PROCEEDINGS:

Thirteenth Annual International Tropical Fruit Conference

October 24-26, 2003

Kaikodo Building
Hilo, Hawaiʻi

sponsored by the Hawaiʻi Tropical Fruit Growers and the County of Hawaiʻi, Research and Development
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Overview of the Australian Tropical Fruit Industry

Yan Diczbalis
Department of Primary Industries
Centre for Wet Tropics Agriculture
North Queensland
• Definition of a tropical fruit
  – Growth/production restricted to the tropical zone (23°27’N to 23°27’S)
  – Grows in areas with high rainfall or irrigation capacity
  – Equatorial fruits require high RH conditions
  – Mostly of SE Asian and Central/South American origin
Tropical — Wet/Dry
Tropical Wet
Sub-Tropical
Warm moist temperate

Climatic Zones  Koeppen Climate Classification
Rockhampton 23.4S

Total Rain = 37.9 in

Nambour 26.7S

Total Rain = 69.4 in
Total Rain = 68.1 in
Kununurra 15.7S

Total Rain = 31.6 in
Research and Development Infrastructure
Federal Government

- Department of Agriculture, Fisheries and Forestry (DAFF)
- Commonwealth Scientific and Industrial Research Organisation (CSIRO)
- Universities
- Research and Development Funding
  - Horticulture Australia (established fruit crops)
  - Rural Industries Research and Development Corporation (new crops)
State Governments

- Queensland
  - Department of Primary Industries (DPI)
- Northern Territory
  - Department of Business, Industry and Resource Development (DBIRD)
- Western Australia
  - Western Australia Department of Agriculture (WADA)
Industry Associations

• QFVG (Queensland Fruit and Vegetable Growers Association)
• NTHA (Northern Territory Horticultural Association)
• Commodity Specific Organisations eg.
  – AMA (Aust. Mango Association)
  – ALGA (Aust. Lychee Growers Association)
  – RTEGA (Rambutan and Tropical Exotic Growers Association)
Industry Group

Project Proposal

R&D providers
DPI
CSIRO
Universities

QFVG

Federal Funding
RIRDC
HAL

$ Project approved

$
Major Fruits

- Banana
- Mango
- Pineapple
- Lychee
- Papaya (Pawpaw)
• 8460 hectares (530 growers)
• Valued at $240 Million per annum (US$168M)
Banana Research

• Varieties
• Nutrition and irrigation management
• Pest and disease management
  – Yellow Sigatoka
  – Nematodes
  – Bunch pests
Mango

Industry based on Australian seedling selection;

- Kensington Pride (Bowen) 80% of trees and 90% of production.

Other cultivars include;

- R2E2, Honey Gold, B74
- Keitt, Palmer
- Nam Doc Mai, Khiew Sawoey, Chok Anan
# Mango Production (tonnes)

<table>
<thead>
<tr>
<th>Region</th>
<th>2002/2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Queensland</td>
<td>32937</td>
</tr>
<tr>
<td>Northern Territory</td>
<td>12600</td>
</tr>
<tr>
<td>Western Australia</td>
<td>3094</td>
</tr>
<tr>
<td><strong>Total Fresh</strong></td>
<td><strong>48631</strong></td>
</tr>
<tr>
<td>Processing</td>
<td>13544</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>62175</strong></td>
</tr>
</tbody>
</table>

Value: $120M (US$84)
Mango Exports
4,700 tonnes

- Singapore: 35%
- Hong Kong: 30%
- Asia (Other): 9%
- Saudi Arabia: 2%
- United Arab Emirates: 6%
- Japan: 11%
- Europe: 3%
- Other: 4%
- United Arab Emirates: 6%
- Other: 9%
- Europe: 3%
- Japan: 11%
- Hong Kong: 30%
- Singapore: 35%
Breeding - Prime Research commitment
Pineapple

• QLD
  – 5,000 ha
  – 128,000 tonnes
  – $36M

• No commercial production in NT and WA
Lychee
## Lychee production trends

<table>
<thead>
<tr>
<th>YEAR</th>
<th>Tonnes</th>
<th>Farm Gate Value</th>
<th>Total Exports</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>4,500 tonnes</td>
<td>$22.5 million</td>
<td>1,200 tonnes</td>
</tr>
<tr>
<td>1998</td>
<td></td>
<td></td>
<td>$6 million</td>
</tr>
<tr>
<td>2001</td>
<td>6,000 tonnes</td>
<td>$30 million</td>
<td>2,100 tonnes</td>
</tr>
<tr>
<td>2002</td>
<td></td>
<td></td>
<td>$10.5 mil</td>
</tr>
<tr>
<td>2003</td>
<td>8,000 tonnes</td>
<td>$40 million</td>
<td>3,200 tonnes</td>
</tr>
<tr>
<td>2004</td>
<td></td>
<td></td>
<td>$16 mil</td>
</tr>
<tr>
<td>2006</td>
<td>12,000 tonnes</td>
<td>$60 million</td>
<td>7,000 tonnes</td>
</tr>
<tr>
<td>2007</td>
<td></td>
<td></td>
<td>$35 mil</td>
</tr>
<tr>
<td>2010</td>
<td>24,000 tonnes</td>
<td>$120 million</td>
<td>19,500 tonnes</td>
</tr>
<tr>
<td>2011</td>
<td></td>
<td></td>
<td>$97.5 mil</td>
</tr>
</tbody>
</table>
Project Newsletter

Contents:
• Inform industry of project progress
• Dates and locations of workshops
• Key links to information sites
• Technical information
Papaya (Papaw)

- 350 hectares
- valued at $13 million
Papaya Research

• Nutrition and irrigation management
• Papaya breeding
• Pest and disease management
• Propagation
Minor Tropical Fruits

- **High Profile**
  - Rambutan - *Nephelium lappaceum*
  - Longan - *Dimocarpus longan*
  - Mangosteen - *Garcinia mangostana*
  - Durian - *Durio zibethinus*
Longan and rambutan production areas

- Nambour
- Rockhampton (23oS)
- Mackay
- Cooktown
- Tully
- Innisfail (17oS)
- Mareeba
- Darwin (12oS)
- Darwin (12oS)
- Cooktown
- Innisfail (17oS)
- Tully
- Mackay
- Rockhampton (23oS)
- Nambour
Longan industry profile

- 45,000 trees $2-3M ($US1.4-2.1M)
  - Industry spread along the east coast of Australia
  - Major production area on the Tablelands
  - 500 – 1500 tonnes/annum
  - Primarily domestic market supply
  - Cultivars; Kohala, Homestead, Biew Kew, Chompoo
Rambutan industry profile

• 30,000 trees $4-5M ($US 2.8-3.5M)
  – Main industry in far north Queensland (300-600 tonnes/annum)
  – Smaller (50-100 tonnes/annum) but lucrative industry based in Darwin (Northern Territory)
  – Primarily domestic market supply
  – Active efforts to develop export markets
  – Cultivars; R9, R134, R156-red, R162, R167, Binjai, Jitlee, Rongrien
Issues - rambutan and longan

- bird and bat problems
- canopy management
- IPM of pests and diseases
- Marketing groups
  - Domestic market profile
  - fruit quality standards
  - new market opportunities
  - packaging
• QLD
  – 20 growers
• NT
  – 6 growers
• Total value $0.5 - 1.0 M
*P. palmivora* diseases of durian

- **Dieback**
- **Fruit rot**
- **Leaf blight**
- **Patch canker**
Durian issues

• Disease management and control
• Reliable varieties (Kan Yao, Luang, Hepe, D. macrantha, D175 (red prawn), DPI Monthong)

• Marketing issues
  – Imports from Thailand allowed
    • No fresh fruit as yet
    • 1,000 tonnes/annum of frozen fruit
  – maturity standards
  – promotion
  – transport
Mangosteen

• Qld main production area
  – 14,000 trees, production valued at $0.75M

• NT
  – 4,500 trees
  – 3,500 managed by one grower
  – no commercial production
Mangosteen Issues

• inferior fruit quality
• crop management
• long juvenile period
• Marketing issues
  – fruit quality standards
  – packaging
  – safe food quality accreditation
• Potential of Thai imports
Tropical Citrus

- NT
  - 20 growers
  - 218 tonnes/annum
  - $1.1 M
Minor Tropical Fruits
“minor commercial”

• Guava - *Psidium guajava*
• Carambola - *Averrhoa carambola*
• Star Apple - *Chrysophyllum cainito*
• Wax Apple - *Syzygium aqueum*
• Jackfruit - *Artocarpus heterophyllus*
• Hogs Plum - *Spondias cythera*
• Sapodilla - *Achras sapota*
• Soursop - *Annona muricata*
• Abiu - *Pouteria caimito*
Guava

- Tree number - unknown
- 6 major growers
- White flesh type
- Price/kg $3.50
- Issues
  - Unserviced
  - Varieties
  - Winged vertebrate pests
Jackfruit

- Tree numbers - unknown
- 10 major growers
- price/kg - $2.00-$4.50
- green and ripe fruit
- Issues
  - unserviced
  - post-harvest / market quality
  - varieties
Abiu

• QLD
  • 10 growers
  • 1,200 trees
  • valued at $80,000
  • var. Z2, Z4, E4 and Gray
Carambola

- Tree numbers - 8,000 –10,000 approx.
- 10 major growers
- Avg. price/kg - $6.00 ($US4.20)
- Issues
  - netting
Pitaya (Dragon Fruit)

- Plant numbers >50,000
- price/kg - $12.00
- Issues
  - cultural practices
  - markets!!!
Cocoa Feasibility Project
Summary

• Australian tropical fruit industry is alive and well
• Grown over a diverse range of environments
• Major fruits (Banana, Mango, Pineapple, Papaya, Lychee) - $440 M (US$300M)/annum
• Minor fruits - $10 - 15 M (US$7 –10M/annum
  – present a challenge to growers and researchers
Longan Fertilizer Nutrient Requirements and Flowering

Fertilizer requirements for bearing trees are influenced by environment, physical and chemical characteristics of the soil, amount of nutrients lost by leaching and runoff, and amounts needed to sustain vegetative health and fruit production. For example, under high rainfall conditions, greater leaching can be expected particularly when soils are rocky and with little clay or organic material. Greater amounts of nutrients will also be required to sustain root, stem, and fruit growth of larger trees compared to smaller trees. An initial consideration in the development of a fertilizer nutrient program for producing longan trees is to determine the amount of fertilizer nutrients contained in the harvested fruits. This amount represents the amount of nutrient elements removed from the soil, which will need replenishment. Nutrient composition of the harvested fruit is only one important factor involved nutrient management of bearing longan trees, but it can provide insight into the nutrient requirements for this crop.

