MANGO DISEASES AND THEIR CONTROL

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Published accounts of mango disease research in Hawaii are very limited. The most recent published work on a mango disease in Hawaii was in 1971, when Dr. A. Cook, while on sabbatical leave here, published an abstract on the scaly bark/woody gall problem on mango trunks (5). Prior to that, Aragaki published two papers on the chemical control of mango anthracnose in 1958 (2) and 1960 (3).

Table 1 lists the major mango fruit, flower and leaf, stem, and root diseases described in the literature. Those reported from Hawaii are identified with an asterisk.

The two major diseases of mango in Hawaii are anthracnose and powdery mildew.

Anthracnose

Anthracnose, *Colletotrichum gloeosporioides* (perfect stage *Glomerella cingulata*), is probably the most important disease of mango wherever it is grown. It is the limiting factor for mango production in areas that are wet. The fungus is ubiquitous and responsible for many fruit diseases of other tropical fruits such as papaya, banana, avocado, coffee, and many others. Although isolates from one host have been inoculated successfully to other hosts, the pathogen is basically host specific. On mango, the fungus affects the inflorescence, young leaves and branches, and fruit.

Symptoms. *Inflorescence.* All parts of the inflorescence are susceptible. The disease first appears as small dark spots that enlarge, coalesce, and eventually affect the entire panicle under rainy conditions. Infected flower parts and young fruits fall off the inflorescence.

Leaves and stems. Infections of young leaves start as small dark flecks that enlarge to irregular dark lesions, often with a distinct yellow halo. Under wet conditions, lesions may coalesce into large infected areas, especially along the leaf margins. Symptoms on young succulent branch tips are similar. Infections begin as small dark flecks that expand and coalesce on branches that are usually no bigger than 1 cm diameter. Older leaves are also susceptible, but the fungus remains latent until the leaves senesce.

Fruit. Infection on young fruits (less than 4–5 cm) appears as dark, irregular, sunken lesions and causes the fruit to abscise from the panicles. Infection of larger fruits usually remains latent (dormant) until the fruit ripens. Lesions are black, expand rapidly in size, and produce pinkish-orange spore masses under wet conditions.

Disease cycle. The fungus survives between seasons primarily on infected and defoliated branch terminals and mature leaves. Conidia are produced in fruiting bodies, referred to as acervuli, over a wide range of temperatures and especially under rainy or humid conditions. Conidia are spread by splashing rain or irrigation water. The ascospores do not appear to serve an important role in the spread of the disease. Conidia are readily produced on all infected tissues and serve as secondary inoculum to spread the disease.

Control. *Site selection.* The best way of controlling anthracnose is to avoid planting mangos where conditions are favorable for disease development. Mango production is best suited for hot and dry areas. In Hawaii, this generally refers to the low elevations on the leeward sides of the islands where rainfall is less than 38 cm (15 inches) a year.

Resistant varieties. Select varieties that are resistant to anthracnose. There are wide differences in anthracnose resistance among mango cultivars. Very few if any replicated studies have been made to evaluate anthracnose resistance of mango cultivars in Hawaii. The literature, however, does contain some information on anthracnose resistance (Table 2). Note that some varieties (eg. 'Tommy Atkins' and 'Zill') have different reported resistance levels when evaluated in different countries. It is not known whether this is due to different strains of the fungus, environmental differences, or evaluation methodology.

Sanitation. Because the fungus survives from season to season on diseased branch terminals,

Table 1. Major diseases of mango (those marked with an asterisk have been reported in Hawaii).

