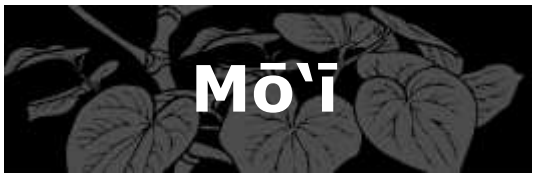

ʻAwa Mōʻī is another of the dark, sacred ʻawa varieties so important in Hawaiian religious and ceremonial life. Kāwika Winter points out that "certain offerings reserved for the gods were often black in color" (2004, 36). For instance, the gods might be offered a black pig along with a dark ʻawa like Mōʻī or Hiwa.

H.E.P. Kekahuna describes Mōʻī as having "dark stems and internodes not quite as long as those of the Awa hiwa. The drink from these varieties was especially offered to mighty Volcano-Goddess Pele and other deities" (see the full quote under "Hiwa," p. 36; Kekahuna unpublished papers, quoted in Winter 2004, 87).

Oscar P. Cox, in his 1930 letter to George R. Carter, stated that "the skin or bark of the stem of this variety of awa-root is red or sort of brownish. The priests of old use this kind of Awa in the sacrificial ceremonies to Pele." According to Kāwika Winter, "Pele is one of the very few akua who is offered ʻAwa in all three forms—as drink, whole plant, and whole root section" (2004, 47).

In all probability, the chiefs could also partake of this ʻawa, and it had its place in medicine. Mōʻī is one of the varieties most effective against urinary problems. It was also used to treat "splitting headache" (Chun 1994, 53-54).

Kamakau ([1869] 1976, 41) says "the stems of … the *moʻi* [variety] grow straight up, with sections like those of the *honuaʻula* sugar cane." It has a normal growth habit.

Cuttings were collected along a high ridge in the Waimā area of Waipiʻo Valley in 1988 by Joel Lau and Ed Johnston.

Table 5.8. Mōʻī
Kavalactone Analysis of Air-Dried Lateral Roots
(Lebot et al. 1999)
HPLC Analysis by Madis Botanicals, Inc.

Sample Name	**APN1**	**PAU1**
Chemotype	462351	463251
Age of Plant (Years)	6	3
Soil Type	Hāmākua	Hāmākua
Location (Hawaiʻi Island)	Hāmākua coast	Hāmākua coast
Shade (1=full sun; 4=full shade)	2	2.5
Growing Methods	Cultivated, irrigated, fertilized	Cultivated, irrigated, fertilized
Damage	Fungi	No damage
Lateral Root Size	>2 cm.	<0.5 cm.
Percentage Kavalactones		
Kavalactone		
Desmethoxyyangonin (1)	0.95	0.73
Dihydrokavain (2)	2.01	1.48
Yangonin (3)	1.53	1.52
Kavain (4)	3.65	2.47
Dihydromethysticin (5)	1.04	0.93
Methysticin (6)	2.12	1.92
Total Kavalactones	**11.3**	**9.05**

Scale is in inches.

Fig. 5.20. Internodes are of medium length. Nodes are beige.

Fig. 5.21. "The skin or bark of the stem . . . is red or sort of brownish" (Cox 1930). (Photo by Kāwika Winter)

Fig. 5.22. The leaf piko is dark, like the stem.

The *Hawaiian Dictionary* describes ʻawa Nēnē as "A variety of ʻawa, stems green with dark green spots." The dictionary notes that it is also called "*ʻawa kua ʻea*," literally "turtle back" (Pukui and Elbert 1986, 34 and 168). According to *Native Hawaiian Medicines* (a recent translation of a work originally compiled in 1922):

> ʻAwa Kuaʻea is the secret name. The stalks of this ʻAwa are like the ʻAwa Mākea. Furthermore, its general appearance is spotted and kind of lumpy like the spots of a turtle's back or also like the Moa hulu Nēnē (Chun 1994, 58).

Ethnographer Martha Beckwith has said, "Babies were given the juice of the nene variety as a soothing syrup. 'This is a fretful (onene) child and must be given the awa nene'" (1970, 94). In Chapter 2, cultural historian Kepā Maly explains that "in this case, use of the word *nēnē* is symbolic of murmuring, like the soft chatter of the native geese. By the play on the word *nēnē*, use of the *ʻawa nēnē* was believed to help temper the voice of the youngster."

This ʻawa is easily recognized by its long, green internodes with raised lenticels and its erect growing habit. The leaf has a green piko.

Today, plants of this variety are relatively common. It seems also to have been a popular cultivar in old Hawaiʻi. It has been collected from a number of Hawaiian valleys: Waipiʻo, Honokāne Nui, and Hanakāpīʻai.

Table 5.9. Nēnē
Kavalactone Analysis of Air-Dried Lateral Roots (Lebot et al. 1999)
HPLC Analysis by Madis Botanicals, Inc.

Sample Name	APN12	APN13	PAU9	NENE
Chemotype	463251	463251	463251	462531
Age of Plant (Years)	6.2	3	1	20
Soil Type	Hāmākua	Hāmākua	Hāmākua	Pāhoa
Location (Hawaiʻi Island)	Hāmākua coast	Hāmākua coast	Hāmākua coast	Puna
Shade (1=full sun; 4=full shade)	3.5	3	2.5	3.5
Growing Methods	Cultivated, irrigated, fertilized	Cultivated, irrigated, fertilized	Cultivated, irrigated, fertilized	Wild, not irrigated, not fertilized
Damage	Not damaged	Not damaged	Not damaged	Not damaged
Lateral Root Size	1-2 cm.	1-2 cm.	>2 cm.	<0.5 cm.
Percentage Kavalactones				
Kavalactone				
Desmethoxyyangonin (1)	0.69	0.54	0.40	0.69
Dihydrokavain (2)	1.63	1.29	1.03	1.25
Yangonin (3)	2.29	1.59	1.11	0.73
Kavain (4)	3.39	2.63	2.09	1.66
Dihydromethysticin (5)	1.07	0.80	0.84	0.90
Methysticin (6)	2.61	1.98	1.67	1.51
Total Kavalactones	**11.68**	**8.83**	**7.14**	**6.74**

Scale is in inches.

Fig. 5.23. ʻAwa Nēnē's many lenticels are its most distinguishing feature.

Fig. 5.24. The cultivar has an erect growing habit.

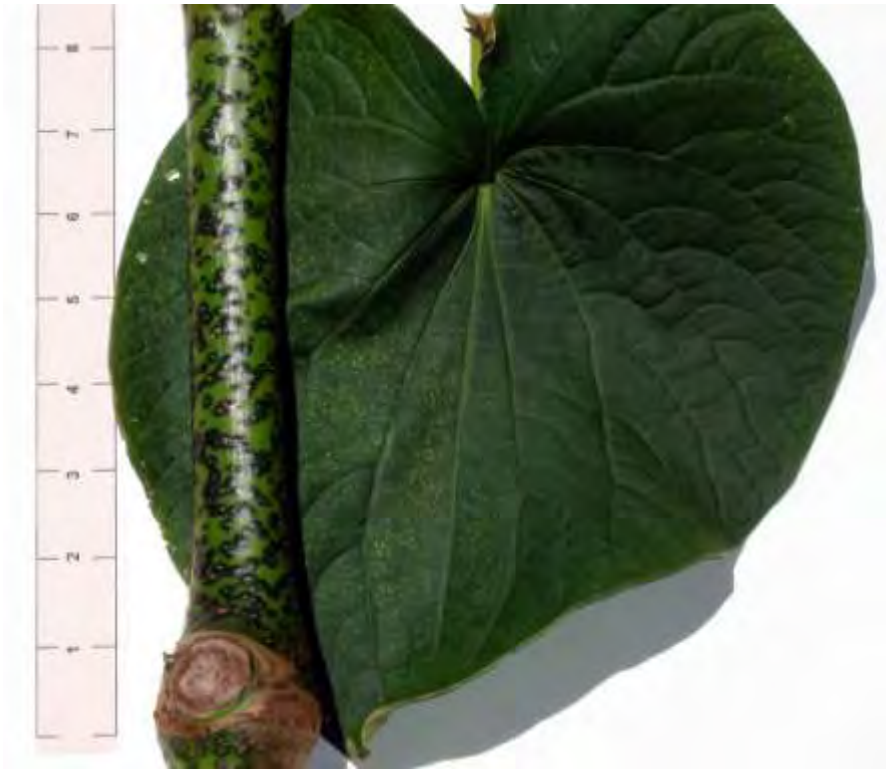

Fig. 5.25. Lenticels are distributed over the entire internode.

ʻOpihikao

ʻAwa ʻOpihikao was the name recently applied to a cultivar found along the ʻOpihikao Ridge on the island of Hawaiʻi. Other names sometimes used today for this cultivar are "spotted Hiwa" or "Hiwa puʻupuʻu."

Its growing habit is erect. ʻOpihikao has been known to reach twelve feet and higher. The internodes are very dark and long—up to twenty inches—with many lenticels.

To the best of our knowledge, this cultivar was only located in one area of ʻOpihikao and nowhere else. In the late 1990s, AHA President Jerry Konanui discovered the three extremely large plants and took cuttings for propagation and root samples for analysis. Thanks to that action, we now have ʻOpihikao in cultivation.

Very soon afterwards, the abundant ʻawa along the ʻOpihikao Ridge simply disappeared. Included in this patch were numerous Mahakea, Nēnē, and Papa ʻeleʻele puʻupuʻu plants, which also are all gone now.

The ʻOpihikao roots analyzed for the 1999 *Economic Botany* paper were from this relict patch. The overall kavalactone level was the lowest of any of the root samples analyzed for that paper: 4.85%.

The clones of the original plants have now grown up, and additional analyses have been done. These show kavalactone levels that are more in line with the other Hawaiian varieties. For instance, the lateral roots of a two-year-old plant, which was cultivated in partial sun and fertilized liberally, had a total kavalactone content of 11.76 percent.

Table 5.10. ʻOpihikao
Kavalactone Analysis of Air-Dried Lateral Roots
(Lebot et al. 1999)
HPLC Analysis by Madis Botanicals, Inc.

Sample Name	**APN18**
Chemotype	462531
Age of Plant (Years)	50?
Soil Type	Pāhoa
Location (Hawaiʻi Island)	Puna
Shade (1=full sun; 4=full shade)	3.5
Growing Methods	Wild, not irrigated, not fertilized
Damage	No damage
Lateral Root Size	<0.5
Percentage Kavalactones	
Kavalactone	
Desmethoxyyangonin (1)	0.49
Dihydrokavain (2)	0.85
Yangonin (3)	0.66
Kavain (4)	1.11
Dihydromethysticin (5)	0.71
Methysticin (6)	1.03
Total Kavalactones	**4.85**

Scale is in inches.

Fig. 5.26. Distinguishing characteristics include its extremely long internodes, dark color, and shiny surface.

Fig. 5.27. Interior stalks of a mature ʻawa ʻOpihikao.

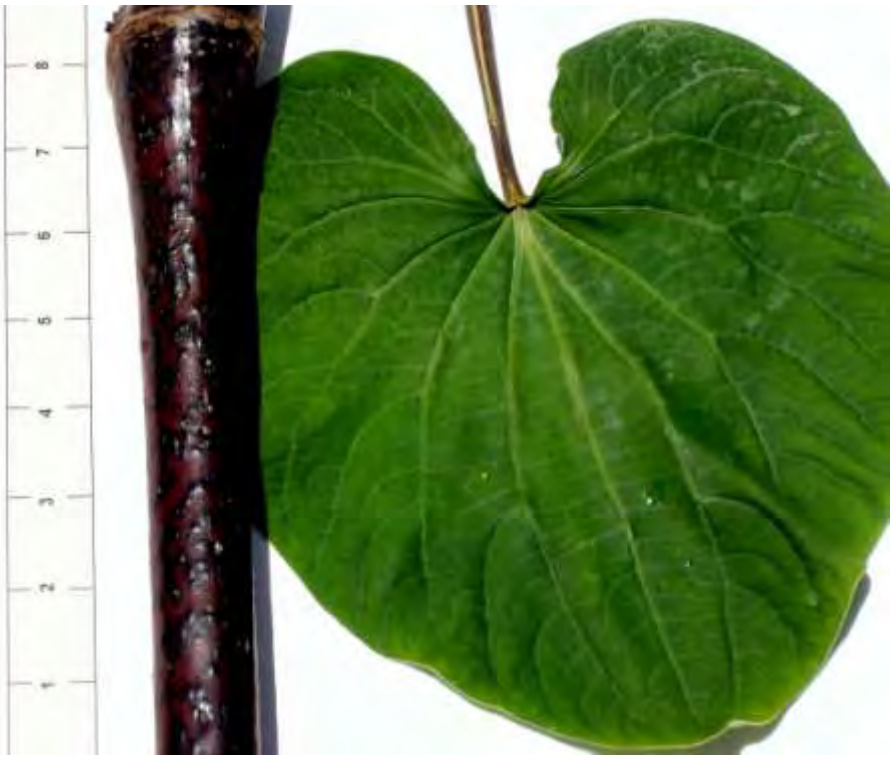

Fig. 5.28. Lenticels are visible all along the internode.

ʻAwa Panaʻewa is not a name we can trace back to old Hawaiʻi. When first collected, this cultivar was tagged as "short internode green" or "SIG," a misleading label but one which persists despite the purple color above the nodes. Kūpuna in the Hawaiian Homelands area of Panaʻewa have preferred to call it "Panaʻewa" because it was once very prevalent there.

This cultivar has also been found growing in other areas on the island of Hawaiʻi, for example, in Maulua gulch and a spot near the village of Honomū.

Otto Degener comments in *Flora Hawaiiensis* that "Awa has been planted by the Board of Agriculture and Forestry on the wet *aa* lava between Olaa and Hilo, a region well suited to it" (Degener 1946, under the entry "Piperaceae"). The remaining forest stands of Panaʻewa may be those plantings from the Territorial Board of Agriculture and Forestry.

ʻAwa Panaʻewa is a low- to medium-growing plant with a mostly prostrate growth habit. The young plant starts out with very short internodes but, as the plant grows larger, they elongate somewhat. Both characteristics are often found on one plant, with very short internodes on the newer growth.

Table 5.11. Panaʻewa
Kavalactone Analysis of Air-Dried Lateral Roots
(Lebot et al. 1999)
HPLC Analysis by Madis Botanicals, Inc.

Sample Name	PANAE	KOLE
Chemotype	463215	462351
Age of Plant (Years)	5	55?
Soil Type	Pāhoa	Hāmākua
Location (Hawaiʻi Island)	Puna	Hāmākua coast
Shade (1=full sun; 4=full shade)	2	3.5
Growing Methods	Wild, rainfed, fertilized	Cultivated, rainfed, not fertilized
Damage	No damage	No damage
Lateral Root Size	>1-0.5 cm.	<0.5 cm.
Percentage Kavalactones		
Kavalactone		
Desmethoxyyangonin (1)	1.61	0.42
Dihydrokavain (2)	2.01	1.36
Yangonin (3)	2.61	1.03
Kavain (4)	4.19	2.63
Dihydromethysticin (5)	1.14	0.95
Methysticin (6)	2.97	2.03
Total Kavalactones	**14.53**	**8.42**

Scale is in inches.

Fig. 5.29. This is a characteristic older stem, with internodes elongating to medium length.