Data presented in Table 1 and 2 show the nutrient content of fruits for two longan cultivars (‘Biew Khiew’ and ‘Sri Chompoo’) growing at 3 different locations in East Hawaii on the island of Hawaii. All trees were treated with potassium chlorate to stimulate flowering, but tree age and field management practices varied between the 3 growing locations. Data shown in Table 1 are dry weight values from whole fruits that were analyzed for nutrient content and were obtained from 3 trees for each variety. Values shown in Table 2 are expressed as the percentage of each nutrient element contained within the fresh fruits.

Results obtained from the two varieties were somewhat similar and showed that P levels for the two varieties were nearly identical but showed some variation between the sampling periods. ‘Biew Khiew’ and ‘Sri Chompoo’ fruits contain relatively high amounts of nitrogen and potassium with N levels exhibiting the largest variation within each variety. Profuse flowering occurs after treatment with potassium chlorate and fruit thinning is recommended as setting of too many fruits can impact upon fruit quality. Many studies have illustrated a relationship between nutrition and fruit quality. Although panicles were thinned by the growers, no attempt was made in this study to regulate the amount of fruit production/tree from the three sites, and the variation in N, K and Ca between the sampling dates may have been due to different levels of fruit thinning practiced at each site. There have been reports suggesting that heavy fruit production on ‘Sri Chompoo’ trees after stimulating flowering with potassium chlorate is sometimes associated with increased splitting of the peel after harvesting. Presently it is not known
whether this observation is related to over production by the tree or inadequate amounts of nutrient elements such as calcium within the affected fruits.

Table 1. Nutrient element composition of ‘Sri Chompoo’ and ‘Biew Khiew’ longan fruits on a dry weight basis.

<table>
<thead>
<tr>
<th>'Sri Chompoo'</th>
<th>Percent of Dry Weight</th>
<th>ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>P</td>
</tr>
<tr>
<td>Farm A Jan 03</td>
<td>0.83 ± 0.05</td>
<td>0.15 ± 0.01</td>
</tr>
<tr>
<td>Farm B May 03</td>
<td>0.82 ± 0.02</td>
<td>0.13 ± 0.01</td>
</tr>
<tr>
<td>Farm C Jan 02</td>
<td>0.49 ± 0.02</td>
<td>0.16 ± 0.01</td>
</tr>
<tr>
<td>Mean</td>
<td>0.71 ± 0.16</td>
<td>0.15 ± 0.01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>'Biew Khiew'</th>
<th>Percent of Dry Weight</th>
<th>ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>P</td>
</tr>
<tr>
<td>Farm A Jan 03</td>
<td>1.22 ± 0.09</td>
<td>0.14 ± 0.01</td>
</tr>
<tr>
<td>Farm B May 03</td>
<td>1.07 ± 0.08</td>
<td>0.17 ± 0.01</td>
</tr>
<tr>
<td>Farm C Jan 02</td>
<td>0.68 ± 0.07</td>
<td>0.16 ± 0.01</td>
</tr>
<tr>
<td>Mean</td>
<td>0.99 ± 0.23</td>
<td>0.16 ± 0.01</td>
</tr>
</tbody>
</table>

Table 2. Nutrient element composition of fresh longan fruits.

<table>
<thead>
<tr>
<th>'Sri Chompoo'</th>
<th>Percent of Fresh Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Farm A Jan 03</td>
<td>.233</td>
</tr>
<tr>
<td>Farm B May 03</td>
<td>.250</td>
</tr>
<tr>
<td>Farm C Jan 02</td>
<td>.137</td>
</tr>
<tr>
<td>Mean</td>
<td>.207 ± 0.049</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>'Biew Khiew'</th>
<th>Percent of Fresh Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Farm A Jan 03</td>
<td>.316</td>
</tr>
<tr>
<td>Farm B May 03</td>
<td>.302</td>
</tr>
<tr>
<td>Farm C Jan 02</td>
<td>.180</td>
</tr>
<tr>
<td>Mean</td>
<td>.266 ± 0.061</td>
</tr>
</tbody>
</table>

Table 2 shows that if 100 pounds of ‘Sri Chompoo’ fruits are harvested, approximately 0.2, 0.042 and 0.37 pounds of N, P and K respectively, will be removed from the orchard. The amount of fertilizer to replace these amounts of N, P and K will be
dependent upon the tree’s ability to absorb the fertilizer nutrients along with weather and soil factors. As an example, if a grower uses fertilizer with an analysis of 10-5-20, an application of 2 pounds of this fertilizer will supply 0.2 lb of N, 0.043 lb of P and 0.33 lb of K and will replace the amounts removed by 100 pounds of fruit. This amount does not take into account the amount needed to maintain tree growth and health.

At the 10th Annual International Tropical Fruit Conference in 2000, we reported that potassium chlorate (KClO₃) stimulates flowering of longan trees (Nagao and Ho-a, 2000; 2000a). Flowering occurs within 2 months after evenly broadcasting 250 or 500 grams onto the soil surface beneath the canopy of each tree in an area extending to about 1.5 meters away from the trunk. All leaves and loose organic matter are removed from under the canopy prior to application, and trees are immediately irrigated to deliver the KClO₃ to the root zone. All longan varieties such as, ‘Kohala’, ‘Sri Chompoo’, ‘Biew Khiew’, and ‘E-Wai’, are responsive to the treatment. Potassium chlorate is a strong oxidizing agent and is used in matches and fireworks. The mode of action of potassium chlorate for longan flowering is not known, but the material is effective in all soil types and in many different climatic areas.

To determine if similar responses could be obtained with other closely related oxidizing agents, experiments were conducted to determine whether strong oxidizing compounds containing hypochlorite (sodium hypochlorite, calcium hypochlorite) could elicit a similar flowering response in longan. Sodium hypochlorite (NaClO) and calcium hypochlorite (Ca(ClO)₂) are commonly used in bleach or as materials for disinfecting swimming pools. Hypochlorite is closely related to chlorate, and the breakdown of hypochlorite will result in the generation of chloride and chlorate.

Four experiments were conducted on 3 to 5 year old longan trees planted in East Hawaii in rocky A’a soils commonly found near Hilo and in the nearby Puna district. Experiments were undertaken during 2002-2003 and on several varieties including, ‘Sri Chompoo’, ‘Biew Khiew’, and ‘Egami’.

**Experiment 1.** Effect of calcium hypochlorite on longan flowering (Table 3).

| Treatment: Calcium hypochlorite suspended into 2 gallons water and irrigated into the root zone. |
| Treatment date: 8/15/02. |
| Observation date: 10/22/02 |
| Varieties: ‘Sri Chompoo’ (n=2) |
| ‘Biew Khiew’ (n=1) |

<table>
<thead>
<tr>
<th>Variety</th>
<th>Treatment (grams active ingredient applied/tree)</th>
<th>Percent of Tree Canopy Flowering</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>154</td>
</tr>
<tr>
<td>‘Sri Chompoo’</td>
<td>0</td>
<td>3.1</td>
</tr>
<tr>
<td>‘Biew Khiew’</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 3 Effect of calcium hypochlorite on longan flowering.
Experiment 2. Effect of calcium hypochlorite on longan flowering (Figure 1).

Treatment: Calcium hypochlorite (500 g A.I.) suspended into 2 gallons water and irrigated into the root zone.
Treatment date: 10/29/02.
Variety: ‘Sri Chompoo’ (3 trees/treatment)

Figure 1. Effect of calcium hypochlorite on flowering of ‘Sri Chompoo’ longan trees.
Experiment 3. Effect of sodium hypochlorite on longan flowering (Figure 2).

Treatment: Sodium hypochlorite solution (2.625 %) in 2 gallons water irrigated into the root zone.

Treatment date: 1/28/03

Variety: ‘Biew Khiew’ (n=4)
‘Egami’ (n=2)

Figure 2. Effect of sodium hypochlorite on flowering and fruiting of ‘Biew Khiew’ and ‘Egami’ longan trees.
Experiment 4. Effect of sodium hypochlorite on longan flowering (Figure 3).

Treatment:
1. Sodium hypochlorite solution (2.625 %) in 2 gallons water irrigated into the root zone.
2. Sodium hypochlorite solution (2.625 %) in 2 gallons water irrigated into the root zone + 0.5 lb potassium chloride fertilizer (KCl).

Treatment date: 1/28/03
Soil type: Rocky A’a soil upper Puna
Variety: ‘Sri Chompoo’ (5 trees/treatment)

Figure 3. Effect of sodium hypochlorite on flowering of ‘Sri Chompoo’ longan trees.

