

## *Avocado, The Fertility Fruit*

by Glenn I. Teves, County Extension Agent  
University of Hawaii, College of Tropical Agriculture and Human Resource,  
Cooperative Extension Service - Molokai

Avocado *Persea americana* is an ancient crop native to Central America and thought to have been around for over 10,000 years when larger prehistoric animals, called mega fauna, roamed the area, swallowing the fruit and spreading avocado seeds around the landscape. After extinction of mega fauna, humans were the main disperser of avocado seeds bringing it into villages and creating orchards.

The name 'avocado' refers to the fruit and is derived from the Aztec Nahuatl word, *ahuacatl* meaning 'testicle'. The name is in reference to the shape of the fruit, which was regarded by the Aztecs as a fertility fruit.



*An unknown winter-spring cultivar with an excellent nutty taste.*

Unlike many European and Asian crops that have been studied and

domesticated since the beginning of civilization, Central and South American crops have only been studied after the arrival of Columbus to the New World in 1492. Both Aztec and Mayan civilizations consumed avocado and even selected for larger fruits, as evidenced by archaeological digs. After reading a couple of books on avocado, and numerous publications, there's a lot of know and to find out about avocado, but a more intimate understanding would come from growing it.

Avocado was introduced to Hawaii in the early 1800's as seedlings and has resulted in a rich gene pool of avocado found throughout the islands, especially in the wetter upper elevations and in wet valleys that includes varieties such as the Guatemalan, and West Indies or more correctly called Lowland, and some Mexican races. The resulting natural crosses created many unique hybrids over the last 200+ years, some of which have yet to be discovered by the masses. Many of the UH-recommended selections are hybrids of at least two races.

There are three distinct groups or races of avocado, originating from different regions in Central America, and adapted to different environmental conditions with unique flowering and fruiting seasons. The subspecies or races

include Guatemalan (var. *guatemalensis*), Mexican (var. *drymifolia*), and West Indies or Lowland (var. *americana*).

Descriptions include the following:

#### Guatemalan:

- A sub-tropical variety from the Guatemalan highlands.
- Intermediate cold- and salt-tolerance.
- Widely adapted to Hawaii, from low to high elevations. Unscented leaves.
- Late maturing, from 10-16 months, winter to spring.
- Hard, tough, thick, rough or pebbled skin; rich flavored pulp with high oil content.
- Small seed size, but variable fruit size (>150 g.)

#### Mexican:

- A semi-tropical variety, native to the uplands of south central Mexico.
- The most cold tolerant and least salt-tolerant of the races.
- Adapted to the higher elevations of Hawaii with a cooler climate. Leaves anise-scented when crushed.
- Mid-maturity from 6 to 9 months; matures from fall to winter.
- Thin, smooth skin, waxy bloom skin surface, often dark purple colored fruit.
- Highest oil content with a rich, anise-like flavor. Many have fiber in pulp
- Large seed size in small to medium fruits (<150 g.).

- More compact tree than other races.

#### West Indies:

- A tropical variety, native to the west coast from Southern Mexico to Northern Costa Rica below 1000 feet.
- The most heat- and salt-tolerant of the three races.
- Lowland variety adapted to the humid lowlands and even coastal areas. Unscented leaves.
- Early maturing; 5 to 9 months from flowering to harvest; matures from late summer to fall.
- Shiny, thin, pliable skin with sweet, mild flavored pulp some consider watery. Has sweet taste.
- Fruit size is variable from medium to large (>150g)



*Growing seeds for rootstock is a good place to start. Avocado seeds have evolved to germinate in shady areas such as on a forest floor where the chances of survival are greater than in open areas.*

Even without hybridization, there's some overlap for many of the listed traits. Since most of the main varieties are hybrids, identification of origin can be difficult. The most useful way to

determine race is season of maturity. Other helpful criterion includes skin thickness and surface texture, and seed size and its tightness in the flesh. The anise scent of Mexican races is an easy determination that doesn't require fruits, while the pale foliage color of West Indies races is another reasonable identifier.

Oil content affects the taste, described as nutty or sweet, and everything in between. Field temperature affects oil content, with higher oil content in cooler climates, while oil content differs substantially between races. The West Indian race varies between 2.5-8%, the Guatemala varies between 10-13%, and Mexican can run from 15-25%. The oil content of some cultivars, such as Fuerte and Hass has reached 25-30% at the onset of the next season's flowering.



