



The Mango Loa Project: A Comparison of Two High Density Orchard Management Systems for Mangoes

Umi Martin (Umi's Farm; Hawaii Tropical Fruit Growers Association)

Emilie Kirk (UH CTAHR Kauai)

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Hawaii is in the process of reimagining our agricultural industry. We are transitioning from large plantation style agriculture to a smaller diversified agricultural approach. The demand for tropical fruits is growing worldwide and is expected to continue to grow, while Hawaii is becoming a visitor's destination to try some of the best locally grown fruits known around the world. This has given rise to tropical fruits as a legitimate sector with a lot of potential for growth. It is up to Hawaii's tropical fruit growers to capitalize on this growing demand by improving the quality and yields of our fruit production. The Mango Loa Project seeks to determine if high density orchards are a good fit for Hawaii by demonstrating these practices on-farm in Kekaha, Kauai.

The Mango Loa Project originated with the goal of improving the production of mangoes in Hawaii by introducing two new innovative orchard management practices that have been producing great results for tropical fruits around the world: the ultra high density plantation (UHDP) and the open Tatura trellis system.

Orchard Layout	Conventional	UHDP	Open Tatura Trellis
Spacing	25' x 25'	8' x 10'	8' x 15', staggered double row
Density trees/acre	50 trees	450 trees	600 trees
Canopy Height	15'-20'	8'-10'	8'
Years to production	7-10	3-5	3-5

Table 1: Summary of different mango orchard layout characteristics.



Photo 1: Ultra high density mango orchard at 2 years after planting, Kekaha, Kauai.

The ultra high density plantation (UHDP) technique has been trialed many places around the world including Israel, South Africa, and India, but it's hard to pinpoint where or when it originated. This method uses a spacing of 6' x 9' to 10' x 20' with a density anywhere from 200 trees to 670 trees/acre.

For this project a spacing of 8' x 10' was used: 10 rows with 31 trees per row were planted on two thirds of an acre in 2018.

The Open Tatura trellis system was designed in Australia over 30 years ago for growing temperate fruits, but was adapted to tropical fruits in the early 2010's. This system uses a V-shaped double trellis system where wires are used to train the trees in an espalier form. Many different tropical fruits such as mangoes, avocados, guava, soursop, starfruit, figs, durian, lychee, and longan have been successfully grown on trellises.

For this project, five open Tatura trellises were erected: each trellis is 260 feet long with five wires, the bottom wire at 2' and the top wire at 8'. The trees are planted in a staggered double row with 30 trees on each side of the trellis at an 8 foot spacing. This is a total of 300 trees on 5 trellises on half an acre in 2019.



Photo 2: Open Tatura trellis with mangoes shortly after planting, Kekaha, Kauai.

According to the Food and Agriculture Organization, the global average for mango production using the conventional orchard is 3.5 tons/acre. Using best practices and high producing mango varieties, some farms have reported as much as 12 tons/acre. Data on high density orchard production is limited, however, reports for mango production have been 8-15 tons/acre.

High Density Mango Planting vs. Conventional Planting

Advantages	Disadvantages
<ul style="list-style-type: none"> • More efficient use of land, resources, and inputs: maximizes land use and allows the canopy to fill in the empty space quicker, optimizing water distribution through micro irrigation • Increases canopy exposure to sunlight: light interception is credited with the increased fruit production • Shorter time for the orchard to reach maturity • Lower trees: easier to manage trees with only hand tools, easier to observe and treat the canopy for pests and diseases, and easier to harvest • Adaptable on a small scale in backyards, with potted plants, or small farm operations; and on a large scale of thousands of acres • Improves the fruit quality, yield, and the overall production of mango. • The low trees or trellises allow the farmer to cover the trees to protect fruits that are susceptible to fruit flies, bird damage, or sunburn • Protects the trees in severe weather 	<ul style="list-style-type: none"> • Higher initial startup costs for larger operations: higher amount of good quality trees needed, irrigation supplies, the costs of erecting the trellises (an additional \$15,000 per acre) • Low trees and hanging fruits are more easily damaged by feral pigs and birds. This system will not work if the trees cannot be protected from ungulates. • Shorter life span of the orchard: some farms have reported having to remove the orchard after about 15 years, but by then the orchard has made its' return on investment and this is part of the rotation. • Requires intensive pruning and orchard management: laborious and time consuming, requiring tractors and implements to reduce the demand on the workforce



Photo 3: Central leader style espalier on the first 4 wires on one side of the open Tatura trellis.

