College of Tropical Agriculture
and Human Resources
University of Hawai‘i at Mānoa

New Plants for Hawai‘i
January 2017
NPH-16

Reflective Guide to Growing Olives for Oil Production in Hawai‘i

Susan C. Miyasaka[1], Randall T. Hamasaki[2], and Russell T. Nagata[3]
[1]Tropical Plant and Soil Sciences, [2]Plant and Environmental Protection Sciences,
[3]Formerly with Komohana Agriculture Research and Extension Center, Hilo, HI

All of the economically important crops grown in Hawai‘i are native to other areas of the world and were selected and adapted to perform well in the Hawaiian environment. This introduction of new crops to Hawai‘i has been ongoing ever since humans have been migrating to these islands. While olives (*Olea europaea* L.) have been grown in Hawai‘i's gardens for more than a century, it has only been in the past decade or two that growing olives commercially has been seriously considered.

The potential exists for high-quality, high-value, vintage boutique olive oil grown and produced in Hawai‘i. Demand for olive oil worldwide is growing due to its reputed health benefits. For example, olive oil has been reported to have a protective effect against coronary heart disease, various cancers, and age-related cognitive decline due to its high content of monounsaturated fatty acids and polyphenols (Dag et al. 2009). The following is a reflective guide to growing olives in Hawai‘i to produce oil; however, much of the information could be applied to growing olives for pickling.

Selection of planting site. Olives are native to the dry, arid region of the eastern Mediterranean and are grown throughout the Mediterranean basin (between 30° to 45° N and S of equator). The best production areas are in a sub-tropical climate characterized by mild, rainy winters and long, warm, dry summers.

When considering olives as a crop in Hawai‘i, several important factors, in addition to variety selection, must be evaluated at each growing site: temperature, rainfall pattern, irrigation availability, soil drainage, and wind. While olive trees will grow and thrive in tropical, coastal areas of Hawai‘i, flowering requires the breaking of flower bud dormancy by cold temperatures. The proper chilling requirement, the accumulation of hours below 45 to 54°F (7.2 to 12.2°C), is variety dependent. Areas with freezing temperatures should be avoided, because frost will damage buds, flowers, and young fruit, while even lower temperatures will kill shoots and branches. In Hawai‘i, desirable temperatures are found at upper elevations of the major mountains. However, information about elevation could be misleading, because its effect on temperatures depends on whether the location is on the windward or leeward sides of the islands. Also, microclimate variations must be considered in their entirety to successfully grow olives.

Evaluations of 10 olive varieties (Table 1) were conducted at the Lālāmilo Research Station of University of Hawai‘i at Manoa on Hawai‘i Island [2,700 feet (820 meters) elevation] and at the Maui Agricultural Research Center in Kula, Maui [3,100 feet (945 meters) elevation] (Miyasaka and Hamasaki 2016). Minimum or low air temperatures at Lālāmilo from December 2012 to March 2013 ranged from 47.1 to 63.7°F (8.4 to 17.6°C), and the high or maximum air temperatures ranged from 61.2 to 79.8°F (16.2 to 26.6°C). The following year from December 2013 to February 2014, minimum air temperatures ranged from 47.6 to 62.8°F (8.7 to 17.1°C), and maximum air temperatures ranged from 61.8 to 79.5°F (16.6 to 26.4°C).

At Kula, from December 2014 to March 2015, minimum air temperatures ranged from 44.0 to 61.0°F (6.7 to 16.1°C), and maximum air temperatures ranged from 58.2 to 78.3°F (14.6 to 25.7°C). Air temperatures were approximately 2 to 3 degrees cooler at the Kula station compared to the Lālāmilo station. This slight variation in temperature had significant effects on flowering and fruiting of olives.

Selection of olive varieties. The 10 olive varieties in the two field trials were selected for oil production partly on recommendations by Mr. Paul Vossen, formerly with the University of California, Cooperative Extension, Division of Agriculture and Natural Resources, and partly on plant availability from nurseries in California and Hawai‘i (Table 1). At Lālāmilo, six olive varieties were planted in February 2011 and four varieties were planted in July 2011 at a spacing of 10 feet in single rows along unpaved roads (Figure 1). After planting, mulch was placed around the trees (but away from the trunk) to control weeds. At Kula, the same olive varieties were planted in June 2011, with the exception of ‘Arbequina’, which was planted in July 2012.