*A mixture of avocado varieties harvested in the winter-spring slot, mostly Guatemalan crosses*

The Guatemalan race is probably the best choice in terms of adaptability to Hawaii's varied climatic conditions, while the West Indies race is ideal for hot dry lowland conditions. Crosses between the two would create some of the best varieties for a wide range of Hawaii's climatic zones. The Guatemalan race is recognized for desirable fruit quality, small seed, and late fruit maturity.

The Mexican race is adapted only to the higher elevations of Hawaii, but one of its advantages is its compact growth compared to the other two races which have a tendency to grow twice the size of the Mexican race. However, two superior varieties grown in Hawaii are hybrids between Mexican and Guatemalan races, Sharwil and Greengold. Crosses between Mexican and West Indies may improve its adaptability to broader climatic conditions found in Hawaii.

Again hybrids offer many possibilities of finding the right cultivar for your specific location. The challenge in selecting what avocado to grow for certain locations is that a cultivar will have different growth and quality characteristic in different locations. A variety that grows well in the uplands may not grow well along coastal areas, so the only way is to determine what is best for your area is to plant and evaluate them against the U.H. recommended varieties.

Another option is to evaluate avocados growing around your location, and ask owners if you could taste one. Just asking them how they taste may not tell

you much since everyone’s tastes are different, and many may not know what

a great avocado tastes like.



**Important Hawaii Avocado Cultivars**

Cultivar	Bearing Season*	Race <sup>+</sup>	Flowering Type	Bearing Habit	Tree Size & Form
<b>Murashige</b>	Sp-Su	uncertain	B	heavy	large, upright
<b>Ohata</b>	Su	G	A	moderate	medium-large
<b>Kahaluu</b>	F	G X WI	B	light, irregular	tall, upright
<b>Malama</b>	F	G	A	heavy	compact, spreading
<b>San Miguel</b>	F-W	hybrid	A	moderate, regular	medium, spreading
<b>Semil-34</b>	F-W	G X WI	A	heavy, regular	medium, spreading
<b>Nishikawa</b>	W	G	B	moderate	medium, spreading
<b>Greengold</b>	W-Sp	M X G	A	heavy, regular	small-med
<b>Sharwil</b>	W-Sp	M X G	B	moderate, regular	low-spreading

**KEY**

\* W=winter, Sp=spring, Su=summer, F=fall

+ M=Mexican, G=Guatemalan, WI=West Indies



*Grafting scion wood of a superior variety onto a rootstock is the only way to assure you'll get a variety identical to the parent tree.*

**Descriptions of Important Hawaii Avocado Cultivars, and their bearing seasons in Kona:**

**Sharwil:** (Oct-Mar) Most popular with commercial growers. Mexican X Guatemalan cross. Type B flower. Has a long and heavy bearing season throughout the winter months. Medium size, pear-shaped fruit with a small seed, high oil content, and a green rough skin. "Sharwil" is a regular bearer. Yield and maturity are variable by location. The only variety presently cleared for export. Size 8-20 oz. Bearing Season: O,N,D,J,F,M

**Greengold:** A seedling from Sharwil developed by the UH, considered by many to be superior to Sharwil. Type A flower. Has a longer and heavier bearing season (January-April). Good flavor. Thick gritty, green skin is sometimes difficult to peel, resulting in stone cells in flesh. Tree is more compact than Sharwil. Medium size, pear-shaped fruit with a small seed, high oil content, Size 8-20 oz. Bearing Season: J,F,M,A

**Kahalu'u:** (Sept-Jan) Ripe in the Fall but sometimes an alternate bearer (every other year). Type B flower. A large, oblong fruit with a tiny seed and green skin. One of the best-flavored Hawaiian varieties. Partners with San Miguel and Semil 34. Upright growth habit. Bearing Season: S,O,N,D,J

**Linda:** (Feb-Mar, July-Nov) Ripens in the Spring. Has a large roundish fruit with a medium seed, dark purple skin when ripe, is regular and heavy bearing. Called the "dieter's avocado" due to its lower oil content and good flavor. Bearing Season: F,M,J,A,S,O,N