C = control; TR1 = 2.625% sodium hypochlorite drench; TR2 = 2.625% sodium hypochlorite drench + 0.5 lb KCl; T1-5 = Tree 1-5.
Stimulation of flowering was observed within 2 months on ‘Sri Chompoo’ and ‘Biew Khiew’ trees growing in rocky A’a soil when 500 grams of calcium hypochlorite was applied as a drench to the soil beneath the canopy to an area extending to about 1.5 meters away from the trunk (Table 3 and Figure 1). As seen in Figure 1, flowering of untreated ‘Sri Chompoo’ trees began in April which coincided with the normal flowering period, but trees treated with calcium hypochlorite displayed increased flowering during February when longan flowering is generally very sporadic.

Application of sodium hypochlorite solution (2.625 %) applied as a 2 gallon soil drench also stimulated flowering of ‘Biew Khiew’, ‘Egami’ and ‘Sri Chompoo’ trees within 2 months after application (Figure 2 and 3). Application of muriate of potash (potassium chloride) fertilizer with the sodium hypochlorite did not affect the drench treatment, indicating that addition of potassium did not enhance the effect of hypochlorite (Figure 3). Although trees appeared uninjured by the treatment, heavy feeding and foliage damage from Chinese rose beetles was often evident in the hypochlorite treated trees just prior to and at the time of flowering. Preferential feeding of Chinese rose beetle on plants treated with ethephon has been previously reported (Arita et al., 1988), and the increased feeding by the rose beetle on the hypochlorite treated plants may be associated with elevated ethylene production.

These experiments showed that treatment with strong oxidizing agents such as calcium hypochlorite and sodium hypochlorite could stimulate flowering of longan trees, however, the response was reduced compared to flowering obtained after treatment with potassium chlorate. Preliminary trials with hypochlorite soil drench treatments to trees growing in deep silty clay loam soils showed that trees were less responsive compared to trees growing in rocky soils. The similar response with chlorate and hypochlorite may help to elucidate the mechanism of action of these materials during flower induction of longan.

Rambutan Flowering, Fruit Set, and Phenology

During the 12th Annual International Tropical Fruit Conference in 2002, we showed that fruit set of rambutan is often limited by the absence of male flowers within the orchard to supply pollen for good fruit set and normal fruit development. We also showed that the acid form of naphthaleneacetic acid (NAA) could stimulate the development of male flowers when applied at a specific period during flower development. Although the NAA is very effective, in the acid form the material is difficult to use due to its insolubility in water. A series of experiments were conducted to determine whether the potassium salt of NAA (K’NAA), which is highly soluble in water, could be as effective as the acid form for stimulating male flower development. The potassium salt of NAA is the active compound in plant growth regulators such as “K-Salt Fruit Fix” which is registered and used to control preharvest drop of apples and pears and for thinning of apples, olives, citrus and pear fruitlets.

To determine the optimum concentration of K’NAA required for development of male flowers, rambutan panicles on ‘R156 Red’ trees were sprayed to wetness with 0, 45, 90, or 135 ppm solutions when approximately 10% of the flowers on each panicle were at anthesis. Data at 7 days after treatment showed that the 90 ppm concentration produced the best result (Figure 4). Additional tests showed that ‘Jitlee’ and ‘Binjai’ developed up
to 50 male flowers/panicle at 6-7 days after panicles were treated with 90 ppm K+NAA (Figure 5). Observations also revealed that panicles with a more robust appearance were more responsive to NAA and that flowers responding to the K+NAA were those where the tip of the flower was beginning to open and the white tip of the pistil was barely visible. Flowers that were entirely closed and those with a fully exposed stigma were not responsive. These results show that 90 ppm NAA can be effective in stimulating the production of male flowers within 7 days after treatment and that only flowers at a specific stage of development are responsive to NAA. Since maximum production of male flowers occurs about 7 days after treatment, multiple applications on different panicles within an orchard will be necessary to insure that male flowers are present throughout the flowering season.

Rambutan is native to Malaysia and Indonesia, where the native growing environment is characterized by high rainfall, high humidity, low evaporation rates and average minimum temperatures above 68° F (Tindall, 1994). Rambutan production in Hawai‘i often occurs in environments that are very different from traditional growing areas of the humid tropics. Typically flowering occurs in response to a dry period followed by intermittent rainfall. Thus in producing areas such as Southeast Asia, regular flowering and fruiting cycles coincide with the wet/dry seasons associated with monsoon climates.

Although warm temperatures and adequate rainfall in windward areas of the Big Island are conducive to rambutan tree growth, production can be very erratic because the onset of dry weather can be unpredictable or inconsistent. A phenological study was conducted at two orchards in East Hawai‘i to characterize the flowering and vegetative flushing patterns of two rambutan varieties, ‘Jitlee’ and ‘R9’. One orchard was located at 390 feet elevation and planted in a well drained deep silty clay loam soil found along the Hamakua coast, while the second orchard was established in upper Puna at 885 feet elevation in a rocky soil consisting of fragmented A’a and a stony silty clay loam with a high amount of organic matter.

Flowering patterns over the three year observation period showed that ‘Jitlee’ and ‘R9’ displayed two distinct flowering periods at the 390 feet elevation site (Figure 6 and 7). Flowering was most frequent between March and May and between July and September. At the 885 feet site a broader flowering pattern was more prevalent with flowering occurring between March and September and maximum flowering occurring between April and July. Flowering intensity is related to the level and duration of water stress. The single and broader flowering pattern observed at the high elevation site may be in part due to more extreme drought stress experienced during January and February by trees growing in the rocky soil. Multiple peaks in vegetative flushing were observed at both sites with at least 3 flushing periods occurring during the year. It was not unusual to observe vegetative flushing and flowering occurring simultaneously within a variety or even within the same tree.

Timely synchronization of vegetative flushing is necessary to maximize the number of mature terminal branches that can flower following a dry period. However, the asynchronous flushing behavior of trees may be beneficial in terms of obtaining some flowering on a regular basis. Multiple flushing will insure that some mature terminals are present on trees at all times during the year. Thus trees exposed to intermittent dry periods will likely have terminals that are sufficiently mature to respond to the water
stress. Multiple or broad flowering peaks could also enable trees to produce up to two crops over a 12 month period and take advantage of off-season production periods.

**Literature Cited**


Figure 4. Effect of potassium salt of NAA (K\textsuperscript{+}NAA) on production of male flowers.

Figure 5. Effect of potassium salt of NAA (K\textsuperscript{+}NAA) on production of male flowers on ‘Binjai’ and ‘Jitlee’ varieties.
Figure 6. Flowering and flushing patterns of Jitlee at two different elevations.
Figure 7. Flowering and flushing patterns of R-9 at two different elevations.
Nutrition Management of
Australian Longan and Rambutan
Orchards

Y. Diczbalis
Department of Primary Industries
Queensland
Presentation topics

• Industry background
• Nutrient survey method
• Mean nutrient standards
• Orchards yields
• Nutrition budget
• Conclusions
Longan and rambutan production areas

- Darwin (12oS)
- Cooktown (17oS)
- Innisfail
- Tully
- Mackay
- Rockhampton (23oS)
- Nambour
- Mareeba
- Longan
- Rambutan
Longan industry profile

• 45,000 trees
  – Industry spread along the east coast of Australia
  – Major production area on the Tablelands
  – 500 – 1500 tonnes/annum
  – Value; $2-3M ($US1.4-2.1M)
  – Primarily domestic market supply
  – Cultivars; Kohala, Homestead, Biew Kew, Chompoo
Rambutan industry profile

• 30,000 trees
  – Main industry in far north Queensland (300-600 tonnes/annum)
  – Smaller (70-100 tonnes/annum) but lucrative industry based in Darwin (Northern Territory)
  – Value; $4-5M ($US 2.8-3.5M)
  – Primarily domestic market supply
  – Active efforts to develop export markets
  – Cultivars; R9, R134, R156-red, R162, R167, Binjai, Jitlee, Rongrien
# Australian Rambutan and Longan production periods

<table>
<thead>
<tr>
<th>Crop</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rambutan</td>
<td>NT</td>
<td>NT</td>
<td>NT</td>
<td>NT</td>
<td>NT</td>
<td>NT</td>
<td>NT</td>
<td>NT</td>
<td>NT</td>
<td>NT</td>
<td>NT</td>
<td>NT</td>
</tr>
<tr>
<td>Longan</td>
<td>NT</td>
<td>NT</td>
<td>NT</td>
<td>NT</td>
<td>NT</td>
<td>NT</td>
<td>NT</td>
<td>NT</td>
<td>NT</td>
<td>NT</td>
<td>NT</td>
<td>NT</td>
</tr>
</tbody>
</table>

- **Light production period**
- **Peak production period**
Development of nutrient standards.

