Technology to improve and prolong production of selected tropical fruits

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<th>Practice(s)</th>
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<td>Guava</td>
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<td>Selective and timed pruning</td>
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Guava (*Psidium guajava*)

• Growth habit
  • Small single to multi-trunked tree easily managed to <10 ft tall
  • Flowers/fruits on new shoots
  • Response to pruning is new shoot initiation where flowers arise in the leaf axils of the second to fourth node

• Potential
  • Synchronize all shoots on a tree to flower and fruit at the same time
  • Alternatively, defoliate entire tree to synchronize and induce flowering
  • Selectively prune shoots to induce flowers and fruit over an entire year
    • Normally two crops: summer and spring
Guava types

Pink types (eaten when ripe)

- ‘Barbie Pink’
- ‘Homestead’ (Ruby Supreme)

White types (eaten hard and crunchy)

- Thai-guava (generic name)
- Taiwan guava types
Crop cycling strategies

<table>
<thead>
<tr>
<th>Method sequence</th>
<th>&gt;= then</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pruning</td>
<td>Harvest&gt;Selectively prune</td>
</tr>
<tr>
<td>Drought</td>
<td>Harvest &gt;Prune and impose drought stress (3-4 wks) &gt;fertilization (N) and irrigation</td>
</tr>
<tr>
<td>Defoliation</td>
<td>Harvest&gt;Prune&gt;apply defoliant&gt;fertilization (N) and irrigation</td>
</tr>
</tbody>
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- Defoliants include: 1) ethrel (900 ml/30 oz), 11 kg/24 lbs urea plus surfactant; 2) ethrel (600 ml/20 oz), 11 kg/24 lbs urea plus surfactant; 3) 25% solution of urea plus surfactant

- Factors:
  - Ambient temperatures
  - Time from treatment to harvest 6-7 months
  - Time from flowering to harvest 4-6 months
Attempting year-round production

- four trees or four blocks of trees
- weather conditions change during the year

Month 1
Prune > drought > irrigation plus fertilizer

Month 4
Prune > defoliation > irrigation plus fertilizer

Month 6
Prune > defoliation > irrigation plus fertilizer

Month 8
Prune > drought > irrigation plus fertilizer

Harvest
Hand pruned, tree size control – white guava
Selective pruning, fruit thinning and bagging

Methodology
• Selectively cut back shoots (>1.0”)
• Selectively remove some fruit (~1 fruit per foot or so)
• Place netting then breathable bag (cut slits in bottom)

Benefits
• Potential year-round cropping
• Reducing fruit load results in remaining fruit to be larger
• Bagging fruit protects fruit from fruit flies, insect probing, and wind scar (scratches)
  • Paper (biodegradable)
  • Plastic
Reaction of guava to pruning
Fruit thinning, bagging and results
Banana (*Musa* hybrids)

**Growth habit**
- Small to large arborescent (tree-like) plants ranging in height from 3 to 26 ft tall. Single to multi-trunked
- Each banana stalk grows vegetatively, then flowers and fruits, then dies and is replaced by a new pseudo-stem
- Flowers after ~26 to 32 leaves or so have emerged
- After flowering 10-15 leaves are present. By harvest usually 5-12 leaves are present
- Time from shooting (flowering) to harvest in subtropics 110-300+ days

**Potential**
- Synchronize plants to flower and fruit at about the same time
- Time pruning so fruit are harvested to meet specific market windows
Fruit description

• **Fruit are seedless**, the pulp develops mainly from the outer edge of the locule (inner face of the skin). However, the septa and axis tissue also contribute

• The **ovules shrivel and remain as minute brown flecks in the edible pulp**

• The **majority of fruit are sterile** probably due to specific sterility genes, triploidy, and chromosome structure
Selected banana cultivars

‘Gold Finger’ (FHIA1)

‘Klunamwa’

‘Mona Lisa’ (FHIA2)
Inflorescence – flower description

• The male and female flowers are grouped in 10-20 and are separated along the inflorescence
• The first flowers to emerge are functionally female and in edible cultivars are seedless (parthenocarpic)
• Next transition flowers
• The last flowers to open are functionally male
Flowering also called shooting
Mat management to synchronize cropping

• Overcrowded, competition for light, water, and nutrients
• Each mat is on its own development cycle
• At any specific time harvest is low

• Minimal competition for light, water and nutrients
• Entire planting is synchronized, i.e., on the same development cycle

• Harvest is high at a specific time
Conventional mat and stem pruning

1. Remove water suckers and re-growths from damaged or previously cut pseudostems
2. Select a daughter sword sucker that is healthy and is most appropriately located to minimize competition with adjacent stems and newly emerging suckers
3. Removal all other suckers 3 ft tall or more.

