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Meisner, a Coffee Rootstock Selection with Increased Tolerance to the Kona Coffee Root-Knot Nematode

Background

On the Big Island of Hawai'i, the Kona coffee root-knot nematode (*Meloidogyne konaensis*), or CRKN, is a serious root pest that affects the majority of coffee farms in Kona [11] causing tree wilt, decline, dieback, yield loss, and ultimately tree death as a result of parasitic feeding on coffee tree roots. This nematode also infests plantations in the Ka'ū district. While it has not yet been found in Hilo or Hāmākua, or on the other Hawaiian Islands, it could easily be introduced via infested soil and plant roots; therefore, prevention is key. The only chemical nematicides currently available for use by Hawai'i producers provide limited nematode suppression, so grafting susceptible varieties onto nematode-tolerant or -resistant rootstocks is the only long-term practical solution, once CRKN is established.

Figure 1. Marc Meisner played a key role in selecting the coffee rootstocks that bear his name. *Aloha Marc, we are forever grateful to you!*

'Meisner' is the common name being given to two accessions (trees) of a variety of *Coffea liberica* selected by the University of Hawai'i at Mānoa's College of Tropical Agriculture and Human Resources (UH-CTAHR) for use as a CRKN-tolerant rootstock. The seeds were obtained from the Instituto Agronômico de Campinas' coffee research program in Brazil and planted over 50 years ago. They continue to thrive at the UH-CTAHR Kona Research Station in the presence of CRKN. These trees have previously been referred to as *Coffea liberica 'Arnoldiana'* [10].

These two accessions are being named in honor of Mr. Marc Meisner (Figure 1), who after 37 years of service, retired in 2018 as Farm Foreman of the Kona Research Station. Through the years, Marc assisted many of Hawai'i's scientists with their research on coffee, macadamia nut, taro other root crops, and tropical fruits. He made significant contributions to the study of the Kona coffee root-knot nematode, which have continued through collaborations and partnerships between researchers and producers.

Located in Kainaliu on the Big Island of Hawai'i, the Kona Research Station is known for its coffee research. A large germplasm collection of more than 30 species and varieties of coffee, including *C. liberica* 'Arnoldiana', was originally acquired from Central and South America in the 1950's and 1960s by Dr. Richard Hamilton, Edward T. Fukunaga, and other UH researchers, and established at the station.

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In the following years, Dr. Phillip Ito utilized germplasm from Dr. Hamilton's collection to initiate rootstock trials and research a coffee replant problem, which is now known to be caused by CRKN. With the tremendous support of Marc and other station staff, nematode studies continued through the 1990s with Dr. Donald Schmitt's research on identifying CRKN and its management strategies, including grafting with nematode-tolerant or -resistant rootstocks.

While much of the germplasm has been lost, some of those remaining varieties show high tolerance or resistance to CRKN; one called 'Fukunaga' (*C. liberica* var. *dewevrei*) was released by UH-CTAHR as a CRKN-tolerant rootstock in 2001 [3]. A critical aspect of using these rootstocks is the ability to successfully graft desirable scions onto the rootstock. Marc's knowledge and skills of grafting have been passed down to research station staff, UH-CTAHR extension agents, and producers such as Kraig Lee, who credits Marc, Dr. Mario Serracin, and Dr. Schmitt in a Fall/Winter 2001-2002 *Coffee Times* article [7] for their research in grafting coffee plants. This article showcased the 2000 Kona Coffee Cultural Festival cupping competition winner, Heavenly Hawaiian Farms, which entered green beans from coffee grafted onto 'Fukunaga' rootstock. 'Fukunaga' was also cared for by Marc and station staff, as it is a part of the Kona Station's germplasm repository.

Figure 2. Marc and Nick pulping cherry or ripe coffee fruits from the long-term CRKN plot. Trees were harvested and data collected by individual trees according to the number of rootstocks and how the trial was set up.

Research on 'Meisner'

In 2005, Dr. Scot Nelson, Virginia Easton-Smith, and Marc initiated a long-term field study to evaluate coffee rootstocks for the management of CRKN. This project also took place at the Kona Research Station, where the rootstock seeds were gathered from the existing germplasm collection. Marc was invaluable in the preparation and grafting of these seedlings in 2005, their field establishment in 2006, field maintenance, and data collection during the 2007/08 harvest season. Throughout the CRKN field trial, the plot was maintained by Marc and station staff. Without this sustained care, the excellent CRKN tolerance level of 'Meisner' would likely not have been revealed or published.