At the Lālāmilo station, flowers were observed on ‘Arbequina’, ‘Arbosana’, and ‘Koroneiki’ during March to April 2013, 2014, and 2015 (Figure 2). The other seven varieties did not flower or produce fruit consistently during 2013 to 2015, perhaps indicating that their requirement for chilling hours was greater than the three fruiting varieties at this location. The same trees did not flower and produce fruit each year. These results were not surprising, because olives are well known to be alternate bearing (Martin et al. 2005). At the Kula station, all olive

Table 1. Olive varieties tested, their country of origin, and source of planting materials

Variety	Country of Origin	Nursery*
‘Arbequina’	Spain	Kealakekua Bay Farm Mgt.
‘Arbosana’	Spain	Duarte
‘Coratina’	Italy	McEvoy
‘Frantoio’	Italy	Duarte
‘Koroneiki’	Greece	Duarte
‘Leccino’	Italy	Duarte
‘Mission’	California	Duarte
‘Moraiolo’	Italy	McEvoy
‘Pendolino’	Italy	McEvoy
‘Taggiasca’	Italy	McEvoy

***Duarte Nursery, Hughson, CA; Kealakekua Bay Farm Mgt., Kailua-Kona, HI; McEvoy Ranch, Petaluma, CA**

Figure 1. ‘Arbequina’ olive plants from a local nursery being planted at the Lālāmilo Research Station in February 2011. The olive plant is shown in a seedling container that was removed prior to planting.

varieties flowered and set fruit in Kula in 2015 except for ‘Moraiolo’. The cooler temperatures found at Kula were likely responsible for breaking flower bud dormancy in nine out of 10 olive varieties.

Rainfall requirement and irrigation. Although olives thrive in an arid climate, irrigation must be considered. It is especially important for young trees to produce early crops and for older trees to consistently achieve economic yields of high-quality fruit. Well-timed application of water leads to crop uniformity and superior quality of the resulting oil. As mentioned previously, olives do well in a climate with rainy winters when the plant is in semi-dormancy. Rainfall during flowering will reduce fruit set due to poor pollination and disease. Also, rain during the harvest may result in less oil of lower quality.

Application of irrigation is necessary to supplement the water supplied by natural rainfall to meet the needs of the plant. In Hawai‘i, olive trees have been known to naturalize on Hawai‘i Island in dry areas with about 50 to 75 inches of rainfall per year (Wagner et al. 1990). The Lālāmilo station has a mean annual rainfall of 28.7 inches (729.4 mm), while Kula station has a mean annual rainfall of 26.2 inches (665.4 mm) (Giambelluca et al. 2013).

Soil characteristics, such as water-holding capacity or hardpan, will influence the necessary frequency and duration of irrigation. For example, during the first year when supplemental water was needed to insure survival and rapid plant growth, each plant at the Lālāmilo site was irrigated at the rate of one gallon, three times a week after planting, while plants at the Kula site required one gallon, twice per week. Drip irrigation lines were installed at both sites, with one emitter placed approximately 1 foot away from the trunk at the Lālāmilo site and two spot emitters placed approximately 1 foot away from the trunk at the Kula site. The soil at each site was classified as a medial, amorphic, isothermic, humic Haplustand (Ikawa et al. 1985, U.S. Department of Agriculture and University of California, Davis 2016). This volcanic ash soil is considered to be “light soil,” hence well drained, thus needing shorter-duration and more frequent irrigations than a heavier dense soil with a higher water-holding capacity. After plants were well rooted and set at the Lālāmilo site, irrigation was scheduled for once per week to avoid pythium root rot (*Pythium* spp.) and salt damage (Miyasaka and Hamasaki 2012). As the plants grew, the amount of irrigation was increased accordingly. At Lālāmilo, the irrigation rate was changed to 3 gallons per tree applied once per week in February 2012. Irrigation was turned off January 2014 and resumed May 2014. A second emitter was placed 12 inches away from the trunk for the three varieties that flowered and fruited, resulting in a doubling of irrigation rate for these trees. At the Kula site during the second year, irrigation was applied at the rate of 4.2 gallons/tree twice per week using multi-drip emitters. Due to heavy fruit set in 2015, irrigation was increased to 10.4 gallons/tree per week starting August 2015.