Maintain just 3 pseudostems until the mother plant flowers or fruits, then select and allow a granddaughter to grow
One-stem method: an alternative mat management

- Constantly remove all but the fruiting pseudostem
- Focus on optimizing cultural practices to enhance plant and fruit growth
- Allow 1 new pseudostem once main stem flowers

- Faster plant growth
- Reduced time to flowering and fruiting
- Faster fruit bunch and fruit finger development
- More intensive mat management
One psuedostem mat management
Mat pruning in Florida to optimize banana production

Objectives - speed fruit development (maturation) and produce fruit at specific times of the year.

1. Plant or replant at a certain time so that the plant crop and follower (next) crops bear at different times of the year.

2. In already established plants, mature pseudostems can be
   - cut down to stimulate the growth of the younger (daughter and granddaughter) plants
   - or remove the fruit from mature (mother) plant but leave the mother plant until the daughter plants become near full size and then remove the mother plant (mother plant provides food sources to entire plant)
   - Removing the mother plant (or removing its fruit) will stimulate the growth of the daughter and granddaughter plants and they will flower sooner
One pseudostem mat management example - Florida

Under south Florida conditions (marine, subtropical) ‘Burro’ usually takes about 538 days and ‘Klunamwa’ takes 514 days (Ploetz, et al., 2000. HortSci. 35:120-124)

By removing all pseudostems but one on each mat and maintaining this one pseudostem, the remaining pseudostem grows more vigorously and flower and fruits sooner than the 3 pseudostem mat management system.

<table>
<thead>
<tr>
<th>Month</th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Burro’ (ABB)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>H</td>
</tr>
<tr>
<td>‘Klunamwa’ (ABB)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>H</td>
</tr>
</tbody>
</table>

Plant (P) = day 0; H (H) = harvest. ‘Burro’ = 301 days; ‘Klunamwa’ = 341 days

Saved 237 (‘Burro’) and 173 (‘Klunamwa’) days
Other practices to enhance fruit development

• Propping (common in Asia) and tying (common in western tropics). To reduce plant losses to toppling, the fruiting stalk/pseudostem may be propped up with poles or stakes or tied to adjacent plants or guy wires for support.

• Deleafing. Removal of leaves that touch or may touch the fruit bunch and cause scaring.

• Debudding. Removal of the male flower bud and breaking off false hands and 1-2 of the smallest apical hands speeds maturation and finger length of the remaining fruit.

• Mulching – enhance nutrient and water management

• Wind protection – enhance water management and reduce mechanical wind damage to leaves and plants
Carambola (Averrhoa carambola)

Growth habit
- Small single-trunked tree easily managed to <11 ft tall
- Flowers/fruits on long whip shoots, short feather shoots, at the collar base of intermediate sized shoots, and large wood
- Flowering response to bending long shoots (clipping terminals) and pruning to collar base of intermediate sized shoots

Potential
- Synchronize many shoots on a tree to flower and fruit at the same time
- Alternatively, mild drought stress entire tree, then irrigate to synchronize and induce flowering (caution)
- To extend the fruiting season (earlier and later); normal cropping behavior in south Florida is July-Sept and Dec-Feb
Fruit description

★ The fruit is a 4 to 5-celled berry with 0 to 12 edible seeds.
★ Fruit range in size from 2 to 6 inches with 4 to 8 ribs; cut in cross section the fruit has a star shape.
★ The fruit skin is edible, smooth, and waxy.
★ The fruit flesh is juicy, light to dark yellow in color, crisp, and without fiber. Desirable cultivars have an agreeable sub-acid to sweet flavor.

‘Sri Kembangan’
Carambola cultivars

- 'Arkin'
- 'Fwang Tung'
- 'Kary'
- 'Kajang'
- 'Sri Kembangan'
- 'Lara'
Fruit development – normal fruit set to harvest

- The fruit development period (anthesis to fruit maturity) is cultivar and temperature dependent ranging from 8-12 weeks during the spring/summer and 10-16 weeks during fall/winter.

<table>
<thead>
<tr>
<th>Season</th>
<th>Days - fruit set to harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring/summer</td>
<td>56</td>
</tr>
<tr>
<td>Fall/winter</td>
<td>70</td>
</tr>
</tbody>
</table>
Pruning for off-season fruit production

• Three methods
  • Bending long shoots and clipping the terminals back 8-12 inches
  • Pruning shoots back to just outside the collar of a major secondary limb
  • Crop sacrifice (removing young fruit)

Photo credit and copyright: Roberto Nuñez
Selective pruning of ‘Arkin’ carambola to the base collar of small to mid-sized stems may induce flowering

Photo credit and copyright: Roberto Nuñez
Selective small-medium-sized limbs cut back to basal collar