At the strong encouragement of Marc, the authors and fellow UH-CTAHR staff restarted efforts in 2015 to collect data from this trial. Subsequently, UH-CTAHR faculty and staff (Figure 2), USDA ARS DKI PBARC researchers and technicians, and nearly a dozen volunteers put in countless hours of hand picking, bagging, weighing, counting, wet and dry processing, and sorting coffee. This 13-year comparison of rootstocks is the longest known *M. konaensis* research trial in the world; other research of CRKN at the Kona Research Station is ongoing.

In 2015, the plot was stumped to manage the Coffee Berry Borer (*Hypothenemus hampei*), a beetle pest discovered in Kona in 2010; data collection began a year later. Results [9] from the 2016/2017, 2017/2018, and 2018/2019 seasons demonstrated 'Meisner' (published as 'Arnoldiana') rootstock to have higher yields of coffee cherry, greater plant vigor, and excellent tree survivability when compared to nongrafted 'Kona Typica' and 'Kona Typica' grafted onto other rootstocks, including *C. canephora* 'Nemaya' and 'Apoata' (also known as robusta coffee), *C. arabica* 'Purpurescens', and two accessions of 'Fukunaga'. On average, three-year old verticals on 'Meisner 1' and 'Meisner 2' rootstock with second year crop produced 20.0 pounds to nearly 24.0 pounds of cherry per grafted tree. In the 2017-2018 season, 'Meisner' outproduced the state's [13] average coffee cherry yield of 3,530 lbs/acre by an estimated four times. One hundred percent of 'Meisner' grafted trees remained alive 13 years after planting; whereas 81% of the nongrafted 'Kona Typica' trees had perished. For farmers, zero tree losses equates to no replant costs and greater yield and revenue over time. All of the 'Meisner' grafted trees planted in 2006 continue to produce coffee to the present day (2024).

Table 1. Comparison of 'Meisner' to other rootstocks grafted with 'Kona Typica' scion and non-grafted 'Kona Typica' for Marketable Green Bean Recovery Ratio (MGBRR) and blind cuppings.

		Blind Cupping Quality Score	
Rootstock	**MGBRR of #1, Fancy & Extra Fancy, 2018**	**2018**	**2020**
Fukunaga #1	6.85	81	-
Fukunaga #2	6.54	83.75	-
Meisner (Arnoldiana) #1	6.39	83.25	81.13**
Meisner (Arnoldiana) #2	6.67	83.5	
Apoata	7.24	83.25	-
Nemaya	6.59	81.75	-
Purpurescens	6.61	83.5	-
Kona Typica (control)*	7.96	83.5	80.54***

*Cherry harvested from a farm in Hōnaunau, Big Island. There was a lack of fruit on the research plot's non-grafted 'Kona Typica' trees due to dieback and damages caused by CRKN.
**Average of six scores from three lots (2 scores each) of 'Kona Typica' on 'Meisner' rootstock.
***Average of six scores from one lot each of A) color break fruit only, B) 1/2 color break and 1/2 ripe fruit, and C) ripe fruit only from non-grafted 'Kona Typica'. Two scores per lot.

In addition to superior growth, productivity, and longevity, the quality of 'Kona Typica' coffee produced on 'Meisner' rootstock was compared to the other rootstocks and non-grafted 'Kona Typica' in 2018 (Table 1). A blind cupping of 'Kona Typica' grafted on 'Meisner' and 'Kona Typica' seedlings was also conducted in 2020. The cupping scores were similar among rootstocks, demonstrating that grafting on 'Meisner' did not diminish the quality of coffee produced by the scion. When compared to other rootstocks in the study, coffee grafted onto 'Meisner' also had a similar marketable green bean recovery ratio [2] of approximately 6.5 lbs of cherry to 1.0 lb of #1, Fancy, and Extra Fancy green beans.

Description of 'Meisner'

There is some confusion as to the botanical identification of the *C. liberica* trees grown at the Kona Research Station. According to Davis et al. [4], *C. arnoldiana* De Wild is a synonym of *C. liberica* Bull. ex Hiern var. *dewevrei* (De Wild. & T. Durand) Lebrun that was originally collected in the Belgian Congo in Central Africa. In the collection that was brought to Kona, historical maps identify these trees as *C. liberica* Arnoldiana (now named 'Meisner') and *C. dewevrei* (named 'Fukunaga'). We continue to use these names until future genetic research can confirm their botanical nomenclature.

In general, *C. liberica* coffee [5] can grow in warm, lowland environments and is thought to have pest and disease resistance and drought tolerance. These coffees carry the SH3 resistance factor [12] for coffee leaf rust caused by the fungus, *Hemileia vastatrix*. Rust resistance is observed in 'Meisner' and 'Fukunaga' grown at the Kona Research Station.

