Nursery and Field Techniques for Restoring the Native Hawaiian Tree, ‘Ohi’a Lehua, *Metrosideros polymorpha* in a Disturbed Forest Area above Lāie, Oahu, Hawaii

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Biology 494

Winter 2012
ABSTRACT

*Metrosideros polymorpha* (Hawaiian name – Ohia Lehua) is the most abundant native tree in the Hawaiian Islands and is the most common canopy-forming tree species. In July 2008, about two acres of *M. polymorpha* forest were burned along the Kahawainui trail above Laie, Oahu, Hawaii. Shortly thereafter, invasive weeds began to colonize the area, although the majority of the area was still bare soil, posing a major erosional threat. As part of a multifaceted restoration effort, reproductive studies were conducted on the native Ohia. The reproductive cycle of the tree was monitored for six months. Various methods of nursery and field techniques including cuttings, air layering, and propagation by germination were also performed. The trees appeared to flower at least twice a year and in the winter months, once in October, February, and March.

INTRODUCTION

The extreme polymorphism of the Hawaiian tree *Metrosideros polymorpha* (Myrtaceae) has long fascinated biologists (Cordell et al. 1998). The *M. polymorpha* (‘ōhia lehua, in Hawaiian) is the most abundant native tree in the Hawaiian Islands (Cordell et al. 1998, Friday & Herbert 2006) and is the most common canopy-forming tree (Burton 1982). It is the dominant pioneer tree in most volcanic successions and often remains dominant in rain forests (Drake 1992). *Metrosideros polymorpha* can be found growing naturally from sea level to an elevation of 2700m (Burton 1982) and in precipitation gradients from less than 400 mm to greater than 10,000 mm annually (Vitousek et al. 1990). This range of elevation suggests that *M. polymorpha* must be able to germinate across an equally wide temperature range such as the one found in the Ko‘olau Mountains with an annual mean air temperature range between 9 and 23°C (Burton 1982). Drake (1993) demonstrated that *M. polymorpha* seeds required no after-ripening, could germinate rapidly, and could germinate under low levels of light, including far-red.

*Metrosideros polymorpha* is also common in seasonally wet forests, where it may be dominant or co-dominant with the native *Acacia koa* (Friday & Herbert 2006). Genetic differences of individual *M. polymorpha* correlate with environmental differences (Friday & Herbert 2006).
James et al. (2004) showed that in some cases differences within phenotypic varieties may be greater than between varieties, and many intermediate phenotypes exist (Friday & Herbert 2006). The flower color and foliage can vary greatly from site to site (Friday & Herbert 2006). *Metrosideros polymorpha* can be established at the extreme ends of wet and dry precipitation gradients. Because this native tree dominates the Hawaiian forest across a broad range of sites, the nutrients available differ along with soil fertility (Vitousek 1998).

In July 2008, about two acres of *M. polymorpha* forest burned along Kahawainui trail, near Laie, Hawaii. A short time later, the fire site was invaded by invasive weeds, dominating much of the area, although the majority of the site was still bare soil. A major threat to native forests is the spread of invasive species because of their ability to alter habitat and cause local extinction of native species (Lynch 2010). Without management this site may be further dominated by invasive species, due to slow native species recovery and the steep topography of the location. Local efforts to remove the invasive species are ongoing. The goals of this study were to document the temporal reproductive patterns in ‘ōhia lehua native to the Kahawainui Gulch and to experiment with several nursery and field techniques for the propagation of ‘ōhia lehua through cuttings, air layering, and seed germination. This effort could provide a valuable source of plants and seeds for out-planting from the local gene pool to aid in restoring the local forest.

**MATERIALS AND METHODS**

The burnt area is located two km from the Kahawainui trailhead and is one and one half km from the Koʻolau range summit where the slope of the area is greater than 45° in most places as Lynch (2010) describes (Figure 1). Photographs of the *Metrosideros polymorpha* near the
burn site were taken once a month for six months (October-March 2012) to monitor the reproductive activity of this native tree.

Cuttings were taken on December 6, 2011. The cuttings were taken close to the tip of branches, dipped in rooting powder, and planted into 24 oz. paper cups, which were filled half way with Miracle-Gro planting soil. The cups were covered and transported to the Brigham Young University – Hawaii campus. The cuttings were watered daily using a hand held squirt bottle to mist the plants and soil. Another set of cuttings were taken on January 14, 2012, and were placed outside in a garden box without rooting powder.