• The process is based on the following parameters;
  – sampling a wide range of commercial orchards with yield being documented
  – identification of leaf standards based on orchard yields and tree health
  – determination of the ideal sampling time (nutrient concentrations are most stable)
  – selection of an easily recognisable leaf for sampling purposes.
Longan nutrition monitoring

- 9 orchards, 11 sampling sites
- Leaf samples
  - Pre-flowering
  - Fruit filling
  - Post-harvest
  - Harden summer flush
- Soil samples
  - Early flowering
  - harvest
Rambutan nutrition monitoring

• 14 orchards, 23 sampling sites
• Leaf samples
  – Panicle emergence
  – Fruit set
  – Fruit filling
  – Harvest
  – Post harvest mature flush
• Soil samples
  – Panicle emergence
  – Harvest
### Mean longan leaf nutrient concentrations

(95% confidence interval)

<table>
<thead>
<tr>
<th>Macro nutrients</th>
<th>%</th>
<th>Micro nutrients</th>
<th>(mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>1.75 (1.68-1.82)</td>
<td>Mn</td>
<td>83 (70-96)</td>
</tr>
<tr>
<td>P</td>
<td>0.17 (0.16-0.18)</td>
<td>Fe</td>
<td>115 (88-141)</td>
</tr>
<tr>
<td>K</td>
<td>0.83 (0.77-0.89)</td>
<td>Cu</td>
<td>84 (36-132)</td>
</tr>
<tr>
<td>Ca</td>
<td>2.66 (2.41-2.91)</td>
<td>Zn</td>
<td>48 (30-65)</td>
</tr>
<tr>
<td>Mg</td>
<td>0.36 (0.34-0.39)</td>
<td>B</td>
<td>56 (48-63)</td>
</tr>
<tr>
<td>S</td>
<td>0.16 (0.15-0.17)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Comparison of longan leaf nutrient concentrations and average yield (kg/ha/annum) over 3 seasons
1 – moderate inputs, low yield
2 – moderate inputs, high yield
3 – low inputs, very high yield

<table>
<thead>
<tr>
<th>Grower</th>
<th>N %</th>
<th>P %</th>
<th>K %</th>
<th>Ca %</th>
<th>Mg %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Av. Yield</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 (971)</td>
<td>1.74</td>
<td>0.19</td>
<td>0.99</td>
<td>1.94</td>
<td>0.28</td>
</tr>
<tr>
<td>2 (10,000)</td>
<td>1.80</td>
<td>0.15</td>
<td>0.65</td>
<td>3.42</td>
<td>0.38</td>
</tr>
<tr>
<td>3 (25,000)</td>
<td>1.48</td>
<td>0.16</td>
<td>0.66</td>
<td>3.08</td>
<td>0.46</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grower</th>
<th>Mn mg/kg</th>
<th>Fe mg/kg</th>
<th>Cu mg/kg</th>
<th>Zn mg/kg</th>
<th>B mg/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Av. Yield</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>70</td>
<td>47</td>
<td>61</td>
<td>27</td>
<td>58</td>
</tr>
<tr>
<td>2</td>
<td>118</td>
<td>152</td>
<td>330</td>
<td>170</td>
<td>59</td>
</tr>
<tr>
<td>3</td>
<td>62</td>
<td>208</td>
<td>28</td>
<td>24</td>
<td>49</td>
</tr>
</tbody>
</table>
Mean rambutan leaf nutrient concentrations (95% confidence interval).

<table>
<thead>
<tr>
<th>Macro nutrients</th>
<th>%</th>
<th>Micro nutrients</th>
<th>(mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>2.00 (1.96-2.05)</td>
<td>Mn</td>
<td>448 (405-491)</td>
</tr>
<tr>
<td>P</td>
<td>0.21 (0.20-0.22)</td>
<td>Fe</td>
<td>78 (73-82)</td>
</tr>
<tr>
<td>K</td>
<td>0.62 (0.60-0.64)</td>
<td>Cu</td>
<td>49 (39-58)</td>
</tr>
<tr>
<td>Ca</td>
<td>1.14 (1.09-1.19)</td>
<td>Zn</td>
<td>27 (23-31)</td>
</tr>
<tr>
<td>Mg</td>
<td>0.33 (0.32-0.34)</td>
<td>B</td>
<td>45 (43-47)</td>
</tr>
<tr>
<td>S</td>
<td>0.20 (0.20-0.21)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Mean grower
Leaf N
and P levels
Mean grower
Leaf K, Ca
and Mg levels
Mean grower
Leaf Mn and Fe levels
Mean grower Leaf Cu and Zn levels
Mean grower leaf B levels
Comparison of rambutan leaf nutrient concentrations and average yield (kg/ha/annum) over 3 seasons

1 – low inputs, low yield
2 – moderate inputs, high yield
3 – high inputs, high yield

<table>
<thead>
<tr>
<th>Grower</th>
<th>N %</th>
<th>P %</th>
<th>K %</th>
<th>Ca %</th>
<th>Mg %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (320)</td>
<td>2.24</td>
<td>0.24</td>
<td>0.53</td>
<td>1.33</td>
<td>0.30</td>
</tr>
<tr>
<td>2 (6240)</td>
<td>1.98</td>
<td>0.23</td>
<td>0.54</td>
<td>1.35</td>
<td>0.40</td>
</tr>
<tr>
<td>3 (5980)</td>
<td>2.11</td>
<td>0.19</td>
<td>0.70</td>
<td>1.06</td>
<td>0.29</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grower</th>
<th>Mn mg/kg</th>
<th>Fe mg/kg</th>
<th>Cu mg/kg</th>
<th>Zn mg/kg</th>
<th>B mg/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>299</td>
<td>72</td>
<td>24</td>
<td>22</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>598</td>
<td>97</td>
<td>70</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>3</td>
<td>217</td>
<td>63</td>
<td>71</td>
<td>23</td>
<td>64</td>
</tr>
</tbody>
</table>
# Accumulated rambutan yield (t/ha) vs accumulated N, P, K Inputs (kg/ha)

<table>
<thead>
<tr>
<th>Macronutrient</th>
<th>Equation</th>
<th>$R^2$</th>
<th>Significance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (N)</td>
<td>$Y = 21.512x + 4759.7$</td>
<td>0.472</td>
<td>$P = 0.087$</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>$Y = 41.113x + 3313.4$</td>
<td>0.614</td>
<td>$P = 0.037$</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>$Y = 33.369x - 164.1$</td>
<td>0.606</td>
<td>$P = 0.039$</td>
</tr>
<tr>
<td>N + P + K</td>
<td>$Y = 14.215x - 720.8$</td>
<td>0.783</td>
<td>$P = 0.008$</td>
</tr>
</tbody>
</table>
Management strategy for fertiliser inputs
Why be concerned about fertiliser inputs?

- Fertiliser accounts for (8-11%) of costs
- We lack strong evidence of yield response
- Excess fertiliser may stimulate unwanted growth
- Excess fertiliser inputs may be harmful to the environment
Nutrient Budget

Fertiliser Required = Nutrient Loss

• Nutrient Loss
  – Fruit removal (off farm)
  – Leaching losses
  – Runoff
  – Volatilisation
## Mean fruit nutrient concentration

<table>
<thead>
<tr>
<th></th>
<th>N %</th>
<th>P %</th>
<th>K %</th>
<th>Ca %</th>
<th>Mg %</th>
<th>S %</th>
<th>Mn mg/kg</th>
<th>Fe mg/kg</th>
<th>Cu mg/kg</th>
<th>Zn mg/kg</th>
<th>B mg/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Longan</strong></td>
<td>1.28</td>
<td>0.20</td>
<td>1.27</td>
<td>0.62</td>
<td>0.13</td>
<td>0.11</td>
<td>26</td>
<td>51</td>
<td>52</td>
<td>26</td>
<td>21</td>
</tr>
<tr>
<td><strong>Rambutan</strong></td>
<td>0.98</td>
<td>0.15</td>
<td>0.88</td>
<td>0.27</td>
<td>0.13</td>
<td>0.09</td>
<td>88</td>
<td>48</td>
<td>15</td>
<td>19</td>
<td>14</td>
</tr>
</tbody>
</table>
### Fruit nutrient removal (g/100 kg)

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
<th>S</th>
<th>Mn</th>
<th>Fe</th>
<th>Cu</th>
<th>Zn</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longan</td>
<td>337</td>
<td>53</td>
<td>335</td>
<td>162</td>
<td>35</td>
<td>29</td>
<td>0.69</td>
<td>1.34</td>
<td>1.36</td>
<td>0.71</td>
<td>0.55</td>
</tr>
<tr>
<td>Rambutan</td>
<td>202</td>
<td>31</td>
<td>180</td>
<td>55</td>
<td>28</td>
<td>19</td>
<td>1.8</td>
<td>0.98</td>
<td>0.30</td>
<td>0.38</td>
<td>0.29</td>
</tr>
</tbody>
</table>
Other losses

• Difficult to quantify and vary from site to site

• Estimates from other researchers
  – N – 30-40% (volatilisation, runoff and leaching)
  – P – 80-100% (fixation and runoff)
  – K – 30% (leaching and runoff)
  – Ca – 10% (leaching and runoff)
  – Mg – 25% (leaching and runoff)
Nutrient replacement

• longan crop (25 tonne/ha) 10 T/acre
  – macronutrient inputs per hectare required are 118 kg N, 109 K, 45 kg Ca, 26 kg P, 11 kg Mg, 7.2 kg S.

• rambutan crop (14 tonne/ha) 5.6 T/acre
  – macronutrient inputs per hectare required are 39.6 kg N, 32.7 K, 8.7 kg P, 8.5 kg Ca, 4.8 kg Mg, 2.6 kg S.
Conclusion

• Longan and rambutan fertiliser management
  – Yields not directly linked to inputs
  – Current management somewhat haphazard
  – Inputs tend to exceed outputs

• Recommend
  – Growers manage inputs based on a nutrient budget system
  – Undertake an annual leaf and soil sample (early panicle emergence)
  – Longan growers should avoid leaf N levels > 1.8%
Floral manipulation and canopy management in Longan and Rambutan
Longan

- Use of KClO₃
- Pruning time (underway)
- Bearing capacity (underway)
Longan Flower Induction

• Potassium Chlorate summary of findings
  – Varieties – wide range of varieties tested
  – Timing
    • Best when used to stimulate normal flowering
    • Can be utilised year round particularly in warmer climates
    • Flush preferably mature
  – Rates
    • Tested from 2 to 15 g/m² (best at 2 to 5 g/m²)
Commercial application of \( \text{KClO}_3 \)
Climate

Harvest

Panicle
Emergence

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Temperature (C)

Mean  Max Temp.

Rainfall (mm)

Mean Min Temp.

Rainfall (mm)

Panicle Emergence

Mean Max Temp.

Mean Min Temp.