**Yamagata:** (Feb-June) Has a long and heavy bearing season of large, pear-shaped fruit with a small seed and green skin. Sometimes fibrous with strong nutty flavor. Considered tough; gritty skin, with curved neck. However, in taste tests, has ranked high in flavor, texture and color. Susceptible to post-harvest diseases. Bearing Season: F,M,A,M,J

**Fujikawa:** (March–May) Has a heavy bearing Spring season. The pear-shaped fruit has a medium-sized seed and green skin. The flavor is very good. Bearing Season: M,A,M

**Murashige:** (May-July) Fruits are ripe in the late Spring and early Summer with a large pear shape. Type B flower. Small seed with a dark green skin. Stem pulls from fruit easily; needs to be cut at harvest. Good storage on the tree, but ripe fruit does not store well once harvested. It has excellent flavor and is a heavy and regular bearer. Good yield. Partners with Ohata. Bearing Season: M,J,J



*Summer pears with receptive female flowers*

**Malama:** (Aug-Dec) A regular, heavy bearer with ripe fruit early in the Fall. Skin is purple when ready to eat, easy to peel, with rich and nutty flavor. High oil content with no fiber or string. Flower type B. A seedling of Kahalu'u, sometimes called "Black Kahalu'u." Bearing Season: A,S,O,N,D

**Ota:** (Nov-Feb) West Indies origin. The fruits are round with great flavor and a

small seed. Very high oil content, and tends to be pasty and dry when ripe. Seed frequently loose in cavity, which could cause internal bruising. Has a long, regular, and heavy bearing season from late in the fall and all through the winter months if grown at 1,000 feet. The fruit holds well on the tree. Tendency for alternate bearing. Bearing Season: N,D,J,F

**San Miguel:** Small pear-shaped fall-winter bearer. Moderate and regular bearer. Thin skin, turns purple when ripe. Guatemala X West Indies hybrid, Type A flower. Medium spreading tree. Partners with Kahaluu. Bearing Season: O,N,D,J

**Semil 34:** Medium sized pear shaped fall-winter producer and complement to Kahaluu. Mexican X West Indies hybrid from Puerto Rico. Green skin, mild flavor, yields well at low elevations. Type A flower. Heavy and regular producer. Medium spreading habit. Partners with Kahaluu. Bearing Season: O,N,D,J

**Ohata:** Large, purple to black, thin skinned, easy to peel, low yield. Moderate summer producer on medium-large tree. Guatemala origin. Type A plant; partners with Murashige. Bearing Season: M,J,J,A

**Bacon:** (Oct-Dec) Mid-winter green variety, green-skinned of good quality. Medium-sized fruit available late fall into spring. Type B flower. Oval-shaped fruit, Medium to large seed, Easy peeling, Light taste. Medium size fruit, ranging

from 6 to 12 ounces. Smooth thin green skin, Yellow-green flesh. Skin remains green, darkens slightly. Susceptible to iron deficiency. Fruit yields to gentle pressure when ripe. Bearing Season: O,N,D

***Special Note: Information on varieties is based on production information in Kona. Varieties may perform differently in other locations of the state.***

Other varieties with potential for commercial production include Beshore, a Sharwil seedling, and also Rodrigues, which has done well at the Poamoho Station. Two West Indies varieties that warrant more field testing include Hulumanu and Serpa.

From a production standpoint, there are many characters combined that makes a desirable cultivar, including high yields, consistent production, begins to bear at a young age, is easy to harvest and determine when to harvest, high fruit quality, and has fruit that can be stored on the tree, can be harvested over a long period of time, and has a good post-harvest shelf life. Very few cultivars have this total package, and all have shortcomings.

Over 70% of Hawaii avocados are grown in Kona and where ‘Sharwil’ is the most cultivated (45% of total local production), followed by ‘Malama’ (21%), ‘Yamagata’ (11%), ‘Murashige’ (3%), and local Hass (0.9%). How these varieties will fare in other parts of state is unknown, but most will probably be

superior to older varieties. UH-selected varieties have undergone decades of extensive field testing at many of the research stations.



