Producing Consistent High Quality Fruit in Japan

John Y. Yonemoto
(Jinnai Tropical Fruit Research Laboratory)
Greenhouses in winter at Jinnai Farm Japan. We grow mango, avocado, cherimoya, passion fruit, star fruit in snow.
Today, I would like to talk about 4 points

• First; Situation of Japanese domestic fruit consumption and production.
• 2nd.; How much fresh fruit we import into Japan.
• 3rd.; Why we must produce high quality fruit to obtain high price.
• 4th.; How we produce high quality fruit, one example of mango production
How much we consume fruits in Japan?

• We used to consumed more than 7 million ton that was 70kg per capita in a year.
• Now we consume less than 3 million ton, 20kg per capita.
• Two major fruit crops are Satsuma mandarin and apple.
• In 2011, total bearing acreage of fruit was (0.2 million ha), and production (2.6 million ton).
Total production in 2011
(2.6 million ton)
How about imported fruit?

- We import **1.8 million tons** annually.
- The value of the imported fruit is **$1.8 million**.
- However, **Banana** occupy **1 million tons**, followed by **grapefruit** (0.2 million tons), **oranges** (0.1 million tons), and **lemon** (0.06 million tons).
Fig. Quantity of marketed fruits in Japan
Fig. Quantity and Value of imported fruits into Japan

- Quantity of imported fruits (million ton)
- Value of imported fruits (million $)
How about imported tropical fruits?

- Banana (1 million ton) is No. 1
- Pineapple (0.14 million ton) is 2nd.
- Avocado (44000 ton)
- Mango (10000 ton)
- Papaya (2800 ton)
- Importation of avocado has been increased
Fig. Imported Banana, Pineapple, Mango, Avocado and Papaya into Japan
Fig. Imported quantity of mango and avocado
Tropical fruit consumption is increasing slowly

- Greenhouse Mango is the most expensive tropical fruit. The highest price at whole sale market was more than 10,000 yen/kg ($50/lb).
- We produce 3,000 ton of mango under greenhouse in Japan.
- We import 10,000 tons and the average price was 500 yen/kg ($2.5/lb).
Mango import into Japan (Exchange rate is 80 yen/US$)
We produce 3000 tons from 400 ha greenhouses.

Fig. Mango production and acreage in Japan.
Price recovers in July for Gift Exchange

The highest price

The lowest price

Date

Price (Yen \cdot kg^{-1})

Fig. 1 Mango prices at Tokyo central wholesale
Why is the a high quality fruit price so different from an ordinary fruit?

• We use the high quality fruits as a gift.
• The higher the price, the larger the pleasure and satisfaction of customers are.
• However, the gift fruit must be perfect;


What means ‘quality’ in Japan

• 1. **Taste** (High sugar content, Full maturity).

• 2. **External appearance** (Perfect color development, Free from any injury).

• 3. **Safety** (free from chemical contamination).

• 4. Traceability.
Fruit Items for Gift

• 1. **Muskmelon** from Shizuoka used to be the most valuable fruit gift.

• 2. **Cherry** (‘Satohnishiki’) and **Mango** (‘Irwin’) have replaced the Muskmelon now.

• Strawberry can be a valuable gift.

• Whatever a fruit is perfect, it can be a valuable gift.
Muskmelon, Cherry and Mango
Strawberry price was 10500yen/box ($125/box)
2012, March, Miyazaki mango price was 15750yen/2fruits ($95/fruit)
At the same store, Mango from Mexico was 2100yen/fruit ($25/fruit)
At a supermarket, mango from Philippines was 395 yen/pack ($1.2/fruit)
Now you know a difference between domestic gift fruit and imported one or domestic common fruit. Japanese growers must produce high quality fruit to obtain high price, even though the production cost is very high.
Let me explain how we produce perfect mango for example.

• **Hokkaido mango**; the most heavily equipped, high cost production.

• **Miyazaki mango**; the highest price mango production with heating facility.

• **Okinawa mango**; the lowest cost production with non-heating facility.
Domestic mango ‘Irwin’ production in greenhouse

**Hokkaido**: High cost production (Potted culture)

**Okinawa**: Non-heating low cost production (planted into a soil)
Fruit with green color remaining is the second grade
Scars caused by Thrips also 2\textsuperscript{nd} grade
This is a high quality ‘Irwin’
Brand name ‘Egg of the Sun’

• Sugar contents is more than 15° Brix.
• Perfect color development.
• No scars from disease and insect on the fruit surface.
• Fruit must be harvested at full maturity when it drops in a net or paper sac.
• However, only 1% of the total production is approved as ‘Egg of the Sun’
Fruit is catch by a net in Miyazaki
Fruit is catch by a paper bag in Okinawa
All mango tree in Japan must be grown under plastic houses.