Rainfall (mm)
# Heat Sum for time from application of KClO$_3$ to harvest

<table>
<thead>
<tr>
<th>KClO$_3$ app. date</th>
<th>Start Harvest</th>
<th>Calendar days to Harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 May 01</td>
<td>2948</td>
<td>243</td>
</tr>
<tr>
<td>18 May 01</td>
<td>2940</td>
<td>237</td>
</tr>
<tr>
<td>19 June 01</td>
<td>2985</td>
<td>226</td>
</tr>
<tr>
<td>23 Oct 01</td>
<td>2909</td>
<td>182</td>
</tr>
<tr>
<td>30 Apr 02</td>
<td>2946</td>
<td>253</td>
</tr>
<tr>
<td>17 May 02</td>
<td>2887</td>
<td>245</td>
</tr>
<tr>
<td>23 Oct 02</td>
<td>2962</td>
<td>202</td>
</tr>
<tr>
<td>Average</td>
<td>2940</td>
<td></td>
</tr>
</tbody>
</table>
Suggested use of KClO₃

- In large orchards (1,000 + trees)
  - Alternate application of KClO₃ with heavy pruning
  - Avoid yearly application to allow trees to recover use non treated season to reduce tree size
  - Bird/Bat netting only required on producing trees
Rambutan pruning questions??

- Why
  - tree size control
  - tree productivity
- When to prune
- Hand pruning vs Mechanical
- Chemical pruning
- Pruning shape
Pruning shapes
Pruning Time
Mean Temperature

<table>
<thead>
<tr>
<th>Port Douglas</th>
<th>South Johnstone</th>
</tr>
</thead>
</table>

Data from Diczbalis 'Environmental factors influencing the growth and yield of Rambutan'

<table>
<thead>
<tr>
<th>Mean Daily temperature (°C)</th>
<th>30 (85°F)</th>
<th>27 (80°F)</th>
<th>23 (73°F)</th>
<th>18 (64°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of flushes (in 18 weeks)</td>
<td>4</td>
<td>4</td>
<td>2.4</td>
<td>1.6</td>
</tr>
<tr>
<td>Duration of flushes (weeks)</td>
<td>5.8</td>
<td>6</td>
<td>8.5</td>
<td>12.5</td>
</tr>
</tbody>
</table>
Regular pruning to determine phenological response

- Choose 12 trees at strategic locations along the coast.
- Prune 2 trees every 2 months (to cover 12 months).
- Monitor flush and flowering patterns.
- Ultimately determine flower/fruiting pattern and relate to time of pruning.
Determine techniques for large tree size reduction

• Reduce large size tree to stump.
• Apply a range of grower determined techniques to manage trees back into production.
Test effectiveness of chemical pruning options

- Ethrel® (5ml/l) + Urea (10g/l) (used in lychee O.S.)
- Ethrel® (5ml/l)
- MKP (40g/l)
- Potassium sulphate (50g/l)
- Wettable sulphur (20g/l)
- Combinations of above
Non-pruning growth regulation

Plant growth regulators (PGR)
Root Pruning
Cincturing
Irrigation scheduling
PGR - trials

• Trial the use of paclobutrazole and uniconazol on rambutan
  – Preflowering application, 2-3 foliar sprays
  – Potential effect will be to
    • Reduce vegetative flushing
    • Shorten internodes
    • Advance flowering
    • Enhance flowering response
Root Pruning - trials

- Root pruning in conjunction with structural pruning to assess the effect on regrowth, tree size and tree productivity relative to untreated trees.
- Root pruning immediately pre or at early flowering to assess the effect of root pruning on fruit set, size and yield relative to untreated trees.
Cincturing - trials

- Cincturing following maturity of the 1\textsuperscript{st} or 2\textsuperscript{nd} flush post structural pruning to assess the effect of the treatment on subsequent vegetative growth and flowering.
- Cincturing immediately pre-flowering or at first signs of flowering to examine the effect on fruit set and final fruit size.
Acknowledgments

• For research funding and support
  – Longan Association Australia (LAA)
  – Rambutan and Tropical Exotic Growers Association (RETGA)
  – Rural Industries Research and Development Corporation (RIRDC)
Thank You
Insecticides and Miticides for Tropical Fruits

October 25, 2003

Arnold H. Hara
University of Hawaii at Manoa – CTAHR
Dept. of Plant & Environmental Protection Sciences
Hilo, Hawaii
What will be covered?

* Broadly labeled Insecticides that includes tropical fruits.
* Insecticides (GRAS) approved for use in organic crop production.
* Insecticides and miticides for non-bearing fruit trees.
* Special Local Need Products.
* Newer reduced-risk insecticides for tropical fruits.
* Potential reduced-risk insecticides and miticides for tropical fruits.
## Broadly Labeled Insecticides including on Tropical Fruits

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Brand Name</th>
<th>Activity</th>
<th>Insects on label</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyrethrins</td>
<td>Pyrenone</td>
<td>Nerve poison, short residual,</td>
<td>aphids, hoppers, stinkbugs, thrips,</td>
</tr>
<tr>
<td>+PBO (synergist)</td>
<td>Evergreen</td>
<td>“exciter” or flushing agent</td>
<td>whiteflies, mites</td>
</tr>
<tr>
<td>+rotenone</td>
<td>Pyrellin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Azadirachtin</td>
<td>Azatin</td>
<td>repellent, antifeedant,</td>
<td>Chinese rose beetle, aphids, leafminers</td>
</tr>
<tr>
<td></td>
<td>Aza-Direct</td>
<td>insect growth regulator</td>
<td>hopsers, caterpillars, thrips, mites</td>
</tr>
<tr>
<td></td>
<td>Neemix</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neem oil</td>
<td>Trilogy</td>
<td>suffocation, ovicidal,</td>
<td>soft bodied insects, (aphids, mealybugs)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>repellent</td>
<td>mites, fungi</td>
</tr>
<tr>
<td>\textit{Bacillus thuringiensis}</td>
<td>Dipel</td>
<td>ingestion, stomach poison, uv breakdown</td>
<td>caterpillars</td>
</tr>
<tr>
<td>Oils &amp; soaps</td>
<td>various</td>
<td>suffocation, disrupts cuticle,</td>
<td>soft bodied insects</td>
</tr>
<tr>
<td></td>
<td></td>
<td>contact action</td>
<td>scale insects</td>
</tr>
</tbody>
</table>
Insecticides for Use on Organic Crop Production

*Substances are also listed as generally recognized as safe (GRAS) by Food and Drug Administration (FDA).

Insecticides:
- Ammonium carbonate – for use in insect traps only
- Elemental Sulfur
- Lime Sulfur – including calcium polysulfide
- Horticultural Oils
- Insecticidal Soaps
- Sticky traps/barriers

Fungicides:
- Copper hydroxide
- Hydrated lime
- Hydrogen peroxide

MAY REQUIRE EPA REGISTRATION; NOT CONSIDERED EXEMPTED!
SUPPLEMENTAL LABELING
For Distribution and Use Only Within the State of Hawaii.

Drexel (MICRONIZED)
Sulfur 90W
A Wettable Sulfur
EPA Reg. No. 19713-238

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

DIRECTIONS FOR USE

CROP/SITE: Kava (kava, ‘awa) (Piper methysticum)

TARGET PEST/PROBLEM: Carmine Spider Mite (Tetranychus cinnabarinus)

APPLICATION RATES: For airblast sprayers: 8-20 pounds in sufficient water to thoroughly cover all leaf surfaces.

APPLICATION FREQUENCY: For severe infestations, apply at 7 to 10 day intervals. For control and prevention, apply at 14 to 21 day intervals.

APPLICATION INSTRUCTIONS: Apply as a broadcast or directed spray making sure to achieve complete coverage of upper and lower leaf surfaces.

Restricted Entry Interval: Do not enter or allow worker entry into treated areas during the restricted entry interval of 24 hours

All applicable directions, restrictions, and precautions on the EPA registered label are to be followed. This label must be in the possession of the user at the time of application.

This label is valid until October 2, 2005 or until otherwise amended, withdrawn, cancelled or suspended.

24(c) Registrant: Drexel Chemical Company
P. O. Box 13327
Memphis, TN 38113-0327

EPA SLN No. HI-000004
Issue Date: October 3, 2000
Expiration Date: October 2, 2005

WHAT IS NEEDED TO REGISTER SULFUR FOR USE ON TROPICAL FRUITS?

1. Efficacy data.
2. Phytotoxicity data.
3. No effective alternative.
4. Registrant-Chemcial Co.
   *No residue data needed.
   (HDOA pers. com. 10/24/03)
*Many insecticides and miticides are registered for use only on Non-Bearing Fruit Trees
*Non-bearing fruit tree up to one (1) year prior to flower initiation (not initial bearing of fruit).
*Cannot be used between non-bearing seasons.

-**Insecticides:**
  - Amdro Pro - ants
  - Carbaryl 4 L – Chinese rose beetle
  - Distance – armored scales

-**Miticides**
  - Hexygon
  - Tetrasan
SECTION 24(c) REGISTRATION

CARBARYL 4L

FOR DISTRIBUTION AND USE ONLY WITHIN HAWAII

APPLICABLE DIRECTIONS, RESTRICTIONS, AND PRECAUTIONS ON THE EPA REGISTERED LABEL ARE TO BE FOLLOWED.

THIS LABEL MUST BE IN POSSESSION OF USER AT THE TIME OF APPLICATION.

DIRECTIONS FOR USE

It is a violation of Federal Law to use this product in a manner inconsistent with its labeling.

NON-BEARING TROPICAL FRUIT TREES SUCH AS (lychee, longan, mangoes, rambutan): For control of Chinese Rose Beetle (*Adoretus sinicus Burmeister*), apply Carbaryl 4L at a rate of 1 qt. per acre. Mix with 20-250 gallons of water in conventional hydraulic-type or airblast sprayers. Apply when insects or their feeding damage appear. Repeat at 7 to 10 day intervals as necessary. Apply dilute spray at full coverage to crop foliage. Spray gallonage will vary according to tree size, density, planting distance, and stage of growth. Keep spray mixture well agitated.