Fig. 5.30. Note the purple band above each node. (Photo by G. Brad Lewis)

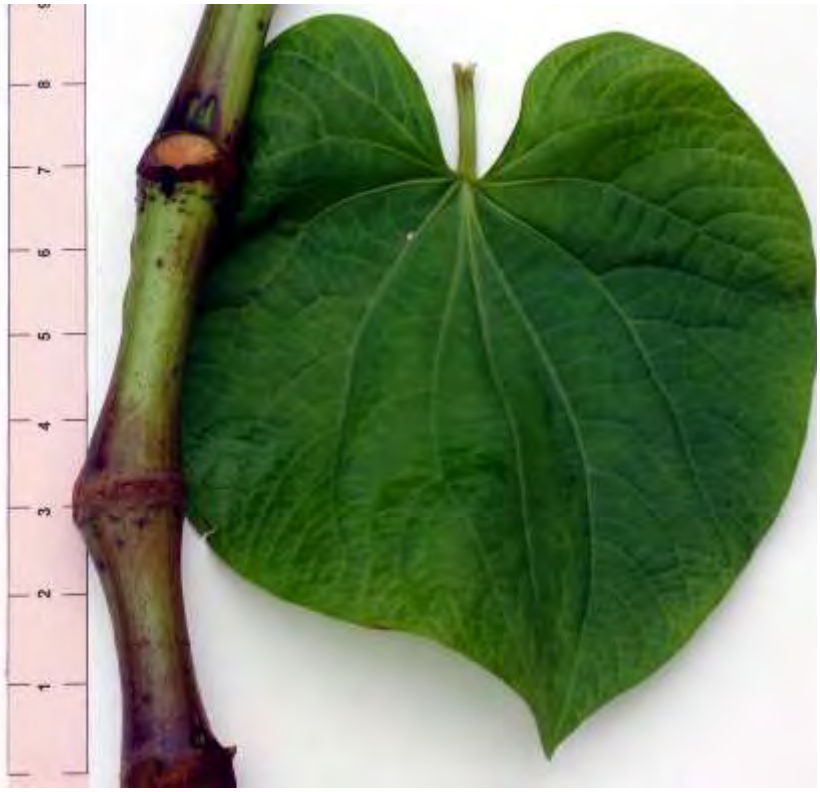

Fig. 5.31. The stem nodes are purple, and the leaf piko is green. There are very few lenticels.

Papa ʻEleʻele Puʻupuʻu

Papa ʻeleʻele puʻupuʻu is a name which was devised recently to match the appearance of this ʻawa. It is named after the dark Papa ʻeleʻele variety with the addition of the word "puʻupuʻu," which means "full of protuberances, lumps" (Pukui and Elbert 1986, 360).

Typical characteristics of this cultivar are its short to medium internodes and dark, highly spotted stalks. Its growth habit is normal, and its leaf piko is dark.

As with any ʻawa plant, the amount of light plays a role in its overall growth. If grown in full sun, the internodes will be shorter than if grown in shade.

Papa ʻeleʻele puʻupuʻu was collected from forest stands in Honolua and Kīpahulu valleys on Maui and in ʻOpihikao in the Puna district of the island of Hawaiʻi. The patch in ʻOpihikao has since been destroyed.

Table 5.13. Papa ʻEleʻele Puʻupuʻu
Kavalactone Analysis of Air-Dried Lateral Roots (Lebot et al. 1999)
HPLC Analysis by Madis Botanicals, Inc.

Sample Name	APN6	PAU7	PAH1	PAH1* (Clone of PAH1)	PONO2
Chemotype	463215	463215	462531	463251	463251
Age of Plant (Years)	4	3	20?	2.4	30?
Soil Type	Hāmākua	Hāmākua	Pāhoa	Pāhoa	Pāhoa
Location (Hawaiʻi Island)	Hāmākua coast	Hāmākua coast	Puna	Puna	Puna
Shade (1=full sun; 4=full shade)	4	3	3.5	2	3.5
Growing Methods	Cultivated, irrigated, fertilized	Cultivated, irrigated, fertlized	Wild, not irrigated, not fertilized	Cultivated, not irrigated, not fertilized	Wild, not irrigated, not fertilized
Damage	Not damaged	Not damaged	Not damaged	Not damaged	Not damaged
Lateral Root Size	<0.5 cm.	1-2 cm.	<0.5 cm.	<1-2 cm.	<0.5 cm.
Percentage Kavalactones					
Kavalactone					
Desmethoxyyangonin (1)	0.83	1.60	0.75	0.97	0.98
Dihydrokavain (2)	1.34	1.93	1.03	1.89	1.29
Yangonin (3)	1.42	2.90	0.85	2.48	1.52
Kavain (4)	2.93	4.34	1.36	4.09	2.46
Dihydromethysticin (5)	0.73	1.29	0.90	1.18	1.07
Methysticin (6)	1.60	3.19	1.32	2.64	2.39
Total Kavalactones	**8.85**	**15.25**	**6.21**	**13.25**	**9.71**

Scale is in inches.

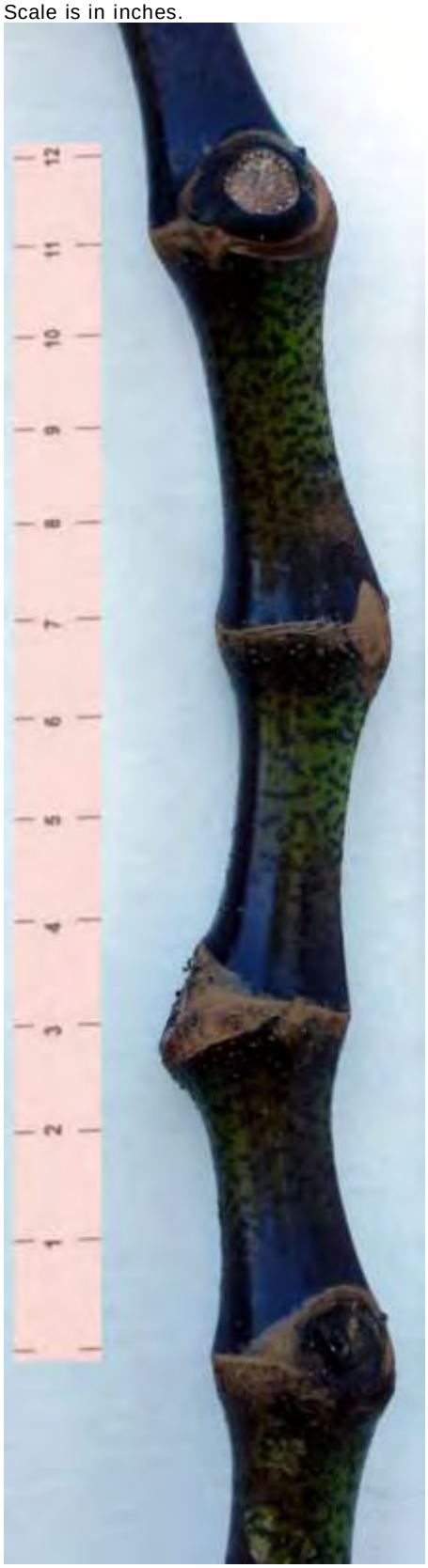

Fig. 5.35. Speckled, short to medium internodes characterize this cultivar.

Fig. 5.36. The growth habit is somewhat more upright than Papa ʻeleʻele. (Photo by Harry Brevoort)

Fig. 5.37. Spots are distributed throughout the internode.

Papa ʻEleʻele

Papa ʻeleʻele is one of the most desirable cultivars. It has short, deep purple to green internodes and beige nodes. Its leaf has a dark piko. The growth habit is prostrate.

Historian Samuel Kamakau mentions this cultivar: "The low-growing *papa ʻeleʻele* and *papa kea* varieties of ʻawa grow to be very handsome and decorative" ([1869] 1976, 41). Kaaiakamanu and Akina reported that it resembles ʻawa Mōʻī, but "its segments are considerably shorter . . . and it grows wildly, its branches scattering here and there among the shrubs" (1922, 19).

Papa ʻeleʻele is sometimes called "the Queen's ʻawa" or "Luʻukia." It was the dominant cultivar found in an area of Waipiʻo Valley that some valley residents call the "Queen's ʻawa patch." The name Luʻukia belonged to the wife of the ruler ʻOlopana, and, according to tradition, she lived for a time in Waipiʻo, perhaps in the 1300s (Cordy 2000, 141).

In addition, this ʻawa is sometimes called "Ālia 3." It has also been referred to as "Mōʻī," but that is now thought to be incorrect. The variety we are now calling "Mōʻī" is described earlier in this chapter.

Chun's compilation of early medicinal lore lists Papa ʻeleʻele among the varieties especially useful in treating urinary conditions (1994, 1:53-54).

This variety has been found growing wild in Waipiʻo and Waimanu valleys on the island of Hawaiʻi, as well as in Kīpahulu Valley on Maui.

Some Papa ʻeleʻele plants have had very high kavalactone levels. The first sample of dried lateral roots in the chart below shows 20.8 percent total kavalactones, with kavain at 6.69 percent.

For the home garden, where space may be limited, consider this variety for the following advantages:

- low-growing and wind-resistant
- ornamental
- stout, sturdy stalks
- disease resistance
- it makes a great drink.

Table 5.12. Papa ʻEleʻele
Kavalactone Analysis of Air-Dried Lateral Roots (Lebot et al. 1999)
HPLC Analysis by Madis Botanicals, Inc.

Sample Name	APN2	APN3	APN4	APN5	PAH2	PAU3	PAU4	PAU5
Chemotype	436215	462351	463251	463215	463251	463215	463215	463215
Age of Plant (Years)	4	3	3	4	2.3	2	1	5.5
Soil Type	Hāmākua	Hāmākua	Hāmākua	Hāmākua	Pāhoa	Hāmākua	Hāmākua	Hāmākua
Location (Hawaiʻi Island)	Hāmākua coast	Hāmākua coast	Hāmākua coast	Hāmākua coast	Puna	Hāmākua coast	Hāmākua coast	Hāmākua coast
Shade (1=full sun; 4=full shade)	4	3	3	4	2.3	2	1	5.5
Growing Methods	Cultivated, irrigated, fertilized	Cultivated, irrigated, fertilized	Cultivated, irrigated, fertilized	Cultivated, irrigated, fertilized	Cultivated, not irrigated, some fertilizer	Cultivated, irrigated, fertilized	Cultivated, irrigated, fertilized	Cultivated, irrigated, fertilized
Damage	No damage	No damage	No damage	No damage	No damage	No damage	No damage	Bacteria
Lateral Root Size	>2 cm.	>2 cm.	>2 cm.	<0.5	1-2 cm.	1-2 cm.	<0.5	1-2 cm.
Percentage Kavalactones								
Kavalactone								
Desmethoxyyangonin (1)	1.67	0.78	0.88	1.54	0.95	1.30	1.17	1.47
Dihydrokavain (2)	3.12	1.50	1.60	1.58	1.63	2.21	1.45	1.97
Yangonin (3)	4.25	1.18	1.95	1.59	1.73	2.70	1.96	2.38
Kavain (4)	6.69	2.94	3.17	3.01	3.19	4.72	3.15	4.16
Dihydromethysticin (5)	1.54	0.85	0.92	0.75	0.96	1.13	1.00	0.99
Methysticin (6)	3.53	1.70	1.98	1.89	2.25	3.01	2.62	2.47
Total Kavalactones	**20.8**	**8.95**	**10.5**	**10.36**	**10.71**	**15.07**	**11.35**	**13.44**

Scale is in inches.

Fig. 5.32. Internodes start out purple at the bottom, often shading to green going up.

Fig. 5.33. True to its prostrate form, this ʻawa's outer branches are creeping along the ground.

Fig. 5.34. The piko of the ʻawa tends to be the same color as the stalk. This one is hard to see, but it is dark like the stem. There are a few lenticels and they tend to appear just under the node.

The ʻawa variety that the Hawaiians called Papa kea is described by Handy as being "like the Papa eleele as to internodes and habit, but has light green stalk" (1940, 202). He also mentions that this cultivar is probably the same as the ʻawa called Keʻokeʻo. Kamakau tells us that Papa kea is one of the low varieties that "grow to be very handsome and decorative" ([1869] 1976, 41).

In recent years, we have called this cultivar by the name "ʻApu" but now believe, thanks to Kāwika Winter, that there is stronger evidence for it to be called Papa kea. ʻApu seems to have been described by only one informant, the Rev. Oliver P. Emerson (1903, 131), who said its joints "are short and green" and that Mākea's are lighter. However, none of the other Hawaiian cultivars could be described as lighter than the cultivar pictured on the opposite page.

The *Hawaiian Dictionary* says that ʻawa Papa kea (or Keʻokeʻo) is "the commonest variety" (Pukui and Elbert 1986, 34). It thus seems likely that Papa kea would be one of the cultivars to survive to the present.

Its growth habit is prostrate. Rarely reaching five feet in height, Papa kea is an attractive and manageable plant.

Plants of this cultivar have been found in old ʻawa fields in Puna. Joel Lau collected it in 1983 by a tributary of the Kamoʻoaliʻi stream system in Kāneʻohe, Oʻahu. It has also been cultivated in the collection donated by Vincent Lebot at the National Tropical Botanical Garden site in Hāna, Maui, where the cultivar was labeled Oʻahu 237.

When the Hawaiian cultivars underwent DNA fingerprinting for the 1999 *Economic Botany* paper, Papa kea (labeled "ʻApu") was one of only two Hawaiian cultivars to be identified as slightly different genetically from the other Hawaiian cultivars. It exhibited eight distinctive bands (out of a possible 1149 or 0.7 percent difference) over three of the 21 pairs of primers assayed.

This cultivar is very susceptible to the shothole disease (*Phoma* sp.), and every precaution should be taken to prevent it. See chapter 9 for more information on controlling this fungal disease in ʻawa.

Table 5.1. Papa Kea
Kavalactone Analysis of Air-Dried Lateral Roots
(Lebot et al. 1999)
HPLC Analysis by Madis Botanicals, Inc.

Sample Name	**PAH4**
Chemotype	462351
Age of Plant (Years)	3
Soil Type	Pāhoa
Location (Hawaiʻi Island)	Puna
Shade (1=full sun; 4=full shade)	3
Growing Methods	Cultivated, rainfed, some fertilizer
Damage	No damage
Lateral Root Size	1-2 cm.
Percentage Kavalactones	
Kavalactone	
Desmethoxyyangonin (1)	0.82
Dihydrokavain (2)	2.00
Yangonin (3)	1.75
Kavain (4)	3.43
Dihydromethysticin (5)	1.04
Methysticin (6)	2.12
Total Kavalactones	**11.16**

Scale is in inches.

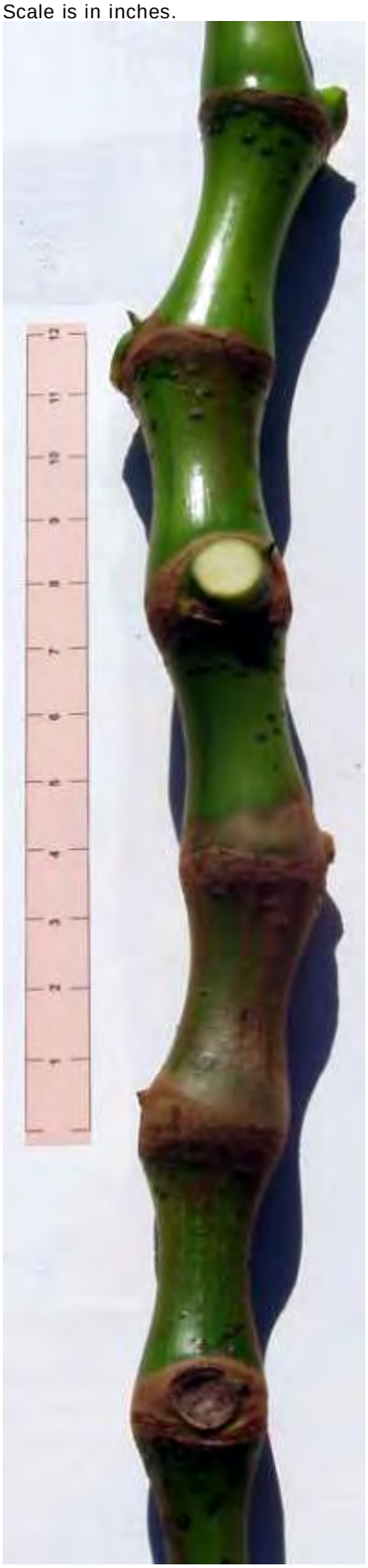

Fig. 5.38. Internodes are quite short.