Figure 2. Olive flowers at the Lālāmilo Research Station in April 2013.

Wind protection. The Lālāmilo station is in a windy area located between two mountain ranges (Mauna Kea and Kohala). According to the National Renewable Energy Laboratory (True Wind Solutions and NREL 2015), wind speeds at Lālāmilo station at 50 m height ranged from 16.8 to 19.7 mph. This is an excellent to outstanding resource for wind power, but could be damaging to young trees even when they are staked. To protect young plants from wind damage, wind screens were constructed from 47% shade cloth placed around a wire cage three feet in diameter (Figure 3). A T-post was installed next to each planted tree for additional support and to retain the cage in place. Weed mat, for weed control, was placed with a hole cut in the middle for the tree trunk. After about 14 months, the wind guards were removed from most of the trees, except for small trees that did not reach the tops of cages. The Maui Agricultural Research Center at Kula

Figure 3. Shade cloth cage constructed to shelter young olive plants at Lālāmilo.

Figure 4. Olive trees at Lālāmilo station on November 2012, at 21 months after planting.

is located on the leeward side of Maui Island and wind speed is low, ranging from 0 to 12.5 mph (True Wind Solutions and NREL 2015), and no wind-protection guards were needed.

Fertilization. Proper fertilization for olives is critical to achieving good growth, although in general, olives do better in less fertile soils than other tree crops. High soil fertility, especially nitrogen, is undesirable during fruit production due to its promotion of excessive shoot development and development of many small fruit. The best way to evaluate plant nutrient needs is through plant tissue analysis (Miyasaka and Hamasaki 2012).

The only time when high fertility is desirable is during early planting and orchard development, when rapid growth is desired. At planting, fertilization practices at Lālāmilo included the following: February 2011, trees were fertilized, with 3.5 ounces (100 g) of slow-release fertilizer (Apex16N-2.6P-9.1K, release rate of 7–8 months at 70°F, J.R. Simplot Co., Lathrop, CA) placed in a ring at an approximately 6-inch radius from each tree trunk. In October 2011, trees were fertilized with the same amount of fertilizer immediately next to the tree trunk, with the fertilizer inserted through the hole in the weed mat. In January 2012, due to concerns about high salinity, this fertilizer was removed. Then, in March 2012, another slow-release fertilizer was applied at 3.5 ounces per tree (Nutricote 13N-5.7P-10.8K, Sun Gro Horticulture) at a radius of 2 feet away from tree trunks, outside the weed mat. This was followed by additional applications during August 2013 and May 2014 consisting of 3.5 ounces per tree of slow-release fertilizer (Apex 12-1.7P-10.0K, release rate 3–4 months at 70°F). On these dates, soluble Mg fertilizer (K Mag 0N-0P-22K-10.8Mg; Mosaic Co., Plymouth, MN) and soluble calcium (Ca) fertilizer (gypsum 0N-0P-0K-22Ca) were also applied outside the weed mat. At Kula, trees were fertilized twice per year, during spring and summer, each time with 3.5 ounces of slow-release fertilizer (Apex 16N-2.6P-9.1K).

Proper irrigation and fertilizer practices can lead to rapid tree growth during the trees' development stage. At Lālāmilo trees averaged 7 feet (2.1 meters) in height and the diameter of the trunk averaged 1.8 inches (4.6 centimeters) at 4 inches (10 centimeters) above the ground level at 17–22 months after being transplanted (Figure 4). For the trees planted at Kula, heights and basal diameters of trees at 18 months after planting (with the exception of ‘Arbequina’) were similar to those grown at Lālāmilo, Hawai‘i Island, at 17–22 months after planting.