- 1. Protection from rain (Anthracnose disease, and from cold temperature.
- 2. Pollination by honeybee or fly)

- There are two types of greenhouses;

- **A: Strong structure** plastic house or
- **B: Simple pipe structure** vinyl film house.
Strong structure plastic house
($380,000/1000m^2$)

Double plastic covering with compressed air between the two layers for better insulation.
Inside of the strong structure house

Fan is for mixing air in the greenhouse
Curtain and supplemental lighting

Thermal screen  Sodium (Na) Lamp
Heating device is necessarily to grow mango in Japan except Okinawa.

- Power of heater: 116 kW
- Fuel consumption: 12.7ℓ/h
- Electricity: AC 200V
Netting on greenhouse for protecting insects and strong wind
Let me talk about simple structure greenhouse in Okinawa

1. **Height of greenhouse** is short because of typhoon.
2. Vinyl film should be **removed quickly** when typhoon comes.
3. However, **net cover** on the greenhouse must be practiced for wind break and for insect prevention.
4. There is **no heating equipment**. **No heating fuel** is the most advantage or disadvantage for Okinawa growers.
Simple structure greenhouse in Okinawa ($38,000/1000m^2)$
Flowering at Ishigaki Island Okinawa. Visitors are from Oman.
At full bloom: mulching with sugarcane leaves

A lot of sugarcane leaves are used for mulching on the ground to develop feeder roots.

Temperature should be 20~25°C at this stage.
High quality fruit is produced on a good root system (many fibrous roots)
Before bagging
White paper bagging for catching fruit and protection from insects or sunburn.

Shading

Netting

Pipes are used for training branches.
50% shading screen for protecting fruit from sunburn
## Cost of Heating Oil

<table>
<thead>
<tr>
<th>Consumption of heating oil per 1000m² (1/4 acre)</th>
<th>Kerosene</th>
<th>Yen</th>
<th>US$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(liter)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miyazaki Forcing culture</td>
<td>25,000</td>
<td>2,000,000</td>
<td>25,000</td>
</tr>
<tr>
<td>Miyazaki heating culture</td>
<td>20,000</td>
<td>1,600,000</td>
<td>20,000</td>
</tr>
<tr>
<td>Hokkaido heating culture</td>
<td>60,000</td>
<td>4,800,000</td>
<td>60,000</td>
</tr>
<tr>
<td>Okinawa non-heating culture</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
$25/kg and 2 tons of yield per ¼ acre is the lowest price and yield for farmers

<table>
<thead>
<tr>
<th>Prices per kg</th>
<th>Gross income</th>
<th>Prices per kg</th>
<th>Gross income</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yen</td>
<td>US $</td>
<td>Yen</td>
<td>US $</td>
</tr>
<tr>
<td>1,000</td>
<td>12.5</td>
<td>2,000,000</td>
<td>25,000</td>
</tr>
<tr>
<td>2,000</td>
<td>25.0</td>
<td>4,000,000</td>
<td>50,000</td>
</tr>
<tr>
<td>3,000</td>
<td>37.5</td>
<td>6,000,000</td>
<td>75,000</td>
</tr>
<tr>
<td>4,000</td>
<td>50.0</td>
<td>8,000,000</td>
<td>100,000</td>
</tr>
<tr>
<td>5,000</td>
<td>62.5</td>
<td>10,000,000</td>
<td>125,000</td>
</tr>
</tbody>
</table>
Let me talk little about our cultural practices

- Pruning
- Flower peduncle hanging
- Flower peduncle thinning
- Fruit thinning and hanging
- Netting and reflector setting
- Harvesting
Let me explain about calendar of cultural practice

• 1. Calendar for harvesting in Summer (Floral initiation can be done during cold winter, but need heating for raising temperature up to $25^\circ C$ for best fruit setting.

• 2. Calendar for harvesting in winter (Floral initiation must be done during hot summer.
• Must lower the night temperature down to $15^\circ C$ to initiate flower. Since Plant growth regulator is not permitted in Japan.
Cultural practices for summer harvesting mango

<table>
<thead>
<tr>
<th>Month</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetative growth</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></td>
</tr>
<tr>
<td>Floral differentiation</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></td>
</tr>
<tr>
<td>Flower bud emergence</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></td>
</tr>
<tr>
<td>Anthesis</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></td>
</tr>
<tr>
<td>June drop</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></td>
</tr>
<tr>
<td>Fruit enlargement</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></td>
</tr>
<tr>
<td>Fruit maturation</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></td>
</tr>
<tr>
<td>Harvesting</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></td>
</tr>
<tr>
<td>Fertilizer application</td>
<td>Basal Application</td>
<td>For Flower</td>
<td>For Fruit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irrigation</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></td>
</tr>
<tr>
<td>Large</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></td>
</tr>
<tr>
<td>Medium</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></td>
</tr>
<tr>
<td>Small</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></td>
</tr>
<tr>
<td>Thinning of shoo</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></td>
</tr>
<tr>
<td>Pruning</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></td>
</tr>
<tr>
<td>Horizontal training</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></td>
</tr>
<tr>
<td>Floral thinning</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></td>
</tr>
<tr>
<td>Hanging of flower</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></td>
</tr>
<tr>
<td>Fruit thinning and hanging</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></td>
</tr>
<tr>
<td>Beehive setting</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></td>
</tr>
<tr>
<td>20</td>
<td>20</td>
<td>20</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>15</td>
<td>17</td>
<td>20</td>
<td>23</td>
<td>23</td>
<td>23</td>
</tr>
</tbody>
</table>
Cultural practices for winter harvesting

