



Shot Hole of 'Awa

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Hawaiian 'awa (kava, *Piper methysticum*) is a plant with medicinal and social uses. A relaxing beverage is made from the roots and stump of this plant on islands where it grows throughout the tropical Pacific. Cultivars of the plant were intentionally transported to Hawai'i by Polynesian colonizers, where it was used ceremonially and medicinally in various occasions. Today the plant is still used, but mainly as a social beverage sold as a bottled drink in stores or served in 'awa bars or circles of friends. 'Awa products are manufactured and exported throughout much of the world and prescribed by some medical doctors for relief of anxiety.

'Awa is susceptible to a number of significant pests, especially where it grows in unshaded monocultures in Hawai'i. One of the severe fungal diseases of leaves and stems is known as "shot hole." Shot hole first caused significant crop losses in the early 2000s as large 'awa monocrops were planted in Hawai'i. Aside from kava dieback caused by cucumber mosaic virus (CMV) and root disease caused by root-knot nematodes (*Meloidogyne* spp.), shot hole is the most economically important, widespread, and most difficult 'awa disease to manage effectively in Hawai'i in higher rainfall areas of the state.

This publication describes the cause and symptoms of shot hole disease and advises farmers how to manage it by choice of 'awa variety, site selection, and use of planting practices such as polycropping, agroforestry, and/or fungicide spray applications.

The pathogen

The disease is associated with a *Phoma* sp. The pathogenicity of this fungus to *P. methysticum* has been demonstrated in Hawai'i but this has not been published in a refereed science journal (Jeri Ooka, UH-CTAHR, personal communication); the sexual stage (teleomorph) of the pathogen is thought to be a *Didymella* sp. (S. Nelson, unpublished).

The host

Piper methysticum Forst. f. is a shrub 4–12 feet tall with dark-colored to green, jointed stems that are swollen at the joints and bear alternate, heart-shaped leaves. Sterile and seedless flowers are borne in narrow spikes. *Piper methysticum* is native to the Pacific islands. The plant is called 'awa in Hawaiian, the most widely known common name is kava, and it is called sakau in Micronesia. It belongs to the pepper family, Piperaceae, which includes 9 to 12 genera and about 1,200 species of herbs, shrubs, small trees, and climbers native to the tropics.