Fig. 5.39. Papa kea is a handsome plant suitable for the home garden.

Fig. 5.40. Most of Papa kea's few lenticels appear right underneath the node.

Chapter 6

Non-Hawaiian Cultivars Grown in Hawai‘i Today

Ed Johnston and Helen Rogers

We are aware of seven ‘awa cultivars grown in the state that are not of Hawaiian origin (though very likely more cultivars have been brought in by people who moved here from Pacific Island countries). Vincent Lebot introduced the seven cultivars in the mid-1980s from a number of South Pacific islands. The University of Hawai‘i's Lyon Arboretum propagated the cuttings, and they were planted between breadfruit trees at the Hāna satellite of National Tropical Botanical Garden (Lebot, personal communication). The non-Hawaiian cultivars we have seen are:

Table 6.1. Non-Hawaiian Cultivars

Place of Origin	Cultivar Names
Pohnpei, FSM	*Rahmwanger* and *Rahmedel*
Fagaloa, Upolu, Western Samoa	*Ava La‘au*
Madang, Madang Province, PNG	*Iwi* and *Isa*
Longamapu, Vava‘u, Tonga	*Akau huli* and a cultivar labeled "*Hina* Tonga" at the Hāna satellite of National Tropical Botanical Garden

Pohnpei, Federated States of Micronesia

“To understand Pohnpei–and Pohnpeians–you must understand *sakau*,” these are the words of Bill Raynor, Nature Conservancy Director in Micronesia. *Sakau* is their word for ‘awa. The indigenous people of Pohnpei never gave up their traditional drink, and it has remained an important part of their culture throughout their history.

The most widely grown cultivar of *sakau* in Pohnpei is *Rahmwanger*, which made up 97% of all the ‘awa plants recorded by Bill Raynor in an island-wide study he did in 1987 for his master of science degree. The most popular Micronesian ‘awa in Hawai‘i is also the *Rahmwanger*. It is hardy and quite easy to grow, adapting to both lowland and mountain conditions.

Rahmwanger is a tall plant with an erect growing habit and long internodes. It is pastel green with dark spots throughout the stalks. It can be distinguished from the Hawaiian cultivar Nēnē by the pastel green coloration and the quick fading of its spots as the stalk ages on the plant. Perhaps the most tell-tale difference is the tough, fibrous integrity of the stalks, which are closer in structure to the PNG cultivars, *Iwi* and *Isa*.

Cuttings of this and the other Pohnpei cultivar, *Rahmedel*, were brought to Hawai‘i by Pohnpeians who moved here as well as by Vincent Lebot.

Bill Raynor comments that *Rahmedel*

> is much less common [than *Rahmwanger*], and while all kava is known traditionally as the property of the *Nahnmwahrkis* (high chiefs), this cultivar is known as the cultivar that was reserved for their use. My observation is that it is slower growing and not as hardy. It takes a bit more work, or more fertile soils to grow well. Many people say it is the “stronger” of the two cultivars and the oldest and largest plants presented in traditional feasts and funerals are often *Rahmedel* cultivar (Raynor, personal communication 2005).

Rahmedel is a medium tall ‘awa plant with light green internodes of medium length. A band of purple color appears just above each node. Its stalks have fewer lenticels than *Rahmwanger* has.

In the 1999 Hawaiian ‘awa study (Lebot et al, 414), the DNA of both Pohnpeian cultivars showed slight differences from the DNA of the Hawaiian cultivars.

Western Samoa

In Samoa ‘awa is spelled *ava*. On the island of Upolu in Western Samoa, the land above Fagaloa Bay is the principal *ava* growing area (Lebot and Lévesque 1989, 263) and the place where Vincent Lebot collected the *Ava La‘au* that he brought to Hawai‘i. *Ava La‘au* is nearly identical in appearance to Hawai‘i’s own ‘awa Nēnē. The difference is in the raised lenticels or spots along the stalks, which protrude more on Nēnē.

Papua New Guinea

Both of the ‘awa cultivars from Papua New Guinea were originally collected by Vincent Lebot from Madang, where ‘awa is seldom consumed.

Isa is a tall plant with dark green stalks and dark spots. The long stalks and portions of the leaf are cov-

ered with a fine down or fuzz known as "pubescence." *Isa* has a normal growth habit and is extremely tolerant of diseases and pests. Lebot et al. (1999, 414) compared the DNA of *Isa* with the Hawaiian varieties and reported that *Isa* "appeared to be the most genetically distant from other accessions."

Here in Hawai'i, the *Isa* cultivar is sometimes mixed with other 'awa cultivars to produce a drink. *Isa* adds a strong, sharp, peppery taste.

The cultivar called *Iwi* is a lighter shade of green along its long stalks. It's also spotted, but it lacks pubescence. *Iwi* has a normal growth habit. Lebot and Levèsque (1989, 266 and 280) report that *Iwi* roots they analyzed had 29.62 percent total kavalactones with a chemotype of 256431. This is the chemotype of a "*tudei*" 'awa (Lebot, Merlin, and Lindstrom 1992, 76), given this name because the effects last for two days.

Both *Isa* and *Iwi* are fibrous plants with strong, tough stalks, stumps, and root systems. *Iwi* is even tougher than *Isa*. Their stalks stay slender as the plants age.

Tonga

In Tonga, *P. methysticum* is called *kava*. Most Tongan cultivars are named by farmers using a traditional classification system based on the characteristics of the stem color and shape of the internode.

For the variety called *Akau huli*, *Akau* means long internodes and *huli* means black or purple (Lebot and Levesque 1989, 262-263). Thus, *Akau huli* should be called by its whole name and not shortened to *Akau*.

Akau huli has medium to long internodes, deep purple in color with spots throughout. This cultivar has been mistaken for *Kasa akau*, a Tongan 'awa which we have not seen in Hawai'i.

The only kavalactone analysis we have of *Akau huli* is from Lebot and Levèsque (1989, 271-273), and the method differs from the one used to analyze the Hawaiian varieties in 1999 (Lebot et al.). *Akau huli*'s overall kavalactone content was 17.90 percent, with a chemotype of 264531.

The identification of the second Tongan variety is more problematic. Like *Akau huli,* it was preserved at the Hāna satellite garden, where it was labeled "*Hina* Tonga." *Hina* means white or light green, and this is a green variety. However, Lebot, Merlin, and Lindstrom describe the Tongan variety called *Hina* as having short internodes (1992, 94), and the internodes of the cultivar at Hāna are medium to long. It is highly speckled and erect in habit.

There is another Tongan cultivar called *Leka hina*, but its name indicates that it, too, has short internodes (*leka* meaning short or dwarf). Thus, it seems unlikely that the plant we have is *Leka hina*. Perhaps one day we will obtain an exact identification.

Table 6.2 Non-Hawaiian 'Awa Varieties
Kavalactone Analysis of Air-Dried Lateral Roots (Lebot et al. 1999)
HPLC Analysis by Madis Botanicals, Inc.

Sample Name	APN 23 Ava La'au[1] (Samoa)	PAU10 Rahmedel (FSM)	APN22 Rahmwanger (FSM)	PAU11 Rahmwanger (FSM)	ISA (PNG)
Chemotype	463251	463251	463251	463251	246531
Age of Plant (Years)	2	2.5	2.5	2	2
Soil Type	Hāmākua	Hāmākua	Hāmākua	Hāmākua	Hāmākua
Location (Hawai'i Island)	Hāmākua coast	Hāmākua coast	Hāmākua coast	Hāmākua coast	Hāmākua coast
Shade (1=full sun; 4=full shade)	4	2	3.5	2.5	3
Growing Methods	Cultivated, irrigated, fertilized	Cultivated, irrigated, fertilized	Cultivated, irrigated, fertilized	Cultivated, irrigated, fertilized	Cultivated, irrigated, fertilized
Damage	No damage	No damage	No damage	No damage	No damage
Lateral Root Size	>2 cm.	1-2 cm.	1-2 cm.	1-0.5 cm.	>2 cm.
Percentage Kavalactones					
Kavalactone					
Desmethoxyyangonin (1)	0.99	0.61	0.62	0.65	0.56
Dihydrokavain (2)	1.94	1.40	1.40	1.20	2.87
Yangonin (3)	2.80	1.77	1.79	2.12	1.34
Kavain (4)	3.99	3.48	3.29	3.58	2.15
Dihydromethysticin (5)	1.05	0.66	0.85	0.82	1.72
Methysticin (6)	2.87	2.21	2.24	2.93	2.14
Total Kavalactones	**13.64**	**10.13**	**10.19**	**11.30**	**10.78**

[1] Incorrectly labeled "*Ava Lea*" in the 1999 paper by Lebot et al.

Fig. 6.1. *Rahmwanger* from Pohnpei, FSM, is distinguished by its bright green color and the fact that its spots fade as the plant ages.

Fig. 6.2. *Rahmedel* from Pohnpei, FSM.

Fig. 6.3. *Ava laʻau* from Upolu Island, Western Samoa. This cultivar can be distinguished from ʻawa Nēnē, whose lenticels protrude more along the stem and are rougher to the touch.

Scale is in inches.

Fig. 6.4. *Isa* from Papua New Guinea.

Fig. 6.5. *Iwi* from Papua New Guinea, a *tudei* ‘awa.

Fig. 6.6. "*Hina* Tonga" from Longamapu, Vava'u, Tonga. It looks similar to Hawai‘i's ‘awa Nēnē except the lenticels of "*Hina* Tonga" are greener in color and have blurred outlines. Its internodes also tend to be shorter than Nēnē's.

Fig. 6.7. *Akau huli* from Longamapu, Vava'u, Tonga.

Chapter 7

Preparing the Drink

Ed Johnston and Helen Rogers

Traditional use of ʻawa spans 3,000 years in time and 4,300 miles of the Pacific Ocean. Today, methods of use vary from country to country and range from chewing the root fresh from the ground all the way to sipping highly refined, standardized extracts.

Isabella Abbott (1992, 43) describes how the native Hawaiians once made ʻawa:

> Children with strong teeth chewed the root to crush and soften it, depositing the results in a special calabash called a *kanoa*. When the desired quantity was accumulated, water was added, and this was sometimes allowed to sit for a while. Next the contents of the *kanoa* were strained into another bowl through a bundle of *ʻahuʻawa*[1] fibers laid in either a perforated gourd or a *niu* "shell," its three small "eyes" serving as drainage holes.

According to Margaret Titcomb, one coconut shell portion was "the amount commonly taken before a meal." After drinking, Hawaiians would rinse their mouths with water and a bit of food (pūpū) would be eaten to clear the taste of the ʻawa, which most people find somewhat objectionable (1948, 116-119).

Learning to drink ʻawa has been compared to acquiring an appreciation for different types of wine. ʻAwa drinkers do enjoy trying different cultivars, but generally not for their taste, appearance, smell, or how they complement food. Drinkers are interested in ʻawa's psychoactive effects, and these are influenced by the chemotype of the particular cultivar being consumed.

Traditional fresh drink is a water-based mix of thoroughly pulverized, strained rootstock served cool or at room temperature. Preparation varies by country and region, but it always begins with a wet fibrous pulp made from a combination of the ʻawa's stump and lateral roots. Vanuatu and Micronesia are famous for their fresh ʻawa drinks, which are quite strong and fast-acting.

In Fiji, the ʻawa rootstock is more likely to be dried and ground into a powder from which the drink is made. Fresh ʻawa drinks are stronger than drinks made from dried ʻawa, and for some people, one serving of fresh ʻawa is sufficient.

Whether the ʻawa is fresh or dried, pay attention to the variety being used and to the effect it is producing. Allow fifteen minutes after each cup to feel the drink's effects before deciding whether or not to have another.

It's best to drink the ʻawa right away or refrigerate it. ʻAwa that has been sitting out for hours acidifies and degrades in warm temperatures (Lebot and Siméoni 2004, 26).

Composition of ʻAwa

Fresh root and stump is 80% water. Dried rootstock is 43% starch, 20% fiber, 12% water, 3.2% sugars, 3.6% proteins, 3.2% minerals, and between 3 and 20% kavalactones.

The ʻawa drink contains fifteen amino acids, four sugars, and seven minerals, as follows:

Table 7.1. Composition of kava stump and roots
% dry matter

Sugars		Amino acids		Minerals	
Saccharose	0.50	Aspartic acid	0.28	Potassium	2.237
Maltose	0.10	Threonine	0.08	Calcium	0.372
Fructose	1.75	Serine	0.11	Magnesium	0.179
Glucose	0.85	Glutamic acid	0.26	Sodium	0.111
		Glycine	0.11	Aluminum	0.150
		Phenylalanine	0.07	Iron	0.106
		Histidine	0.05	Silica	0.090
		Lysine	0.10		
		Arginine	0.08		
		Alanine	0.16		
		Valine	0.11		
		Methionine	0.02		
		Isoleucine	0.07		
		Leucine	0.14		
		Tyrosine	0.06		

From Lebot and Cabalion 1986, quoted in Lebot, Merlin, and Lindstrom 1992, 60-61.

Refer to Chapter 3, "The Active Ingredients in ʻAwa," and Chapter 4, "Chemistry, Pharmacology, and Safety Aspects of Kava," for details on ʻawa's psychoactive ingredients. Some warnings to be aware of are summarized on page 4.

[1] *Mariscus javanicus*, a native sedge.

Fig. 7.1. How to Make Fresh ʻAwa Drink

1. Grinding fresh ʻawa root in a Corona hand-cranked grinder.*

2. Place 16 ounces of pulp into mixing bowl.

First, chop the fresh material to a size that will fit through a Corona corn mill or sausage grinder. For large quantities of root/stump, a Hobart Industrial Food Chopper or a LaMilpa Power Mill is excellent. The object is to process the fresh ʻawa to as fine a consistency as you can. The more completely it is processed, the greater will be the release of kavalactones.

3. Add 4 to 6 cups of water. (Coconut water may also be used.)

4. Hand mix pulp into water vigorously, then squeeze and knead the mixture.

Mix the ʻawa into the liquid so that it's distributed. Start kneading it (squeezing and pressing).

5. Pour into silkscreen strainer.

6. Knead pulp in strainer. Liquid filters out into bowl.

After the liquid becomes thick and resinous and has turned a greenish gray color, you then squeeze it through a fine mesh strainer such as silkscreen.

7. Squeeze and press pulp through the strainer.

8. Serve fresh ʻawa drink.

Fresh ʻawa prepared this way is much more potent than drinks made from dried ʻawa. It is best to drink a single five- or six-ounce serving quickly, then wait fifteen minutes to feel the effect before deciding on a second cup.

(Photos 2-8 by Jeffrey Burger)

*Alternatively, cut root into 1" pieces and stump into 1" or smaller cubes. Put in blender with water to cover. Blend and follow steps 5-7 above. Follow this procedure two more times (placing the pulp in the blender, covering with water, blending, etc.). It should yield about a 1 to 5 ʻawa to water ratio (Bittenbender 2006, personal communication).