Pest management. Olives so far have few pests in Hawai‘i. At Lālāmilo, fuller rose beetles (*Naupactus cervinus*) were observed to damage young olive leaves during 2011. These are flightless, nocturnal beetles that feed on leaves, causing notching of leaf margins (Figure 5). No chemical treatments were instituted for this pest due to low levels of economic damage.

During 2014 and 2015, ash whitefly (*Siphoninus*

Figure 5. Fuller rose beetle damage on young olives at Lālāmilo.

Figure 6. Ash whiteflies on underside of olive foliage. Photo credit, J.B. Friday.

phillyreae) was observed to infest the olive trees at Lālāmilo (Figure 6). Insect growth regulators pyriproxifen (Knack, Valent U.S.A. Corp., Walnut Creek, CA) and buprofezin (Applaud, Nichino America, Inc., Wilmington, DE) were applied according to the label in August 2015 and September 2015, respectively.

Pruning. There are different philosophies about pruning olive trees. The ultimate goals in pruning are to train individual trees to aid in ease of harvesting and to improve fruit yield and quality. During the first two years, trees were pruned to a single main trunk for the first 2 to 3 feet of height. To prevent wind damage, each tree was secured to a T-post. Then we followed the recommendations of Mr. Paul Vossen to achieve an open vase shape, allowing maximum light penetration into the tree canopy. Approximately four main scaffold branches were selected, and the other branches were removed (Figure 7). As multiple new sprouts grew after pruning, most were removed. Pruning to control tree height, in which individual branches were removed, was conducted on an as-needed basis. It must be kept in mind that olives will flower and fruit on second-year wood.

Figure 7. Olive trees pruned to produce an open center and approximately 4 main scaffold branches.

Harvesting. The best time to harvest fruit for oil is determined according to a maturity index (MI) based on fruit color (Figure 8 and Table 2). Depending on the variety and desired flavor characteristics of the oil, a fruit MI between 2.5 to 4.5 is used (Vossen 2005). Experience will be the best guide in determining the best MI for your particular location. At Lālāmilo station, we found that high winds can cause olive fruits to fall off trees as they mature. As a result, we harvest in early October each year. At Kula, high winds are not a problem, and olive harvests can occur over a longer period of time.

Olive fruiting and yields varied between the Lālāmilo and Kula sites. In once-over harvesting of fruit from individual trees at Lālāmilo in October 2013, only 'Arbequina', 'Arbosana', and 'Koroneiki' trees (Figure 9) were found to have sufficient fruit for harvest (Table 3). In

Figure 8. Maturity index (MI) for olive ripeness.

Table 2. Maturity Index for Olive Ripeness

0	deep green color
1	yellow or yellow-green skin color
2	yellow-green with less than ½ of fruit with reddish spots and violet skin color
3	red to purple skin color on more than ½ of fruit
4	light purple to black skin color with white-green flesh color
5	black skin color and violet flesh color less than ½ way to the pit
6	black skin color and violet flesh color almost to the pit
7	black skin color and dark flesh color all the way to the pit

October 2014, ‘Arbequina’, ‘Arbosana’, and ‘Koroneiki’ again produced fruit and were harvested in a one-time harvest. In each of these two years, only about half of the 10 trees of each variety had yields that warranted harvesting. In October 2015, only two trees each of ‘Arbequina’, ‘Arbosana’, and ‘Koroneiki’ produced fruit and were harvested. Yields were lower in 2015 due to a substantial number of fruit dropping prior to the harvest that year; as a result, fruit weights are not reported here. In each of these years, not all trees produced fruits in sufficient quantities to justify harvesting, and yield of these trees was recorded as zero. Fresh weight of fruit per tree was determined, and then 100 representative fruit were graded for color according to the maturity standard (Tables 2, 3; Vossen 2005). The other seven varieties grown at Lālāmilo did not produce any fruit or produced in such low numbers that harvesting was not done. For individual trees, yields were averaged across 2 years (2013 and 2014; Table 3) due to the known alternate-bearing characteristics of olives (Martin et al. 2005).

