Germinating Five Forest Tree Species Native to the Virgin Islands

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Abstract

The scarcity of native trees in production at nurseries of the U.S. Virgin Islands is due in part to the lack of published seed and germination data. To address this, we provide descriptions for five trees that are native to the Virgin Islands and have production potential: wild cinnamon [*Canella winterana* L. (Gaertn)], coco plum (*Chrysobalanus icaco* L.), lignum vitae (*Guaiacum officinale* L.), locust (*Hymenaea courbaril* L.), and ironwood [*Krugiodendron ferreum* Vahl (Urban)]. We developed baseline fruit and seed data and tested the effect of three pregerminative treatments on the seeds: 24-h water soak, boiling water, and 1-h gibberellic acid (GA_3). Seed collection times, fruit and seed weight, time to germination, and expected rates are given. Treatments affected germination in all species except *H. courbaril*, which germinated well with all treatments and the control. All species except *C. winterana* germinated above 70 percent under at least one treatment.

Introduction

There is a growing consensus among both ecologists and urban foresters that using native flora in new plantings is desirable. Exotic plant species represent one of the greatest threats to global biodiversity (Vitousek and others 1997), and the threat is worsening (Mack and others 2000). Invasive or benign, exotic species are now ubiquitous in most of the world's habitats and are costly and difficult to remove (Baskin, 2002). They will always be ecologically significant (Lugo and Helmer 2004). Using native plants reduces the risks inherent with introducing new organisms. Some frequently cited advantages for utilizing native plants include the preservation of genetic diversity (Ewel and Putz 2004), their adaptation to local climate and soil (Parrotta and others 1997), beneficial wildlife interactions (Martinez and Howe 2003), and others.

In the U.S. Virgin Islands, territorial agencies and nonprofit organizations have jointly compiled detailed lists of native trees recommended for both urban forestry and forest restoration (O'Reilly 2002; Daley and Zimmerman 2004). There are, however, several practical impediments to increased utilization of native plant species; primarily, the plants are generally not available in nurseries. This is especially true throughout the Caribbean (Overton and others, in press). A general lack of published germination information may be partially to blame for the absence of many native plants from nurseries.

This paper provides information that will facilitate the production of five Virgin Islands native plants by public and private nurseries. We selected species previously identified as suitable to both ecological and urban forestry plantings. For each taxon, a brief description of the plant and its range, together with data on seed collection time, fruit weight, number of seed per fruit, and seed weight, is provided. We present germination rates for three pregerminative seed treatments for each species and the length of time required for germination. This information should facilitate collection and handling of native seeds and production of native forest tree seedlings in the territory.

Materials and Methods

Five tree species native to the U.S. Virgin Islands were examined in this study: wild cinnamon [*Canella winterana* L. (Gaertn)], coco plum (*Chrysobalanus icaco* L.), lignum vitae (*Guaiacum officinale* L.), locust (*Hymenaea courbaril* L.), and ironwood [*Krugiodendron ferreum* Vahl (Urban)]. They were chosen for their potential use in urban forestry systems and because of their local scarcity. Seed collection times were documented for each species during 30 mo, starting in August 1999. Seeds were collected along an island-wide transect on St. Croix that included ridge tops, sandy beaches, and the elevation gradient in between. Fruit was collected from multiple trees in multiple locations whenever possible. Collection times are listed in table 1.

All seed germination was conducted at the Agriculture Experiment Station at the St. Croix campus of the University of the Virgin Islands. Upon collection, the fruit were cleaned, counted, and weighed. Seeds were then removed

Table 1. Fruit and seed data for each species.

Tree	Fruit kg^{-1}	Seeds $fruit^{-1}$ [mean (observed range)]	Seed kg^{-1}	Seed collection time
C. winterana	2,324	1.74 (1 or 2)	22,000	Sep–Nov
C. icaco	820	1	446	Aug–Dec
G. officinale	1,390	1.70 (1 or 2)	3,220	Aug and Mar*
H. courbaril	11.3	8.51 (4–12)	270	Aug and Mar*
K. ferreum	2,050	1	11,100	Aug–Oct

*Trees tend to have two fruiting periods per year.

from their fruit, rinsed clean, counted, and weighed. Pregerminative treatments were conducted within 24 hours of collection. The handling procedure varied slightly depending on the size and texture of the fruit, but all seeds were free of fruit material and undamaged at the time of treatment. Only fresh seeds from mature fruit were used.

