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Raspberry Late Leaf Rust in Hawai'i Caused by *Pucciniastrum americanum*

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Red raspberries (*Rubus* spp.) are aggregate, perennial fruits with distinctively sweet and tart flavors. Two types of red raspberry plants are commonly grown commercially. One is a summer-bearing raspberry that produces fruit on floricanes (second-year canes) during the mid-summer months. The second type is a double- or ever-bearing raspberry that produces fruit on primocanes (first-year canes) during the late summer and fall. This double-bearing type also produces a summer crop on floricanes.

Raspberry late leaf rust causes precocious (uneven) ripening of infected drupelets and renders fresh fruits unmarketable.

Farmers usually grow red raspberries in plant hardiness zones 3 to 9. In these zones, the minimum temperatures range between –30°F (–35°C) and +20°F (7°C), respectively. In Hawai'i, however, some grow them as diversified specialty crops in hardiness zone 10, with minimum temperatures above +30°F (1°C), and zone 11, with a minimum temperature of +40°F (4°C).

A farmer near Pāpa'ikou, Hawai'i, planted an acre of organically cultivated red raspberries in 2005. He grew four cultivars and supplied fresh fruit to local chefs and produce markets. In 2009, he reported a severe yellow rust-like disease on leaves and fruits of several cultivars. The most severe symptoms appeared on 'Caroline' (everbearing, *Rubus idaeus*). His other cultivars, 'Himbo Top,' 'Joan J.' (a thornless cultivar), and 'Autumn Britten,' varied in their expression of symptoms. Adjacent to the affected farm was a gulch with a thriving population of wild thimbleberry plants (*Rubus rosifolius*, ola'a). The thimbleberry plants had no disease symptoms.

A number of different rust fungi have been reported to infect *Rubus* spp. (Ellis et al. 1997). *Phragmidium rubi-idaei* (= *Phragmidium imitans*) causes a yellow rust of *Rubus* spp. *Gymnoconia nitens* and *Arthuriomyces peckianus* cause orange rusts. *Hamaspora longissima* infects *Rubus* in the subtropics. *Kuehneola uredinis*, causing leaf and cane rust, was reported from *Rubus* in Hawai'i (Raabe et al. 1981). A microscopic examination of symptomatic raspberry leaves and fruit from Pāpa'ikou, however, revealed that the pathogen differed morphologically from all of these rusts.

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Scientists at the USDA/APHIS/PPQ National Identification Services identified the Pāpa‘ikou rust pathogen as one previously unreported in Hawai‘i, *Puccinastrum americanum* (Kumashiro et al. 2009). This fungus causes late leaf rust of red raspberry. Other common names for this disease are autumn rust, late raspberry rust, late yellow rust, and American spruce-raspberry rust. In this paper we describe *P. americanum*, detail the rust disease symptoms and epidemiology, and suggest complementary practices to manage the disease.

Geographic distribution of the disease in Hawai‘i

Since the outbreak in 2009, no surveys have been conducted to determine the geographic distribution of the disease in Hawai‘i. Since rust spores are readily dispersed by wind and wind-blown rain, it is likely that spores were spread all through the Hāmākua district. Other rust diseases that have entered Hawai‘i on other crops (e.g., Plumeria rust in 1991) rapidly became established throughout the state. Since the initial 2009 outbreak, however, no other reports of raspberry rust have been received by the University of Hawai‘i or the Hawai‘i Department of Agriculture. This may be due to the small number of red raspberry farms in Hawai‘i.

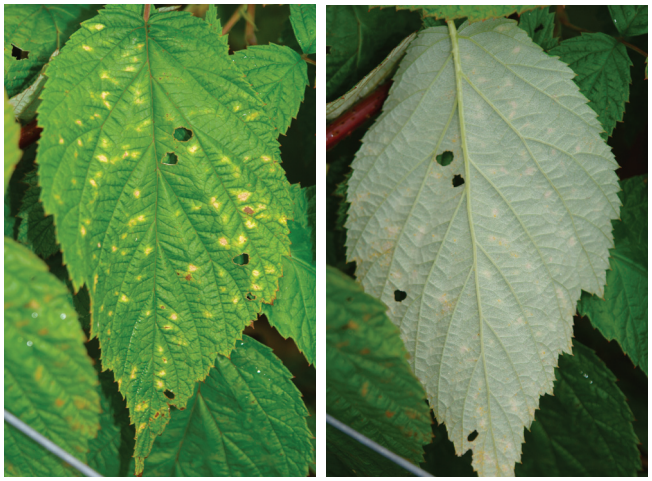
Host range

Hosts of *P. americanum* include cultivated red raspberry (*R. idaeus*), purple raspberry (*R. occidentalis*, *R. odoratus*), and some wild red and purple raspberries (Ellis et al. 1991). *Pucciniastrum americanum* does not infect black raspberries or blackberries. The wild or naturalized raspberries commonly found in Hawai‘i—thimbleberry (*R. parviflorus*) and yellow Himalayan raspberry (*R. ellipticus*)—are not susceptible. The native Hawaiian raspberry (*R. hawaiiensis*) is probably not susceptible; to date, no cases of rust have been reported on this species.

Symptoms

Pucciniastrum americanum infects canes, leaves, petioles, and fruits at all stages of development.

Trellised, 1-acre organic raspberry farm near Pāpa‘ikou on the island of Hawai‘i where the outbreak of late rust occurred in 2009. Four raspberry varieties were cultivated: ‘Himbo Top’ (rust resistant), ‘Autumn Britain’ and ‘Joan J.’ (early varieties), and ‘Caroline’ (mid- to late-season variety). The farm was planted in 2005. ‘Himbo Top’ was planted in January 2009. (Photograph: Scot Nelson, UH-CTAHR).