No difference among the three harvested varieties was found in fruit yields averaged over 2 years (2013 and 2014; Table 3). Average fresh fruit yields ranged from 4.7 to 5.4 pounds/tree (2.14 to 2.45 kg/tree) for trees grown at Lālāmilo. These yields were low compared to yields reported for ‘Arbequina’, ‘Arbosana’, and ‘Koroneiki’ three years after planting in Spain, which were 18.6, 19.2, and 23.2 pounds/tree (8.43, 8.69, and 10.50 kg/tree), respectively (De la Rosa et al. 2007).

‘Arbosana’ had a low mean fruit maturity index (MI) in 2013 (Table 3), due to fruit from two trees that were much greener than those of the other three trees of the same variety. This index should be between 2.5 to 4.5 (Vossen 2005) for most varieties. One possible explana-

Figure 9. Left to right: 'Arbequina', 'Arbosana', and 'Koroneiki' fruits at Kula on 25 September 2015. These varieties produce small-sized fruits most suitable for oil production.

tion for this low fruit MI is a second flowering; we have observed flowering in the presence of developing fruit similar to that reported by Malik and Bradford (2006). In 2015, we harvested later in October in an attempt to increase fruit MI; however, we found that mature fruit fell off trees in large quantities, and as a result usable harvest data was not collected. Perhaps the windy conditions in Lālāmilo resulted in mature fruit falling more readily off trees, making it difficult to increase fruit MI through later harvests.

At the Kula location, all olive varieties flowered and set fruit in 2015, except for 'Moraiolo'. No significant differences in fresh weight fruit yield per tree were found among varieties, with yields ranging from a high of 48.5 pounds/tree (22.1 kg/tree) for 'Koroneiki' to a low of 0.6 pounds/tree (0.25 kg/tree) for 'Arbequina'. This lack of significant differences among varieties was probably due to high variability, since only two trees were planted per variety. For example, one tree of 'Leccino' yielded 3.4 pounds (1.52 kg) fresh weight, whereas the second tree of 'Leccino' had a yield of 32.8 pounds (14.86 kg), almost 10 times greater. One olive variety, 'Mission', produced large-sized fruit suitable for pickling or canning.

Of the three varieties that produced fruit at Lālāmilo, 'Arbosana' and 'Koroneiki' produced much higher yields at Kula (Figure 10), whereas 'Arbequina' produced lower yields at Kula, probably due to its being a year younger (Table 3). Fresh fruit yields of 'Arbosana' and 'Koroneiki' at Kula were within the range of yields of the same varieties grown for 3 years after planting in Spain (De la Rosa et al. 2007).

Figure 10. Heavy fruit set on 'Koroneiki' tree at Kula, Maui

Fruit were processed for olive oil immediately after harvest. Cooperator Douglas McKanna used a modified version of an olive oil press (First Press home olive oil press, The Olive Oil Source, Santa Ynez, CA) (Figure 11). Olive oil was shipped immediately in 2013 to the Univer-

Table 3. Average fresh weight (FW; lbs) of olive fruit per tree during 2013 and 2014 harvests at Lālāmilo, fruit maturity index (MI) based on color in 2013, and average fresh weight yield in 2015 at Kula (Miyasaka and Hamasaki 2016).

Variety	Lālāmilo 2013 FW, lbs/tree	Lālāmilo 2014 FW, lbs/tree	2013 14 ave. FW, lbs/tree	2013 MI (0 7 scale)	Kula 2015 FW, lbs/tree
‘Arbequina’	3	7.8	5.4	3.5	0.6
‘Arbosana’	7.7	2.7	5.2	2.1	13.3
‘Koroneiki’	3.9	5.6	4.7	3.3	48.5

sity of California Davis (UCD) Olive Center for chemical analysis of free fatty acids (FFA), peroxide value (PV), ultraviolet (UV) absorption for conjugated double bonds, 1, 2-diacylglycerol (DAGs), and pyropheophytins (PPP).