The pregerminative seed treatments were a 24-h water soak at room temperature (soaking); 30-s dip in 100 °C water, followed by cooling under running water (boiling); 1-h soak in a 2,000 ppm aqueous solution of gibberellic acid (GA_3); and no pretreatment (control). The three pregerminative seed treatments and the control were applied to all species, with 20 seeds per treatment. Preliminary analysis detected no significant date effect, so for each taxon, we treated experiments on different dates as true replications. There were at least five replications per treatment per species.

Treated seeds were sown in trays with potting soil and kept moist. Seed germination data were collected daily and expressed as a percentage once germination was completed. The germination start time is the average time elapsed between seed treatment and emergence of a seedling. Percent germination data were inverse sine transformed before analysis. ANOVA was conducted and the means for species with significant differences among treatments were compared by Least Significant Difference (SAS version 8, SAS Institute, Cary, NC).

Results

Canella winterana. This is a small tree between 7 and 10 m (23–32 ft.) tall that has a dense, dark green crown and a smooth to warty gray bark. The petite, dark, red to purple flowers are rich with nectar. Small round, red berries contain one or two seeds and a sticky resin (figure 1). Leaves and bark are said to be medicinal; the fruits, when collected green and dried, are reported to be hot like black pepper (Little and Wadsworth 1964). Timber is blackish and extremely hard (Timyan 1996). The tree is found primarily in dry sandy areas from south Florida through the Greater Antilles and into the Lesser Antilles to St. Lucia and Barbados. In St. Croix, only isolated examples remain in the wild, but the tree could do well as an ornamental (Jones 1995).

Fruits were collected from the west of St. Croix in September and October 1999 and September and November 2000. The seeds were easily removed from the berries and the clear, sticky resin was rinsed off before treatment. There are 2,324 fruits kg^{-1} (1,000 lb^{-1}), with an average of 1.74 seeds per fruit and 22,000 seeds kg^{-1} (9,285 lb^{-1}) (table 1).

Germination, which began at 30 d, was sporadic and concluded after 120 d. No treatment successfully initiated early germination. The boiling water treatment was ineffective, killing all seeds in all five replications (table 2). The GA_3 and control treatments were the most successful,

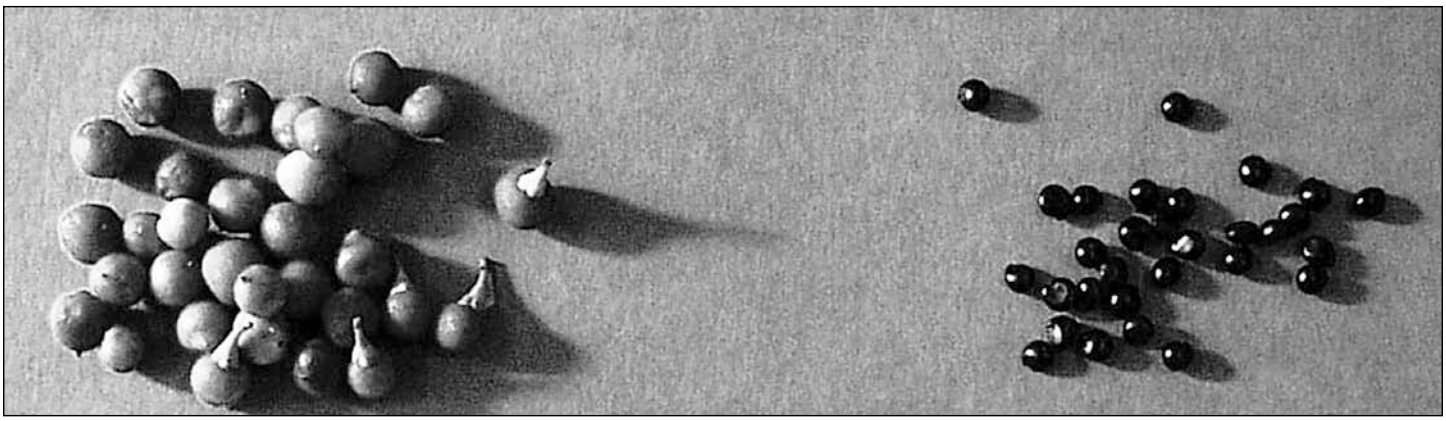

Figure 1. Mature fruit (left) and cleaned seeds (right) from wild cinnamon (*Canella winterana*).

Table 2. Average germination percentage of five tree species after seed pretreatment.

Pretreatment	*C. winterana*	*C. icaco*[1]	*G. officinale*[2]	*H. courbaril*	*K. ferreum*[2]
Water soak	6ab	91a	46ab	64	86a
Boiling water	0b	32b	4b	65	0b
GA_3	33a	73a	71a	70	13b
Control	29a	50ab	29b	56	85a

[1] Mean separation by LSD ($p<0.01$)

[2] Mean separation by LSD ($p<0.05$)

though both treatments produced <30 percent germination. Therefore, no treatment is recommended for this species. Low germination rates should be anticipated and sufficient seeds should be collected to compensate.