Left: Early symptoms of late rust on the upper surface of a mature leaf of highly susceptible ‘Caroline’ include chlorotic yellow spots scattered over the leaf surface. Right: On the lower leaf surface, uredinia form, containing powdery, light yellow masses of urediniospores.

Unlike orange rust of raspberry and blackberry caused by A. *peckianus*, infections caused by *P. americanum* are not systemic (i.e., the infection does not spread within the plant). Small spots form on mature leaves and turn yellow and then brown, causing the leaves to die and drop prematurely. Highly susceptible cultivars are often reduced to leafless canes. Small uredinia filled with fine, powdery, light yellow spores appear on the undersides of infected leaves. On fruits, uredinia develop on individual drupelets. Powdery masses of light yellow uredinia render fresh fruits unmarketable. Fruit infections cause precocious ripening of individual drupelets and rotting of the fruit.

Disease cycle and epidemiology

This heteroecious (having alternate hosts), macrocyclic (producing all rust spore types) rust produces spermagonia and aecia on white spruce (*Picea glauca*), which is not grown in Hawai'i, and uredinia and telia on *Rubus* spp. Urediniospores are spread by wind and on hands and clothing during harvest. Infections occur as the spores germinate and enter stomata, which are mainly on lower leaf surface. The optimum air temperature for disease development is from 18 to 26°C (65 to 80°F) (Ellis et al. 1997). Within about one week after infection, lesions begin to produce spores.

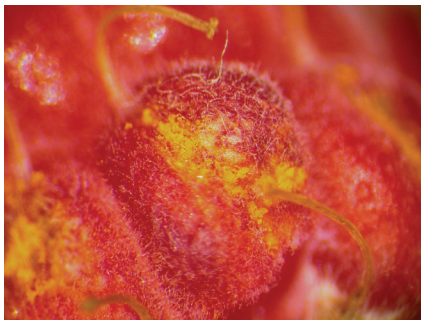
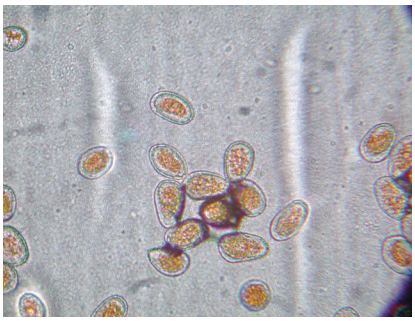
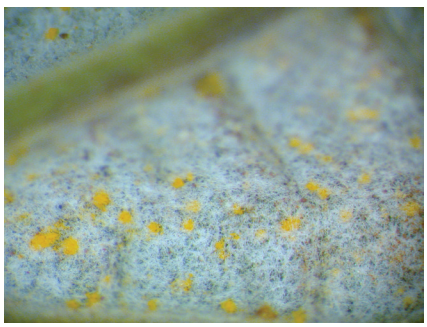
Integrated disease management

Use a combination of the following practices to manage late rust of raspberry in Hawai'i.

Plant resistant cultivars. Resistance to *P. americanum* among red raspberry cultivars ranges from highly susceptible to highly resistant. Do not plant the highly susceptible cultivars 'Caroline,' 'Carnival,' or 'Comet' in Hawai'i. Plant only resistant cultivars such as 'Nova,' 'Boyne,' and 'Himbo Top.' Partially resistant cultivars include 'Royalty' and 'Heritage.' Note: experimental data indicate that a single major gene is responsible for complete resistance in raspberry to *P. americanum* (Luffman and Buszard 1989). Major-gene resistance to different rust fungi tends to be overcome by the pathogen through mutations or sexual recombination. Therefore, it is wise not to rely on plant resistance as the only disease management practice.

Site selection. Avoid planting raspberry in a high-rainfall location. Even though leaf wetness is not required for infection, rainfall increases disease severity. Select a place where prevailing winds can dry wet foliage.

Disease-free planting material. Avoid planting infected or symptomatic specimens; inspect them before accepting.

Left: Rusted raspberry drupelet on fruit of cultivar 'Caroline,' showing the typical powdery, light yellow masses of urediniosopres. Middle: Urediniospores of *P. americanum*, magnified (both photographs: Brian Bushe, UH-CTAHR). Right: Yellow rust pustules on the underside of an infected red raspberry leaf (magnified).

Grow raspberries in micro-tunnels or high tunnels. Heinderick et al. (2009) discussed the agronomic benefits of growing red raspberries in high tunnels, which are large hoop houses covered in plastic. Crops are grown under cover and sheltered from wind and rain. Less wind makes dispersal of spores less likely, and rust disease is less severe on leaves and fruits that remain dry.

Practice sanitation. Remove heavily infected floricanes and primocanes to reduce number of fungal spores and reduce disease severity.

Relative humidity. High humidity is essential for infection. Frequent rainfall and overhead irrigation promote high humidity and create more severe disease symptoms.

- Avoid using overhead irrigation. Irrigate plants by drip irrigation to avoid high humidity in the canopy.
- Ensure adequate soil drainage. Well-drained soils release little water vapor into the canopy, which lessens relative humidity.

Intercropping. Grow non-host plants between raspberry plants or rows to interrupt spore dispersal.

Fungicides. Although some fungicides may be available for control of late rust of raspberries in Hawai‘i, such products would generally not control the disease economically on tropical farms. We advise use of the non-chemical, integrated practices described above.

“Rusted” green fruits of the cultivar ‘Caroline,’ showing masses of urediniospores on individual drupelets.

Acknowledgements

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Severe rust causes fruits of the highly susceptible red raspberry cultivar 'Caroline' to rot.