Fig. 7.2. How to Make the Drink from Dried ʻAwa Powder

Place the powdered ʻawa into your mesh bag.

The drink is made traditionally in many Pacific Island cultures by straining the dried ʻawa powder in water or coconut water. You could use a fine, silkscreen cloth that has been sewn to resemble a bag. Another method is to just tie cotton string around the silkscreen cloth so that the powder does not leak out into the water.

Immerse it in water. (Coconut water may also be used.)

The amount of water will vary according to individual preference, but a good rule of thumb is 16 ounces of good ʻawa powder to a gallon of water. Place the powder into the strainer bag, hold its edges together at the top so that none of the whole powder escapes, and immerse the bag into a bowl of cool water.

Holding the bag closed, knead the ʻawa until the consistency is right.

(Photos by Rune Pedersen)

Use your other hand to knead the bulk of powder under the water. If the ʻawa has a high kavalactone content, it will feel oily, almost like a ball of greasy clay. This is the kavalactone resin. The longer you press and squeeze the bag, the less oily it will feel and the more oily the water will feel and look. The water should begin to look like mud. To get the most from the already wet ʻawa powder, some people place it again in a smaller amount of water and continue the kneading process, then combine this weaker mix into the stronger.

Traditionally, each serving of this prepared ʻawa is swallowed in one or two quick drinks from a coconut shell. It's a good idea to space servings at least fifteen minutes apart. Kavain, the kavalactone highest in most Hawaiian ʻawa varieties, is usually felt quite soon after drinking, but the other kavalactones' effects may not register for 20 minutes or so.

Store your dried ʻawa in an airtight container in the freezer.

Chapter 8

ʻAwa Production in Hawaiʻi

Jeri J. Ooka, Jerry Konanui, Scot Nelson, Jim Henderson, Ed Johnston, Tom Osborn

Production Systems

Bringing an ʻawa crop to a successful harvest involves many things. The land available, its topography and growing zone are major determining factors on the production system selected. In general, ʻawa needs good moisture, good drainage, and wind protection. The physical attributes of the site need to be modified to optimize these conditions.

Five production systems based on soil type or planting method are being used in Hawaiʻi. These are: 1) deep soil, 2) rocky soil, 3) forest planting, 4) lava soil, and 5) basket planting. These systems can be modified to fit most situations in areas where ʻawa can grow.

Deep Soil

Lands formerly in sugarcane or pineapple often have deep, well developed soils. Such soils can be plowed and rotovated. They should be amended before planting as indicated by soil analysis.

If the soil is well drained, ʻawa can be planted on the flat. However, flat planting makes harvesting difficult. Hilling, mounding, ridging or raised beds facilitate lifting the plants with more roots intact. Raised beds of some kind are therefore encouraged. Raised beds are an advantage in heavier soils to discourage accumulation of water in the root zone. The raised beds may be as wide as 4 feet and 1 to 3 feet high. These soils are the most amenable to mechanization of farming operations.

Fig. 8.1. Deep soil planting method: row-cropping ʻawa on mounds.

Rocky Soil

Some well developed soils are similar to soils of the deep-soil category but have a lot of rocks, which makes fine cultivation difficult or impossible. While building beds with a rotovator may not be possible, other conventional hilling devices such as mould board plows and disks on a tool bar or bed builder (metal box attached to tractor three point hitch, see figure 8.2) can generally be used to build raised beds in these soils.

Fig. 8.2. Bed builder, which attaches to tractor with three-point hitch, for forming mounds in deep soil or rocky soil. Not commercially available. This one was constructed by a welder.

Forest Planting

In some cases ʻawa is planted into lands where the existing vegetation, generally large trees, is not removed. Forest plantings enjoy natural shade, good soil moisture, wind protection, and low pest populations. Under story plants are cut or pushed down, and access lanes are cleared.

These forests usually have rocky soil or are on lava lands of the ʻaʻa type (see the next category). Where the soil is thin, the ʻawa is planted on mounds of planting media brought to the site. The medium is generally a cinder-based mix with added compost, soil, and fertilizer.

Problems in the forest environment have included pigs, goats, and plant thieves. If isolated, abundant natural rainfall is generally needed. If there are an-

nual rainy and dry seasons, catchment tanks or ponds can be constructed to collect water for the dry season.

Lava

On the island of Hawai'i, large areas of lava land are so new that soil has not developed. These lands are mostly 'a'a rock and may have a thin surface layer of organic material. Lava land is relatively inexpensive and also less conducive to root rot or nematodes but is susceptible to leaching and retains water and fertilizer poorly. Such sites may be in native forest or have been cropped with papaya, anthurium, or other plants.

These lands are usually bulldozed to clear them of vegetation and shape the surface. The land may be ripped to break up pahoehoe or plow soles formed during previous crops. A cinder-based planting medium is generally brought in and mounded for the 'awa plants. Material scraped from the site may be used to form rocky ridges on which plants are planted into "starter" media.

Fig. 8.3. Lava soil planting: young, irrigated ʻawa plants on cinder mounds, Puna District of Hawaiʻi Island. Spacing is 6 feet between plants and 8 feet between rows.

Basket Planting

Planting in wire mesh baskets lined with weed mat can be an attractive method for small-scale farmers and hobbyists. Weed mat is a woven polypropylene fabric usually laid on the soil for weed suppression. The cylinders can be 2 to 4 feet high and up to 3 to 4 feet in diameter. Any wire mesh that can form a free-standing cylinder strong enough to support the weight of the planting medium may be used, including hog wire, welded wire, and concrete reinforcing mesh. A weed mat bottom in the cylinder is optional. Large weed-mat planting bags of about 30 gallons (e.g. GrowBag®, Easi-Lift®), available commercially, could also be used.

The basket method reduces labor for maintenance and harvesting. While experimental data has not yet been collected, reduced pest and disease incidence may be a benefit of this method. On the other hand, labor and materials costs are high. In addition, baskets must be regularly watered and carefully protected from wind.

Fig. 8.4. ʻAwa is being grown in weed mat baskets on a limited experimental basis in Hawaiʻi.

Several of these production methods rely on supplementing the existing soil resource with a growing medium brought to the site. The principles of the "virgin soil technique" (Ko 1971) developed to cope with the papaya re-plant problem on 'a'a lava lands should be considered when moving growing media to fields formerly cropped with papaya or anthurium. These fields will probably have significant levels of fungal pathogens and nematodes.

The success of the "virgin soil technique" depends on media being almost free of plant parasitic nematodes and plant-pathogenic organisms and being biologically active. That is, it must have a good population of microorganisms antagonistic to the plant pathogens. In the context of the papaya re-plant problem virgin soil was any soil from a site where papayas had never been planted. This unfortunately, did not always mean that the soil was disease suppressive.

Well prepared and cured compost and relatively sterile materials such as newly mined cinder can usually be safely used for this purpose. Mixing the cured compost with the cinders insures that beneficial microorganisms will colonize the cinders first. Cau-

tion is advised whenever mineral soil, which may harbor pathogens, is part of such medium.

Planting Material

Now that we have some recent local experience growing ʻawa, we can more critically look at the topic of planting material. Your market has a significant influence on the cultivars you plant. If you are planting for the beverage market you want to plant good drinking cultivars. If you are planting for the pharmaceutical market high producers of kavalactones are desired. However, the long crop cycle of ʻawa probably dictates that a mixture of cultivars with good drinking quality and good kavalactone production be planted to hedge on market conditions at crop maturity.

Regardless of the market segment targeted, the planting material used needs to be from healthy plants free of pests. Since ʻawa can only be vegetatively propagated, this cannot be emphasized enough. Your stock plants must be free of systemic diseases.

Once you have selected your healthy stock plants, the type of cuttings taken will be determined by whether you will transplant rooted plants or plant cuttings directly in the field. The advantages of transplanting generally outweigh those of planting cuttings directly in the field.

Propagating ʻAwa

Insufficient planting material was probably the major short-term constraint to realizing the potential of ʻawa as a crop in Hawaiʻi during the 1990's. Innovations to maximize the scarce planting resource have been great. An excellent method of producing vigorous cuttings from a small number of stock plants is called the tipping-and-pinching technique.

Apical dominance in a stalk is removed by cutting off the terminal, which stimulates the buds at lower nodes on the stalk to grow. When these buds have grown to about the size of a pencil they too, are tipped and, in turn, their secondary buds are stimulated to grow. At this stage, the top-most node can be removed from the source plant for rooting, and so forth down the stalk. This technique produces excellent rooted cuttings that do well in the field.

To preserve the stock plant and ensure a good and sustainable yield of nodes, certain steps must be followed. This begins with obtaining your stock plants from a reputable source of healthy plants. The plants should be free of diseases such as cucumber mosaic virus, Pythium root rot, and nematodes. (There is as yet no program in Hawaiʻi to certify pathogen-free ʻawa propagation materials, so the buyer must beware). Examine the plants for insects, mites, and other pests. Remove these pests before bringing the plant to your stock plant area.

New plants should be isolated from other nursery or production plantings. The area should be free of plants that are known hosts of cucumber mosaic cucumovirus. Plant the ʻawa in containers or in the ground. Make sure the medium is well drained, has high nutrient levels, and is pathogen free.

Keep the plants free of insect and other pests by examining them regularly and treating them promptly with the appropriate materials or methods. Insecticidal soaps and vinegar and chili pepper water repellents may be used to control insects. Hand picking or traps baited with stale beer can be used for slugs and snails. Systemic acquired resistance to many fungi can be induced by using composts on the plants.

A system of record-keeping should be devised and maintained for stock plants to prevent overuse and track a plant's progeny. These records may help in obtaining certification for the nursery and stock plants if such a system should be established.

Once the plants are established, the tipping-and-pinching process can begin. Start tipping the plants one to two weeks after they receive their normal monthly application of fertilizer. This is to insure that the plants have the nutrients and energy available to put into the new growth stimulated on a stalk by removing apical dominance.

Tipping is the removal of the terminal of a mature stalk. This application of a well-known scion wood preparation technique will accelerate the lateral flushes on the main stalk. Do not remove leaves and secondary branches yet. This often causes the individual stalk to die. Mature stalks require a fair amount of pressure to penetrate the internodes with a thumbnail. If your thumbnail easily penetrates the stalk, it is too soft. Do this test two or three internodes down from the tip.

Removing the tips stimulates the axillary buds to grow. Nodes from secondary branches are not used. They produce crawling, vine-like ʻawa plants.

Pinching removes the tip of the new bud, stimulated to grow by tipping, when it is at least 1 inch long. Pinching the newly stimulated bud removes the apical dominance that it exerts, which allows buds already initiated on its little stalk to begin growing.

The rooted cutting will thus have multiple stems instead of only a single stem. When a multiple stemmed ʻawa is transplanted to the field it grows more rapidly than a single stemmed plant. This is especially noticeable in the size of corm and root mass.

Fig. 8.5. Stalk that was tipped some weeks prior. Sprouts shooting from the nodes are ready to be pinched to stimulate other buds on those nodes to sprout. Note leaves were left on stalk when it was tipped.

The node is ready to cut from the stalk when the buds below the pinched bud begin to swell and show some growth. The node is cut from the stalk about 0.75 to 1 inch from the nodal plate with clean, sharp pruning shears, loppers, or a saw. The internode is removed 0.75 to 1 inch above the nodal plate on the next node. The cuts are made close to both sides of the node because the wounds heal and harden more rapidly when most of the internodal material is removed.

All nodes with buds beginning to grow should be removed from the stalk. The remaining nodes are harvested as they become ready. However, the last one or two nodes nearest the stump should not be harvested. This protects the stump from infection by microorganisms, which could rot the stump. Again, don't forget to remove the internode, cut close to the node.

The harvested nodes should be carefully handled to prevent the stimulated bud from being damaged. Pinching lowers the profile of the shoot thus reducing the chance of the bud breaking off when the node is removed from the stalk and placed in a bucket in contact with other nodes.

Using sphagnum moss or other cushioning materials is desirable but not always feasible when dealing with thousands of nodes at a time. However, a 5-gallon plastic bucket containing a bed of moist sphagnum moss is an ideal container for protecting and transporting high value harvested nodes. A single layer of nodes is placed on the sphagnum moss. When that layer is complete, enough moss to cushion them is placed over the nodes and another layer of nodes is added until the bucket is full. Approximately 100 standard-sized nodes can be held in a bucket packed this way. The sphagnum moss will reduce the physical injury to the nodes as well as provide some inhibition of bacterial and fungal growth on the nodes.

Rooting Stem Cuttings

The nodes should be kept cool and prepared for planting as soon as possible after harvest--at the most, within 24 hours of harvest.

Lay the nodes on seed flats with the buds facing up. The preferred seed flats are plastic trays with 1/4-inch mesh on the bottom. A common flat size is 17 inches square and 2 inches deep. These provide better drainage than perforated, solid-bottomed trays. Seed flats allow processing with a minimum of handling.

The node-filled seed flat is immersed in a solution of dilute disinfectant, such as 10% Zerotal, to kill bacteria and fungi on the exposed surfaces and retard rotting. After a timed immersion of one to two minutes the flat is removed from the bath and drained. The nodes are lightly rinsed with fresh clear water immediately after draining to minimize damage to tender young buds. The nodes are air-dried before going into the next bath. (This step is optional.)

The nodes are then soaked in a nutrient bath of seaweed extract and high-phosphate foliar mix for 5 minutes at the concentration recommended on the product label. The nodes are then removed, drained and air dried. (This step is optional.)

The cut ends of the nodes may be sealed with a horticultural pruning paint to retard moisture loss. (This step is very optional.)

Place the flat of nodes on a misting bench for rooting. The bench should have 60 to 80% shade and a timer to provide mist for 5 seconds every 30 minutes during daylight hours. The timing cycle will, of course, depend upon the equipment used and the environment where the nursery is located.

Check the flats daily to remove stubs of cut secondary branches, which separate from the stems after a few days, and any cuttings showing signs of rot.

While thus grooming the flats, use a stream of water to wash the cuttings. Look for roots arising from the nodes and remove any cuttings with roots for potting.

The nodes may be soaked or sprayed weekly with a nutrient mixture of seaweed extract and high-phosphate foliar fertilizer mix. (This step is optional.)

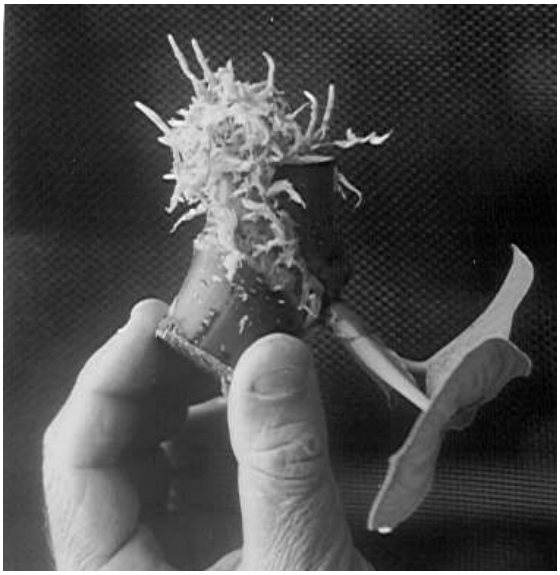

Fig. 8.6. Rooted node ready to be planted in a pot. (Photo by David Rogers.)

