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Scaling up Māmaki (*Pipturus albidus*) in Non-Forest Areas for Commercial Production

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Māmaki (*Pipturus albidus*) is an endemic plant to Hawai`i which can be found in the understory of native forest from sea level to elevations up to 6,000 feet (Wagner *et al.* 1990). There are four species of *Pipturus* in Hawaii (*P. albidus, P. forbesii*, *P. kauaiensis* and *P. ruber*) (Wagner *et al.* 1990). Hawaiian's used the inner bark of the māmaki plant for tapa or bark cloth (Bishop Museum, 2018). Locher et al. (1995) found that māmaki had anti-viral properties against Herpes Simplex Virus-1 and 2 and Vesicular Stomatitis Virus and inhibited the growth of Staphylococcus aureus and Streptococcus pyogenes. Additionally, other parts of the māmaki plant have many cultural uses for healing different ailments (Table 1).

Table 1. Uses of Different Plant Parts of Māmaki

Plant Part	Use	Source
Bark, leaves, stems	Medicine for loss of strength, blood purification, laxative, and for expecting mothers	Hilgenkamp & Pescaia 2003
Fruit	Thrush (`ea), latent childhood disease (pa`ao`ao)	Chun 1994
Leaves (fresh or dried)	Tea used for general "run down" conditions, debility, and "cleansing agent"	Abbott 1992; Krauss 1993; Krauss 2001

Karita et al. (2007) found that there are three major polyphenols (phyto-chemicals) in māmaki leaves which are: catechins, chlorogenic acid, and rutin; a flavonoid (plant compound) found in the polyphenol family. Concentrations of catechins and rutin in māmaki leaves were found to be higher than commercial tea leaves such as Gyokuro green tea leaves, Chinese oolong tea leaves, and Kenya black tea leaves (Karita et al., 2007).

There has been a recent surge in consumer interest and a growing (local and export) market for māmaki. To safeguard māmaki growing in the native forest system, this project focuses on finding ways to grow māmaki commercially to meet market demands while minimizing over exploitations of resources.

Propagation

Māmaki fruit are white to translucent with small brown seeds. Seeds are an efficient way to propagate new plants, however, each plant may be genetically different from its parents. Māmaki fruit can be planted whole or mashed and sprinkled over a tray of moist growing medium. Seeds typically germinate 2-4 weeks after sowing. Due to the high mortality rate of māmaki plants per growers' testimonials, we transported newly emerged seedlings into Ray Leach "cone-tainers" or T.O. Plastics Sure Root Plug Trays (Stuewe & Sons) which prevent roots from circulating. A month after transplanting the newly emerged seedlings, the plants are ready for field planting. Our attempts at direct seeding māmaki into the ground has not been successful to date. Prior to using the anti-circulating tubes and containers, seedlings were transplanted into 8-12" round pots. Utilization of the anti-circling tubes and trays have increased transplant success rate by 90-95%.

Photo 1. From seed to non-circulating seedling tubes

Photo 2. Seedlings are transplanted into non-circulating Ray Leach “cone-tainers” or T.O. Plastics Sure Root Plug Trays (Stuewe & Sons)

Māmaki can also be vegetative (asexually) propagated with 4-6-inch-long cuttings (Bornhorst, 1996). We have found that vegetative tip cuttings have a 5% success rate compared to 30% hard or back wood cuttings under a mist system. Utilization of the etiolation technique or stimulating new tissue with darkness was unsuccessful. Plants that are vegetative propagated must be transplanted in a timely manner. Transplants with a strong and vertical root systems have a higher chance of survival than plants initiated in standard round pots. Installing root bound plants will cause the roots to eventually choke the plant to death. The benefits of using cuttings vs. seeds is to safeguard the horticultural characteristics of the parent plant.


Photo 3. Failed attempts at vegetative cuttings and etiolation.

Photo 4. Hardwood cuttings had a higher success rate than tip cuttings. However, mortality of field transplanted cuttings ranged from 90-95% regardless of the cutting length and size.