Levels of FFA, PV, UV, DAGs, and PPP in the oil produced from all three of the varieties of fruit harvested at Lālāmilo in 2013 met all analytical criteria for acceptable “extra virgin” olive oil classification (Frankel et al. 2010, U.S. Department of Agriculture, and Australian Olive Association). Oil yield was calculated in 2013 based on 0.91 specific density of olive oil (Vossen 2005), and it ranged from 13 to 24%. An acceptable oil yield for commercial purposes is considered to be 20% or higher (Vossen, 2005).

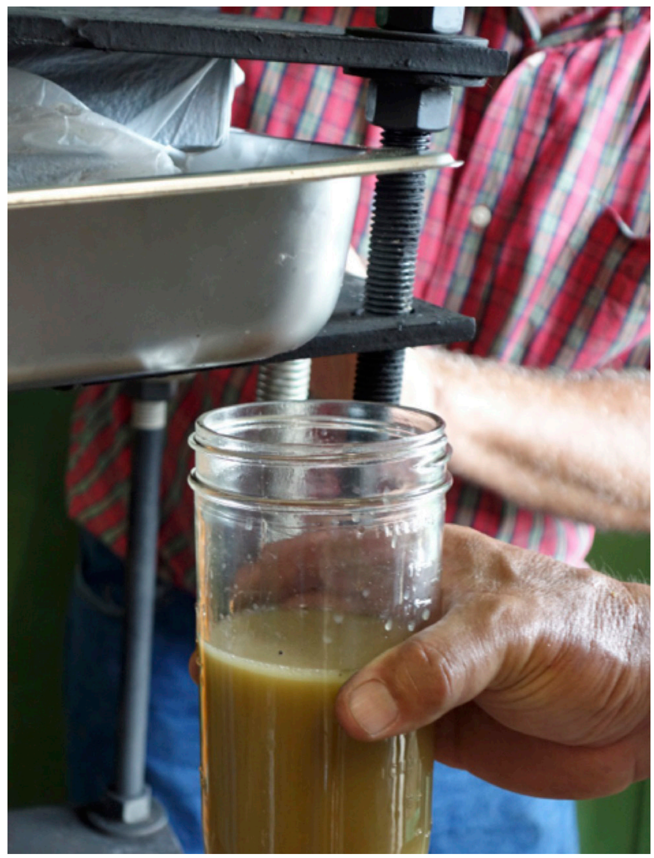

Figure 11. Extracting olive oil using a modified olive oil press.

Conclusions

Based on harvest data from 2013 to 2015, olive varieties ‘Arbequina’, ‘Arbosana’, and ‘Koroneiki’ appear to grow well in the high-elevation agro-environment of Lālāmilo Agricultural Experiment Station in Waimea, Hawai‘i Island (elevation 2700 feet). In 2013, after only 2 years of growth, they flowered, fruited, and produced a high-quality “extra-virgin” olive oil. However, yields of these three varieties at Lālāmilo were low compared to those obtained on similar-aged trees planted in Spain. The lack of flowering and fruit production of the other seven varieties at Lālāmilo could be due to a greater requirement for chilling hours. At Kula, Maui (elevation 3100 feet), all varieties flowered and fruited after three years of growth, except for ‘Moraiolo’. Although only two trees per variety were planted at Kula, much higher yields were recorded here for ‘Koroneiki’ and ‘Arbosana’, perhaps indicating that temperatures at this location were more suitable for breaking flower bud dormancy in these varieties than at Lālāmilo.

There is a need to determine chilling requirements for various olive varieties, so that recommendations for suitable geographic locations for planting of olive orchards in Hawai‘i can be made. In addition, further studies of orchard management in the areas of tissue analysis to determine fertilizer requirements, optimum irrigation, and pruning for improved light interception need to be conducted to maximize olive oil production and quality for promising olive varieties grown in Hawai‘i.

References

Dag, A., E. Ben-David, Z. Kerem, A. Ben-Gal, R. Erel, L. Basheer, and U. Yermiyahu. 2009. Olive oil composition as a function of nitrogen, phosphorus and potassium plant nutrition. *J. Sci. Food Agr.* 89:1871–1878.