Potting and Grow-out

Rooted nodes removed from the misting bench should be potted in pathogen-free media. The size of the container used depends on the desired size of the plant at transplanting and may also be dictated by the cost of potting materials. The container may be as small as 1-pint size, but, although more medium and bench space is required, planting a rooted node into a 1-gallon container allows more options for plant handling and field preparation. Using 1-gallon pots is highly recommended for the small-scale or part-time grower, where time and labor are limiting factors.

The potted plants should, like the misting bench, be under 60 to 80% shade in a protected nursery area, such as a greenhouse or shade house. During very wet weather, it may be desirable to keep the plants under a solid-roofed greenhouse structure so that moisture in the media can be controlled.

The potting medium should be free of soil-borne pathogens such as root-knot and burrowing nematodes and pathogenic fungi such as *Pythium splendens* and *Rhizoctonia solani*.

A suitable mix contains volcanic cinders or perlite and compost (prepared without adding soil) in a ratio of 4 parts cinder to 1 part compost. A medium of all cinder or perlite without the compost is a good second choice. Using newly mined cinders, new perlite and properly matured and cured compost for your medium greatly increases the probability of having a pathogen-free medium. Any good soil mix is enhanced by adding endomycorrhizal inoculant.

Irrigating the pots with a sprinkler, mist, or drip system controlled by a timer is desirable, but watering by hose or sprinkler once or twice daily works as well most of the time. An automatic sprinkler system is a labor saving device and must be adjusted to give the plants enough water for a given site and environment.

Fertilize the pots with a 3-month slow-release complete fertilizer with micronutrients. A teaspoon per gallon container is generally a good rate to use with a cinder/compost medium. In addition, apply a foliar fertilizer every other week. The foliar formulation may be the same seaweed-extract, high-phosphate mixture used in the node rooting procedure, or use any commercial soluble fertilizer at about half the recommended concentration for vegetables. For instance, use Miracle-Gro all-purpose water soluble plant food (15-30-15 NPK) at ½ tablespoon per gallon and spray just to wet the leaves.

Compost extracts and teas can also be used for foliar feeding. A nice compost extract can be made from 500 to 1,000 grams of cured compost in 20 liters of water. Put the compost in a cloth bag or old nylon stocking and squeeze water through it until the water is light to golden brown. This is then sprayed on the plant every week or every other week.

Compost teas are brewed products that may be made from the same compost as the extract. Unlike the compost extract, which is used immediately, the compost tea requires an incubation time of 24 to 96 hours to allow the microorganisms in the compost to become active and multiply. There are many recipes for the two major categories of compost teas: non-aerated and aerated. Some experimentation needs to be done to adjust the strength of the compost extracts and teas to best benefit the plants.

The plants should be hardened off (acclimatized) before transplanting them to the field. Move the plants from the nursery in one or two stages of increasing sunlight. If your nursery has 80% shade, it would be safer to use a two-stage hardening-off process. From nursery shade at 60 to 70%, one-stage hardening-off at 30% shade can be successful. Hold the plants at each stage for about a week.

Consider field conditions and pests when transplanting ʻawa. Small plants under a foot tall are best used in shaded fields with few weeds, insects, slugs, and snails. Large plants over a foot tall can tolerate full sun and compete with weeds and pests better than small plants.

ʻAwa Nursery Beds

For an established ʻawa farm where planting material is abundant, a nursery bed system may be an efficient approach to plant propagation. This method would have most of the advantages of single node propagation while being initially less labor intensive.

The nursery beds should be located on well-drained land free of soil pathogens with access to irrigation. Structures for shading the nursery should be built over the nursery beds. Healthy stem cuttings, of two to many nodes from the woody mid portion of the stalk, are laid horizontally across the bed 4 to 6 inches apart with buds up. (The soft tops of the stalk will rot, and the buds on the lower portion of the stalk will not germinate.) The stalks are then covered with about 1 to 2 inches of topsoil, cured compost, or potting mix and well watered.

The beds are kept moist but not waterlogged until the first sprouts appear in about 4 weeks. If node stalks are used, this is the time to carefully cut the germinated nodes off and transplant them to pots for growing to field size. If two-node cuttings are used, a foliar feeding schedule can commence followed by a granular fertilizer schedule as the plants enlarge. As they approach a foot in size, they can be transplanted into gallon-sized pots or directly to the field.

Planting 1- to 4-node cuttings directly into pots is another method of propagation used in a nursery setting when planting material is not limited. Depending on the size of the pot and cuttings, one to three cuttings can be placed at a 20 to 30 degree angle from vertical in each pot. Be sure that the top of the stalk is up and the bottom down. The plant will grow slower if it is planted upside down. Four-node cuttings grow faster than two-node cuttings in general.

Direct Planting of Cuttings

Direct planting of cuttings in the field is traditional in many areas. For the casual grower of a few plants or the grower with many plants but no immediate commercial goals, this may be all right. For commercial production, this method generally is not an efficient way to establish a field that can be easily cared for and harvested.

While cuttings used for direct planting can be of any number of nodes, 6 nodes or a stalk about 2 to 3 feet long seems to be the norm. They may be planted horizontally or vertically. CTAHR extension specialist Skip Bittenbender reports good success with direct planting of 3-node stem pieces trimmed at the ends close to the nodes and planted horizontally 0.5 to 1 inch below ground in well drained, moist soil (pers. comm. 2006).

Many times the hole from which the parent plant is harvested is where its stalks are placed, covered with soil and mulch, and left to fend for themselves.

Soil Fertility Management

ʻAwa requires the right soil conditions for optimum growth. To begin with, Lebot (1992, 83) recommends soil with a pH of 5.5 to 6.5. The Cooperative Extension Service of the University of Hawaiʻi, College of Tropical Agriculture and Human Resources on your island can test your soil and make recommendations for the appropriate soil amendments.

Controlled experiments to study fertilizer effects on ʻawa growth and yield in Hawaiʻi's conditions, such as Bittenbender 2004, are still few in number. Bittenbender 2004, in a small study, sought to research the roles of fertility, shading, and pruning on kavalactone concentration and yield in ʻawa. The major conclusion on fertility was ʻawa does not require high levels of commercial nitrogen when grown in a basket culture medium of 60% black volcanic cinders and 40% compost made from plant-only feed stocks.

Bittenbender's rates of nitrogen application were 220 kg/ ha/ year and 560 kg/ ha/ yr applied as a 12N, 4P, 16K 180 day rated slow release formulation. There was no control (0 kg/ ha/ yr commercial N added). After a year the variety Mōʻī produced 1280 kg dry wt stump and root / ha and 89 kg of kavalactones/ ha at the 220 kg N/ ha/ yr rate. At the higher N rate of 506 kg N/ ha/ year, 1590 kg dry wt stump and root/ ha and 78 kg kavalactones/ ha were produced. It appears that higher fertility produced more biomass but reduced the percentage of kavalactones. The 1 to 2 percent depression of kavalactone percentage in the 1-year-old Mōʻī plants is also seen in the 2-year-old *Isa* plants.

The methods shared here by growers reflect their attempts to develop "best management practices" for ʻawa production, and they are given as suggestions for others to start their own trials. Many different me-

thods to provide plant nutrients to ʻawa crops are being tried. To discover the best techniques for ʻawa production, farmers have experimented with a wide range of fertilizer formulations, placement, rates and application frequencies. Many have drawn on their experience with other root crops, such as ginger and taro. Foliar application of fertilizer is emerging as an important component of fertilizer programs for ʻawa, both for starting out the plants and, in some systems, for the maturing crop.

This section describes a conventional approach to nutrient management using inorganic fertilizer formulations. The case study given later in this guide describes an organic fertilizer program. One schedule of fertilizer application:

Monthly application: NPK
14-14-14 slow-release formulation (1st 3 months)
14-14-14 granular (1 year)
16-16-16 granular (1 year)
10-20-20 granular (6 months)

Another schedule applies 14-14-14, then 10-20-20, then back to triple-14 or triple-16. Many farmers are supplementing applications of broadcast fertilizers with applications of foliar formulations such as Foliar 62® (12-24-24) twice a month.

A small handful (1/8 lb) of a complete fertilizer is spread around and over the mound for small plants. One schedule applies a handful to plants 1 foot high, evenly broadcast around the plant. The application increases to 1/4 to 1/2 lb of fertilizer for a plant over 4 feet tall. To avoid burning the roots, it is important to broadcast the fertilizer evenly within the drip line of the plant and not to throw handfuls of fertilizer into piles at the base of the plant. It is better to have more frequent, light applications of fertilizer than less frequent, heavy applications.

C. Brewer & Company's Hawaiian Pacific Kava Company grew 20 acres of ʻawa in Pepeʻekeo in the latter half of the 1990s. They conducted many nutritional trials and had kavalactone tests conducted on cultivated as well as wild-collected root samples. They concluded that fertilizer can be used to increase kavalactones and developed a fertilizer schedule. At planting, lime with 2 parts calcium carbonate and 1 part dolomite to achieve a soil pH of 5.8-6.5, apply treble super phosphate (0-45-0), and split application of potassium chloride or potassium sulphate (at planting and six months later). Following planting, apply 10-20-10 with full spectrum minors every 3 months throughout a 14-month "kava-grow" period. After 14 months of regular applications, a "kava-ripe" blend is applied, which is 5-19-19 plus 8% magnesium until harvesting the plants at two years old (John Cross and Matthew Archibald, pers. comm., 2006).

Elevation

ʻAwa grows best at lower elevations where there is high rainfall, generally below 1,500 feet on the windward sides of the islands and below 2,500 feet on the leeward sides. Lebot (1992, 83) specifies rainfall needs: over 85 inches per year if under 1,200 ft. elevation. Above that, at least 70 inches is needed.

Handy (1940, 203) reports that "Hawaiians planted it in or just below the borders of the lower forest zone, in clearings within the lower ranges of the forest, along streams, and in pockets along the base of and upon wet escarpments. ... In Kaʻu, Hawaiʻi, it was customary to plant ʻawa in the forest above the upper taro plantations." He goes on to quote Kamakau as saying "Some [Hawaiians] planted fields of ʻawa, but mostly it was planted along the borders of wauke and taro plantations."

Weed Management

Weeds can be a major problem for newly transplanted and young ʻawa plants. Weeds compete for sunlight and soil nutrients and may be alternate hosts for pathogens and pests of ʻawa. On the other hand, the shade and wind protection weeds provide may be beneficial to establishing the young ʻawa plants by conserving moisture during the hot summer months.

Fig. 8.7. ʻAwa mounded and mulched at Puʻu O Hoku Ranch on Moloka'i.

Waiting until the ʻawa plants are large in the nursery can help them compete with weeds for sunlight after transplanting. But a preferable strategy may be to inhibit weeds by mulching around the ʻawa plants and planting intercrops that will shade the interrows and serve as windbreaks (figure 8.7). As the ʻawa canopy closes and provides enough shade to stop weeds from growing, the intercrops can be cut and used for mulch or composted for later application to the field.

A major reason for controlling weeds before planting ʻawa and maintaining a weed-free field is that weeds may be hosts of plant pathogens. A plant pathogen requiring special attention is cucumber mosaic cucumovirus (CMV), which is found in the weed known as "honohono" (*Commelina diffusa*). Almost all honohono in Hawaiʻi is infected with this virus, and it should be thoroughly removed before planting ʻawa.

CMV causes a "kava die back" that kills small ʻawa plants within two to four weeks after infection. Larger ʻawa plants decline and die over several months. To make sure your ʻawa plants are not exposed to CMV, control honohono in the vicinity of the nursery and keep the ʻawa free of aphids, the CMV vector, which transmit the virus from plant to plant.

No herbicides have been cleared by the Environmental Protection Agency for use in plantings of ʻawa in Hawaiʻi. Therefore, in-field use of herbicides is not an option. Nonchemical weed control methods such as mulching, mechanical cultivation, torching, and shading are the only legal methods at present. Many herbicides can, however, be used for post emergence control of weeds before planting ʻawa, as well as to control weeds in areas adjacent to ʻawa fields.

Considerable care needs to be taken to protect ʻawa from contact with "drift" of herbicides used to control weeds in nearby areas. ʻAwa is extremely sensitive to glyphosate (Roundup®), a nonselective, systemic herbicide commonly used for roadside vegetation control. Depending on the dose, it takes from one to three weeks before the plants begin to show symptoms. A light drift causes the plant to stop growing for several months; the leaves may develop chlorotic margins, newly emerged leaves may shoestring or are thin and brittle. There may be minor defoliation and stalk death. Heavier doses result in a rapid and severe onset of symptoms, major defoliation, and death of the entire plant. Glyphosate (*e.g.*, Roundup®) should not be sprayed near ʻawa.

Irrigation

Irrigation is essential for ʻawa in dry, leeward sites, and it is often needed even in windward areas during their periodic droughts. A combination of drip tape and spinner sprinklers or mini-sprinkler nozzles mounted below the canopy probably is best for total coverage of the root zone. ʻAwa needs plenty of water but does not tolerate waterlogged conditions for any length of time. Impact sprinklers may also be used, but these may not use water efficiently as the plants get larger because of interference to water distribution caused by the canopy. Ask the advice of your irrigation specialist to design a system for your unique environment and resources.

Fig. 8.8. Young, irrigated ʻawa plants, Puʻu O Hoku Ranch, Molokaʻi. Note temporary windbreaks made from shade cloth. Weed mat can also be used as temporary windbreak.

Relying on natural rainfall is the norm in many of the ʻawa producing areas of Hawaiʻi. The farmer needs an intimate knowledge of rainfall patterns and must be prepared for both wet and dry periods. The hot and often dry summer months will tax the farmer's ingenuity in developing practices to conserve moisture. The effects of wind and altitude also must be factored into water management strategies.

For high-rainfall areas, large, well drained planting hills or beds allow excess water to move rapidly through the root zone and off the field without creating waterlogged conditions. In addition to being well drained, the soil in these beds, and the media placed in planting pockets to nurture the ʻawa, must have enough organic material to retain moisture during the

drier times of the year. Soil structure, tilth, and organic matter levels should be optimum. Media used should have some component of suitable size to ensure enough pore spaces for quick drainage during wet times, and it should contain enough organic matter to hold moisture during dry times. In dry, windy areas, pore spaces need to be smaller to slow the movement of water through the hill, and various water conservation techniques need to be employed.

Windbreaks reduce plant transpiration (water loss) caused by dry air moving across the ʻawa leaves; they also provide some shade, depending on their orientation. If nitrogen-fixing plants are used for windbreaks, they may enhance soil fertility. Mulching with organic or artificial materials helps retain moisture and suppress weeds. Groundcover crops may also help in moisture conservation and management.

Spacing and Shading

As more ʻawa is planted and farmers have become familiar with the growth habit of the plant, the spacing of plants has moved from dense spacing, as close as 2 feet apart in the row and 4 feet between rows, to wider spacing that makes field operations easier and gives the plants more room to grow. The distances between rows have increased to about 6 feet and may go up to 12 feet. In-row spacing ranges from 3 to 8 feet. In general, planting at 6 x 6 ft or 8 x 8 ft seems to be good for the ʻawa plant.

Wind protection appears more important than shading in conserving moisture for young plants at mid-elevations (300 to 600 feet) on windward sites. Sunlight has been shown to increase kavalactone content (Lebot 1999, 412). On low-elevation leeward sites, where hot temperatures and drying winds are common, both shade and wind protections are necessary for small ʻawa plants. Partial shade and wind protection may be provided by shrubs such as pigeon pea, or harvestable crops such as taro and cassava. While papaya, ginger and bananas can also serve in this capacity, they are hosts to pathogens of ʻawa. Papaya and ginger are good hosts of root knot nematodes and should not be used. Banana is a host of the cucumber mosaic cucumovirus (CMV). It may be best to avoid using banana for a windbreak or shade interplanting until more is known about the relationship between banana as a host of CMV and ʻawa decline.