Carbaryl 4L may be applied to nonbearing crop up to one (1) year prior to their initial bearing of fruit.
## Newer Reduced-Risk Insecticides for Tropical Fruits

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Brand Name</th>
<th>Activity</th>
<th>Insects on label</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>REGISTERED</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>imidacloprid</td>
<td>Provado</td>
<td>Nerve poison, systemic</td>
<td>aphids, soft scales, whiteflies, Chinese rose beetle, mealybugs ambrosia beetles</td>
</tr>
<tr>
<td>spinosad</td>
<td>Success</td>
<td>fermentation product from a soil bacterium, nerve poison, contact and stomach activity</td>
<td>thrips, caterpillars, leafminers, katydid, Justice is a bait for little fire ant</td>
</tr>
<tr>
<td></td>
<td>Justice</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>POSSIBILITIES</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>buprofezin</td>
<td>Applaud</td>
<td>IGR, chitin synthesis inhibitor</td>
<td>mealybugs, scale insects, whiteflies</td>
</tr>
<tr>
<td>milbamectin</td>
<td>?</td>
<td>Natural product from soil microbe, nerve</td>
<td>spider, erineum, broad mites</td>
</tr>
</tbody>
</table>
## Tropical Fruit Crops

<table>
<thead>
<tr>
<th>Provado</th>
<th>Success (Justice – ant bait )</th>
</tr>
</thead>
<tbody>
<tr>
<td>aphids, leafhoppers, whiteflies, scales (suppressed)</td>
<td>thrips, caterpillars, katydids</td>
</tr>
<tr>
<td>Acerola</td>
<td>Passion fruit</td>
</tr>
<tr>
<td>Avocado</td>
<td>Persimmon</td>
</tr>
<tr>
<td>Canistel</td>
<td>Pulasan</td>
</tr>
<tr>
<td>Feijoa</td>
<td>Rambutan</td>
</tr>
<tr>
<td>Guava</td>
<td>Spodilla</td>
</tr>
<tr>
<td>Jaboticaba</td>
<td>Sapote (Black)</td>
</tr>
<tr>
<td>Longan</td>
<td>Spanish Lime</td>
</tr>
<tr>
<td>Lychee</td>
<td>Star Apple</td>
</tr>
<tr>
<td>Mamey Sapote</td>
<td>Starfruit</td>
</tr>
<tr>
<td>Mango</td>
<td>Wax jambu</td>
</tr>
</tbody>
</table>

Including, but not limited to:

| Acerola | Mango |
| Atemoya | Papaya |
| Avocado | Passion fruit |
| Biriba | Pulasan |
| Canistel | Rambutan |
| Cherimoya | Sapodilla |
| Custard Apple | Sapote (Black) |
| Feijoa | Soursop |
| Guava | Spanish Lime |
| Ilima | Star Apple |
| Jaboticaba | Sugar Apple |
| Longan | Ti Palm Leaves |
| Lychee | Wax jambu |
| Mamey Sapote | White Sapote |
Provado (Merit, Marathon)
* Relatively new systemic insecticide
* Low risk to humans and the environment
* Highly effective against aphids, Chinese rose beetle, lacebugs, soft scales & whiteflies. Moderately effective against mealybugs.

Applied as a drench, by 21 DAT >90% mortality observed on gardenia plants. Control lasted for approximately 1 year.

Growth difference of gardenia due to control of green scale.
Imidacloprid against Chinese Rose Beetle

Dying Chinese rose beetle after feeding on rose plant drenched with Merit about 2 weeks earlier.

New growth with no beetle damage.
**Buprofezin**

*Insect growth regulator*

Talus = ornamentals, Sepro (Submitted)

Applaud = food crops, Nichino (Available)

*Inhibits chitin synthesis which interrupts molting, suppresses oviposition & reduces egg viability.

*High level of activity against most homopteran insect pests including whiteflies, mealybugs, soft scales, armored scales, leafhoppers and planthoppers.

*Vapor activity allows buprofezin to reach the undersides of leaves and new growth.

*Applaud is available in Hawaii for use on bananas and citrus controlling:

<table>
<thead>
<tr>
<th>Whiteflies</th>
<th>Mealybugs</th>
<th>Soft Scales</th>
<th>Armored Scales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silverleaf</td>
<td>Longtailed</td>
<td>Black</td>
<td>Coconut</td>
</tr>
<tr>
<td>Greenhouse</td>
<td>Citrus</td>
<td>Brown</td>
<td>Cockerell</td>
</tr>
<tr>
<td>Sweet potato</td>
<td>Mexican</td>
<td>Hemispherical</td>
<td>Fern</td>
</tr>
<tr>
<td>Ash</td>
<td>Obscure</td>
<td>Wax</td>
<td>Boisduval</td>
</tr>
<tr>
<td></td>
<td>Comstock</td>
<td>Tessellated</td>
<td>White peach</td>
</tr>
</tbody>
</table>
**Milbemectin** (Gowan Co)  
(a potential miticide for lychee mite)

*A natural compound derived from the soil microorganism, *Streptomyces*. (related to abamectin).
*Active against spider, broad, cyclamen, rust, bud and erineum mites.
*Active on all stages of mites through both contact and ingestion.
*Affects nerve transmission in mites.
*Translaminar – penetrates leaf tissue for longer effectiveness.
*Minimal impact on non-target organisms.
*Classified by U.S. EPA as a reduced risk miticide.
*Residue work is already completed for lychee, longan, Spanish lime, rambutan and pulasan.
*Efficacy data from Hawaii against the lychee mite is needed.
Acknowledgements

For technical assistance:

Stacey Chun
Patrick Conant
Christopher Jacobsen
Robert Hamilton
Clyde Hirayama
Mike Nagao
Ruth Niino-Duponte
Ken Ogawa
Derek Shigematsu
Mangosteen Caterpillar \textit{Sictoptera cucuilioides} Guenee
\textit{(LEPIDOPTERA: NOCTUIDAE)}

Mike A. Nagao, Heather M.C. Leite, Arnold H. Hara, and Ruth Y. Niino-DuPont
University of Hawai’i at Mānoa, CTAHR
Beaumont Agricultural Research Station  Hilo, Hawaii

Introduction
A caterpillar that causes extensive damage to young leaves of mangosteen trees in Hawai’i has been identified as \textit{Sictoptera cucuilioides} (formerly called \textit{S. subobliqua} (Walker)). The mangosteen caterpillar was first recorded in Hawai’i in 1949 from larvae and adult specimens obtained in Honolulu in 1948.

Distribution
This noctuid moth was first described in Sri Lanka, and has been reported in parts of India, Thailand, Singapore, Malaysia, Papua New Guinea, and Guam. In Hawai’i, the mangosteen caterpillar is found on the islands of O’ahu, Hawai’i, Maui and Moloka’i.

Hosts
In addition to mangosteen (\textit{Garcinia mangostana}), \textit{S. cucuilioides} feeds on related latex-bearing plants (Guttiferae family), including \textit{G. cambogia}, mammee apple (\textit{Mammea americana}), kamani (\textit{Calophyllum inophyllum}), autograph tree (\textit{Clusia rosea}), \textit{Ochroma obovalis}, and \textit{O. excelsus} or \textit{M. odorata}.

Damage
The caterpillars feed upon emerging leaves and shoot tips of their host plants, causing extensive defoliation of new flushes (Fig. 1a, b), often leaving only the leaves’ midribs. A single caterpillar as small as 0.6 cm (1/4 in) will cause significant damage to tender, young leaves. Due to their nocturnal feeding behavior, caterpillars are inconspicuous until the damage is severe.

Behavior
Mangosteen caterpillars are active at night but can be observed feeding on young leaves until early to mid-morning. During daylight hours, they retreat into the denser parts of tree canopies where they are not easily detected. Under laboratory conditions, the caterpillars will hide during the day under mangosteen leaves left in their cage and are most active during the early evening. Prior to pupation, the caterpillars burrow into soil media, or when media is not present, cocoons develop under leaves or in dark, shaded areas.

Life Cycle
Few reports on the life cycle of the mangosteen caterpillar have been published. Both the larval (caterpillar) and adult stages of \textit{S. cucuilioides} are variable in size and color. Caterpillars range from light green with black or maroon spots and white stripes to dark purple with white stripes and dots just before pupation (Fig. 2a to d). Just prior to pupation, the last instar ranges from 2.5 to 5.0 cm (1 to 2 in) in length. Pupation occurs in the soil. The pupa (cocoon) is dark brown, 1.3 to 1.6 cm (1/2 to 5/8 in) in length, and 0.6 cm (1/4 in) wide (Fig. 2e). The adult moth is brown but can vary in color tones and patterns (Fig. 2f). The adult male appears to have a more ornate wing pattern and a larger abdomen compared to the female.

Previous reports indicate that the larval stage averages 15 days and pupation lasts 10-12 days. Under laboratory conditions (20.9 °C or 69.6 °F min / 24.9 °C or 76.8 °F max), the duration of the pupal stage can be extended to as long as 18-20 d. There are no reports on the duration of the adult moth stage.

Management
Growers should monitor new flushes as they emerge for evidence of feeding damage. Insecticides containing \textit{Bacillus thuringiensis} are effective in controlling leaf-eating caterpillars, including \textit{S. cucuilioides}. Azadirachtin (neem extract) is reported to provide effective control in Thailand. Consult product labels for information on application rates and pre-harvest intervals. No biocontrol agents have been detected on mangosteen caterpillar infestations in Hawai’i.
Figure 1. Damage to mangosteen foliage caused by *Stictoptera cuculioidea* larvae: a) Monitor evidence of caterpillar feeding on tender, new leaves; b) remaining leaf midribs.

