Growing and Harvesting the Best Avocados

John Yoshimi Yonemoto (Japan Tropical Fruit Association)
1. Selection of the best cultivar

- In Japan: *Winter temperature* determine the cultivar.
- Okinawa Islands: *West Indian type*
- Coastal region of southern part of Kagoshima and Amami islands: *Guatemalan type*
- Coastal region of southern part of Honsyu island: *Mexican type*
Origin of avocado

- Mexican race
- Guatemalan race
- West Indian race
## Characteristics of three avocado subspecies (horticultural races)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Mexican</th>
<th>Guatemalan</th>
<th>West Indian</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Climatic adaptation</strong></td>
<td>Warm temperate~ Subtropical</td>
<td>Subtropical</td>
<td>Subtropical~Tropical</td>
</tr>
<tr>
<td><strong>Cold tolerance</strong></td>
<td>Most (-5~6°C)</td>
<td>Intermediate (-3~4°C)</td>
<td>Least (-2°C)</td>
</tr>
<tr>
<td><strong>Salinity tolerance</strong></td>
<td>Least</td>
<td>Intermediate</td>
<td>Most</td>
</tr>
<tr>
<td><strong>Fruit maturation</strong></td>
<td>Early</td>
<td>Late</td>
<td>Early-Intermediate</td>
</tr>
<tr>
<td></td>
<td>Fall-Winter (5~6 months after pollination)</td>
<td>Spring-Summer (10~18 months after pollination)</td>
<td>Fall-Winter (6~8 months after pollination)</td>
</tr>
<tr>
<td><strong>Skin Color</strong></td>
<td>Usually purple</td>
<td>Black or green</td>
<td>Pale green/maroon</td>
</tr>
<tr>
<td><strong>Oil content</strong></td>
<td>Highest</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Cold storage tolerance</strong></td>
<td>More</td>
<td>More</td>
<td>Less</td>
</tr>
</tbody>
</table>

Most of the cultivars are hybrid between these three horticultural races. Therefore, characteristics are mostly intermediate.
In Hawaii

• **Elevation** might determine the cultivar

• However, you can grow any kind of avocado cultivars.

• Therefore, there are **too many cultivars** grown in Hawaii

• This causes trouble at market. (No name of avocado fruit, Mixture of **immaturely harvested** fruit).
Must know your avocado cultivar and its harvesting time

• Make sure what cultivar you grow: Malama, Kahaluu, Sharwil, etc.?
• Make sure the characteristics of your cultivar: Early, Middle or Late maturing?
### Harvesting period of Hawaii Avocado

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sharwil</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>Fall-Winter</td>
</tr>
<tr>
<td>Kahaluu</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>Fall-Winter</td>
</tr>
<tr>
<td>Nishikawa</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>Fall-Winter</td>
</tr>
<tr>
<td>Yamagata</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>Spring-Summer</td>
</tr>
<tr>
<td>Ohata</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>Spring-Summer</td>
</tr>
<tr>
<td>Linda</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>Fall-Winter</td>
</tr>
<tr>
<td>Malama</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>Fall-Winter</td>
</tr>
<tr>
<td>Murashige</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>Spring-Summer</td>
</tr>
<tr>
<td>Hass</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>Spring-Summer</td>
</tr>
</tbody>
</table>

Hawaii avocado industry analysis, Part 1: Supply focus.

CTAHR Economic Issue Nov. 2007 El-12

Peak Harvesting | Small Harvesting
Harvest the fruit after maturation period

- Each cultivar has the **optimum harvesting period**. The length of time from pollination to harvest differs according to cultivar.
- In Japan, I harvested Hass when the fruit skin start developing purple color for selling at the high price ($10 a fruit) as the fully matured domestically produced avocado.
Fruit skin color tells you full maturity
2. Plant Both **A** and **B** flowering type cultivars

<table>
<thead>
<tr>
<th>Avocado Flower Types</th>
<th>First opening</th>
<th>Second opening</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flower Type</td>
<td>AM</td>
<td>PM</td>
</tr>
<tr>
<td>A</td>
<td>♀</td>
<td>—</td>
</tr>
<tr>
<td>B</td>
<td>—</td>
<td>♀</td>
</tr>
</tbody>
</table>

### Flower Type AM PM

<table>
<thead>
<tr>
<th>Flower Type</th>
<th>AM</th>
<th>PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>♀</td>
<td>♂</td>
</tr>
<tr>
<td>B</td>
<td>♂</td>
<td>♀</td>
</tr>
</tbody>
</table>
Flowering behavior follows normal patterns when the minimum night temperature is above 12°C and maximum day temperature is either above 22°C for Group A cultivars, or 26°C for Group B cultivars.
3. Honey bee and bumblebee work well for pollination
4. How to minimize the June Drop

• 1. Spraying Paclobutrazol (0.06-0.25% ai) at mid-bloom.
• 2. **Thin out water sprout** after the first June drop through the second June drop.
• Give enough water and light for **better photosynthesis**.
Paclobutrazol was sprayed on March 5, 2014, Paclobutrazol reduce the feeder roots for 6 months, But the roots will recover.

