College of Tropical Agriculture and Human Resources
University of Hawai'i at Mānoa

Plant Disease
April 2014
PD-100

Fig Rust in Hawai'i

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Ficus carica, the edible fig, is cultivated globally, including in Hawai'i, for its sweet fruit. It may be dried or preserved, eaten fresh, or cooked in a variety of sweet and savory dishes. Major producers of figs include Turkey, Egypt, Morocco, Spain, Greece, California, Italy, Brazil, and Japan (Tous and Fergusen 1996). The edible fig is native to the Middle East and the Mediterranean, and it grows best in subtropical climates with hot, dry summers and mild winters (Tous and Ferguson 1996).

Host: Edible fig, *Ficus carica*
Hawaiian names: Fiku, Piku (Neal 1965)
Pathogen: Fig rust, *Cerotelium fici* (syn. *Physopella fici*)

Figs are vigorous, drought-tolerant trees that are relatively resistant to disease when grown in a suitable climate. However, figs grown in warm, humid climates are highly susceptible to *Cerotelium fici*, a rust fungus that infects the leaves and fruit. Fig rust is widely distributed in the tropics and subtropics and can be problematic for growers, causing significant defoliation and yield loss. Here we discuss the symptoms and integrated cultural management of fig rust in Hawai'i.

Host

There are 720 known varieties of *F. carica*. Many produce edible fruits that range from pale yellow-green to deep purple on the outside, with light to deep pink flesh (Himelrick 1999). Figs grow best in well-drained soil and require sunlight to ripen the fruit, with 6–8 hours of full sun being optimal. Figs are slightly salt-tolerant and can be grown at varying elevations from sea level to 5,000 ft (Love 2005b). Figs will develop extensive root systems when planted in the ground but can also be grown successfully in pots. They can reach a height of 20 ft, but most commercially grown trees are pruned so they can easily be harvested by hand. Figs can produce an abundance of fruit, particularly the "everbearing" varieties, which can produce up to 2,000 figs per tree in a season (Ken Love, personal communication).

The edible fig belongs to the genus *Ficus*, in the family Moraceae (mulberry). All *Ficus* species are either dioecious, consisting of separate male and female plants, or, in the case of *F. carica*, gynodioecious, consisting of hermaphroditic and female plants. Most of the edible fig varieties are parthenocarpic (self-fertilizing). These produce seedless fruit and are propagated by cuttings (Starr et al. 2003). However, some varieties require pollination by certain wasps. For every *Ficus* species, there is usu-

Published by the College of Tropical Agriculture and Human Resources (CTAHR) and issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, under the Director/Dean, Cooperative Extension Service/CTAHR, University of Hawai'i at Mānoa, Honolulu, Hawai'i 96822.


Fig. 1


Fig. 2

ally a unique Agaonid wasp that is associated with it. Fig wasps only lay their eggs inside the florets, pollinating the fig in the process (van Noort 2012). Therefore, figs that require pollination cannot be cultivated or become naturalized without the presence of the associated pollinator wasp. Likewise, a fig wasp population cannot successfully reproduce without an established number of fig trees. There are no fig-pollinating wasps in Hawai‘i. Both ‘Smyrna’ and ‘Capri’ figs will bear fruit in Hawai‘i, but they are inedible due to lack of pollination. The ‘San Pedro’ type will produce a few figs, but these pale when compared to the common, parthenocarpic fig.

The fig is an emerging crop in Hawai‘i and can be grown year-round in its subtropical climate. Figs are valued for their high productivity and market value. Their fruit is in demand by Hawai‘i’s restaurants, farmers’ markets, and supermarkets, and currently the supply cannot meet the demand. The Hawai‘i Tropical Fruit Growers Association, headed by executive director Ken Love, conducts research on the tropical fruit industry in Hawai‘i, and in 2004, Love identified the fig as a crop with a growing demand for sale as fresh fruit and with potential for value-added products in preserved or dried forms.

As part of the “12 Trees” Project, Love tested over 50 varieties of edible figs to identify commercially viable figs for Hawai‘i. The project grew figs in different microclimates to determine optimal elevation and climate conditions. Irrigation and cropping systems were tested, along with non-chemical controls to deter birds. Production costs, including labor and packaging, were also examined (Love et al. 2007). Fresh figs are extremely delicate and perishable, so they need to be harvested carefully by hand and transported in protective packaging. The development of value-added products is another option for fig-growers in Hawai‘i.

Commercial fig production in Hawai‘i is limited to five producers on Hawai‘i Island (Stankov 2013). Commercial fig production in Hawai‘i will likely expand due to the increasing demand and high profitability of this fruit. The fig cultivars currently being marketed are ‘Brown Turkey’, ‘White Kadota’, and ‘Black Mission’. Other fig cultivars that produce well in Hawai‘i include ‘Excel’, ‘White Texas Everbearing’, ‘Ischia White’, ‘Conadria Early Violet’, ‘Rattlesnake’, ‘UCR 197-25’, ‘Beall’, ‘Deanna’, ‘LSU Purple’, ‘LSU Gold’, ‘Flanders’ (highly susceptible to pathogens at higher elevations), ‘Violette de Bonstrueuse’, and ‘Masui Dolphin Sierra’.