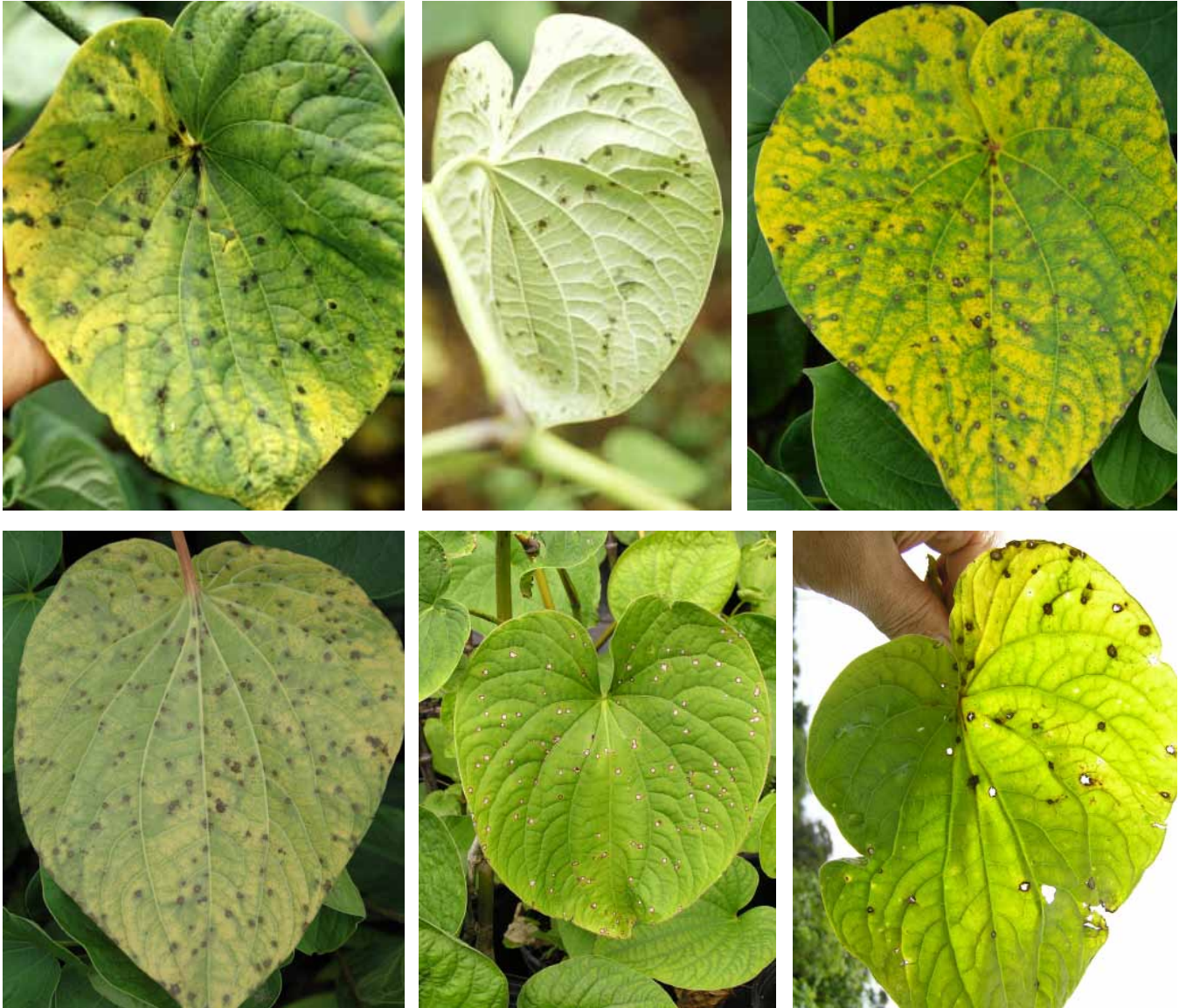
Disease symptoms

Leaves have small spots, approximately $\frac{1}{16}$ – $\frac{1}{8}$ inch diameter, that initially are black but later develop whitish to tan centers with well defined, dark colored margins. Centers of lesions tend to detach and fall away, creating small holes in leaves resembling injury from a shotgun blast. Heavily spotted leaves usually develop large chlorotic (yellow) areas before defoliating prematurely. Adjacent lesions may coalesce. All diseased leaves on a stem may fall off prematurely, leaving stems bare. There may be dozens of distinct spots on a single leaf.

Infected stems initially have small, dark colored to black spots that expand and develop whitish to tan centers that develop cracks. The spots can extend deep into the stem beneath the epidermis, eventually killing the stem if enough lesions are present.

Effects of the disease on 'awa plants in Hawai'i include premature defoliation and leaf death, premature death of stems, reduced plant yield, plant decline, and death. These effects are not present in Micronesia, where the plant is grown in agroforestry settings and not in unshaded monocultures.

The pathogen is known to be present in Hawai'i, Micronesia, Samoa, and probably elsewhere. In Hawai'i,



Symptoms of shot hole on *Piper methysticum*

On leaves, spots are small, approximately $\frac{1}{16}$ – $\frac{1}{8}$ inch in diameter, initially black but later developing whitish to tan centers with well defined, dark margins. Centers of lesions tend to detach and fall away, creating holes in leaves. Leaves develop chlorotic (yellow) areas before defoliating prematurely. Adjacent lesions may coalesce. Spot symptoms are always visible on both sides of infected leaves. There may be dozens of distinct spots on a single leaf.

Photos by S. Nelson

the author first observed epidemics of shot hole in 2000 on the island of Moloka'i. Thereafter, epidemics of the disease occurred on the islands of Hawai'i, O'ahu, Maui, and Kaua'i in 'awa monocropping systems. The epidemics coincided with the large-scale monocropping of *P. methysticum* that began in the late 1990s and early 2000s, and the disease eventually affected 'awa wherever it grew under sufficient rainfall or overhead irrigation.

Life cycle

Very little is known about the pathogen and its cycle. Spores probably disperse mainly by wind and splashing rain or irrigation water. The sites of infections are 'awa leaves and stems. About 18 days are required from inoculation to symptom development on leaves (S. Nelson, unpublished observation). Spores probably survive in diseased leaf or stem tissues.



On stems, spots are initially small and dark to black colored; they expand and develop whitish to tan colored centers that can develop cracks. The spots can extend into the stem below the epidermis, causing stem death and complete defoliation where enough spots accumulate.

Integrated disease management

- Practice sanitation: remove severely diseased leaves and stems from plants periodically.
- Plant more resistant cultivars if available (the Papua New Guinea cultivar Isa, for example).
- Use fungicides, such as sulfur, neem oil, Zeritol, or EM (Effective Microorganisms).
- Intercrop 'awa or grow it in agroforestry planting systems with plants that are not susceptible to *Phoma* sp.
- Harvest severely affected plants early, at about 22–24 months of age. The longer they are in the ground, the more likely the stumps are to suffer rot related to infected, rotting stems.
- Treat infected stem cuttings with a fungicide before planting them.