Photo credit and copyright: Roberto Nuñez
**Effect of selective pruning on time to harvest and fruit yield in ‘Arkin’ carambola in Homestead, FL, 1994–1995**

<table>
<thead>
<tr>
<th>Pruning date</th>
<th>Harvest date&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Weeks from pruning to harvest</th>
<th>Fruit yield&lt;sup&gt;b&lt;/sup&gt; (g per bud&lt;sup&gt;c&lt;/sup&gt;)</th>
<th>Fruit yield&lt;sup&gt;b&lt;/sup&gt; (kg per branch&lt;sup&gt;d&lt;/sup&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>March 7</td>
<td>June 25</td>
<td>14</td>
<td>223 b</td>
<td>18.1 b</td>
</tr>
<tr>
<td>May 12</td>
<td>August 18</td>
<td>13</td>
<td>259 b</td>
<td>18.7 b</td>
</tr>
<tr>
<td>July 17</td>
<td>October 29</td>
<td>13</td>
<td>381 a</td>
<td>23.6 a</td>
</tr>
<tr>
<td>September 7</td>
<td>December 22</td>
<td>14</td>
<td>255 b</td>
<td>21.3 a</td>
</tr>
<tr>
<td>November 9</td>
<td>February 26</td>
<td>14</td>
<td>325 a</td>
<td>19.2 ab</td>
</tr>
<tr>
<td>January 12</td>
<td>June 30&lt;sup&gt;d&lt;/sup&gt;</td>
<td>22</td>
<td>185 c</td>
<td>14.5 c</td>
</tr>
</tbody>
</table>

<sup>a</sup> Harvest of non-pruned trees began July 30, 1995.
<sup>b</sup> Means with different letter within columns are significantly different according to Duncan’s multiple range test, *P* ≤ 0.05.
<sup>c</sup> Includes fruit from panicles formed at branch collars from removed lateral branches.
<sup>d</sup> No fruit set occurred on these branches until March 15.

- **P-pruning**
- **F-start flowering**
- **H-harvest**

- Pruning in Jan. or March resulted in early-season fruit by end of June
- Pruning in July resulted in fruit in October
Off-season bloom induction and fruit production via crop removal (crop sacrifice)

- Removing young fruit from trees during Nov.-Dec. results in a more vigorous tree during winter (leaf retention) and early spring canopy recovery and potentially earlier flowering; resulting in June-July fruit.

- Removing the fruit from the tree may result in off season flowering and fruit production.
  - Fruit were 50% or more full size (shake branches)
  - May be more effective if removed at smaller size but more difficult to remove (stripped)
Effect of time of crop removal on the intensity and earliness of flowering in ‘Arkin’ carambola in Homestead, FL, 1994

<table>
<thead>
<tr>
<th>Crop removal date&lt;sup&gt;a&lt;/sup&gt;</th>
<th>% of flowering shoots&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>March 26</td>
</tr>
<tr>
<td>Control</td>
<td>12.7 b</td>
</tr>
<tr>
<td>November 19</td>
<td>40.2 a</td>
</tr>
<tr>
<td>December 3</td>
<td>35.7 a</td>
</tr>
<tr>
<td>December 12</td>
<td>37.4 a</td>
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</table>

<sup>a</sup> Fruits were removed manually from treated trees; control trees were left intact. Flowering rates were monitored on 10 one-year-old shoots per tree, selected from the canopy periphery.

<sup>b</sup> Means with different letter within columns are significantly different according to Duncan’s multiple range test, $P\leq0.05$.

Effect of fruit removal on subsequent flowering and fruit production
Other practices to prolong/enhance production

Natural wind breaks (e.g., avocado)

Man-made wind breaks

Mulch
Longan (*Nephelium longana* var. *longan*)

Growth habit

- Medium to large tree to 60 ft, vigorous and spreading canopy
- Flowers are held on panicles (thyrses) which are produced from the terminal and subterminal buds on matured stems (shoots)

Potential

- Synchronize entire tree through pruning, nutrient and water management
- Off-season production to almost anytime of year with KClO$_3$
  - Normal season, July
Fruit description

• Longan fruit is a drupe with a thin, leathery, smooth exocarp (peel) surrounding a translucent white, sub-acid flavored flesh (aril)
• The pulp surrounds a single seed
• Fruit may be round, oval, or oblong shaped
• The peel is tan to light brown.
• Fruit may weigh up to 22 g (usually 10-20 g); total soluble solids, 15-25%

‘Hong Kong’
Longan cultivars in Florida

Numerous cultivars

• Top Florida cultivars
  • ‘Kohala’
  • ‘Chomphoo’
  • ‘Edau’
  • ‘Biew Keiw’
Crop production strategy – setting up trees to be induced to flower

• Maintain light exposure to entire canopy and synchronize all shoots through pruning