When the ʻawa is large enough, usually about a year after transplanting, the shade trees may be pruned or removed to allow more sunlight. The prunings may be chipped and used as mulch for water conservation and weed control or composted.

Fig. 8.9. Hawaiian Pacific Kava Company's ʻawa plantings organized by cultivar. Spacing is 5 feet between plants and 6 feet between rows. Windbreak is sudan grass.

Fig. 8.10. ʻAwa plants grown in the shade of *Acacia angustissima*, Hawaiʻi Island.

Pruning

To obtain planting material rapidly from a small number of source plants, they must be drastically pruned. From 10 to 30 percent of a healthy ʻawa plant's stalks may be removed twice a year without adverse effect.

Judicious pruning results in larger plants when outer, older branches are removed, exposing the inner, younger, soft, and succulent branches to sunlight. This causes them to develop and mature. Pruning the stalk terminal removes apical dominance and stimulates dormant buds in the stump to develop into stalks, which causes the plant to produce more roots.

Pruning is also believed to enhance production of kavalactones in the stump and roots. The ancestors were probably right to believe that the strength of *ʻawa kau laʻau*, the famous tree growing ʻawa of Puna, came from the roots growing in the sun (Handy 1940,

203). Pruning exposes the stump and roots to the sun just as the roots of *ʻawa kau laʻau* were exposed as they grew to the ground along the trunk from an aerial perch in a tree. *ʻAwa kau laʻau* can be any variety of ʻawa growing from material thought to be taken into trees by birds (Handy 1940, 202).

Plant Height and Yield

The height of the ʻawa plant varies with the variety and, within varieties, can be affected by exposure to sunlight. Plants with short internodes can be as short as 4 to 6 feet at maturity, while plants with long internodes can grow 12 to 16 feet tall in node-elongating shade conditions.

A 3-year-old ʻawa plant can yield 20 to 40 pounds of fresh ʻawa root and stump. One farmer has reported an average yield of 37 pounds per plant in 12 months, with unspecified cultural practices.

Organic ʻAwa Production in Hawaiʻi

An organic approach to growing ʻawa has been taken at Puʻu O Hoku Ranch, on the east end of the island of Molokaʻi. This approach makes philosophical and economic sense to the owners of Puʻu O Hoku, who believe that the niche market for organic ʻawa is significant and expanding in the USA.

Fig. 8.11. Certified organic ʻawa fields at Puʻu O Hoku Ranch, Molokaʻi.

Because the nutrient requirements for producing the greatest yield and kavalactone content of ʻawa are not known, the fertilizer program was based on knowledge of other plants' needs. Foliar fertilizer applications were used to ensure that the nitrogen supply was not limiting.

The soils at this site are deep and well drained humiclatosols in the puuohoku series with pH 4.5 to 5.0. This is a non-phos-phorous fixing soil series. Soil analysis, however, indicated it was low in phosphorous and calcium. This calls for liming with 1 ton of $CaCO_3$ per acre to increase calcium levels and to raise soil pH. To correct the low phosphorus levels, 500 lbs per acre of P was recommended. The amendments added were oyster shell lime and soft rock phosphate, both at 1 ton per acre.

A green-manure crop of sudan grass (*Sorgum bicolor* var. *sudanese*) or sunn hemp (*Crotalaria juncea*) was then planted and incorporated into the soil at peak flowering approximately three to four months after sowing. The material was allowed to decompose for two to three months before planting beds were formed and ʻawa transplanted into the field. While the sunn hemp was not inoculated with rhizobium to maximize its nitrogen fixing capabilities, good nodulation was present.

The ʻawa was planted on raised beds about 4 feet wide at the top, 6 feet wide at its base, slightly higher than a foot, and of variable length. The beds were formed on 7-foot centers with 12-foot roadways between every eight beds. The beds were formed on the contour of the land to minimize water erosion.

One pound each of oyster shell lime, soft rock phosphate, Norwegian kelp meal (Algit®), fish meal, and diatomaceous earth were added to each planting hole and mixed with the soil. These are for calcium, phosphorus, minor elements, nitrogen, and silica respectively. Nitrogen can also be supplied by blood meal, but the fear of mad cow disease has restricted the use of blood meal in organic farming. Diatomaceous earth, fossilized shells of diatoms, can control soft bodied insects. A 3-month-old ʻawa plant 8 to 12 inches tall was transplanted into the hole. The plant spacing within the row is 5 feet. Compost was broadcast on top of the bed at 30 pounds per 100 feet of bed. The bed was capped with a 4-inch layer of wood-chip mulch for weed control.

Irrigation is provided by running two drip tapes down the bed on either side of the plant. As the plant grows, the tape is moved nearer to the edge of the bed to prevent it from becoming crimped in the growing plant. When the canopy closes and the roots begin to fill the beds, spinner sprinklers were placed between every other bed at intervals to cover 4 plants each. This ensures adequate moisture distribution.

Windbreaks are needed to protect the plants at this site, but shading is not necessary. Windbreaks of shade cloth 5 feet high, sudan grass, or woody shrubs such as pigeon pea, gliricidia, and sesbania are provided for every 8 rows of ʻawa. The windbreaks may be removed as the plants grow. Ironwood, Formosan koa, or timber bamboo on the valley ridges surrounding the planting are the major windbreaks. These are from 30 to 500 feet from the nearest ʻawa plants.

Except for collecting nodes for propagation and removing damaged or poor stems, the plants are not pruned. This allows the canopy to close and shade out weeds. Hilling is done six months after transplanting.

Foliar fertilizer is applied every three weeks throughout the life of the crop with a tractor-mounted power sprayer. Maxicrop® foliar fertilizer (0.1% N, 0.0% P, 1.0% K) and Mermaids® fish powder (12% N, 0.25% P, 1.0% K) are normally used at 20 lbs formulation per 100 gallons of water per acre. Yucca extract (ThermX 70) as a spreader sticker, hydrogen peroxide for oxygen, and vinegar as a pH modifier may be added to enhance the fish powder and foliar fertilizer.

Six months after transplanting, the ʻawa was side-dressed with 500 lb of soft rock phosphate, 500 lb oyster shell lime, and 125 lb blood meal per acre. Twelve months after transplanting, Algit ® for potassium and fishmeal for nitrogen were each applied at 500 lb per acre. This cycle is to be repeated at 18 and 24 months, and harvest is projected to be done at 30 to 36 months.

At about two-thirds of the way through the life of the crop, disease problems have been limited to a few plants that died from root rot (*Pythium splendens*). *Rhizoctonia sp*. and *Fusarium sp*. have also been isolated from the roots and stalks of a few poorly growing plants. A shot-hole type leaf spot associated with a *Phoma sp*. and an unidentified ascomycete periodically appears. Insects, mites, and nematodes have caused problems in the crop. Feeding by katydids, African snails, and slugs did minor damage to younger plants.

A three-crop rotation cycle is followed after the initial ʻawa is harvested. The field is plowed and fallowed for several weeks to a couple of months. A cover crop is planted, allowed to flower, and plowed down as a green manure (approximate time = 3 to 4 months), *e.g.*, Sunn hemp for nitrogen fixing and root knot nematode control, sudan grass for nematode control. After the green manure decomposes (2 to 3 months) the field is prepared for planting the next crop in the rotation cycle. Papaya has been the follow on crop. The third crop in the cycle is dry-land taro. Following this crop, the field is to be prepared for the next ʻawa crop.

Compost at 5 tons per acre and chitinous material (crab or shrimp meal) at 500 pounds per acre is worked into the soil. Planting beds are created, drip irrigation installed, and plants transplanted. Compost at 30 pounds per 100 feet is broadcast on top of the planted bed which is then capped with a three inch layer of semi-composted wood chip mulch for weed control and moisture conservation.

The plants are foliar fed every three weeks with compost tea and fish emulsion throughout the life of the crop. Six months after planting the plants are side-dressed with soft rock phosphate (500 lb/ac), oyster shell lime (500 lb/ac) and fish meal (125 lb/ac). Twelve months after planting Algit ® (500 lb/ac) and fishmeal (500 lb/ac) are applied. This application is repeated at 18 and 24 months into the growth cycle.

The plants are normally harvested 30 to 36 months after transplanting but may be allowed to grow for 60 or more months before harvest.

Harvesting Methods

There are a number of ways to harvest ʻawa, depending on the size of individual plants, the number of plants the farmer intends to harvest, and the planting method the farmer used.

Fig. 8.12. Harvesting ʻawa with a small backhoe at Puʻuʻala Farm and Ranch.

To harvest large individual plants manually, cut the stems just above the first node. Begin exposing the lateral roots by carefully scraping back the soil with a potato fork. As more soil is removed, you should be able to begin rocking the plant back and forth to loosen more soil around the base. Some farmers use an

ʻōʻō bar. Continue scraping away soil with the potato fork. As the plant is loosened from the soil, it can be lifted out of the ground. Harvesting is far easier when ʻawa has been planted on mounds and the soil has been aerated with mulch and compost.

Mechanized harvesting of ʻawa is uncommon but will likely become a regular practice if high density monocropping systems increase in Hawaiʻi. Some farmers are using small backhoes to harvest ʻawa (see photo below). A backhoe can help you harvest quickly, but some lateral roots may be lost.

Other farmers are considering more specialized equipment such as potato harvesters and the Egedal Side digger (which has moving fork prongs to lift plants out of the ground). This system will probably be most useful when farmers harvest plants growing on mounds.

Harvested stumps with laterals are given a quick wash with a hose and then are cut up using cane knives or machetes. Some farmers use electric powered pressure washers. Cut laterals off the stump leaving a small portion of stump, just enough to hold a few laterals together. Then cut the stump itself into manageable sections.

Place the plant material on the washing table. Ideally, the washing table will have a plastic mesh screen to allow water to drain, but corrugated plastic or metal at an angle can also work. Wash the root and stump, without removing peelings. Washed root and stump should be immersed in a light bleach solution and thoroughly rinsed again.

It is important not to let the ʻawa mold or rot. Therefore, even if you are selling your ʻawa as fresh root, it is important to remove excess moisture and to coordinate the harvest with the shipping schedule.

Fig. 8.13. Harvested ʻawa is cut into smaller pieces for washing.

Fig. 8.14. Washing the root and stump with a pressure washer. (Photo by Jeri Ooka.)

Fig. 8.15. Clean ʻawa root and stump ready for drying or fresh processing. (Photo by Jeri Ooka).

Commercial Parts of the ʻAwa Plant

In light of the liver problems possibly associated with above-ground parts of the plant, commerce should be restricted to the roots and rootstock of the ʻawa plant.

Lateral roots. Since these are high in kavalactones (generally ranging from 8 to 16%), they are the most in demand on the international market.

Stump. Kavalactones usually vary from 3-8%. This is traded on the international market.

Peelings of the rootstock. These are high in kavalactones (7-11%) and are sometimes sold on the international market.

Stem. Relatively low in kavalactones. The basal stem (lowest on the plant) has a higher percentage of kavalatones (3-5%) than the topmost part of the stem. Stems have been dried, chopped up and used as ingredients in teas. The use of stems in products is not recommended.

Leaves. These contain kavalactones, mostly yangonin, dihydromethysticin and dihydrokavin, in low

concentrations. Leaves have been used as ingredients in a calming tea. This is no longer a recommended use of leaves. Fresh leaves have been used in a hot bath to relax sore muscles. Dried leaves are being ground into a powder and included in oil for massage.

Resources

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

In the University of Hawai'i at Mānoa's College of Tropical Agriculture and Human Resources, the Department of Plant and Environmental Protection Sciences, or PEPS, brings together faculty in several fields (plant pathology, entomology, weed science, integrated pest management) that are dedicated to protecting both crops and the environment. The department's purpose is to develop and disseminate environmentally friendly plant protection principles and practices for the tropics and subtropics, protect the structural integrity of buildings from destructive pests, provide strong programs in fundamental science and provide a quality education in related areas.
http://www.ctahr.hawaii.edu/peps/index.htm

Information on ʻawa can be found on CTAHR's Farmer's Bookshelf under "nutraceuticals":
http://www.ctahr.hawaii.edu/fb

UH CTAHR Cooperative Extension Service

Hawai'i County
Kamuela Extension Office, 887-6183
Komohana Extension Office (Hilo), 959-9155
Kona Extension Office, 322-4892

Kaua'i Country
Kaua'i Extension Office, 274-3471

Maui County
Kahului Extension Office, 244-3242
Moloka'i Extension Office, 567-6833

O'ahu County
Honolulu Extension Office, 956-7138
Kane'ohe Extension Office, 247-0421
Pearl City Extension Office and Urban Garden Center, 453-6050
Wahiawā Extension Office, 622-4185
Association for Hawaiian ʻAwa
P.O. Box 636
Pepe'ekeo, HI 96783

Chapter 9

Integrated Pest Management for ʻAwa (Kava, *Piper methysticum*)

Scot Nelson

Piper methysticum, a tropical, forest-dwelling shrub, called ʻawa in Hawaiian and also known as kava, is the source of a relaxing root extract esteemed as a ceremonial beverage throughout the Pacific region. It has traditionally been grown in relatively pristine native forest ecosystems by indigenous horticulturists who made extensive varietal selections and recognized the optimal environmental conditions for the plant. Growing it as an agricultural crop often removes the plant from its optimal habitat, and its successful field production generally requires considerable patience, knowledge, and skill.

Numerous pests and plant diseases are a constant threat to large-scale ʻawa cultivation and can cause irreversible damage and crop loss. Growers must generally wait two years before the plants have accumulated sufficient amounts of root kavalactones, the pharmacologically active substances, that they can be harvested. That is a relatively long period of time to expose a sensitive, vulnerable plant like *P. methysticum* to the aggressive pests, parasites, and pathogens common in agricultural environments, which are highly contaminated compared to the traditional growing environments in native forest ecosystems. Problems can be especially severe when ʻawa is grown as a field crop in sole stands.

Successful ʻawa growers must recognize the various pest problems when they occur and know how to manage them effectively. Growers in Hawaiʻi and the Pacific do not use many pesticides for growing ʻawa. They deal with their problems strategically by integrating various cultural practices.

This publication identifies, describes, and illustrates the most important pests and diseases of ʻawa in Hawaiʻi, and then it suggests strategies for their management. The tables accompanying the text contain photographs of pests and symptoms and give additional pertinent data useful in bringing ʻawa to maturity in good health. A list of additional readings is provided for access to more in-depth coverage of these topics. The information in this article is derived mainly from the author's experience and research in Hawaiʻi and Micronesia; it is intended to be a concise and useful resource for Hawaiʻi's ʻawa growers.

Integrated pest management (IPM) of significant ʻawa pests in Hawaiʻi

A "pest" is considered here to either be a plant disease, weed, insect, or other organism such as slugs. Disease can be caused either by pathogenic microorganisms or by non-living factors within the plant's environment. Both pathogens and insects may be food-seeking parasites of ʻawa in Hawaiʻi. Weeds can harbor pests and compete with ʻawa plant establishment and growth. Following are descriptions of the most damaging ʻawa problems in Hawaiʻi and suggestions for their effective management.

Kava dieback

A viral disease, kava dieback, is the major threat to *Piper methysticum* cultivation throughout the Pacific. As its name implies, this disease can kill plants, especially in their first year of growth. The virus is the cucumber mosaic cucumovirus (CMV), which has a wide host range, infecting various common weeds and crops in Hawaiʻi. Controlling this disease can mean success or failure for kava growers.