Unlike *C. arabica*, the primary species produced in Hawai'i, the *C. liberica* and *C. dewevrei* accessions show relatively high genetic diversity. This is observed in the physical characteristics of the two accessions of 'Meisner'. 'Meisner 1' has slightly smaller flowers and a smaller flower scar on the fruit; larger, heart-shaped versus round fruits; and leaves that are slightly larger than 'Meisner 2'.

Overall, 'Meisner' has large, white blossoms (Figure 3) up to 1.75 inches in diameter with 5 petals, 5 stamens, and one pistil. At the Kona Research Station,

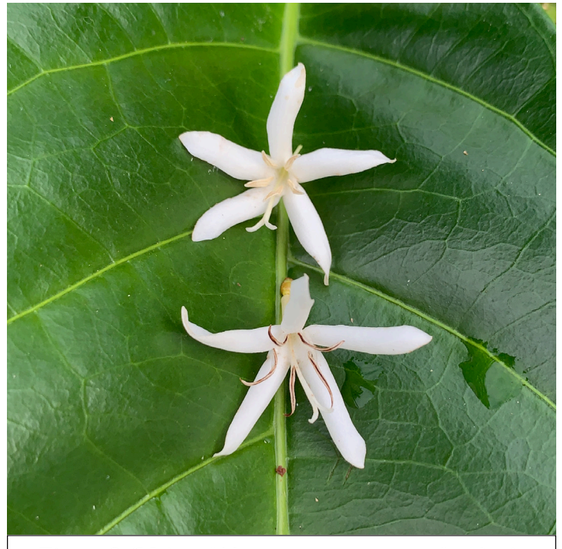

Figure 3. 'Meisner' blossoms at two stages of anthesis or opening: (top) recently opened and (bottom) several hours old, noted by the browning of the stamens. At the Kona Research Station, fruiting occurs year-round, with peaks in late summer.

there typically are several flowerings in a year. 'Meisner' fruit clusters (Figure 4) are dense and tight, making picking somewhat challenging. The average fruit or cherry (Figure 5) is dime-sized (0.6 × 0.52 × 0.57 inches) and weighs about 0.07 ounces*, although peaberries (which have just one seed) are slightly smaller. The leaves are thick, large (up to 17.0 in long and 9.8 in wide) (Figures 6 and 7) and start off bronze in color, then change to a light- and then dark-green color when mature. Leaves are borne opposite on the branch and have pinnate venation. When fully established, 'Meisner' is a large, robust tree (Figure 8) that easily grows to 15 feet in height or taller. Trees should be aggressively pruned for ease of harvest, as the verticals do not bend easily. These trees have an extensive root system (Figure 9) that tolerates root damage caused by CRKN; hence, it is an ideal rootstock for nematode-infested soils.

Figure 4. Immature fruit of 'Meisner' along with developing flower bud clusters in the foreground. As fruit grow and mature, clusters are packed even more tightly.

Figure 5. Ripe coffee fruit from 50+ year old 'Meisner' trees at the Kona Research Station. Fruits are often misshapen from growing in dense clusters.

Fruiting can occur with just one tree, but seed production on 'Meisner' is best with two or more trees growing in close proximity for cross-pollination to occur. Fruit ripening happens nearly year-round in Kona with peak harvests taking place from August to September. Davis et. al. [5] mentions *C. liberica* var. *dewevrei* (excelsa coffee) having potential as a commercial crop but 'Meisner' has not yet been cupped and so its use is recommended as a rootstock only. The cherries should be freshly pulped, fermented overnight, washed, and then sown to optimize seed germination. Sprouting can take up to several months but once germinated, the seedlings can be grafted [1,9] using the "Reyna Method" (cleft graft) or a splice graft.

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*value corrected 12.30.2024

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Figure 6. Young, bronze-colored leaves and older, green leaves of 'Meisner'.

Figure 7. A visual comparison of the larger, deeply veined 'Meisner' (left) leaves and smaller, corrugated-edged 'Kona Typica' (right) leaves.

Figure 8. 14-foot tall 'Meisner' trees planted in 2020. These trees are difficult to bend so will likely be pruned to allow harvest without the use of ladders.

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Figure 9. (left) 15-year-old 'Meisner' seedling trees being removed from the field. Note the 1½ -inch lateral roots that had to be sawed before the tree stumps could be pulled out of the ground. Chains and a large truck were required to uproot the trees. (right) In comparison, most ungrafted 'Kona Typicas' (left tree) died before 15 years. Those surviving were severely damaged and did not have the vigor of 'Meisner'.

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