![Image of mangosteen foliage damage](image)

Fig. 2. Life stages of the *S. cuculioidea*: a) through d) caterpillar (larva) color variations (actual size ranges from 2.5 to 5.0 cm), e) pupa (actual size 1.3 to 1.6 cm in length, and 0.6 cm wide), and f) adults.

![Image of life stages of *S. cuculioidea*](image)

References:

Acknowledgements: The authors would like to thank Mr. Shin Matayoshi; HIDOA (retired), Mr. Dick Tsuda, UH CTAHR, and Dr. Surmsuk Salakpetch, Chantaburi Horticultural Research Center for their contributions to this publication.

FOLLOW SAFETY PRECAUTIONS GIVEN ON MANUFACTURERS' LABELS

PRECAUTIONARY STATEMENT
Consult a chemical sales representative, the Hawaii Department of Agriculture, or the University of Hawaii Cooperative Extension Service for correct formulation of insecticides, more information, or updated recommendations. The user is responsible for the proper use, application, storage, and disposal of pesticides.

DISCLAIMER
Reference to a product does not imply approval or recommendation by the College of Tropical Agriculture and Human Resources, Cooperative Extension Service, University of Hawaii, or the United States Department of Agriculture and does not imply its approval to the exclusion of other products that may be suitable. All materials should be used in accordance with label instructions.
This information is the culmination of a series of interviews with researchers, extension agents, chemical sales representatives, and growers in Hawaii and a worldwide literature search.
Arthropod Pests of Lychee, Longan, and Rambutan

Peter A. Follett, USDA-ARS, U.S. Pacific Basin Agricultural Research Center, Hilo, Hawaii
Lychee and Longan Pests

- Oriental fruit fly
- Litchi fruit moth (*Cryptophlebia*)
- Litchi erinose mite (lychee only)
- Chinese rose beetle
- Mealybugs (long-tailed, citrus, obscure), Scales (red wax, green)
- Thrips (red-banded)
Oriental fruit fly

- Attacks ripe fruit only
- “Sting” causes water soaked spot
- Lychee and longan are poor hosts
- Damage 5-25%: lychee > longan
GF-120 Fruit Fly Bait

- Spinosad + protein/sugar bait
- Over 250 crops registered, including all our tropical fruits
- 20 oz./acre, 2 ½ gal./acre formulated, cost = $15/acre
- 7-day activity (rainfall? phyto?)
Litchi fruit moth
Cryptophlebia

• Attacks all stages of fruit but more as fruit ripen
• Larval entry hole causes water soaked spot
• Lychee and longan are poor hosts
• Damage 5-10%: lychee > longan
Attract and Kill

Last Call

Litchi fruit moth

- Pheromone + insecticide
- Droplets imitate calling females
- Kills males after contact
- 1200 droplets/acre

Field tests

- Lychee, longan, and macadamia
Experiments

### 2002
- Last Call only
- 2 split orchards
- Trap catch
- Harvest data on eggs, larvae, and damage

### 2003
- Last Call and GF-120
- 3 treated orchards, 2 untreated
- Trap catch
- Harvest data on eggs, larvae, damage, and other blemishes
Harvest Lychee - % Damage
All orchards 2003
Litchi erinose mite

- Moved by wind, honey bees
- Virtually invisible; erinea
- Move from old infested leaves to new flush leaves
- Can attack florets, preventing fruit set
Litchi erinose mite

Control

• Inspect for symptoms monthly
• Apply insecticide at early flushing
• 2 applications, 2-3 weeks apart
• Control during off season
• But especially before flowering!
Chinese rose beetle

• Polyphagous
• Adult feeding cause lace damage

Control
• Barriers (cages)
• Insecticides (carbaryl: non-bearing trees, only)
Rambutan Pests

- Mealybugs (pink hibiscus, long-tailed, citrus, obscure)
- Scales (red wax, green)
- Thrips (red-banded)
- Mites
- Oriental fruit fly
- Tortricid moths
Mealybugs

Scales

- Parasitoids common
- Tended by ants

Control

- Insecticides
- Ant baits in bait stations
- Check ant species first
Registered Insecticides
2002

• Spinosad (FF)
• Pyrethrin + rotenone (all)
• Bacillus thuringiensis (LFM)
• Soaps (Mb, Sc, Th)
• Summer oils, Sun spray (Mb, Sc, Th)
• Carbaryl (CRB)
Approvals for New Irradiation Treatments Continue

This is a list of the main tropical fruits in Hawaii and quarantine treatments developed to disinfest fruits of fruit flies and other insect pests before shipment from Hawaii to the U.S. mainland and foreign markets. Treatments are categorized as submitted, proposed, or accepted. Accepted treatments are underlined, and only accepted treatments are available for exporting fruit at this time. This is general information only; consult APHIS-PPQ for complete quarantine treatment or protocol regulations.

What's New: Irradiation is now an approved treatment for mangoes (300 Gy) and pineapple varieties other than smooth Cayenne (250 Gy). Pest risk assessments (the first step in developing a quarantine treatment for export) have been submitted to APHIS for breadfruit and jackfruit, and pest risk assessments for dragonfruit and mangosteen are being prepared by the Hawaii Department of Agriculture and USDA-APHIS. A rule proposing a generic irradiation dose of 150 Gy for all tephritid fruit flies is being prepared. We currently irradiate all our fruit at 250 Gy for fruit flies. Reducing the treatment dose will lower treatment costs and increase treatment capacity at the irradiation facility.

Abiu
- **Irradiation** -- 250 Gy -- treatment carried out only in an approved facility in Hawaii or in non-fruit fly supporting areas of the mainland US. Other conditions apply.

Atemoya
- **Irradiation** -- 250 Gy -- treatment carried out only in an approved facility in Hawaii or in non-fruit fly supporting areas of the mainland US. Other conditions apply.

Avocado
- **Cold treatment** -- all cultivars, 12 days at ≤ 1.1°C (34°F), 14 days at ≤ 1.67°C (35°F), 16 days at ≤ 2.2°C (36°C); requires heat shock pretreatment.

Bananas
- **Nonhost status** -- green bananas, cv. ‘Williams’, ‘Valery’ and ‘dwarf Brazilian’. Regulation includes specific conditions: bananas must be picked green and packed for shipment within 24 h after harvest; no bananas from bunches containing prematurely ripe fingers; and must be inspected and found to be free of pests and defects.
- **Irradiation proposed** -- as a clean up treatment for surface pests (400 Gy).
Breadfruit
- Pest risk assessment submitted (completed by HDOA, submitted to APHIS)

Carambola
- Cold treatment -- storage for 10 days at ≤ 0.0°C (32°F), 11 days at ≤ 0.6°C (33°F), 12 days at ≤ 1.1°C (34°F), 14 days at ≤ 1.67°C (35°F).
- Irradiation -- 250 Gy -- treatment carried out only in an approved facility in Hawaii or in non-fruit fly supporting areas of the mainland US.

Citrus
- High temperature forced air -- fruit core temperature heated to > 47.2°C (117°F) in not less than 4 hours.

Dragonfruit
- Pest risk assessment in preparation by HDOA and APHIS.

Durian
- Nonhost status -- must be inspected and free of surface pests.

Jackfruit
- Pest risk assessment submitted (completed by HDOA, submitted to APHIS)

Longan
- Hot water immersion -- 49°C (120°F) or above for 20 minutes. (approved June 17, 2002)
- Irradiation -- 250 Gy -- treatment carried out only in an approved facility in Hawaii or in non-fruit fly supporting areas of the mainland US. Other conditions apply.

Lychee
- Hot water immersion -- 49°C (120°F) or above for 20 minutes.
- Irradiation -- 250 Gy -- treatment carried out only in an approved facility in Hawaii or in non-fruit fly supporting areas of the mainland US.
- Vapor heat -- internal fruit temperature raised by saturated water vapor (>90% RH) to 47.2°C (117°F) (or above) in at least 60 min. Hold at 47.2°C for 20 min. Hydrocool with a cool water spray. (approved June 17, 2002)

Mango
- Irradiation -- To U.S. -- 300 Gy -- treatment carried out only in an approved facility in Hawaii or in non-fruit fly supporting areas of the mainland U.S.
- Vapor heat -- To Japan -- cv. ‘Haden’ and ‘Keitt.’ Fruit core temperature heated to > 47.2°C (117°F) in not less than 4 hours. Other conditions apply.
Mangosteen

- Pest risk assessment in preparation by HDOA and APHIS.

Papaya

- **High temperature forced air** -- fruit core temperature heated to > 47.2°C (117°F) in not less than 4 hours.
- **Vapor heat** -- fruit core temperature heated by saturated water vapor to 44.4°C (112°F). Hold fruit temperature at 44.4°C for 8.75 hours, then cool immediately, OR, fruit core temperature heated to > 47.2°C (117°F) in not less than 4 hours.
- **Irradiation** -- 250 Gy -- treatment carried out in an approved facility in Hawaii or in non-fruit fly supporting areas of the mainland US.

Pineapple

- **Nonhost status** -- for cultivars with 50% or more ‘smooth Cayenne’ parentage; includes ‘Sugarloaf’.
- **Irradiation** -- 250 Gy -- for cultivars other than 50% ‘smooth Cayenne’. Treatment carried out only in an approved facility in Hawaii or in non-fruit fly supporting areas of the mainland US.
- **Vapor heat** -- for cultivars other than 50% ‘smooth Cayenne’. Fruit core temperature heated by saturated water vapor to 44.4°C (112°F). Hold fruit temperature at 44.4°C for 8.75 hours, then cool immediately.