Disease	Pathogen	Remarks
Fruit Diseases		
Anthracnose*	*Colletotrichum gloeosporioides*	Most important
Stem-end decay	*Lasiodiplodia theobromae* *Phomopsis mangiferae* *Dothiorella dominicana*	Postharvest/storage
Bacterial black spot	*Xanthomonas campestris* pv. *mangiferae indica*	Very serious; S. Africa India, Brazil, Aust.
Rhizopus soft rot	*Rhizopus stolonifer* *R. arrhizus*	Postharvest/storage
Soft brown rot	*Hendersonia creberrima*	S. Africa, cold storage
Jelly seed*	Physiologic	Certain cultivars prone
Flower And Leaf Diseases		
Anthracnose*	*C. gleosporioides*	Common
Powdery mildew*	*Oidium mangiferae*	Recent introduction
Mango malformation	*Fusarium moniliforme* var. *subglutinans*	Mites often vectors
Bacterial black spot	*X. campestris* pv. *mangiferae indica*	
Scab	*Elsinoe indica*	Fla., Americas, Phil.
Blossom blight*	*Botrytis cinerea*	Not serious
Many leafspots	Many	Not serious
Stem Diseases		
Anthracnose*	*C. gloeosporioides*	Mainly branch tips
Bacterial black spot	*X. campestris* pv. *mangiferae indica*	Can be moved on scion wood; serious threat
Mango malformation	*F. moniliforme* var. *subglutans*	Can be moved on scion wood; serious threat
Verticillium wilt	*Verticillium albo-atrum*	Old vegetable fields
Scaly bark/woody gall*	Unknown	Colombia/Hawaii
Dieback*	*L. theobromae* (Botryosphaeria)	Not severe
Recife sickness ?	*Diplodia recifensis* ?	Assoc. w/ambrosia beetles
Root Diseases		
Nematode	Name	
Sting	*Hoplolaimus* sp.	
Dagger*	*Xiphinema* sp.	
Lesion*	*Pratylenchus* sp.	
Reniform	*Rotylenchulus reniformis*	
Rootknot	*Meloidogyne* spp.	
Ring*	*Criconemoides* sp.	

leaves, and old flower panicles, sanitizing orchards by pruning and removing debris from under trees should reduce inoculum and, therefore, disease levels.

Field fungicide sprays. Commercial orchards in all but the driest environments need to be sprayed with a fungicide on a regular basis. Spray intervals vary from weekly to monthly, depending on rain. Spraying weekly during flowering and up to when fruits are about 4–5 cm long, and once every two weeks during fruit development, appears to be a standard recommendation. Fungicides reported to be effective against anthracnose in field trials are benomyl, thiophanate methyl, captafol, mancozeb,

and vinclozolin (9). Fungicides effective against anthracnose that are registered for use in Hawaii are benomyl, captan, basic copper sulfate, and sulfur plus basic copper sulfate.

Mancozeb is currently recommended on a weekly basis in Australia (13), and maneb and mancozeb is recommended on a 5–10 day interval in the Philippines (1). Ferbam and chlorothalonil were being used under a Section 18 Emergency Use Exemption in Florida (10), but most growers currently use copper-based fungicides for anthracnose control.

Postharvest treatments. Postharvest hotwater treatments (15 minutes at 51°C (124–125°F)) have been shown to reduce anthracnose development in ripe fruits of the cultivar 'Larravi' in Puerto Rico (12) and with the cultivars 'Zill', 'Haden', 'Sensation', 'Kent', and 'Keitt' for 5 minutes at about 55°C (131°F), and 15 minutes at 49°C (120°F) in Florida (17). Hot water dips also reduced stem end decay caused by several fungi (21). Because of varietal differences in heat tolerance, tests must be conducted to determine the optimum time and temperature for each cultivar.

Vapor heat (4) and forced-air dry heat used to meet quarantine regulation against fruit flies have shown some efficacy against postharvest diseases on the cultivars 'Tommy Atkins', 'Keitt', and 'Palmer' (8). The major disadvantage of these methods is the long treatment time required, typically 3–6 hours.

Refrigeration at 10°C (50°F) will significantly slow the development of anthracnose. However, since chilling injury might occur, fruit should be ripened before refrigerating.

Benomyl and thiabendazole at 500–1000 ppm heated to 52°C (126°F), in which mango fruits were dipped for 1–3 minutes, were effective in controlling postharvest decay on 'Tommy Atkins' and 'Keitt' (7, 19, 20). Unheated benomyl was ineffective. However, within a short time the fungus developed resistance to benomyl and had cross resistance to the related fungicides thiabendazole and thiophanate methyl (18).

Heated iprodione (14), unheated prochloraz (7), and unheated imazalil (21) have also shown efficacy in controlling anthracnose. Gamma radiation has shown some efficacy in reducing anthracnose, but the doses required are higher than the dose required for fruit fly quarantine treatments. Radiation does not appear to be feasible for postharvest mango disease control at this time.