• Control (amounts and timing) nutrient and water applications to control vegetative flushes and induce dormancy (quiescence)
  • Leaf N content ~1.4% to 1.1%
  • Eliminate irrigation after harvest
Pruning to synchronize the tree (all the shoots)
Off season longan fruit production
Potassium chlorate background

Characteristics
• odorless, solid, fine crystalline, white colored material
• is a powerful oxidizing agent and used in making explosives, matches, and pyrotechnics.
• This material can explode if handled improperly

• When heated it emits toxic fumes of chloride and potassium oxide. It is categorized as a compound that requires precaution in handling and storage
• Read and follow all precautions for the Safety Data Sheet (formally Material SDS)
How to use potassium chlorate: recommended steps for applying potassium chlorate as a soil drench to induce longan bloom

- Tree phenology. Trees should not be flushing, about to flush or have just completed a flush
  - Stems need to be mature and dormant
  - You may need to wait or set trees up for the future
- Tree health. Trees should not be nutrient deficient; they need to be healthy

<table>
<thead>
<tr>
<th>Tree size/age</th>
<th>Rate of KClO₃ per tree</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 to 8 years old*</td>
<td>4 to 7 oz</td>
<td>Usually 1 application only</td>
</tr>
<tr>
<td>8 to 15 years old</td>
<td>7 to 13 oz</td>
<td>Usually 1 application only</td>
</tr>
<tr>
<td>15 plus years old</td>
<td>13 oz to 22 oz</td>
<td>Some people apply twice to very large trees.</td>
</tr>
</tbody>
</table>

The first application may be 16 oz/tree and the second application 30 days later at 8-10 oz per tree.
How to use potassium chlorate (KClO₃) - the application

- Pull back leaf litter and/or the organic mulch layer from under the canopy
- Irrigate the grove a day or so before application
- Either apply dry by sprinkling or carefully mix with sufficient water to cover under the canopy
- Apply the material to the soil surface under the canopy
- Irrigate trees immediately to move the material into the root zone
- Irrigate for several hours every 3 to 4 days for the next several weeks
- Bloom should initiate in 3 to 6 weeks and harvest 4-6 months later

The rate of KClO₃ for older trees (>10 years old) increases up to About 0.5 kg/tree or slightly more
Time from $\text{KClO}_3$ treatment and flowering and harvest

• Influenced by temperature and cultivar
• Flowering ranges from 30 to 60 days after treatment
• Harvest ranges from ~6 to 10 months after treatment
• No residues of $\text{KClO}_3$ in fruit
• If application rates are too high $\text{KClO}_3$ may be toxic
  • Marginal leaf necrosis – oldest leaves
  • Leaf drop, oldest leaves first
Papaya (*Carica papaya*)

Growth habit

- Gian arborescent herbaceous tree, usually single-trunked, and short lived
- Three plant types: males, females, and bisexuals
- Male flowers held on long branched cyme whereas female and bisexual cymes arise from leaf axils
- Flowers in response to tree size and ambient conditions

Potential

- Year-round production BUT as plants grow the fruiting column moves upward making harvest more difficult and in-efficient
- Potential to maintain fruit production through planting plants on a angle or ratoon to induce lateral branches and fruit production from these branches
Fruit description

• Papaya fruit is a berry with a thin, smooth exocarp (peel) and thick fleshy mesocarp surrounding an open cavity containing many small seeds

• Fruit may be globose, ovoid, obovoid, and pyriform, 2.5 - 14 inches long and 0.3 – 22 lbs in weight

‘Red Lady’

• The peel changes from green to yellow to orange. The pulp may be yellow, orange or red, soft, and sweet to sour.
‘Red Lady’
Cuba

‘Maradol’

‘Red Maradol’
Mexico

‘Known You-1’
‘Red Lady’

‘Maradol’
Cuba

‘Red Maradol’
Mexico

‘Known You-1’
Papaya branching and ratooning

Trees pruned to 48” in Trial 1 and 12”, 24”, 36” and 48” in Trial 2

Fruit production began about 3.5-4.0 months after pruning
Trial 2. Effect of pruning at 12, 24, 36 and 48 inches on plant mortality

<table>
<thead>
<tr>
<th>Treatment (pruning height, inches)</th>
<th>Percentage of plant mortality 5 ½ months after pruning</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>100</td>
</tr>
<tr>
<td>24</td>
<td>19</td>
</tr>
<tr>
<td>36</td>
<td>31</td>
</tr>
<tr>
<td>48</td>
<td>34</td>
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</table>
Ratooning papaya plants to facilitate culture and harvest

• Comparing the yields ~three months after selectively pruning plants to 24-48 inches and non-pruned control

• No significant difference in yield over the next 12 months

Hainan, China: Angle planting to lengthen the period of harvest efficiency
Thanks
Q&A