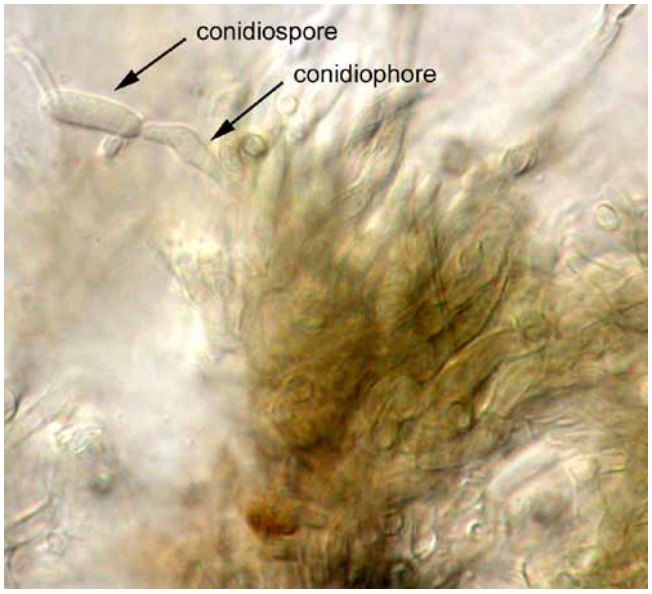
Pathogen survival: the pathogen survives between seasons on infected and defoliated branch terminals and mature leaves

Integrated disease management practices

Management of mango anthracnose consists of five approaches:

- site selection
- cultivar selection
- cultural practices in the field (sanitation, plant spacing, intercropping, etc)
- fungicide sprays in the field
- postharvest treatments (physical, chemical).





The pathogen. Conidiogenesis in *Colletototrichum gloeosporiodes* (highly magnified) from mango in American Samoa. A conidium (pl. conidia) is an asexual, nonmotile fungal spore that develops externally or is liberated from the cell that formed it. Conidiogenesis is the formation of asexual spores (conidia or conidiopspores). A conidiophore is simple or branched hypha on which conidia are produced. Photos: Fred Brooks

Table 2. Mango cultivar reaction to anthracnose (after Nishijima 1993).

Country	***Resistant***	***Moderate***	***Susceptible***	***Very susceptible***
Australia	Carrie Caraboa Florigon Tommy Atkins Saigon	Kensington Pride		Willard Neelum Manaranijan
Philippines	Palmer Siam Velei-Colomban Joe Welch	Fernandin Arumanis Edward Gedong Tjenkir	Carrie Peter Passand	Ah Ping, Julie Zill, Willard Cherakuruasa Hingurakgoda Kensington Otts, Pope
Hawaii	Paris, Fairchild Rapoza	Haden	Exel	Pirie
Florida	Zill	Haden	Irwin, Sensation Kent, Keitt Tommy Atkins	

Panicle symptoms of mango anthracnose on various mango cultivars in Hawai'i and Micronesia. Infections appear initially as tiny, well-defined black flecks or specks on all tissues of the panicle. As the infection spreads, clusters of flowers turn inky black and die. The panicle becomes prone to nearly complete disintegration.

Mango anthracnose symptoms on fruits
Above, a basket of anthracnose-diseased mango fruits at a farmer's market in Hilo, Hawai'i. Such fruits may be acceptable for some lower-quality local markets but are certainly not for shipping off-island. Development of the lesions occurs within days from quiescent infections after the fruits begin to ripen. Irregular, dark brown to black lesions form anywhere on the fruit and often coalesce to form larger, severely blighted areas. Lesions are somewhat depressed or sunken, initially superficial but can penetrate deep into the flesh as disease progresses. During humid or moist conditions, abundant orange-brown to salmon colored spore masses of the pathogen form in lesions on the fruit surface.

Symptoms of mango anthracnose on cultivar Rapoza: tan colored centers and blackened margins.

On common mango and other mango types, two basic symptom types for mango anthracnose are sunken black lesions (above, left) or the "tear stain" effect (above right and below, left), linear necrotic regions lending an alligator-skin effect, often associated with cracking of the epidermis (below).

Leaf symptoms
New mango leaves are most susceptible to infection, especially when their emergence coincides with frequent rainfall. Leaf lesions begin on these immature leaves as tiny brown to black specks (above) which develop chlorotic halos (right). Mature lesions on fully expanded leaves are dark brown and often irregularly shaped, not vein delimited, and tending to occur at leaf margins. The lesions can remain small under most conditions, but can enlarge to create leaf blight where relative humidity is high.

Table 3. Disease reactions of fruit of different mango cultivars to anthracnose (adapted from Pernezny and Ploetz 2000).

Disease reaction	***Cultivars***
Highly susceptible	Irwin, Kent
Susceptible	Fascell, Haden, Palmer, Sensation, Zill, Rapoza
Moderately resistant	Carrie, Earlygold, Edward, Florigon, Glenn, Julie, Keitt, Tommy Atkins, Van Dyke

Choose a hot, dry area, and avoid wet areas. Practically speaking, this means in Hawai‘i that one should grow mango trees at lower elevations, on leeward sides of islands, where rainfall is less than 15 inches per year.