*Bacon Avocado and a bird habitat*

Avocado is an underexploited crop in Hawaii with many bottlenecks to expansion, and as a result we import more avocado than we harvest. Hawaii avocado growers need to reduce their losses as almost 50% of their avocados fall to the ground.

The expression of an avocado cultivar's genetic characters varies with environmental influences associated with climate and seasonal variation in temperature, relative humidity, and rainfall. Avocado characters affected by climate include disease resistance, yield, bearing habit, seed size, fruit size and quality, and season of maturity. As a result, most avocado cultivars are site-specific in their adaptation, making it a gamble when growing new varieties. A variety that grows well in the uplands may not grow well along coastal areas, and vice versa.

It's so much easier to see what grows best in your neck of the woods and run with it, or identify what varieties are the most in demand and saleable.

It's the 'Food of the Super Bowl' when the consumption of avocado is greater than on any other day of the year. Avocado is a nutrient-rich tropical fruit that contains an unsaturated oil promoting health of the heart and circulatory system, and it continues to attract the interest of especially baby boomers and the health-conscious that fuels its continued demand.

The oil content increases with delayed harvest, and has to be monitored by occasionally harvesting them to evaluate the balance between oil content and taste. Very late harvests can yield avocados with a high oil content and rancid taste, especially on varieties that store well on the tree.



*Type 2 Anthracnose on Bacon avocado. Lesions are associated with infection of lenticels.*

'April showers bring May flowers' is a phrase that ushers in the flowering season of many temperate plants and

trees starting around the Spring Equinox on March 21. This is when the day and night is the same length, and plants sense the arrival of spring, but in the tropics, there are other factors that trigger the flowering of plants, including rainfall, dry periods, temperature, and some combinations of these conditions. Even soil temperature can signal the arrival of a new season, when it's time to wake up from a winter's rest.



*In Hoolehua, Molokai, avocados require protection not only from the wind, but also deer through use of a perimeter deer fences.*

However, for tropical fruit trees such as mango and avocado, flowering occurs much earlier. December 21 is the Winter Solstice, the shortest day of the year. In Hawaii, since we're close to the Equator, the shortest day is about 11 ½ hours. As days start to lengthen, many species will sense a new season and flowering will be triggered. However, avocado doesn't seem to be affected by day length in its flowering habit, so there are other factors involved.

It's fairly consistent that avocado will start to sprout flower buds from November into March and even later in

preparation for summer to winter fruiting, or even fruiting the next spring, depending on the cultivar's genetic makeup. The different avocado races flower at slightly different times and take different lengths of time to mature, and hybrids fill in gaps to the point where, theoretically you could have fruit year-round, but life is not that simple with many factors coming into play.

My grandfather used to tell me when avocados have heavy flowering, this means the wind and rains have yet to come, and in Manoa that's a foregone conclusion especially in January, or February for that matter. The late winter months are usually when the wild weather occurs, and we've seen our share of very strong winds and heavy downpours lately that raise havoc on flowers.

Avocado has evolved to produce more flowers they can possibly hold, anticipating all the challenges they'll face from flower to harvest, including heavy winds, rains, drought, and diseases that may come with the season, followed by insects and feeding on flowers or fruit flies and rodents attacking fruits.

In a pleasant, mild winter and spring, more flowers are retained and high yields can be realized, but this can mean an overproduction of fruits, a smaller and more variable fruit size, with a higher demand for water, followed by stress that can lead to heavy flower drop or even fruit drop. This stress can linger into the next season, possibly creating

an alternate bearing habit for some cultivars.

It's estimated that of the flowers produced, only a small percentage will set fruit and make it to maturity, but an avocado tree has the potential to produce a 1-2 million flowers on a large tree. It's believed that a high percentage of flowers are likely to be abnormal or sterile, but about 200-300 flowers can still be pollinated and will develop fruit that make it to maturity in a good season.



*Cephalosporium virens*, a plant-parasitic algae.

In its native Central American environment, avocado flowering occurs in a dry season with high flower drop, and climatic conditions have a strong influence on flowering, flower retention, and yield. This is not the case in most areas of Hawaii as we're in the midst of our rainy season, with the exception of Kona with its dry winters. In wetter areas, flowering can be prolonged, which can affect time of flowering for the same variety in different areas of the state. Cooler weather can also prolong the flowering period.