The virus is transmitted between plants by the melon aphid *(Aphis gossypii*, also known as the cotton aphid), a small, sap-feeding, and sometimes winged insect. Ants spread, tend, and protect the aphids and eat their post-feeding secretions. Dieback in the field spreads most rapidly when aphid and ant populations are large.

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Infected node cuttings from diseased stems can also introduce kava dieback into a nursery or field. CMV-infected ʻawa plants and weeds can display a wide range of symptoms; a single plant may have several symptoms. The initial ones usually include leaf mosaic, yellowing, curling, and puckering of the youngest leaves on a stem. ʻAwa plants should be inspected weekly for symptoms, especially when they are in a monocrop planting or are near vegetable production areas, where the virus may be common.

Stems with symptoms should be broken off immediately, about two nodes from the base of the stem. Wilting plants should be dug out and destroyed. Before breaking off stems, look for aphids, and destroy them first.

Virus-free node cuttings must be used to start new plants, and aphids must be controlled in the nursery. If the first leaves growing from a node have symptoms such as mosaic or large ringspots, they should be destroyed immediately, and the remaining plants should be examined and monitored closely for symptoms and aphids. Aphids may be killed or knocked off plants with a strong spray of water or may be killed with sprays of approved insecticidal soaps or oils. The only pesticides legally allowed for use on ʻawa in Hawaiʻi list *Piper methysticum* on the product label. The best course is to consult the Hawaiʻi Department of Agriculture with questions about specific products and their approved crops in Hawaiʻi.

Windbreaks provide shade and protection, which can reduce kava dieback disease levels in some cases. Companion plants should not host aphids, nematodes, or CMV.

Certain weeds that host aphids and CMV must be controlled in and around the ʻawa field where CMV is present. Otherwise, attempts to manage or eradicate the disease within plantings may fail.

Selecting the right location for planting can help to avoid infection and dieback. Forest or secluded plantings are much less at risk from kava dieback than are open, exposed ʻawa monocrops in agricultural areas. Intercropping with plants that are not hosts of aphids or CMV may help slow down epidemics.

Plants wilting from kava dieback do not respond well to irrigation; in fact, excessive water and especially excessive fertilizer can promote a deadly root rot for such plants.

Best management practices

Select a remote location or lightly forested site.

Use windbreaks and shade plants for the first year, then cut them back.

Use only CMV-free node cuttings.

Monitor plantings for symptoms and rogue diseased stems and plants immediately.

Control aphids and ants.

Do not prolong the harvest of mature, diseased plants.

Minimize plant stress factors; stressed plants may be attractive to aphids (plants may be yellow) and predisposed to dieback.

IPM strategies

Modify fertilizer practices—excessive use of nitrogen fertilizer promotes plant succulence, which attracts aphids and allows them to develop large populations rapidly.

Look and select for varietal resistance to the disease—one variety, '*Isa*' from Papua New Guinea, is probably resistant to CMV.

Pythium root rot

The *Pythium* pathogen can quickly destroy the most important part of an ʻawa plant—the root system—and thus kill entire plants of any age. The disease is mainly a field problem and in Hawaiʻi is usually caused by the plant pathogenic, soil-dwelling, fungus-like organism *Pythium splendens*. The disease can also occur in potted ʻawa plants.

This disease tends to occur where soil drainage is poor or when flooding occurs. Saturated soil allows the pathogen to disperse and infect roots. Avoiding flood-prone areas is important. Growers should also be aware of how subsurface soil water moves or collects in the field.

Pythium is very aggressive and destructive under saturated and flooded conditions, and infection and disease development can be quite rapid. Diseased plants can wilt and die quickly, and it is useless to try to replant ʻawa in the same location.

Avoidance of susceptible locations is the best strategy. Plants that are stressed or damaged in some way, as by too much or too little fertilizer, are more prone to infection and severe damage. Too much fertilizer can easily burn ʻawa roots, leading to an overall root rot and plant wilt that resembles *Pythium* root rot very closely. It is not unusual for the two conditions to appear together in a field.

There is no known resistance to *Pythium* in ʻawa. Planting in raised baskets filled with a well drained medium such as cinder can help minimize the risk. There are no registered fungicides for *Pythium* control in ʻawa.

Mulching or compost dressings around plants before they are infected may help to protect them, and widely placed plantings or intercrops may help reduce or minimize disease and pathogen spread. Diseased plants,

especially when their roots are rotting and leaves are wilting, should not be irrigated excessively or fertilized but rather should be uprooted and destroyed.

Best management practices
Avoid disease-prone sites.
Use disease-free planting material.
Apply compost.
Improve drainage.

IPM strategies
Select sites carefully—consider the potential for this disease in low-lying areas.
Practice attentive crop husbandry—plant stress factors may predispose plants to root rot.

Phoma shot hole

Epidemics of "shot hole" caused by the *Phoma* fungus can wreak havoc where ʻawa is grown in monocrops in a wet and humid environment. Entire fields of ʻawa plants can become virtually defoliated where these environmental conditions are pronounced and the disease is not managed in some way.

Phoma is dispersed by wind and splashing rainwater and can infect ʻawa stems, petioles, and leaves. After infection, small circular lesions form; the centers of the lesions often fall out, hence the disease name. Leaves turn yellow and fall off. Severely affected stems die prematurely. Overall plant vigor is severely compromised.

Some ʻawa varieties may prove to be more susceptible at a given location. Generally, the varieties with emerald or green stems tend to sustain greater damage in Hawaiʻi than some dark-stemmed varieties.

Plants should be kept well fertilized and growing vigorously to compensate for damage from *Phoma* infection. Although there are no fungicides currently registered for use on ʻawa in Hawaiʻi, slight control of *Phoma* leafspot may occur where foliar sprays of sulfur are applied to control mites.

Best management practices
Intercrop.
Maintain good field sanitation.
Manage humidity in the field by maximizing aeration.
Apply fungicides.

IPM strategies
Consider this disease when selecting a variety or choosing a planting style or location—the Papua New Guinea cultivar '*Isa*' is highly resistant to shot hole.

Root-knot nematode disease

Meloidogyne nematodes are destructive root parasites that can reduce ʻawa yield and quality enormously. Nematodes are microscopic roundworms that infect kava roots, causing them to swell, crack open, and rot inside and out. Opportunistic fungi and bacteria associated with the infections cause root tissues to become spoiled and virtually unpalatable.

It is important to keep nematodes out of propagation media and nurseries and to test media and field soils for nematode presence before planting. Nematode-infected plantlets should not be outplanted, and nematode-infested fields should be avoided.

Root-knot nematodes have a wide host range and usually are present in most agricultural soils. Their numbers diminish in soils that are fallowed for a period of time, provided that weeds in the field do not host them.

The first sign of root-knot disease may be poor growth, leaf yellowing, and drooping of petioles. Upon inspecting roots of diseased plants, the swellings can be seen. Later, plant dieback and stump rot can follow. Do not delay the removal of severely diseased plants.

High natural levels of organic matter or regular additions of compost can help to suppress root-knot nematodes, to a degree. Cultivating ʻawa in baskets filled with nematode-free media can help avoid the problem altogether. No ʻawa varieties have shown resistance to root-knot disease.

Although no effective nematicides are registered in Hawaiʻi for post-plant control of nematodes in ʻawa, growers may have some pre-plant pesticide options is some cases.

Best management practices
Avoid growing in soil with nematodes.
Apply compost regularly.
Harvest early.

IPM strategies
The nematode status should be a major consideration during site selection and plant propagation.

Spider mites

If ignored, spider mites can completely defoliate an ʻawa crop. Growers in Hawaiʻi can use a form of sulfur as a foliar application to control mite outbreaks.

Where ʻawa is grown in a dry environment or during extended dry periods, plants should be monitored for mite populations by inspecting the lower leaf surfaces. That is where sprays should be directed if mite

populations are large. Repeated sprays and some pruning may be necessary.

Monocrops of ‘awa in open, windy, dry areas are most vulnerable to attack. All varieties are probably susceptible to spider mites, but some may perform better in particular locations. Plants should be kept healthy and unstressed so that mite and insect infestations can be better tolerated.

Best management practices
Select a site not in an open, dry, windy area.
Intercrop with non-host plants.
Scout for mites on lower leaf surfaces.
Spray mites with sulfur.
Keep the crop healthy and vigorous.

IPM strategies
Integrate site management with site selection.
Avoid monocropping in dry, windy areas.
Scout for mites.
Control fungal leaf spot while controlling mites (insecticidal sulfur also acts as a fungicide).

Melon aphids

Aphids pose a significant threat to ‘awa because they acquire viruses from infected plants and later transmit them to healthy plants, leading to kava dieback disease. Aphids can also stunt young plants in nurseries. It is very difficult to control them in ‘awa monocrops.

Best management practices
Select a site that is not near vegetable or fruit crops; avoid very dry locations. Intercrop with non-host crops. Scout regularly for aphids. Control ants in and around ‘awa nurseries and fields.

IPM strategies
Scout for aphids and ants.

Node rot

Node rot is a nursery disease when nodes are used to start new plants, usually in trays. It is caused by unfavorable environmental conditions and is associated with various opportunistic microbes including fungi and bacteria. Node rot is also caused by fertilizer burn; do not apply granular fertilizers before new leaves have emerged. Dilute liquid fertilizers may be applied periodically at any stage.

Node cuttings from healthy, unstressed, vigorous mother plants are less prone to rot than cuttings from weak plants. Cuttings should be planted as soon as possible and not allowed to dry out or crack. Cuttings should not remain waterlogged or be exposed to high temperatures.

Sterile or inert media, or at least pathogen-free media, should be used. Clean water should be used to mist the cuttings to stimulate rapid rooting. Fertilizers should not be used in early stages or node tissues might burn.

Avoid excessive heat in propagation areas and remove diseased nodes and destroy them as they are identified. There are probably no resistant varieties. This disease is quite dependent on environment. Do not dip ‘awa node cuttings into bleach or peroxide solutions before planting; these solutions can injure the node tissues and allow rot to occur.

Best management practices
Plant healthy, vigorous cuttings into a clean environment.

IPM strategies
Consider this problem in light of fertilizer use in the nursery and in relation to the health of mother plants from which cuttings are taken. Fertilizer burn can lead to node rot, and stressed mother plants do not provide vigorous cuttings for propagation.

Locally severe and minor pests

Various other pests common in kava plantings are usually only nuisances, but some can become locally severe. Information on these pests is presented in the tables. A few pests cause only sporadic damage, including two caterpillars, the Mexican leafroller, and the green garden looper. Some insects may only pose a problem in greenhouses or shadehouses (mites, whiteflies, and some scales, for example).

Weeds

‘Awa crops can be severely threatened by weed presence in certain situations. Already mentioned is the potential of weeds to harbor CMV, other ‘awa pathogens, and serious insect pests such as aphids. Also, many weed species can easily choke out young ‘awa plants and must be controlled. It is important to manage weed populations within an ‘awa field very early in the cropping cycle, especially during the first year of growth. Thereafter, most growers rely on the plants’ leaf canopy to shade out weeds. The challenge, then, is how to control weeds within and around the crop during the first year.

The herbicide glyphosate may be used to control weeds in areas adjacent to an ‘awa planting and as a

preplant herbicide within ʻawa fields. However, extreme caution is warranted when using glyphosate near ʻawa plants, which are hypersensitive to glyphosate injury, easily damaged by spray drift, and susceptible to damage by glyphosate residues in soils. Care should be taken not to over-apply glyphosate or to plant ʻawa immediately after the herbicide has been used. Weeds in ʻawa fields postplanting are best controlled manually (hand-pulling or chopping) or physically (mulches, weed mat, etc.).

New herbicides may appear on the market, and some may be labeled for use in ʻawa plantings. Any question about the legality of use of an herbicide or other pesticide with ʻawa in Hawaiʻi should be referred to the Hawaiʻi Department of Agriculture.

Pesticides for ʻawa in Hawaiʻi

Most diseases and pests of ʻawa must be controlled by using non-pesticidal strategies. ʻAwa growers in Hawaiʻi have very few approved pesticide options as of 2005. The main one is Drexel sulfur, which has a 24-c label for mite control; however, it expires in 2005. With other products (herbicides, pre-plant materials, organic products, etc.), it is recommended that a label interpretation be obtained from the Hawaiʻi Department of Agriculture before using them.

Further information

For more information on the pest problems mentioned here, please contact the Cooperative Extension Service office near you or consult the sources listed below.

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Table 9.1. Effect of some IPM tactics on the principal pests of ʻawa.
An "x" in the table indicates that the tactic can have a significant effect upon the occurrence and/or severity of the corresponding pest problem.

	Kava dieback	Pythium root rot	Phoma shot hole	Root-knot nematode	Spider mite	Melon aphid	Node rot	Other insects	Weeds
Site selection	x	x	x	x	x	x		x	x
Nursery practices[1]	x	x		x	x	x	x	x	
Fertilizer practices[2]		x	x			x	x	x	x
Irrigation	x	x	x	x	x	x	x	x	x
Drainage	x	x	x						
Plant stress	x	x	x	x			x	x	
Compost		x		x					x
Sulfur			x		x			x	
Soaps						x		x	
Variety	x		x						
Avoidance	x	x	x	x	x	x	x	x	x
Intercrop	x	x	x	x		x		x	x
Basket planting		x		x					x
Scouting	x	x	x	x	x	x	x	x	x

[1] Nursery practices include choice of mother plants for node cuttings, nursery sanitation, choice of propagation media and containers, environment, pesticide applications, etc.
[2] Fertilizer practices include choice of fertilizer, mode of application, amount used, frequency, and timing of application.

Table 9.2 Kava dieback

Kava dieback	Cause	Symptoms	Risk	Management
Infected plants can display a wide range of symptoms; from one to several of the following symptoms may appear on a given plant.	***Virus:*** cucumber mosaic cucumovirus (CMV) ***Insect vector:*** melon aphid (*Aphis gossypii*) ***Other:*** ant species tend and protect aphids (*e.g.*, longlegged ant, bigheaded ant, Argentine ant, whitefooted ant).	***Leaves:*** mosaic, ring-spots, yellowing, necrosis, wrinkling and deformation, vein clearing or necrosis ***Stems:*** dieback, wilt, collapse, black lesions, blackened veins ***Roots:*** rotten, soft, black ***Plants:*** dieback, wilting, death	***High risk:*** this disease may be fatal to young plants and spreads quickly; the disease is less of a threat and more manageable in older plantings through the practice of regular scouting to identify and remove diseased plants or individual stems.	Keep a virus-free nursery, practice vigilant ant and aphid control, use tall windbreaks, control weeds that are hosts for the virus, scout field regularly for diseased plants, rogue out infected plants or stems, locate the field in isolation from other ʻawa plants or farms, plant a resistant variety (the Papua New Guinea cultivar '*Isa* ' is immune to the disease), intercrop.