<table>
<thead>
<tr>
<th>Month</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetative growth</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></td>
</tr>
<tr>
<td>Floral differentiation</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></td>
</tr>
<tr>
<td>Flower bud emergence</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></td>
</tr>
<tr>
<td>Anthesis</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></td>
</tr>
<tr>
<td>June drop</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></td>
</tr>
<tr>
<td>Fruit enlargement</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></td>
</tr>
<tr>
<td>Fruit maturation</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></td>
</tr>
<tr>
<td>Harvesting</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></td>
</tr>
<tr>
<td>Fertilizer application</td>
<td>For Fruit</td>
<td>Basal Application</td>
<td>For Flower</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irrigation</td>
<td>Large</td>
<td>Medium</td>
<td>Small</td>
<td>For Fruit</td>
<td>Basal Application</td>
<td>For Flower</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pruning</td>
<td>Horizontal training</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>
</tr>
<tr>
<td>Hanging of flower</td>
<td>Floral thinning</td>
<td>Netting or bagging</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruit thinning and hanging</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></td>
</tr>
<tr>
<td>Heating</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>15</td>
<td>5</td>
<td>5</td>
<td>17</td>
<td>20</td>
</tr>
<tr>
<td>Night cooling</td>
<td>15</td>
<td>10</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Now I will show our practices for producing high quality fruit
Before and after pruning

Main branches are trained horizontally at the height of waist
Every flower peduncle is hanged upward to get better sunlight
Basal floral peduncle is cut off to set fruit far from leaves for better color development and for protection from rubbed injury by leaf.
For winter harvesting culture

One third of the basal portion is removed during flower cluster development for fruit production much farther away from leaves to get better sun light.
At Full Bloom: pollinated by honey bee ($270/beehive) or fly ($0)
Before fruit thinning
After fruit thinning (One or two fruit per peduncle is left)
Leaf and fruit ratio; 70~80 leaves per fruit as a standard
Netting for catching fruit and reflector under a fruit for better color development at fruit apex
Sunshade and reflector
Only a **fallen fruit** is harvested
NIR fruits sorting

Setting fruit on a tray

Fruits are sorted by sugar content (Brix°)
Each fruit is **printed number** which detects where the fruit come from.
Let me explain little about Winter-harvesting of Irwin mango.
Problems for Harvesting in December for gift

1. Must initiate flower bud in Summer
2. Must develop a red color under short and weak daylight in fall and winter.
3. Must force photosynthesis under short and weak daylight in fall and winter.
4. Must consume a lot of heating Fuel.
Horizontal training of bearing shoot
Facilities used for floral initiation

Electric cooler

Outside

Inside
Ice meltwater conversion into cold air

Ice is produced in a pool under ground during winter, ice meltwater comes in greenhouse and converted into cold air by these equipment and the cold air is supplied into greenhouse.
Better color development; A piece of paper retards anthocyanin
LED light and UV ray promote red color

UV250nm: 80μw/cm²
Diurnal change of PPFD under greenhouse in winter in Hokkaido
Diurnal change of CO$_2$ level under greenhouse in winter in Hokkaido
Diurnal change of AC under greenhouse in winter in Hokkaido

Ac (μmol m⁻² s⁻¹)

-2

0

2

4

6

8

10

8:00 10:00 12:00 14:00 16:00

ハウス1

ハウス2
Relationship between PPFD and CO$_2$ on Ac

![Graph showing the relationship between PPFD and CO$_2$ concentration on Ac](image-url)
We use \( \text{CO}_2 \) producer

\( \text{CO}_2 \) gas moves into air duct
Conclusion: About mango

- There are $65\text{ million import}$ market and $75\text{ million domestic}$ market in Japan for mango.
- Japanese consumers do not know real taste of other mango cultivar. They are beginners who are satisfied with a cultivar ‘Irwin’.
- If the Japanese know other mango taste, We must supply many kinds of mango cultivars.
- However, High quality requirement is remained.
About avocado

Japanese consumer want domestic avocado

- **Hass** is the only avocado imported from Mexico. 37,000tons ( $131million) were imported in 2011.

- **Domestic production** is almost nothing.

- Price of domestically produced avocado is $4/fruit.

- We should try to grow avocado in Japan.
I’m trying to grow avocado in greenhouse

Lamb Hass

Japanese love to eat high oil content avocado. We must develop such cultivars with high cold temperature tolerance.
Locally produced fruit has its own value which has much higher quality than imported ones. We must make an effort to bring out the quality for our local consumers and for our income.

Thank you very much for your kind attention.