Control

Paclobutrazol was sprayed on March 5, 2014, Roots system in December in 2014.
Paclobutrazol produce round fruit on Pinkerton

Paclobutrazol

Control
Day and night temperature difference effects the fruit length.

Pinkerton: 27/12°C 30/8°C
Then you can get 100 fruit on a tree grown in a 60ℓ pot.
5. It is important to make a low height tree to produce high quality fruit.

- **Key words:**
  - Limiting *root growth*
  - Against the *gravity*
  - Increase the number of shorter branches by *pinching*
  - Adequate *fertilizer* and *water* supply
Tall Zutano tree in Japan

Only way to make the tree shorter is using a chain saw by this time.

Must start making a low height tree from the planting time.
It is important to make a tree short for:

- easy harvesting,
- minimize the wind damage

This is a low tree-height avocado tree in Hawaii.
Low height avocado in Kona

Tree became short but Fat trunk and main limb are the same size
Mr. Nakano and his 30 years old avocado tree less than 2m height
His tree has slender main limb because he supports the limb by a stake
Low tree height avocado in Japan

Avocado training with stakes in Ishigaki Island, Okinawa, Japan

Wind break is required
Make slender limbs to reduce energy for supporting the limbs

- Big fat limbs means that there is a big root system which also consume a lot of energy (water, nutrients and photosynthete).
- Never get high yield and high quality fruit by this conditions.
- Support your tree to concentrate producing fruit.
Tall tree has deep taproot. **Limiting the taproot growth** is required for making short tree height.

We do not need a strong taproot. **We need only healthy feeder roots.**
How to make a tall avocado tree short.
Limiting root growth is one way to make a small tree using a root limiter sheet.
Root limiter is required for keeping compact tree

Making a frame

Root limiter sheet
(Nonwoven fabric) SH150
(150g/m², 0.4mm thickness, 2.1m width × 100m long/$1300
Root limiter is required for keeping compact tree

Soil mix (soil: peat moss:perlite; 2:1:1)

Soil for good drainage at the bottom
Train tree as short as possible. Produce lateral branches as many as possible by pinching. Produce fruits within 2 years.
May, 2009, Planted in 300ℓ pot (3.8 × 3.5 = 13.3m² = 75 trees/1000m² = 300 trees/1 acre)

May 24, 2009, Soon after planting

June 30, 2009
New shoot is pushing out on Bacon tree
Horizontal training of Bacon

December 3, 2009
New shoots flashing on Bacon

June 8, 2010
June 21, 2014 Produced 300 fruits per tree
300 litter and 60 litter pot culture
Yield per tree increased up to 250 in the 5 years after planting

Number of fruit per tree after planting

Years (planted in April, 2009)

Number of fruit/tree

Hass-W  Hass-E  Hass-P
Harvesting 250 Fruits/tree from $3.8 \times 3.5\text{m}$ spacing means:

- $250\text{fruits/tree} \times 70 \text{ trees}=17,500 \text{ fruits/1,000m}^2$
- If average fruit weight is 380g,
  - $380\text{g/fruit} \times 17500 \text{ fruits}=66450\text{kg}(3019\text{Lbs})/1000\text{m}^2.$
- $3019\text{lbs} \times 4 = 12,076\text{Lbs/acre}$
- You can harvest $70,000 \text{ fruits, 12,076Lbs / acre}$
- We sell $5/\text{fruit}, \text{Then } 5/\text{fruit} \times 70,000\text{fruits} = 350,000\text{/acre}$
- Even if the price was $3/\text{fruit}, \times 70,000\text{fruits} = 210,000\text{/acre}$
- Isn’t it amazing?
6. Training (frame-work) and pruning

- Once you have developed main trunk structure,
- Then after, you can do only thinning branches and taking out waterspout in every year for avocado.
Planting and training for fruit tree

At planting
- Cut back
- Select 2~3 main branches

If you pinch the tip during a new shoot growing

Secondary branches grow

Leaning of the main branches

Main branch grows upward

Pinching

Train main and secondary branches horizontally
Keep the tip of main branch higher for preventing water sprout comes out.

Once you have developed main trunk structure, it is not so difficult to maintain the low tree height by pruning.
Straight line training of avocado on 60 litter pot.
When a water sprout became bigger than the main limb,

Make a girdling around the water sprout, to lower its vigor and increase flower production on the water sprout.
Let us start pruning practice

My pruning tools

Fungicide paste for protecting cut surface
Heavy pruning on deciduous trees, but

- **Light pruning on ever green trees**
- Cutting branch always kill some part of roots
- Cutting off branch decrease reserve nutrient and numbers of flower
- Heavy cutting always ends up vigorous tree growth and never produce fruit
Before and after thinning branches on avocado

I have done this after June-drop of fruit. Thin off the branches without fruit. Then the branches with fruit get more sun light.
After **thinning** out a branch, many new shoots sprout

As long as the tip of the main branch locates at the highest position, these new shoots will never become too strong.
Cut-back pruning rejuvenates the tree.