Air layering experiments were performed on 15 Ohia on December 6, 2011, near the burn site. The bark was pulled off and removed with a knife, and two handfuls of slightly damp moss were used for proper moisture. A piece of plastic wrap went completely around the moss and branch with both ends tied securely with duct tape. Aluminum foil was wrapped around the plastic wrap for protection. This was left on for two months and then reexamined. On January 14, 2012, another 15 Ohia were air layered in the same form with the exception of the use of rooting powder. They were left for two months and then reexamined.
Seeds were collected in October 1, 2011, from a *Metrosideros polymorpha* near the burn site. The tiny seeds (Figure 2) were contained in a cup-like capsule, which had turned brown showing maturity, and they were not split open. The capsules were stored in a paper bag to keep them dry. The capsules were transferred to a Ziploc container to allow them to open for easier seed collection. They were spread onto germination trays in a nursery setting at the Brigham Young University – Hawaii campus. Eight trays contained only Miracle-Gro, eight trays contained Miracle-Gro and Peat Moss, and eight trays contained Miracle-Gro and moss that was collected at the burn site. After sowing the seeds, the medium was misted every day starting on November 4, 2011.
Figure 2. The small wind dispersing seeds that opened in the Ziploc container were placed into various soil treatments in germination trays.

RESULTS

The reproductive activity was monitored from the months of October 2011 to March 2012. The Ohia flowered in October, but not in November or December (Figures 1-3). In December the tips of the leaves began to change from green to a red. In January flower buds appeared and were fuzzy (Figure 4). February and March the trees were again in full flower (Figures 5-6).

The cuttings with rooting powder did not root and died. The cuttings that were left outside did not root. They experienced a flooding rain event.
The 15 air layered Ohia without rooting powder showed no roots after three months. Of the 15 air layered Ohia with rooting powder, one had roots after two months (Figure 7). This branch was collected and planted in the BYU-H nursery on March 29, 2012. There has been no sign of seed germination in the germination trials as of March 15, 2012.

Figure 1. The Ohia in October showed flowering at the burn site on the Kahawainui Gulch.
Figure 2. In November the Ohia showed no flowers and the leaves had not changed color. Many seed capsules were split open.

Figure 3. The red leaves of the Ohia came in December.
Figure 4. There was a fuzzy covering of the budding seeds, which were first seen in January 2012.

Figure 5. The flowers bloomed and are seen in February 2012.
Figure 6. Some flowers were still in bloom in March 2012.

Figure 7. After two months, the first air layer that showed rooting on March 28, 2012, had rooting powder.
DISCUSSION

This study done in the Kahawainua gulch showed that the *M. polymorpha* trees mature and are in bloom in October, February, and March. The *M. polymorpha* is able to flower during the winter months, which agrees with the study done by Drake (1993). The Ohia in this gulch also appear in bloom twice a year, which agrees with the study done by Friday and Herbert (2006). It is assumed that October is the end of the flowering cycle, while February is the beginning of the next cycle. Friday and Herbert (2006) state that flowering generally peaks in the spring and summer, which is in agreement with this study in the Kahawainua gulch.

Both indoor and outdoor cuttings failed to root. Soon after the cuttings were planted outside there was a significant rainstorm, which may have destroyed their chance of rooting. The upper portions of the leaves of the cutting were left on, which may have led to increased water loss.

The air layering experiment results are still pending. Lilleeng-Rosenberger (2005) suggests that the *M. polymorpha* may take up to six months to see any signs of rooting. The one air layer that showed rooting appeared after two months and was on a smaller branch. The small branch and rooting powder may have led to quick rooting. There were some air layers that were taken over by ants and their larvae. The ants rip holes in the plastic wrap, which cause the moss to dry out and can kill the stem and roots. There were some rainstorms that occurred after the air layers had been applied, which may have also caused rips in the aluminum foil and plastic wrap leading to delay or even prevent rooting.

Propagation by seed has not yet been successful, although some Ohia seeds are known to take up to six months to germinate if the seedlings are very small (Lilleeng-Rosenberger 2005). Burton (1982) suggests that only 14 percent of the seeds sampled appeared to have intact
embryos, which led to poor germination results even with optimal conditions. Because the seeds collected were small, this may have been the problem for the seeds in this study. The viable, embryo-containing seeds are plumper than the others, but all the seeds in this study appeared to be the same size. Another explanation may have to do with the seeds being exposed to nutrient stress (Burton 1982).

It would be beneficial to try these techniques again using a mist system, optimal temperature ranges, different strengths of rooting powder, and a pesticide to control ants. Because only one air layer has worked, it may be beneficial to try in the spring months rather than in the rainy winter months. And it would be helpful to know the entire reproductive cycle of the Ohia to make more observations about flowering.

The major purpose of this study was to observe the local reproductive cycle of the M. polymorpha for six months and to use various nursery and field techniques to aid in the restoration process of the native Hawaiian tree in a disturbed forest area above Laie, Hawaii. The flowering of the tree seemed to be in agreement with Friday and Herbert (2006), in that the tree should flower once or twice a year. The cutting and germination techniques were not successful in obtaining new individuals to replant and restore the burn site. One air layer has been successful after two months, but results are still pending. Obtaining this knowledge is important for restoration work so that native forests can be restored using material from local native populations.
LITERATURE CITED