Chrysobalanus icaco. Low-growing and multistemmed, this shrubby tree reaches 3–6 m (9.8–19.7 ft) in height. It has a canopy of dark green, thick, leathery leaves. It is found primarily at sea level on sandy beaches. Flowers are small and grow in clusters. The edible, round fruit is about 5 cm (1.97 in) in diameter, containing a sweet, white, meaty flesh around one large, woody seed. The Virgin Islands variety has a white to pink skin; those from Florida and the rest of the Lesser Antilles are dark purple and smaller. This species' natural range is from southern Florida through most Caribbean islands and along the coastline from Mexico to Brazil and Ecuador (Little and others 1974).

Fruiting season varies annually. We collected fruit in September 1999 and August, November, and December 2001. Ripe fruit was taken directly from the tree or freshly fallen fruit was collected from the ground. The seed was cleaned by floating the fruit in water and then scraping on a screen to remove the flesh. Overall, the four collections averaged 82.7 fruit kg^{-1} (37.2 lb^{-1}) and 446 seeds kg^{-1} (202 lb^{-1}).

Germination (figure 2) began between 42 and 60 d and was considered complete by 100 d. None of the treatments significantly reduced germination start time or germination period. Ten percent of germinated seeds produced two individual plants. Soaking and GA_3 (91 and 73 percent, respectively) were significantly more effective than boiling (32 percent) (table 2). The difference between the soaking and control (50 percent) treatment means was not significant, largely due to high variability between replications. Nonetheless, the numerically higher rate and slightly improved germination start time represent a real improvement, and we recommend the soaking treatment for this species.

Guaiacum officinale. This is a small to medium-sized, multistemmed tree reaching a maximum height of 10 m (figure 3). It has a dense, rounded crown of dark green leaves. The bark is light brown, mottled and peeling. Masses of light to dark blue flowers bloom at various times during the year in different parts of the same tree. Fruit are flat, yellow, heart-shaped capsules, containing one or two seeds covered in a bright red aril, which are released at maturity. Its native range extends through the Greater and Lesser Antilles, Panama, Colombia, and Venezuela, though it is planted as an ornamental through much of tropical America (Little and Wadsworth 1964). It is the national

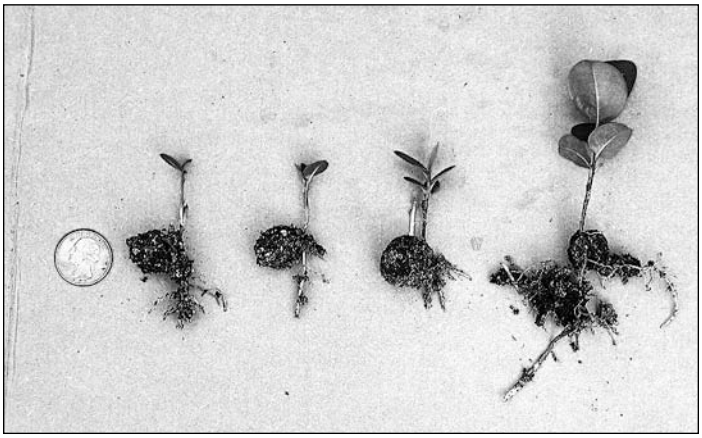

Figure 2. Early development of coco-plum (*Chrysobalanus icaco*) seedlings. Ten percent of the seeds were polyembryonic, which can be noted in the second plant from the right.

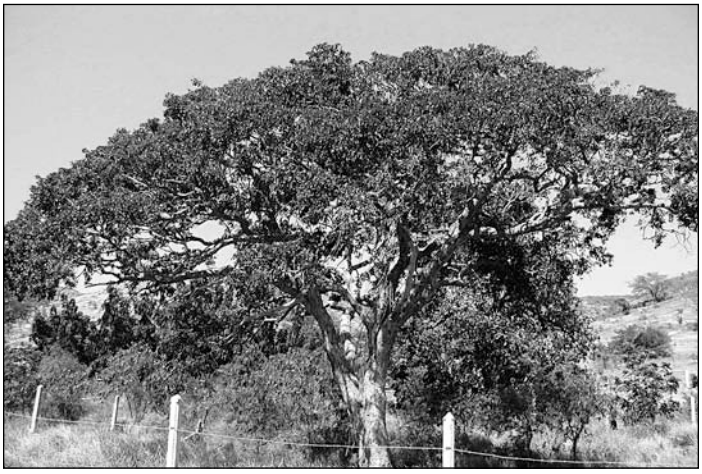

Figure 3. This lignum vitae (*Guaiacum officinale*) tree is estimated to be 150 years old and is an iconic hardwood of the Caribbean dry forest.

flower of Jamaica and appears on the Virgin Islands list of endangered species (Gibney and others 1991). This species readily self-propagates in the wild, grows well under shade, and is extremely resistant to drought, which have all contributed to its recent spread in Forest Service Estate St. Thomas property in St. Croix and many areas of the drier east side of St. Croix.