Leaf mosaic

Leaf puckering and wrinkling

Black veins within stem (break open stem to observe this symptom)

Ringspots on leaves

Black veins in leaves, leaf curling and wrinkling

Curled apical leaves with conspicuous mosaic symptom

Yellow or "cleared" veins in leaves

Wilting and complete dieback (left) is possible and can happen very rapidly

Black stem lesions, stem collapse

Melon aphids (here highly magnified) are the insect vectors that transmit CMV. They are often tended and protected by one of several ant species

Table 9.3. Phoma shot hole

Phoma shot hole	Cause	Symptoms	Risk	Management
This disease was first recorded in Hawaiʻi in 2001 and is most severe during wet and humid weather	***Fungus:*** *Phoma* sp., a highly contagious fungus that is favored by wet weather and is dispersed by wind and splashing water; symptoms appear about 2-3 weeks after infection; it is not known if there are any other hosts besides ʻawa for this pathogen.	***Leaves:*** small, black spots (1/8 inch diameter) on leaves that develop whitish gray centers that fall out, lending a shot-hole appearance to leaf; leaf yellowing; defoliation ***Stems:*** Lesions with brown margins and whitish to tan centers, circular at first and developing irregular shapes later; whitish gray centers and dark margins ***Plants:*** Dieback, death	***High risk:*** extremely high risk is associated with this disease (massive defoliation and sometimes plant death are likely).	Periodically trim severely diseased stems; use approved fungicides, use host resistance (the Papua New Guinea variety '*Isa*' is resistant), use wider plant spacing, control weeds to reduce relative humidity in canopy, promote good aeration within plant canopy, promote good soil drainage, intercrop.

Massive defoliation, leading to denuded stems

Leaf yellowing and spotting

Plant dieback

"Shot holes" in leaves that can be easily seen when holding the leaf between your eyes and the sun

Stem lesions, circular at first and developing irregular shapes that coalesce to create large, longitudinal blighted areas on the stem.

Table 9.4. Node rot

Node rot	Cause	Symptoms	Risk	Management
 *Node rot lesions on an ʻawa node cutting in a propagation bed*	***Fungi:*** *Fusarium* sp. (fungus); other fungi are associated with the disease. ***Bacteria:*** *Pseudomonas* sp., *Erwinia* sp. are associated with the disease ***Insect:*** *Drosophila* larvae (fruit fly) (incidental); insect feeding can create wounds in nodes that allow pathogens and opportunistic microbes to enter and infect tissues.	***Nodes:*** dark lesions on nodes that often coalesce to form large blighted areas, soft rot, all tissue may turn black or mushy, death of cuttings; node rot can be caused by fertilizer burn and is favored by waterlogged or poorly aerated media.	***High risk:*** the disease may destroy node cuttings before plants become established, causing losses up to 100%; however, once conditions and methods are improved, the risk is very low.	Irrigation and temperature control during propagation; protect cuttings from excess sun and rain; use sterile or inert media; keep nursery clean through sanitation practices; accelerate rooting by applying hormones; use clean, sharp pruning knives to obtain node cuttings with smooth cuts; use approved fungicides; plant node cuttings promptly before they dry out and form cracks for pathogens to enter; obtain cuttings from healthy, vigorous plants; remove and destroy severely diseased nodes promptly; avoid heavy use of fertilizers in propagation beds

Table 9.5. Root-knot disease

Root-knot disease	Cause	Symptoms	Risk	Management
This disease can reduce ‘awa yields and quality	***Nematodes:*** *Meloidogyne* sp., the root-knot nematode; these are internal root parasites that may infest nursery soils and field plantings; no ‘awa varieties are known to be resistant.	***Roots:*** swelling, galling, knotting, internal rot, stunting, stubbiness ***Basal stems:*** although rare, galls can form on basal stems where plants are "hilled" with infested media after planting ***Leaves:*** yellowing, wilting, defoliation	***Moderate to high risk:*** plants are not usually killed, but root quality can be severely affected. (Severely affected roots must be discarded, and moderately affected roots produce a discolored and foul-tasting product.)	Use nematode-free media in the nursery; avoid planting in heavily infested soils; use compost and organic soil amendments (green manure, mulches, etc.), intercrop, crop rotations, fallowing of field, use approved pre-plant nematicides.


Knotted or galled roots


Galls on basal stems


Deformed and rotting roots


Swollen and cracked roots


Yellow leaves, wilting


Internal root rot


Blackened, swollen roots

Table 9.6. Stump rot

Stump rot	Cause	Symptoms	Risk	Management
 *Rotten stump*	***Fungi:*** various species (*Fusarium* sp., others), slugs feeding injury, fertilizer burn	***Stump:*** decay and disintegration of stump, internal, rot of stump	***Moderate risk:*** Although moderate risk, the disease can be locally severe and ruin a harvest.	Avoid contact between granular fertilizers and stump, control slug feeding or other sources of mechanical injury, do not prune stems too close to stump, avoid pesticide injury, promote good drainage and minimize plant stress.

Table 9.7. Root rot

Root rot	Cause	Symptoms	Risk	Management
Infected plants of all ages can die very quickly after infection  *Stunted, unthrifty plants*	***Fungi:*** *Pythium splendens*, *Rhizoctonia solani* ***Nematodes:*** *Meloidogyne* spp. (root-knot nematodes). ***Fertilizer burn:*** quick-release ammonium fertilizers can easily damage ʻawa.	***Roots:*** rotten, soft, black. ***Foliage:*** wilting and collapse of leaves and stems; yellowing; stunting; leaf curl; leaf marginal scorching; basal stem rot. The disease can resemble nitrogen deficiency at first, or drought stress. ***Plants:*** poor growth; wilting; stunting; death	***High risk:*** The disease is fatal. The fungi that cause this disease can survive in soils for a very long time; infection and disease progress very rapidly during wet weather; even very old or mature plants can die rapidly; some planting areas must be abandoned when infested with the root-rot pathogens.	Plant ʻawa on raised beds or hills; use disease-free planting material only; ensure good drainage around plants; use compost; avoid over-fertilization and over-watering; plant ʻawa in baskets; intercrop ʻawa with other plants; no effective fungicides are approved for controlling the disease in the field.


Stem wilting and dieback, leaf yellowing and collapse


Plant death


Wilting


Blackened roots and basal stem rot

Table 9.8. Crinkle leaf (aphid burn)

Crinkle leaf (aphid burn)	Cause	Symptoms	Risk	Management
 *Crinkled leaf due to aphid feeding, with lady beetles and aphid lions present*	***Insects:*** the melon aphid *(Aphis gossypii*) ***Associated:*** ants obtain food from aphid excretions, protect aphids, and move aphids from plant to plant.	***Leaves:*** distortion, curling, wrinkling, or crinkling with black or dark spots or small ringspots, leaf stunting ***Plants:*** stunting and unthrifty growth (young plants)	***Low to moderate risk:*** plants can recover from the damage; aphids are potential CMV vectors and in high numbers can destroy a young plant.	Spray soap plus water, exclude ants from plantings, plant ʻawa in enclosed nursery, use elevated benches, increased plant spacing, promote beneficial insects that are aphid predators (*e.g.*, lady beetles).

Table 9.9. Environmental and abiotic disorders

	Cause	Symptoms	Risk	Management
Environmental and abiotic disorders	Wind, cold, altitude, sun, rain, drought, pesticide injury, fertilizer burn, fertilizer deficiency	***Foliage:*** tattered leaves; thin stems; blackened or necrotic leaves; defoliation; stunting; wilting; slow growth; yellowing; leaf marginal burn, leaf curl, and distortion; leaf bleaching; leaf yellowing; leaf spotting; leaf blight; leaf wrinkling	***Moderate risk:*** These problems are usually not fatal and are often correctable.	Use windbreaks; acclimatize plants with stepwise hardening; do not over-water or over- or under-fertilize; grow ‘awa at appropriate elevation to avoid chill; use only approved pesticides and follow label directions; avoid waterlogged soils.

Rotted node cuttings (brown spots) in perlite were "burned" by excess fertilizer (yellow granules)

Pesticide injury (diazinon)

Wrinkled leaves (sun damage)

Pesticide injury (leaf bleaching)

Nutrient deficiency, probably iron

Sunburn

Table 9.10. Slug and snail damage

	Cause	Symptoms	Risk	Management
Slug and snail damage	Gray garden slug (*Deroceras laevae*), other slugs, various snails	***Leaves:*** irregular shaped holes in leaf centers or margins ***Stems:*** Basal wounding and rot (see below)	***Low to moderate risk:*** these pests are most damaging to young plants; however, where feeding damage is severe, the basal stems can rot and ruin the stump tissues	Use approved slug and snail baits; manually remove slugs; use of slug traps or deterrents; locate slug hiding places and destroy them; use geese, chickens, or ducks

Large holes in leaves created by slugs

The gray garden slug

Table 9.11. Minor leaf spots

	Cause	Symptoms	Risk	Management
Minor leaf spots	***Fungi:*** *Colletotrichum* sp., *Phyllosticta* sp., algae (*Cephaleuros virescens*)	***Leaves:*** dark or chocolate colored spots of various diameters	***Low risk:*** restricted in occurrence to very wet environments	Sanitation (leaf removal); pruning; humidity control (weed management, good drainage); intercropping; foliar spray of insecticidal sulfur has moderate fungicidal effect

Algal leaf spots (left): brown spots are caused by a plant-parasitic alga (Cephaleuros virescens): green spots are superficial algae that do not infect the leaf

Fungal leaf spot

Fungal leaf spot disease (rare)

Pin-prick lesions associated with the fungus, Colletotrichum *sp.*

Not leaf spots, but a variegated plant

Table 9.12. Locally severe insects, mites

	Cause	Symptoms	Risk	Management
Locally severe insects, mites	***Insects:*** spiraling whitefly (*Aleurodicus dispersus*); fringe guava whitefly (*Aleurotrachelus* sp.); banana silvering thrips (*Hercinothrips bicinctus*) ***Mites:*** carmine spider mite (*Tetranchyus cinnarbarinus*); broad mite (*Polyphago-tarsonemus latus*); false spider mite (*Brevipalpus phoenicis*); flat mites	Leaf yellowing; necrosis, and/or defoliation	***Moderate risk:*** damage potential is high with these pests if popula-tions are allowed to grow without control	Use approved insecticides or insect repellents; irrigation and fertilizer management (insects are attracted to heavily fertilized plants); windbreaks; weed control; use sulfur for mite control; use neem oil.

Thrips feeding injury causes blackening of leaves near veins

Aphids are usually tended by ant species, such as the longlegged ant (above, right)

Spider mites can be serious greenhouse and field pests, causing defoliation and unthrifty plant growth

A colony of the spiraling whitefly; many sap -feeding insects usually feed on the undersides of ʻawa leaves

Table 9.13. Troublesome weeds and other plants

A number of common range, pasture, canefield, and residential weeds can interfere with ‘awa cultivation by competing with ‘awa or by harboring insect pests and plant diseases. Grasses, which compete strongly with ‘awa root systems, must be controlled. Some weeds harbor severe diseases or insect vectors of diseases that can seriously affect ‘awa. Honohono grass (*Commelina diffusa*) and *Glycine* sp. harbor CMV, the cause of ‘awa dieback, and aphids, the insect vectors of CMV. Where the virus is present, avoid intercropping ‘awa with hosts of the melon aphid (*Aphis gossypii*), such as solanaceous food crops and cucurbits. Impatiens and noni and many other plants or weeds are hosts for the destructive root-knot nematode, *Meloidogyne* sp., and should not be planted near ‘awa in locations where root-knot nematodes have infested the soil.

Glycine *sp., a common weed in pastures and waste areas showing mosaic symptoms of infection by CMV (cucumber mosaic cucumovirus), cause of ‘awa dieback disease*

*Honohono grass (*Commelina diffusa*) showing mosaic symptoms of infection by CMV (cucumber mosaic cucumorvirus), cause of ‘awa dieback disease; right: a colony of melon aphids feeding on a honohono leaf — melon aphids can transmit CMV from honohono to ‘awa*

A year or more after planting, the ‘awa canopy is so large that most weeds are shaded out and no further weed management is needed

Table 9.14. Minor insect pests

Minor insect pests	Cause	Symptoms	Risk	Management
 *Pupae of the fringe guava whitefly*	***Insects:*** Coconut scale (*Aspidiotus destructor*); green scale (*Coccus viridis*); planthopper (*Kallataxila granulate*); mealybugs; Mexican leaf-roller (*Amorbia emigra-tella*); Chinese rose beetle (*Adoretus sinicus*); katy-dids; green garden looper (*Chrysodeixis eriosoma*); root mealybugs; barnacle scale (*Ceroplastes cirripediformis*)	Holes in leaves; rolled leaves; leaf yellowing; sooty mold; leaf necrosis	***Low risk:*** damage caused by these pests is sporadic, not widespread, and of relatively minor economic importance.	Encourage natural predators and pathogens; exclude ants; modify the environment; intercrop.

Katydid

Coconut scale

Barnacle scale

Root mealybugs in greenhouse

Chinese rose beetle damage

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Supplement to the Web Edition

Recent Studies on Potential Health Effects of ʻAwa

The information in the web pages is virtually unchanged from the book. However, since the science associated with ʻawa has advanced in the past few years, we wanted to note some of the recent research on ʻawa's potential effects on human health.

ʻAwa and Cancer

This website's introduction and the chapters entitled "Active Ingredients in ʻAwa" and "Chemistry, Pharmacology, and Safety Aspects of ʻAwa" cited early studies of ʻawa's potential in cancer prevention. In 2008, Johnson et al. published research on ʻawa and lung cancer in mice that had been given carcinogens. ʻAwa reduced lung tumor multiplicity when administered concurrently with carcinogens and when administered after carcinogen treatment. Best results occurred when ʻawa was administered along with carcinogens and continued after carcinogens were discontinued: lung tumor multiplicity was reduced by 56% compared to mice that received carcinogens but no ʻawa.

The study above appeared in Cancer Prevention Research in November of 2008. The same issue included an article by Tang et al. adding to prior research on the effects on bladder cancer of a particular ʻawa constituent, flavokavain A.

In 2009, an article by Shaik et al. suggested that the kavalactone methysticin may be the chemical in ʻawa that appears to prevent lung cancer. This study also indicated that methysticin is not toxic to liver cells.

ʻAwa and Alzheimer's Disease

We would like to call attention to a recent study suggesting that ʻawa may be of use against Alzheimer's disease (Wruck et al., 2009). The kavalactones methysticin, kavain and yangonin were tested in vitro and shown to protect neural cells. The article concludes, "If studies using kavalactones in an in vivo model of Alzheimer's disease prove this beneficial effect, the use of kavalactones might be considered as an adjunct therapeutic strategy to combat neural demise in Alzheimer's disease . . . ."

Potential Liver Toxicity

The webpage on "Chemistry, Pharmacology and Safety Aspects" discusses the chemistry of ʻawa and potential liver toxicity in some detail. A number of studies have been conducted since this chapter of the book was written, but the results are still inconclusive.

The World Health Organization performed an extensive assessment published in 2007. The resulting opinion stated:

> Evidence of our review of case reports suggests that kava lactones in any type of product may rarely cause hepatic adverse reactions because of kava-drug interactions, excessive alcohol intake, metabolic or immune mediated idiosyncracy, excessive dose or pre-existing liver disease. . . . In addition to this background incidence, products made from acetonic and ethanolic extracts appear to be hepatotoxic on rare occasions, seemingly from non-kava lactone constituents. . . (WHO 2007: 63).

Fu et al. (2008) review many of the studies done up to that point. Baker (2008) also provides a review of the literature on ʻawa's effects on the liver as well as insights on the divergent opinions with respect to the safety of ʻawa.

Jhoo et al. (2006) examined extracts from leaves, roots and stems for liver toxicity using a number of different solvents. Flavokavain B was noted for cytotoxicity in this study. The article by Shaik mentioned above found flavokavains A, B and C to be toxic to liver cells. These flavokavains were found in the commercial product tested but not in the traditional water extract.

Zhou et al. (2010) have shown flavokavain B to be toxic to HepG2 liver cells and in vivo with mice. If this proves to be the explanation for the rare cases of liver damage associated with ʻawa, it has been proposed that extracts be developed to exclude the flavokavains.

—Ed Johnston and Helen Rogers, September 2010

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