Cut-back pruning before flowering reduces flowers. It should be done after flowering or after June-drop to increase the fruiting branches for the next year.
When you cut-back a shoot

- Cut the shoot at the length of 10-15 times the diameter of the shoot.
- For example; if the shoot has one inch diameter, the shoot should be cut back at the length of 10-15 inch. Then you will not get too strong or too weak new growth from the cut-backed shoot.
- **Cutback too short**, get a few *vigorous* new shoots
- **Cutback too long**, get many *weak* new shoots
Making a upright limb down to horizontal position

Sawing a limb to the half of its diameter

bending the limb down until the cut area closed

Cover with a tape to protect from disease and mechanical damage

anchor
Make cuts into the bark with a knife.

Hold the cut area by your palm.

Twist the limb and bend down.

Cover the twisting area with a tape.

Twist until the xylem is broken.
If you have strong water sprout which became a scaffold limb

Girdling is one of the techniques to increase the yield
V-shaped saw cut into the strong limb can be done

This year's cut after June-drop

Last year's cut has been callused
Should be aware of which are primary or secondary scaffold

Place only 2-4 primary scaffold limbs per tree.

Narrow spacing between limbs makes crowded limbs and prevent the light penetration.

Fig. 4. Bird’s eye view schematic diagram of 3-scaffold limbs training with secondary scaffold limbs.
Unit pipe model or Leonardo da Vinci’s rule in 16th century

Relationship of xylem areas before and after branching in citrus

We are in 21st century now and still do not know how to control our fruit trees. We must learn more and try many ways to keep our tree as low as possible.
I prune avocado tree soon after the end of June drop

Select **non fruiting branches**
**Thinning out** to make better light penetration
**Cut back** a branch to make new fruiting shoots for the next year
• Develop a low height tree framework and produce a lot of high quality avocado
60 litre pot
years and 11 months after planting. 50 fruits on the tree.
7. Changing cultivar by top working

- Chicken farmer never keep unproductive chicken.
- Keeping an unproductive tree means loosing money.
- Top working is effective way to change variety in short period.
Stumping a large tree. Graft on the new shoots.
Top-working for changing cultivar and germination after the grafting
Yield per tree after top working

Number of fruit per tree

Top worked year  | Next year  | Second year  | Third year
---              | ---        | ---          | ---
0                | 1          | 80           | 200
Fruit set in the third year after top working

Grafted in May, 2012
8. Irrigation

- Water supply is a major factor influencing tree growth, *productivity* and fruit *quality*.

- **Critical period** is during flowering and early fruit development.

- **Second critical period** is the rapid fruit growth phase.

- 4-year-old tree require a maximum of 70 litres of water per day.
The relationship between seasonal water application (mm) and relative yield
Too much water causes fruit that will not soften after the harvest.

Water soaked fresh around the seed.
Lack of water during winter cause wilting of fruit
9. Fertilizer application

- Fall, spring and summer applications
- **Frequent applications** are more important where the soil is light and low fertility, and rain fall is high.
- Amount should be calculated by *leaf analysis*
Annual loss from abscised buds, flowers, fruitlets and fruit per hectare

Kg/ha

Major nutrients

N  P  K  Ca  Mg

0  5  10  15  20  25  30  35
### Nutrients removed in avocado fruit by 10 ton/ha crop is not so much

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>% of dry weight</th>
<th>kg/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>0.54</td>
<td>11.3</td>
</tr>
<tr>
<td>P</td>
<td>0.08</td>
<td>1.7</td>
</tr>
<tr>
<td>K</td>
<td>0.93</td>
<td>19.5</td>
</tr>
<tr>
<td>Ca</td>
<td>0.10</td>
<td>2.1</td>
</tr>
<tr>
<td>Mg</td>
<td>0.24</td>
<td>5.0</td>
</tr>
</tbody>
</table>

CABI(2013)
Expanded mature leaves from non-fruiting and non-flushing terminals on the spring shoot growth

<table>
<thead>
<tr>
<th>Elements</th>
<th>Deficient (less than)</th>
<th>Commercial range</th>
<th>Excess (more than)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N (%)</td>
<td>1.60</td>
<td>1.6–2.8</td>
<td>3.0</td>
</tr>
<tr>
<td>P (%)</td>
<td>0.14</td>
<td>0.14–0.25</td>
<td>0.3</td>
</tr>
<tr>
<td>K (%)</td>
<td>0.90</td>
<td>0.9–2.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Ca (%)</td>
<td>0.50</td>
<td>1.0–3.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Mg (%)</td>
<td>0.15</td>
<td>0.25–0.80</td>
<td>1.0</td>
</tr>
</tbody>
</table>

CABI(2013)
What I would like to do in Hawaii is

- Use tall wild mango trees as a stake for wire
- Hang branches and fruits to the wire
Thank you very much for your attention