Seeds were collected in August 1999 and March 2000 and 2001, although they are abundantly available at many other times of the year on St. Croix. Fresh seeds can be collected from the ground around the tree or taken from the tree once the seed is released from the fruit. Seeds were cleaned of their fleshy arils by a brief soaking in water and rinsing under running water, leaving a black, porous, oval seed. Five collections averaged 1,390 fruit kg^{-1} (630 lb^{-1}) and 3,200 seeds kg^{-1} (1,460 lb^{-1}) similar to that reported by Betancourt (1987) and Francis (1993).

Germination began in 15 to 20 d and concluded in 5 wk. The GA_3 treatment was significantly better than both boiling and control. The boiling treatment showed a negative effect, resulting in 4 percent germination, whereas the control produced 29 percent. The control rate is half of the 60 percent reported for fresh seeds in Cuba (Betancourt 1987). We recommend GA_3, which resulted in 73-percent germination, for this species. This treatment had a higher germination percentage in 5 wk than previously reported rates of 50 percent germination over 6 mos (Francis 1998; 2002). Rapid, even germination at high rates with this treatment makes this species well suited to commercial production by nurseries.

***Hymenaea courbaril*.** This medium to large, spreading, usually evergreen tree reaches heights of 15 to 20 m (49.21–65.62 ft) and stem diameter of 1 m (3.28 ft). It has smooth, gray bark and produces large, woody fruit pods [figure 4]. The sweet, edible, but strong-smelling pulp inside the fruit earns it the name 'stinking toe' in the Virgin Islands. It produces a durable, heavy, hard, highly valuable wood for timber (Timyan 1996). Its native range extends from southern Mexico through Central America and south to Peru, Brazil, and Bolivia (Little and Wadsworth 1964). In the Virgin Islands, the fruit bat (*Brachyphylla cavernarum)* feeds on the nectar of the flowers (Gary Kwiecinski, personal communication).

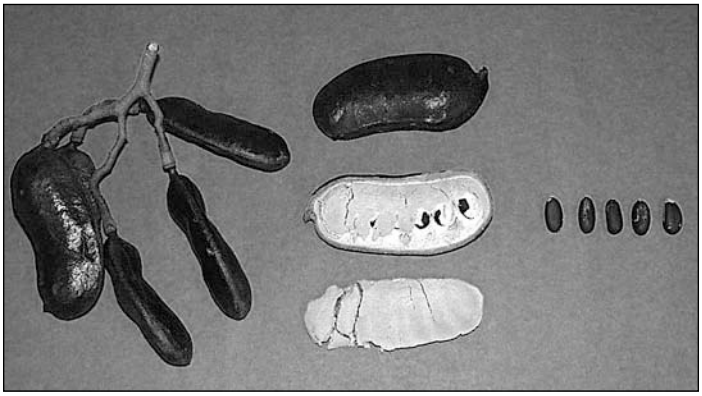

Figure 4. From left to right, mature locust (*Hymanaea courbaril*) fruit, cross-sectioned pods with seeds visible within the pulp and the cleaned seeds extracted. The strong-smelling pulp earns it the name "stinking toe" in the Virgin Islands.

We collected seeds of this species in March and August of 2000 and 2001. Ripe brown fruit were cut from the tree canopies with a pole-pruner and opened with a hammer. Average weight for the pods was 88 g (3.1 oz) or 11.4 fruit kg^{-1} (5.16 lb^{-1}) with 8.5 seeds pod^{-1} and 270.3 seeds kg^{-1} (120.2 lb^{-1}).

Germination began in 20 d for the control and in 14 d for the three pregerminative treatments. Both scarification and soaking in sulfuric acid have previously been shown to increase germination percentages and reduce germination time (Francis 1990; Vozzo 2002). Other studies suggest manual scarification and several other treatments made germination more uniform and improved rates, though they did not determine if the improvements were significant (CATIE 1999). Our research supports the previous findings, as rate and speed of germination were enhanced by all three treatments, relative to control. Although numerically greater, these differences were not significant. Therefore, a pregerminative treatment may be used to achieve only slight improvements in germination rate and time. This was the only species of the five that was not negatively affected by the boiling treatment.