In general, there is a high mortality rate associated with transplanting māmaki. The root system is often compromised before planting. The adoption of Ray Leach "cone-tainers," T.O. Plastics Sure Root Plug Trays or larger Mini-Treepots ™ (Stuewe & Sons) helps to reduce transplant mortality issues. However, mortality is also associated with pathogen such as *Rhizoctonia, Phytophthora and Pythium* (personal communication with ADSC, 2016). Planting media that retains moisture such as peat, vermiculite, etc. should be avoided in media mixes or discarded at planting to avoid creating favorable growing conditions for root rot pathogens.

Photo 5. Seedlings planted in circular pots produce root bound transplants at the Poamoho Research Station. Planting in a timely manner is important for long term success.

Pruning
Māmaki is extremely vulnerable to pruning. Twig borer infestation and secondary infections often occur after pruning. Pruning should be minimized, but if pruning is necessary, utilization of a pruning seal should be considered.

Photo 6. Twig borers invade the tissue of māmaki trees and can cause plant death.

Shade
Māmaki grows on the edges and understory of mesic forests on all islands with the exception of Kaho`olawe and Ni`ihau (Wagner *et al.* 1990). To meet the growing demand for māmaki for the local and export market, an alternative cropping system for commercial production in low land areas is being evaluated. Developing an alternative cropping system may help to reduce the overexploitation of māmaki being grown in our forest systems and destruction of surrounding resources. In general, māmaki grown outside of the estimated ranges by USGS (Photo 8) has a difficult time overcoming the extreme temperatures and conditions (Photo 7).

Photo 7. Healthy māmaki (left) vs. heat stressed māmaki (right)