Anthracnose is best controlled by a combination of preventive measures, field fungicide sprays, and postharvest treatments.

Powdery Mildew

Powdery mildew (*Oidium mangiferae*) is the only other significant disease of mango in Hawaii. It is a relatively new introduction to Hawaii, having been first reported in 1983. It is most severe in the drier areas of the state when rain occurs during the flowering season. Worldwide, it is found in most mango growing areas. It is often sporadic in severity but has been reported to cause up to a 20 percent loss in production (6). Mango is the only known host.

Symptoms. Powdery mildew is primarily a disease of flowers, young shoots, and young fruits. From a distance, the infected parts of the mango tree have a grayish haze resulting from the masses of conidia and fungal growth on the infected surface. Closer inspection will show a velvety, white growth. The fungus grows primarily on the plant surface but obtains its nutrients from living plant cells through a system of haustoria that grows within the infected plant cells.

Young leaves are mostly infected on the underside, especially along the veins, but more susceptible varieties are also infected on the upper surface. Infection causes flowers and small fruits to abort and fall off, usually when the developing fruits are about pea size (11). Early infection of shoots causes panicles and young leaves to become curled, distorted, and reduced in size. Infected areas eventually may turn brownish and necrotic. Fruits that become infected after they have set have purple-brown blotchy lesions that crack and form corky tissue as the fruitlet enlarges.

Disease cycle. The fungus survives in old leaves and branch tips when young succulent growth is not present on the tree. Spores are spread short distances by wind and long distances by infected scion wood. Unlike most fungi, spores of the fungus do not require free water or high humidity for germination. Spores are capable of 70 percent germination at 20 percent RH and 33 percent germination at 100 percent RH. However, germ tubes and hyphae from spores that germinate at low relative humidities are less aggressive than those that germinate at higher humidities. The disease is most severe in dry areas that receive intermittent rains during the flowering season. Ideal temperature for disease development is 20–25°C (68–77°F) (11).

Control. As with any disease, the use of resistant varieties is the ideal control measure. Varieties vary considerably in their susceptibility to powdery mildew. Table 3 is a compilation of published evaluations of resistance by mango cultivars to powdery mildew.

Avoiding the disease through site selection is difficult because the disease is relatively independent of moisture. Hot, dry areas are still best overall for mangos. If possible, avoid areas that consistently have rain during the flowering season.

Powdery mildew can be controlled by sprays applied during flowering at 10–14 day intervals. Sulfur dusts and sprays have been demonstrated to be very effective and are exempt from tolerance. However, sulfur must be used with caution because of the potential for scorching if used during too-hot periods or if used in conjunction with oils. In Israel, wettable sulfur provided better control than benomyl and piparazin (11).

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Table 2. Resistance or susceptibility of mango cultivars to anthracnose (*Colletotrichum gloeosporioides*).

Country	Resistant	Moderate	Susceptible	Very susceptible
Australia[14]	Carrie Caraboa Florigon Tommy Atkins Saigon	Kensington Pride		Willard Neelum Manaranijan
Phillipines[15]	Palmer Siam Velei Columban Joe Welch	Fernandin Arumanis Edward Gedong Tjenkir	Carrie Peter Passand	Ah Ping Julie Cherakurasa Hingurakgoda Kensington Otts Pope Willard Zill
Hawaii[22]	Paris Fairchild Rapoza	Haden	Exel	Pirie
Florida	Zill	Haden	Irwin Sensation Kent Keitt Tommy Atkins	

Table 3. Resistance or susceptibility of mango cultivars to powdery mildew (*Oidium mangiferae*).

Country	Slightly susceptible	Moderately susceptible		Very susceptible
Australia[14]	Carrie Sensation Tommy Atkins			Zill Kent
Israel[11]	Carrie Gondo	Haden Mabroka		Bullock's Heart Zill Mistakawi Pairee Faizanson Alphonso
Venezuela[16]	Carrie Sensation Tommy Atkins Banana	Haden Lippens Smith Keitt Glenn Pico deLoro Martinique Springfels Rosa	Graham Divine Peter Hilacha Bocado Edward Mango criolla Fresca	Amini Kent Labich Apple Zill Blackman