Krugiodendron ferreum. This small, multistemmed tree grows to 6–8 m (19.69–26.25 ft) tall. It has a dense crown of leaves, which are reddish when immature, turning dark and shiny green. The bark is gray and smooth, becoming scaly with age. Flowers are inconspicuous, yellow–green, and lacking petals; they appear in clusters intermittently throughout the year. Berry-like fruits are elliptical, purple to black, and contain one seed. Its native range spans from southern Florida through the Greater and Lesser Antilles to St. Vincent and Curacao (Little and Wadsworth, 1964). Distribution on St. Croix is mostly in the moister west end of the island; it is fairly common along some road sides. Average fruit weight is 0.45 g (0.016 oz) each, or 2,054.7 kg^{-1} (932.4 lb^{-1}) and 11,100 seeds kg^{-1}(5,038 lb^{-1}).

Fruits for this study were collected in the northwest of St. Croix in August and October 1999 and November 2000. Ripe fruit was taken directly from the tree. The seeds are

easily removed from the soft, juicy drupes by squeezing them out and rinsing away the remaining pulp. Germination (figure 5) began after 14 d and finished in 4 wk. Soaking and control treatments were significantly better than boiling or GA_3. Not a single seed in any replication from the boiling water treatment germinated, and GA_3 had only 13 percent germination. Therefore, no treatment is recommended to increase germination.

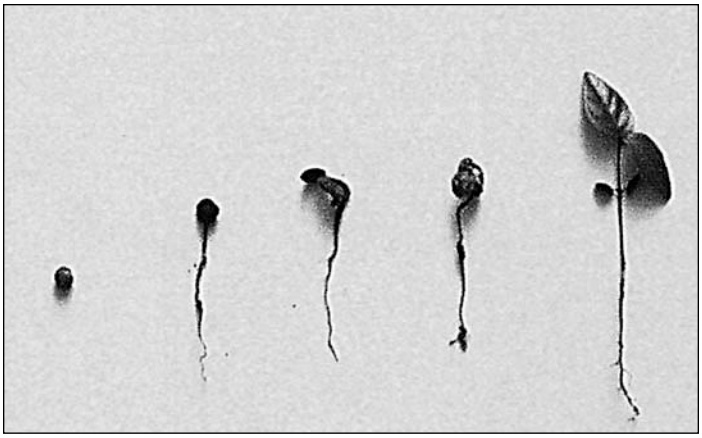

Figure 5. Stages of seed germination for the Virgin Island's ironwood (*Krugiodendron ferreum*).

Discussion

We know of no published germination rates for three of the species (*C. winterana*, *C. icaco*, and *K. ferreum*). Several organizations in the U.S. Virgin Islands have identified these species as desirable for use in reforestation and urban and community forestry. The sparse local distributions of all these species make seed collection difficult during parts or all times of the year. Limited distribution and a low germination rate (below 30 percent) make *C. winterana* the only tree of the five that remains problematic to reproduce in larger quantities. The other four species in this study have more extensive populations on St. Croix and germination rates ≥70 percent, making large-scale or commercial production possible.

Numerically, GA_3 treatment achieved the highest germination rates in *C. winterana*, *G. officinale* and *H. courbaril*. Soaking was highest for *C. icaco* and *K. ferreum*. In the case of *H. courbaril*, all three treatments made germination more rapid. These increases did not represent statistically significant improvements over other treatments, however. In fact, a pregerminative treatment significantly improved germination, relative to control, only for *G. officinale*. Although a pregerminative treatment is not required to germinate these species, we observed the higher germination percentages to be a real benefit, especially when seed sources are limited. Additionally, in treated seed groups a flush of seeds frequently germinated within a day or two of one another. Our experience in the greenhouse was that seedlings from treated seeds were more uniformly sized, making them easier to transplant.

Conclusions

Throughout the United States and the Caribbean, there is an increasing trend toward using native plants in landscapes. Our experience with nursery operators in St. Croix and elsewhere indicates their first obstacle in growing more native plant material is not knowing where and when to collect seeds and how to handle them. These replicated experiments provide growers with a proven method and expected germination rates for these taxa. A high degree of variability is inherent whenever working with seeds from wild species. This can be minimized by following the appropriate standardized protocol described in this paper. In many cases, germination can be further improved by using pregerminative treatments. Applying this data will streamline the seed collection and germination process for large and small producers alike.

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