A successful mango orchard starts with the mango variety. Regardless of the orchard management practices, it is most important to choose a variety that is excellent to begin with. There are thousands of mango varieties throughout the world, yet there is so much variability in each mango that only a small select group have been identified as suitable for the orchard. People's preference for mangoes varies depending on the region, but in Hawaii and the United States, consumers prefer large round mangoes with lots of red, orange, and yellow coloration; fiberless, sweet, with a small seed. As a farmer, we need the mango variety to be a regular yearly producer, have resistance to powdery mildew and anthracnose, as well as other characteristics that make it an ideal cultivar, like drought tolerance, salinity tolerance, compact tree, and good shelf life. Best practices in the orchard will not make a moderate producing mango and excellent producer, so the first step is to choose your varieties wisely.



Photos 4 and 5: Shade cloth draped over the top of open Tatura trellises to protect newly planted trees susceptible to sun burn. This is much easier than protecting each tree individually.



Photo 5: UHDP 'Keitt' tree fruiting in the third year. Note how low and plentiful the fruit is.

So, are high density orchard management systems right for Hawaii? Hawaii has a lot of challenges in producing high quality tropical fruits. We have innumerable pests, high humidity that allows for the proliferation of fungi and bacteria, limited workforce, and high costs for labor, inputs, and land, isolated location, limited population, and all of these things need to be addressed in order to be sustainable. The greatest advantage of the high density orchard is the low trees and the ability to easily observe the canopy. This has become more evident with the recent proliferation of the avocado lace bug, which has been defoliating avocado trees throughout the state, severely impacting fruit production. The old trees that are 30+ feet tall are nearly impossible to treat, and the owners can only look up in horror as all the leaves fall off the tree.

Mangoes need a lot of sunlight and a lot of airflow. The high density orchard systems get great sunlight exposure in the canopy and as a result produce great looking fruit with lots of beautiful colors. The tree spacing for this project was 8' x 10' or about 450 trees per acre. This spacing may be too dense for Hawaii's humidity and may restrict too much airflow. Trees in the UHDP field that were not treated with fungicides had more noticeable damage to the outside of the fruit as well as more anthracnose damage. The location of the farm is on the leeward side of the island, which is hot and dry, so treating for anthracnose is not always necessary. These signs of fruit damage were less noticeable in the trellised field.



Photo 6: Examples of different mangoes with good coloration from proper sunlight exposure.

As a result of these observations and after talking with mango growers in Mexico and Australia, we have started widening out the rows from 10' to 20' and widened the in-row spacing to 10', or about 220 trees/acre. We also oriented the field in the direction of the prevailing winds, or East to West. The primary motivation for widening the spacing is to allow for better airflow through the orchard, more room for maneuvering big equipment,

and more space to work when pruning and harvesting. At the current spacing, there is plenty of room for the lawnmower, but it gets pretty tight towards the end of the harvest.

Both the UHDP and the open Tatura trellis systems have been successful in growing mangoes to this point, however, there is still a lot to observe. I am not able to accurately compare the production of these two systems because different varieties were planted in each field. The UHDP field has more productive varieties ('Keitt', 'Rapoza', 'Manzanillo') than the trellised field, which is mostly 'White Pirie', with one row of 'Keitt' and one row of 'Nom doc mai'. If I compare the 'Keitt' from each field, the trellised field appears more productive, but maybe not enough to offset the added costs of installing the trellises. Also, mangoes do very well as freestanding trees and don't require some of the benefits imparted by the trellises, like shade for sunblock and protection from strong winds. Also, fruit trees that are vigorous, tend to flower once a year, and flowers from the terminal ends as opposed to axillary buds are less suited to the trellis. With that said, as we expand our orchard, we are moving forward with the open Tatura trellis system for other fruits and at this time we have avocados, mountain apples, soursop, and lilikoi on trellises, and guavas soon to follow.

More detailed information can be found at sare.org and on the **Mango Loa Project** YouTube channel [here](#).



Photo 7: UHDP tree showing good fruit set and flowering in the third year after planting.