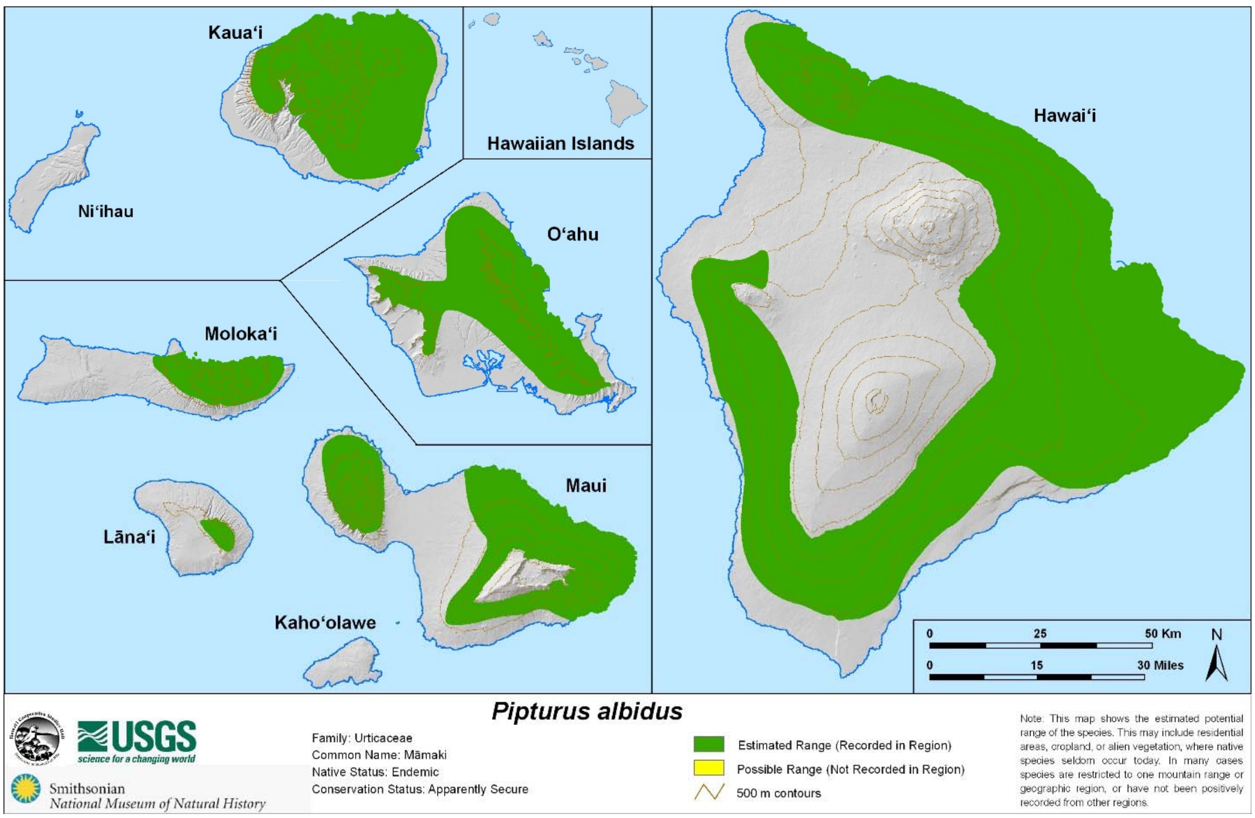

Photo 8. USGS map of māmaki distribution in Hawaii (USGS)

We are currently evaluating an agroforesty approach to provide shade for māmaki when grown outside of its natural forest habitat. Planting of unrooted, cuttings of seedless *Leucaena spp. and Gliricidia* (*Gliricidia sepium)* were installed in April 2018 at the Waimanalo Research Station. Initial field evaluations indicated that the infield planting of *Leucaena* cuttings were not compatible with our proposed cropping systems. Heavy and unexpected rains in April 2018 caused 100% of the *Leucaena* cuttings material to rot and deteriorate. The success rate of *Gliricidia* cuttings (Photo 9) was 5% during this same time period.

Photo 9. Infield plantings of unrooted *Gliricidia* cuttings.

Evaluation of *Moringa oleifera* cuttings were conducted at two university research stations with different soil types. Radovich (personal communication, 2018) found the success rate of *Moringa oleifera* to be 10-50% when vegetative propagated via cuttings. Despite using older vegetative material, we have not been able to successfully propagate unrooted *Moringa oleifera* in the field as well. While air laying is an option for *Moringa, Gliricidia and Leucaena,* we are ultimately, looking for an agricultural crop that can root easily via infield establishment (planted along drip line between māmaki plants) and provide adequate shade for the māmaki plants for a minimum of two years or until productivity declines. Mulberry (*Morus nigra*) and panax (*Polyscias guilfoylei*) are currently being evaluated as an inline and border shading system (Photo 10). Previous work with panax and mulberry suggests that both crops root easily in moist soils. One inch cutting materials were treated with Hormodin (0.8% IBA) and directly planted between māmaki plants with varied plant spacing.

Photo 10. In Field Border Planting (left) and inline cuttings (right).

Observations from previous field trials using EZ Corner pipes and shade cloth suggest that the productivity and the quality of māmaki leaves were higher when grown under shade vs full sun (Photo 11). Affordability and practicality are concerns with using man-made shading systems. For the interim, a short term and fast-growing cover crop, Sunn Hemp (*Crotalaria juncea*), was used to provide initial shade for newly transplanted plants (Photo 12). Establishing trees prior to transplanting māmaki may provide an agroforestry environment which plants may also acclimate faster to.

Photo 11. Artificial and plant based shading systems being evaluated

Photo 12. Temporary plant based shading system is being evaluated at the Waimanalo & Poamoho Research Stations

With more time, our goal is to find a suitable inline crop to create an adaptable environment for commercial māmaki production. Future work includes evaluating the area of shade provided by Mulberry and panax and developing recommendations on plant spacing for optimal performance.

Harvest

Under cool and shaded conditions māmaki can be harvested as early as 2.5-4 months after transplant. Māmaki can be harvested for 2-3 years but lose vigor over time. Termite and twig borer damage cause premature plant death if not properly managed. Crop yield and productivity will be monitored, tabulated and reported in a future Hanai`ai submission.

Photo 13. Under ideal growing conditions, mature leaves can be harvested 2.5-4 months after transplanting.

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