Of the tropical fruits, avocado has the longest flower initiation-to-harvest season, sometimes twice as long as mango. Flower initiation-to-harvest can run from 5 months for some West Indies races, to 16 months for some of the Guatemalans. Generally, Mexican cultivars flower earliest, West Indian cultivars next, and pure Guatemalans last. The flowering period can be extended by cooler temperatures, and flowering can be advanced as much as 2-3 months by girdling.

Any weather anomaly can radically change the outcome of a crop, and wind is the great destroyer of flowers that can arrive at the most inopportune time, which makes avocado a risky crop in windy areas. Mitigating measures need to be implemented, starting with sufficient windbreaks to protect your investment. Windbreaks are critical if avocados are grown in windy areas or in areas with unpredictable weather.

Anticipation is an important strategy in growing avocado, knowing what the weather will become, and what a tree needs, and is very important in preparing them for what is ahead. When trees enter the seasonal flowering phase, they consume and transpire a lot of water as if the tips open and water flows out of them. When this happens, they require additional irrigation especially during hot spring days as we've experienced lately. If they don't receive sufficient water during periods of heavy flowering, especially with high temperatures and dry conditions in

spring as we've seen lately, many flowers will drop, and in extreme situations, all flowers can abort.

Some plant species have complete flowers with both male and female parts, referred to as bisexual. This type of flower will usually pollinate itself if both types open at the same time. Many flower types require self-pollination or fruit set is enhanced by cross pollination.

However, avocado has a unique or strange flowering behavior, referred to as protogynous dichogamy. Within the same flower cluster, male and female flowers are usually receptive at different times of day to discourage self-pollination.

There are two different types of avocado trees, referred to as Type A and Type B. In Type A trees, female parts will open in the morning then close at noon. The next day, flowers will open at noon as males.

In Type B trees, flowers open as females in the afternoon and close in the evening. The next day, flowers will open as males at noon and close in the evening. This flowering phenomenon is found in all three races of avocado.

When the two types with similar flowering times are planted nearby, they will improve the pollination of both types. In some varieties, flowering may extend over a period of six weeks, with new flowers opening each day.



*Winter-Spring harvesting by the buckets. Ho'olehua Winter 2016*

Tree types can only be determined by inspecting the flowers, but by having the two types nearby such as in a residential area with lots of avocado trees, ample cross pollination will occur. In more isolated rural areas away from high concentrations of avocado trees, the amount of avocado flowers pollinated and fruit produced can be impacted, so planting cultivars of both tree types that flower around the same time is encouraged.

Although there's overlap of open male and female flowers to induce high levels of self-pollination due to weather anomalies or high insect populations carrying lots of pollen around, this flowering phenomenon of avocado is intended to encourage cross-pollination.

There's a lot of variability in growth habits between varieties, from a low spreading habit of Sharwil, an upright habit of Kahaluu, and compact growth of Greengold or Malama that can affect the efficiency in harvesting and a useful harvest life before they should be

pruned. In Hawaii, overall we rarely prune trees, which become giant trees that are difficult to manage and nearly impossible to harvest safely. The trend is to manage avocado tree height by training and pruning from a very early stage and keeping the height less than 8 to 10 feet.

Large, upright, vigorous growing trees require additional pruning since fruit will be out of reach for efficient harvesting in a short time and will crowd the orchard. The ability to store fruit on the tree is connected more to the genetics of the variety. Fruit with loose seeds will damage flesh in windy areas, especially on large trees.



*Using weed barrier to establish an avocado orchard*

The avocado root system is described as relatively shallow, and not spreading much beyond the tree canopy. The roots have adapted to frequent good rains, those found in the indigenous rainforest habitat, and also rapidly draining soils as shown by their high oxygen requirement and their sensitivity to poor drainage. They prefer rich surface organic mulch, as shown by the

tendency of healthy feeder roots to grow into any decomposing litter. Microbes such as vesicular-arbuscular mycorrhiza (VAM) can be found on roots.

The ability of avocado roots to ‘breathe’ is critical, and if this environment is not provided to trees, root damage can occur. Avocadoes are highly susceptible to root rot caused by *Phytophthora cinnamomi* in the soil and is the worst disease of avocado worldwide.