Common fig cultivars that did not perform well at the test locations in Hawai‘i are ‘Panachee’ (also known as ‘Tiger’), ‘Ischia Black’, ‘Santa Cruz Dark’, ‘Tena’, ‘Vernino’, ‘Yellow Neches’, ‘St Jean’, and ‘Native de Argentile’.

The Disease and Pathogen

Fig rust is most often seen on *F. carica,* although other host genera include the genera *Maclura, Morus,* and *Brous-*

Fig. 3

Fig. 4

sonetia papyrifera (paper mulberry) (McKenzie 2013).

Fig rust has been reported in the southern U.S. from Alabama, Florida, Louisiana, Mississippi, North Carolina, South Carolina, and Texas. It is also found in Bermuda, West Indies, Central America, and other tropical regions (Arthur 1929).

Fig rust is most likely to occur during warm and humid weather, which is conducive to the development of rust spores. In hot and dry climates, fig rust does not pose significant risk to fig cultivation.

Fig rust is caused by the fungus *C. fici* (syn. *Physopella fici*). The rust spores are spread by wind and splashing rain to other leaves and plants. Rust spores that land on the surface of leaves and fruits require at least 14 hours of continuous wetness to germinate (McKenzie 2013).

A few days after the spores germinate and penetrate a leaf, small yellowish spots develop on the upper leaf surface. These are the first symptoms of the disease. Soon after, reddish-brown pustules are visible on the undersides of leaves opposite the yellowish spots (Fig. 1). The raised, blister-like pustules appear on fruits at about the same time. Pustules are typically scattered on the underside of the leaf but may be clustered at the edges and in areas where water or dew collect (McKenzie 2013) (Fig. 2).

In later stages of the disease, the rust-infected areas form angular brown spots on the upper leaf surface, opposite to the sporulating pustules on the opposite, lower leaf surface (Fig. 3). The angular spots then coalesce and form necrotic regions (Fig. 4). The premature shedding of leaves follows this. Fruit on a defoliated tree will not able able to ripen fully.

Rust infections are more severe in windy, rainy weather, which promotes the spread and increased germination of spores. Rust spores can survive on fallen leaves and serve as a source of inoculum for new infections.

Cultural Management

Once the rust is present on a tree, the management options are limited. However, fig growers in Hawai‘i can integrate the following cultural practices to successfully manage fig rust.

- **Irrigation.** Avoid sprinkler irrigation that wets the leaves. Apply irrigation water at the ground level directly to the soil. Watering should be done early in the day to reduce humidity and leaf wetness during the night.
- **Pruning.** Prune fig branches to increase air circulation in the canopy. This will result in faster drying of the leaves after rain. The spores cannot germinate as readily if the leaves are dry. Pruning short also facilitates harvest. While pruning may increase the

risk of damage to the figs from birds, you can use reflective material such as old CD-ROMs or aluminum foil or Mylar tape to deter birds (Love 2005b). Pruning should be done every three months.

- **Sanitation.** Remove rust-infected leaves and fruit attached to plant, including those showing the first visible symptoms of yellowing lesions on leaves. Leaves on the ground must be raked and removed. Cease watering temporarily after removal of infected leaves (Love, personal communication).
- **Weather Monitoring.** New rust infections will usually follow a rainy period. Check for and remove leaves that are showing first symptoms after rains.
- **Resistant cultivars.** A fig breeding program conducted by the Louisiana Agricultural Experiment Station, Louisiana State University, identified ‘Tiger’ as being slightly more resistant to fig rust than other cultivars (Johnson et al. 2010). However, the cultivar ‘Tiger’ (‘Panachee’) does not produce well in Hawai‘i. There are some other more resistant fig cultivars, but the fruits do not sweeten adequately. It is best to select a cultivar that bears well in your area (consult “Choosing the Best Figs for Hawaii” http://www.hawaiifruit.net/index-figs.html).
- **Site selection.** To avoid damaging epidemics of fig rust, cultivate figs in low-rainfall areas of Hawai‘i. A state rainfall atlas is available at http://rainfall.geography.hawaii.edu/. In Mānoa Valley (annual rainfall approx. 751–1350 mm), for example, fig rust can cause extensive defoliation if unmanaged. Especially avoid planting figs as an understory crop in areas where rust is prevalent, as a well-aerated canopy will suffer less disease than a sheltered, humid canopy.
- **Weed management.** Keep weeds cut back to reduce relative humidity in the fig canopy.
- **Ensure adequate soil drainage.** Avoid planting in soils that puddle water after rainfall.
- **Host nutrition.** Fertilize fig trees adequately to ensure that they produce new leaves as rapidly as possible. This will counteract the loss of leaves due to defoliation caused by the rust.

Fungicides

While some fungicides are effective for managing fig rust, none are currently registered for use in Hawai‘i for the disease. Elsewhere, foliar spray applications of fungicides are effective as preventive treatments (e.g., copper sulfate, sulfur, zineb, and maneb) (McKenzie 1986).

Acknowledgements

The authors thank Fred Brooks and Ken Love for their thoughtful reviews of this manuscript.

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