De la Rosa, R., L. Leon, N. Guerrero, L. Rallo, and D. Barranco. 2007. Preliminary results of an olive cultivar trial at high density. *Austral. J. Agricultural Res.* 58: 392–395.

Ikawa, H., H.H. Sato, A.K.S. Chang, S. Nakamura, E. Robello, Jr., and S.P. Periaswamy. 1985. Soils of the Hawaii Agricultural Experiment Station, University of Hawaii: Soil survey, laboratory data, and soil descriptions. Univ. Hawai‘i, College Trop. Agr. Human Resources, Honolulu, HI, Res. Ext. Ser. 022.

Frankel, E.N., R.J. Mailer, C.F. Shoemaker, S.C. Wang, and J.D. Flynn. 2010. Report: Tests indicate that imported “extra virgin” olive oil often fails international and USDA standards. Univ. California Davis Olive Center, Davis, CA. 19 Nov. 2013: <http://olivecenter.ucdavis.edu/publications/olive%20oil%20final%20071410%20updated.pdf>.

Giambelluca, T.W., Q. Chen, A.G. Frazier, J.P. Price, Y.-L. Chen, P.-S. Chu, J.K. Eischeid, and D.M. Delparte. 2013. Online Rainfall Atlas of Hawai‘i. *Bull. Amer. Meteor. Soc.* 94, 313–316, doi: 10.1175/BAMS-D-11-00228.1.

Malik, N.S.A. and J.M. Bradford. 2006. Regulation of flowering in ‘Arbequina’ olives under non-chilling conditions: The effect of high daytime temperatures on blooming. *J. Food Agr. Environ.* 4:283–286.

Martin, G.C., L. Ferguson, and G.S. Sibbett. 2005. Flowering, pollination, fruiting, alternate bearing, and abscission, pp. 49–54. In: G.S. Sibbett and L. Ferguson (eds.). Olive Production Manual. Univ. California Agr. Natural Resources, Publ. 3353. Richmond, Calif.

Miyasaka, S.C. and R.T. Hamasaki. 2016. Promising olive cultivars for oil production in Hawaii. *HortTech.* 26:497–506.

Miyasaka, S. and R. Hamasaki. 2012. How extension agents diagnose plant nutrient disorders. EcoLearnIT Reusable Learning Object System. 4 Sept. 2015. <http://ecolearnit.ifas.ufl.edu/viewer.asp?rlo_id=540&final_id=101>.

True Wind Solutions and National Renewable Energy Laboratory. 2004. Hawaii 50 m wind power class. 20 Dec. 2015. <http://www.nrel.gov/gis/data_wind.html>.

U.S. Department of Agriculture and University of California, Davis. 2016. SoilWeb: An online soil survey. 8 Feb. 2016. <http://casoilresource.lawr.ucdavis.edu/gmap/ >.

Vossen, P. 2005. Olive oil production, p. 157–173. In: G.S. Sibbett and L. Ferguson (eds.). Olive Production Manual. Univ. California Agr. and Natural Resources, Publ. 3353. Richmond, Calif.

Wagner, W.L., D.R. Herbst, and S.H. Sohmer. 1990. Manual of the Flowering Plants of Hawaii, Vol. 2. Univ. Hawai‘i Press and Bishop Museum Press, Honolulu, Hawai‘i. pp. 992–994.

Acknowledgements

We acknowledge the funding provided by the Department of Research and Development, County of Hawai‘i. We thank the farm manager (Marla Fergerstrom) at the Mealani Research Station and agricultural technicians (Roy Ishizu, Lori Hasegawa, Leslie Hasegawa, Damien Arruda III, and Mary Kaheiki) at both Mealani and Waiakea Research Stations. In addition, we also thank farm managers and agricultural technicians (David Oka, Pamela Shingaki, Edwin Perez, Glenn Otani, Earl Fujitani, Mark Kubo, Alredo Hernandez, and Lanny Billings) at the Maui Agricultural Research Center for their installation, maintenance, and harvesting of the field trial on Kula, Maui. Finally, we thank volunteer Douglas McKanna for extracting olive oil from the three varieties.

Disclaimer