This fungal disease develops when soils are temporary waterlogged or kept moist for long periods of time by excessive rainfall or irrigation. Once infected, the trees die or their growth is inhibited. Avocado should not be planted on soils that are subject to flooding or have poor drainage, and this is the most important prerequisite when selecting a site for avocado production.

The Kona area was selected for commercial plantings because of its sloping, rocky, very well-drained soils. Other areas of the state may have similar conditions that are ideal for the growing of avocado. One strategy may be to select root stocks with large root systems to compensate for less than ideal growing conditions. Usually, larger seeds will produce larger root systems and will give trees a better start. Fuerte was one cultivar recommended in Hawaii by the late UH Tropical Fruit Specialist Richard Hamilton due to its large seed size. Still, *Phytophthora* is a constant threat to avocado production, especially in a time of climate change and unpredictable weather.

As a farmer, taking a holistic approach begins with an intimate knowledge of the crop, and an economic analysis. It's better to lose money on paper than in the ground. Market analysis and knowing what the market demands is one of the first steps and may determine what cultivars to grow that can be sold, and also times of the year when avocados are in short supply. Having climatic and soil conditions that favor the growing of avocado is an important prerequisite.



*After all is said and done, you still have to control rats.*

There's so much more to discuss about avocado than a 'short' newsletter can cover. For more information, check out these UH CTAHR publications on avocado:

**What Makes a Good Avocado Cultivar Good**

[https://www.ctahr.hawaii.edu/oc/freepubs/pdf/F\\_N-1.pdf](https://www.ctahr.hawaii.edu/oc/freepubs/pdf/F_N-1.pdf)

**Avocado**

<https://www.ctahr.hawaii.edu/oc/freepubs/pdf/HC-4.pdf>

**Fertilizing Avocado Trees**

<https://www.ctahr.hawaii.edu/oc/freepubs/pdf/CFS-AVO-3B.pdf>

**Producing Avocado in Hawaii**

<https://www.ctahr.hawaii.edu/oc/freepubs/pdf/C1-382.pdf>

**Greengold, A Late Season Avocado**

<https://www.ctahr.hawaii.edu/oc/freepubs/pdf/CFS-AVO-3D.pdf>

**Malama, An Early Fall Avocado**

<https://www.ctahr.hawaii.edu/oc/freepubs/pdf/CFS-AVO-3C.pdf>

**Hawaii Avocado Industry Analysis.**

**Part 1: Supply Focus**

<https://www.ctahr.hawaii.edu/oc/freepubs/pdf/EI-12.pdf>

**Hawaii Avocado Industry Analysis.**

**Part 2: Buyer Preference Focus**

<https://www.ctahr.hawaii.edu/oc/freepubs/pdf/EI-15.pdf>

*The information for this newsletter was gleaned from many sources, including 'The Avocado, Botany, Production and Uses, Edited by A.W. Whiley, B. Schaffer, and B.N. Wolstenholme, and Tropical Fruits, Volume 1, 2<sup>nd</sup> Edition by Robert Paull and Odilo Duarte. Other sources include many of the UH CTAHR avocado publications listed above, and also from personal experience growing avocados on Molokai. Thanks to Kona Experiment Station manager Marc Meisner for sharing his knowledge and personal experience maintaining the Kona Avocado Collection, and to the late UH Fruit Specialist Dick Hamilton for sharing his vast wealth of knowledge on avocado. Special thanks to Dr. Robert Paull for his critical review of this newsletter.*

**Well, that's it for this quarter. It's been a very hot spring and probably an even hotter summer is waiting in the winds, so**

***get ready. Insects and mites love the heat, and with insects come diseases, especially viruses, so cover the ground to keep plant roots cool and also disrupt those ground dwelling insects that attack above ground. Hopefully we'll get a reprieve from this heat with some rain, gentle rains that is. If you irrigate, check your water regularly to make sure it's getting out to where the roots are, and also walk the fields so you can nip some problems in the bud or the butt. More next time...***

***/\/***

***The views contained in this newsletter are that of the author, and are not the views of the University of Hawaii, College of Tropical Agriculture and Human Resources or the Sustainable and Organic Agriculture Program. The author takes full responsibility for its content.***