

Santalum freycinetianum Gaudich.

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SANTALACEAE (SANDALWOOD FAMILY)

S. freycinetianum var. *auwahiaense* Stemmermann; *S. freycinetianum* var. *lanaiense* Rock; *S. freycinetianum* var. *longifolium* (Meurisse) Degener; *S. freycinetianum* var. *pyrularium* (A. Gray) Stemmermann; *S. involutum* St. John.; *S. lanaiense* (Rock) Rock; *S. longifolium* Meurisse; *S. majus* St. John; *S. pyrularium* A. Gray; *S. pyrularium* var. *sphaerolithos* Skottsbo. (Wagner and others 1990)

Freycinet sandalwood, 'iliahi

Santalum L. is a genus of about 25 species growing from India and Nepal to Australia and Polynesia, four of which are native to Hawaii (Wagner and others 1990). The native range of *S. freycinetianum* includes the Hawaiian islands of Oahu, Kauai, Lanai, Maui, and Molokai.

Santalum freycinetianum is capable of reaching approximately 25 m in height and 90 cm d.b.h. (Little and Skolmen 1989) but is typically much smaller. This relatively slow-growing evergreen is characterized by slender, often drooping branches and narrowly elliptical gray-green leaves. It grows on a range of volcanic soils but does not become established on poorly drained sites. Most often found on slopes and ridges, the species can be locally common in dry, mesic, and wet forests with mean annual rainfall between 500 and 3800 mm. It is most often found growing between 250 and 950 m but has been found at elevations as low as 15 m (Applegate and others 1990, Wagner and others 1990). Like other members of the genus *Santalum*, it is hemiparasitic on the roots of other plants.

Like many other Hawaiian plant species, *S. freycinetianum* is highly variable, and its taxonomic status might still be considered unresolved. Currently, three morphologically overlapping varieties are recognized: *S. f.* var. *freycinetianum*, *S. f.* var. *lanaiense*, and *S. f.* var. *pyrularium*. The varieties vary in their geographic range and the site types on which they grow (Applegate and others 1990, Wagner and others 1990). Further information on the taxonomic status of Hawaiian sandalwoods is provided by Wagner and others (1990) and Stemmerman (1980a, 1980b; 1990).

Santalum freycinetianum is highly valued for the oil contained in its heartwood, which gives the wood an attractive fragrance. The wood, which is hard, heavy, yellow-brown in color,

and fine textured, is used for ornamental carvings and fine furniture (Little and Skolmen 1989). Like the other sandalwoods, the oil is extracted for use in perfumes, incense, and medicines (Applegate and others 1990, Little and Skolmen 1989).

The weakly fragrant red flowers, each about 6 to 15 cm long, are borne in terminal or lateral clusters (cymes). Flowering generally peaks in the late summer and fall, but flowering also occurs in late winter and early spring. The single-seeded fruits (drupes) are 8 to 17 mm long and reddish-purple to black at maturity. Other sandalwoods (e.g., *S. album* L.) begin producing viable seeds at about 5 years (Applegate and others 1990), but information specific to *S. freycinetianum* is unavailable.

The general recommendations for propagating sandalwoods (Applegate and others 1990, Utomo and others 1990) are believed applicable to *S. freycinetianum*. Seeds should be collected directly from trees by hand or with pruning poles but can be collected from the ground. The seeds should be depulped by washing in water and treated with a disinfectant or fungicide. Seeds should be sowed immediately or dried in the sun or an oven before storage. Seeds can be stored in a dry, cool location or dried to approximately 8 percent moisture content and refrigerated at about 5 °C. Sandalwoods can be successfully stored under refrigeration for several years.

Like other sandalwoods, *S. freycinetianum* is difficult to propagate. Although considerable progress has been made over the last 10 to 15 years, unresolved questions remain about seed dormancy, seedling nutrition, and using host plants. Because untreated seeds may take from several months to well over 1 year to germinate (Hirano 1990), seed pretreatment is recommended. Presoaking in water for 3 to 5 days helps; however, complete removal of the seedcoat (Nagaveni and Sri-

mathi 1980), soaking for 8 to 12 hours in 0.05 to 0.1 percent gibberellic acid (Applegate and others 1990, Nagaveni and Srimathi 1981), manual scarification followed by soaking in water (Applegate and others 1990), or acid scarification (Nagaveni and Srimathi 1980) are reportedly more effective. Full light has been shown to enhance germination of *S. album* (Utomo and others 1990), but no information on the light requirements of *S. freycinetianum* is available.

Seed should be sowed in a sterile media such as vermiculite, well-drained potting mix, or sterilized sand-soil mixture. Optimal temperature for germination of some sandalwoods appears to be about 25 °C, and one effective technique involves bottom-heating germination beds to maintain the temperature at this optimal level (Applegate and others 1990). *Santalum freycinetianum* seedlings are susceptible to both fungi and nematodes, and applications of appropriate pesticides may be necessary. Careful attention must be paid to seedling nutrition in this hemiparasitic species. Hirano (1990) reported that seedlings of three sandalwood species (two native to Hawaii, but not including *S. freycinetianum*) developed severely chlorotic leaves that did not respond to a foliar (20-20-20) fertilizer. They did, however, improve significantly with the application of chelated iron. Seedlings should be kept in partial shade (30 to 50 percent) and protected from stressors such as temperature extremes, frost, and wind.

When seedlings reach the four-leaf stage, they can be transplanted into containers, such as a 13-x 30-cm pot, filled with a well-drained potting mixture. A primary host plant may also be transplanted into the pot. Potential host plants include native Hawaiian species such as *Acacia koa* A. Gray, *A. koaia*,

or *Dodonaea viscosa* Jacq., or nonnative species such as *Leucaena luecocephala* (Applegate and others 1990, Scheffel 1990). Seedlings have also been grown successfully with no primary host plants for at least 18 months (Hirano 1990), and primary host plants are not currently used in Hawaii Division of Forestry and Wildlife nurseries (Lum 1997). Seedlings reach adequate size for outplanting about 8 to 9 months after transplanting.

In the field, seedlings should be planted near potential host plants. In some situations, such as *S. austrocalendonicum* plantations in New Caledonia, secondary host species are established on plantation sites 1 year before the sandalwoods are outplanted (Applegate and others 1990). In commercial sandalwood plantations, seedlings are outplanted at 4 to 5 m spacings. Plantation practices have not been documented for *S. freycinetianum* or other Hawaiian sandalwoods. Seedlings are generally planted within existing vegetation near potentially suitable hosts; the best host may be *Acacia koa*. Success is generally good (Scheffel 1990), especially in locations where seedlings can be watered occasionally and weed competition is controlled. Periodic trimming of the secondary host may benefit seedlings.

ADDITIONAL INFORMATION

In Hawaii, sandalwood populations were decimated in the early 1800's during a period of intensive harvesting that had far-reaching environmental and socioeconomic consequences (Merlin and Ravenswaay 1990). Although the sandalwoods have partially recovered, relatively few large trees are found and the distribution is more restricted than it was in the early 19th century.