Aside from site selection, the best way to manage anthracnose is to plant a resistant cultivar.

Cultivars recommended for Hawai‘i

The following cultivars have been recommended by UH-CTAHR for Hawai‘i based on their horticultural properties: Ah Ping, Fairchild, Gouveia, Harders, Keitt, Momi K, Pope, and Rapoza. All of these cultivars are productive and have superior quality fruit. Flowering occurs from December to April in Hawai‘i, but off-season flowering is common. Growers may have to use fungicide sprays

Stem, branch, and twig symptoms. Twig dieback occurs when severe, elongated, blackened lesions form on stems and twigs die back apically. In these photos, abundant sporulation of the pathogen covers the most decomposed points of the infection.

to control anthracnose and/or powdery mildew on these varieties in some locations.

Cultural practices

Practice sanitation: prune trees yearly and remove fallen plant debris from the ground.

Plant spacing: wider plant spacing will inhibit severe epidemics.

Intercropping: interplanting mango with other types of trees that are not hosts of mango anthracnose will inhibit epidemics.

Chemical control

Control of anthracnose on very susceptible mango cultivars and in very conducive environments requires periodic fungicide sprays. The timing and frequency of applications are very critical for adequate disease control. Sprays should begin when panicles first appear and continue at the recommended intervals until fruits are about 1½–2 inches long.

In Hawai‘i, a range of foliar fungicides are registered for control of mango anthracnose, including products containing clarified neem oil, mono- and di-potassium

Table 4. Some fungicides for sale in Hawai'i* for control of mango anthracnose, *Colletotrichum gloeosporiodes*, and *Glomerella cingulata*, the sexual stage of the pathgen.

Product name*	Active ingredient	Formulation
70% Neem oil	Clarified hydrophobic neem oil (70%)	Soluble concentrate
Agri-Fos Systemic Fungicide, Alude Systemic Fungicide	Mono- and di-potassium salts of phosphorous acid (45.8%)	Emulsifiable concentrate
Basic Copper 53	Basic cupric sulfate (98%)	Emulsifiable concentrate
Champ Formula 2 Flowable Agricultural Fungicide/Bactericide	Copper hydroxide (37.5%)	Flowable concentrate
Champion Wettable Powder Agricultural Fungicide (also Champion WG)	Copper hydroxide (77%)	Wettable powder
Decco Salt No. 19	Thiabendazole (98.5%)	Wettable powder
DuPont Kocide 101 Fungicide/Bactericide (also Kocide 2000, Kocide 2000, Kocide 4.5 LF, Kocide DF)	Copper hydroxide (77%)	Wettable powder (and other formulations)
Copper hydroxide (46.1%)	Water dispersible granules	
Echo 720 Turf and Ornamental Fungicide	Chlorothalonil (54%)	Emulsifiable concentrate
Messenger (For Home and Garden)	Harpin protein (3%)	Water dispersible granules
Nu-Cop 3L (also Nu-Cop 50 DF, Nu-Cop 50WP, Nu-Cop HB)	Copper hydroxide (37.5%) (other concentrations available in other Nu-Cop products)	Flowable Concentrate (and other formulations)
Prescription Treatment Brand Camelot Fungicide/Bactericide, Tenncop 5E Fungicide/Bactericide	Copper salts of fatty and rosin acids (58%)	Emulsifiable concentrate
Sonata	*Bacillus pumilis* strain QST 2808 (1.38%)	Emulsifiable concentrate

*Availability is subject to state pesticide registrations, which are subject to change. Information in the table is believed to be current as of May, 2010. Source of information: Hawaii Pesticide Information Retrieval System (HPIRS, http://state.ceris.purdue.edu/doc/hi/statehi.html). Always follow pesticide label instructions and allowances exactly; do not use more or less than the label rate. Consult the pesticide label and the Hawai'i Department of Agriculture for questions about product applications. Other product names with similar active ingredients may not be displayed in this table; mention of a product here is not a recommendation of the product in preference to other products that may also be labeled for the use and approved for sale in Hawai'i.

salts of phosphorous acid, chlorothalonil, basic cupric sulfate, copper hydroxide, wettable sulfur, harpin protein, and copper salts of fatty and rosin acids. These products vary in their mode of action and efficacy. Consult the CTAHR Cooperative Extension Service for current product names and specific recommendations.

Postharvest treatment

The following can retard or reduce symptom development:

- Refrigerate: keep at 50°F (10°C), but do not chill fruits before they are ripe or there may be chilling injury.
- Hot water dip: dip fruits for 15 minutes at about 120–130°F (49–55°C), depending on variety. Contact the CTAHR Cooperative Extension Service for details, and always test a few fruits before treating large batches.
- Vapor heat, forced-air dry heat: apply for 3–6 hours at various temperatures, depending on variety.
- Heated fungicide dips (aqueous): products and temperatures may vary.

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