- Select, if possible, non-infected or lightly infected 'awa cuttings for propagation.
- Manage moisture: avoid or minimize overhead irrigation in nurseries or field plantings.
- Manage humidity: select locations with air circulation adequate to dry off leaves and stems.
- Avoid planting large acreages of contiguous 'awa.
- Increase spacing between 'awa plants.
- Avoid excessive fertilizer applications.
- Ensure good drainage of soil or other plant growth media.
- Control weeds to minimize relative humidity in the crop canopy.
- Exclude *Phoma* sp. and other pests from plant nurseries; use disease-free plants for transplanting.
- Do not purchase severely infected plants or stem cuttings.
- Scout fields weekly for disease development, and use control measures if necessary.
- Surround plants with partially composted mulches.
- Grow 'awa plants under the shade of trees to protect them, to a degree, from the impact of rainfall.

Fungicides

In high-rainfall areas of Hawai'i, growers find that fungicide applications to plants are needed to control shot hole disease. The following pesticides have some effect in controlling shot hole of 'awa in Hawai'i and may be used in Hawai'i on *P. methysticum*.

- Effective Microorganisms (EM) (<http://www.emhawaii.com>). Weekly sprays on leaves can prevent disease under controlled conditions if sprays are started before inoculation or infection occurs. It is not known if this will work in field plantings (Jeri Ooka, UH-CTAHR, personal communication).
- Drexel Sulfur 90W. Intended for controlling mites, this product will also provide some control of shot hole disease when sprayed weekly or bi-weekly during high-rainfall periods.
- Neem oil or Zeritol. Use weekly sprays where disease incidence or severity is high.

Cultivar selection

About 13 Hawaiian 'awa cultivars and some non-Hawaiian cultivars are being grown in Hawai'i. These vary in reaction to the disease, but most are susceptible in very wet or humid conditions.

The two cultivars grown in Hawai'i with the most resistance to shot hole disease are Nene (a Hawaiian cultivar) and Isa (from Papua New Guinea) (listed in Table 1).

In general, the darker-stemmed cultivars are more resistant to epidemics of the disease in Hawai'i, although under very wet conditions all Hawaiian cultivars may become severely diseased.

On Kaua'i, information about resistance to shot hole disease is based on observations and not on experimental data. The cultivars are not equally susceptible to the disease, but the resistance is not that effective. All varieties are susceptible, including Isa. Papa Kea is very susceptible. Panaewa develops severe stem lesions. Mahakea and Nene are not as susceptible. The disease occurs mostly during winter months at the CTAHR's Kaua'i Agricultural Research Center (Jeri Ooka, personal communication).

References

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Table 1. Disease reaction of 'awa cultivars to shot hole disease on the island of Hawai'i near Pepe'ekeo.

'Awa cultivar	Reaction to shot hole*
Hawaiian	
Hanakāpi'ai	MR
Hiwa	R
Honokane Iki	S
Kumakua	MS
Mahakea	MS
Mapulehu	VS
Mo'i	R
Nēnē	R
'Opihikao	R
Pana'ewa	S
Papa 'Ele'ele	R
Papa 'Ele'ele Pu'upu'u	R
Papa Kea	MR
Non-Hawaiian	
Iwi (Papua New Guinea)	MR
Isa (Papua New Guinea)	I
Rahmwanger (Pohnpei)	R
Rahmedel (Pohnpei)	S
Lauu (Samoa)	R

*Key: VS = very susceptible; MS = moderately susceptible; S = susceptible; MR = moderately resistant; R = resistant; I = immune or very resistant.

* Note: disease reaction in Table 1 refers to the reaction in Hawai'i near Pepe'ekeo (on the Hāmākua coast on the island of Hawai'i, receiving approximately 130 inches of rainfall per year). 'Awa cultivar reaction to shot hole disease varies depending on location, rainfall, relative humidity, length of exposure to the disease, use of fungicide sprays, and cultivation methods (monocropping, polycropping, or agroforestry, fertility of soil and fertilizers, cultural practices). Some 'awa cultivars are stronger-growing plants than other cultivars, in general (and not necessarily related to shot hole disease reaction). Source: Ed Johnston, Association for Hawaiian 'Awa, based on observations, not experimental data. There are more non-Hawaiian cultivars grown in Hawai'i than are mentioned in the table.

Acknowledgments

Ed Johnston and Jerry Konanui (Association of Hawaiian 'Awa) provided information, as did CTAHR colleagues Jeri Ooka and Mike Kawate; Fred Brooks (UH-CTAHR) provided review.



Massive defoliation of 'awa plants in a monoculture on the Hāmākua Coast of the island of Hawai'i



Stem symptoms and defoliation due to shot hole disease of *Piper methysticum* in Hawai'i. Damage can be severe during wet periods, resulting in reduced yields and even plant decline or death.