Rambutan

- **Irradiation** -- 250 Gy -- treatment carried out only in an approved facility in Hawaii or in non-fruit fly supporting areas of the mainland US.
- **Vapor heat** -- internal fruit temperature raised by saturated water vapor (>90% RH) to 47.2°C (117°F) (or above) in at least 60 min. Hold at 47.2°C for 20 min. Hydrocooling is optional.

Sapodilla

- **Irradiation** -- 250 Gy -- treatment carried out only in an approved facility in Hawaii or in non-fruit fly supporting areas of the mainland US. Other conditions apply.
<table>
<thead>
<tr>
<th>Commodity</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abiu</td>
<td>I</td>
</tr>
<tr>
<td>Atemoya</td>
<td>I</td>
</tr>
<tr>
<td>Avocado</td>
<td>C</td>
</tr>
<tr>
<td>Bananas</td>
<td>N</td>
</tr>
<tr>
<td>Bell pepper</td>
<td>I, H</td>
</tr>
<tr>
<td>Carambola</td>
<td>I, C</td>
</tr>
<tr>
<td>Citrus</td>
<td>H</td>
</tr>
<tr>
<td>Durian</td>
<td>N</td>
</tr>
<tr>
<td>Eggplant</td>
<td>I, H</td>
</tr>
<tr>
<td>Italian squash</td>
<td>I, H</td>
</tr>
<tr>
<td>Longan</td>
<td>I, H</td>
</tr>
<tr>
<td>Lychee</td>
<td>I, H</td>
</tr>
<tr>
<td>Mango</td>
<td>I</td>
</tr>
<tr>
<td>Papaya</td>
<td>I, H</td>
</tr>
<tr>
<td>Pineapple</td>
<td>I, N, H</td>
</tr>
<tr>
<td>Rambutan</td>
<td>I</td>
</tr>
<tr>
<td>Sapodilla</td>
<td>I</td>
</tr>
<tr>
<td>Sweet potatoes</td>
<td>I, F</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>I, H</td>
</tr>
</tbody>
</table>

I = irradiation, C = cold, N = non-host status, H = heat (hot water immersion or vapor heat), F = fumigation

compiled by:
Dr. Peter Follett, Research Entomologist, Postharvest Tropical Commodities Research Unit
Tel. (808) 959-4303, Fax (808) 959-5470, email pfollett@pbarc.ars.usda.gov
Converting off-grade Hawaiian tropical fruits into minimally processed convenience items

Alvin Huang
Dept. of Human Nutrition, Food, and Animal Sciences
College of Tropical Agriculture & Human Resources
University of Hawaii at Manoa
Goals of the project

- Treat and vacuum pack cut traditional tropical and exotic fruits
- Conduct storage studies on fruits under controlled storage conditions
Specific objectives

- Determine or Design
  - appropriate ripeness
  - treatments to control microbial growth
  - treatments to minimize negative attributes
  - appropriate packaging
Fruits tested thus far:

- Papaya
- Pineapple (supersweet variety)
- Lychee
- Rambutan
- Jackfruit
Treatments used in tests

- Inhibition of microbial growth
  - Antimicrobial agent
    (Grapefruit seed extract)
  - Pasteurization
  - Modified atmosphere packaging
    (vacuum packaging)
  - Organic acid treatment (citric acid)
Treatment used in tests

- To delay ripening process
  - Minimal heating to retard enzymes
  - Removal of air from storage containers
- To control softening tissues
  - Use of calcium firming agents
Vacuum packaging

- Provides an environment that contains little oxygen.
  - Advantage: inhibits aerobics microbial growth
  - Disadvantage: promotes anaerobic microbial growth
    → control by lowering the pH value
    (goal: pH 4.5)
Vacuum packaging

- Papaya
- Pineapple
- Papaya
- Rambutan
Papayas

Characteristics

- Climacteric fruit  
  (High ethylene gas sensitive)
- Non-acidic fruit  
  (pH 5.20-5.72)
- Soft tissues
- The skin color does not indicate degree of ripeness
Improvements needed for papaya

- Prevent microbial growth
  - Vacuum packaging
    - Use of anti-microbial agent
    - Use of citric acid
    - Refrigeration
  - Delaying ripening process
    - heat treatment
    - refrigeration
Improvement needed for papayas (cont.)

- Firming soft tissues
  - Use of calcium firming agents
  - Cut fruits to minimize damage by packaging

- Prevent tissue breakdown
  - Under going studies
Papaya test (heat treatment)

- Treatment: to delay the enzyme activities that promote ripening process

Soaking in hot water to reach core temperature 49°C for 20 min

Soaking in ice water bath
Papaya test 1
(Mild heat treatment)

- Heat treatment delayed ripening process.
- It slowed down ....
  - Development of transparent tissue
  - Development of soft tissue
Papaya test 2
(pH control test)

- Use of 1% citric acid solution lowers the pH value of papaya.
  (average: pH 5.64 → 4.86)
Calcium firming agents appear to prevent softening of tissues.

Test: Papaya chunks dipped into the firming agent solution (Calcium lactate or Calcium lactate gluconate) were tasted by 8 volunteers.
Future papaya testing

- Microbial growth test on papaya slices with several treatments
  - ozonated water (anti-microbial)
  - vacuum packaging
  - citric acid
  - calcium firming agent
- Sensory evaluation
Pineapples (*supersweet*)

- Characteristics
  - A climacteric fruit (low ethylene gas sensitive)
  - Acidic fruit (pH 3.2-4.5)
    - Higher than regular pineapple (pH 3.2-4.0 from FDA data)
  - Relatively firm flesh
Improvements needed for pineapple studies

- Prevent microbial growth
  - Vacuum packaging
  - Use of anti-microbial agent
  - Pasteurization
  - Refrigeration
- Prevent browning
  - Pasteurization
  - Use of citric acid
Pineapple Testing

- Pasteurization decreased the initial bacteria load.
- Treatments
  - Pasteurization (80°C for 45 sec.)
  - Anti-microbial agent (GFSE)
  - Citric acid
Pineapple Test 2

- Pineapple slices with three treatments had a better color.
  - anti-microbial agent (GFSE)
  - Citric acid (CA)
  - Pasteurization (P)
Pineapple Test
(Ongoing storage test)

- Checking pineapple samples for TPC
- Treatments
  - Pasteurization (80°C for 40 sec.)
  - Antimicrobial agent (grapefruit seed extract)
  - Citric acid
  - Vacuum packaging
Lychees/rambutans

- Characteristics
  - Non-climacteric fruit (Low ethylene gas sensitive)
  - Non-acidic fruit
  - Development of opaque color after peeling
Improvements needed for Lychees/rambutans

- Preventing microbial growth
  - Vacuum packaging
  - Use of antimicrobial agents
  - Use of organic acid
  - Pasteurization
- Preventing color change (browning)
  - Pasteurization
  - Use of organic acid
- Simplifying deseeding process (rambutans)
  → use of stoner
Lychee (storage Test)

- Grapefruit seed extract appeared to inhibit microbial growth.
- Treatments
  - Dip into anti-microbial solution (GFSE: 500 ppm or 1000 ppm)

Grapefruit seed extract appeared to inhibit microbial growth.

Treatments
- Dip into anti-microbial solution (GFSE: 500 ppm or 1000 ppm)
Rambutan
(On-going storage testing)

- Examine the bacteria growth on rambutan
- Treatments
  - Pasteurization (80°C for 40 sec.)
  - Antimicrobial agency (grapefruit seed extract)
  - Citric acid
  - Vacuum packaging
Jackfruit

- Characteristics
  - Climacteric fruit (ethylene gas sensitive)
  - Non-acidic fruit
  - Stringy tissue
  - Edible nuts
Jackfruit testing

- Examine the bacteria growth on jackfruit segments
- Treatments
  - Antimicrobial agency (GFSE)
  - 500ppm
  - 1000ppm
Jackfruit testing

- **Dried jackfruit**
  - Pulps were dipped in citric acid solution (to prevent browning) and dried.
  - Flavor variation (Li hing powder)

- **Seeds**
  - Boiling and roasting
  - Seasoning (sugar, salt, cream, honey)
QUESTIONS?
Marketing and Post Harvest Treatment of Tropical Fruits in Queensland

Yan Diczbalis
Department of Primary Industries
Queensland
Producer

• Backyard to commercial
  – 100 to 30,0000 trees
• “Rugged” Individuals
Marketing Groups

The concept

• More product under the control of one entity
• More potential to influence product quality, reliability and consistency
• Expanded market opportunities
• More resources to direct at marketing activities
• Provides a vehicle for small producers
• Producers can employ professionals to do their group’s marketing
Marketing Groups

Getting Started

- By meeting or invitation, see who wants ‘in’
- Identify types, volumes and timing of supply
- Short list markets/customers
- Consultant helps to develop the group’s strategy
- Adopt a quality system; create brand/packaging
- Agree on operational details
- Complete a trial cycle/season and evaluate it
Marketing Groups
Reality

• Self interest rules every time there’s a critical issue to resolve
• The alliance never gets a clear focus on its markets, customers and consumers, and misses their signals
• Real trust fails to develop
• The alliance is starved of essential resources such as capital and management expertise
• And worst of all……..
Marketing Groups

Reality ……

• The alliance becomes unable to create any kind of competitive advantage, there’s no reason for its members to continue to belong to it, so people revert to their old ways of doing business.
Wholesale Markets

• Key markets - Sydney, Melbourne and Brisbane
• Range of “tropical specialists” wholesalers
• Sydney handles 25 tonnes/rambutan/wk
  – 70 to 90% goes to Asian fruit and vegetable suppliers
  – City farmer markets
  – Remainder to Restaurants, Supermarkets,
Consumer

• 70 –90% of production goes to ethnic Chinese and Vietnamese communities
  – Fresh snack, palate cleanser, religious offering, gift

• Consumption by Caucasian consumers – low
  – Low awareness and high prices
Better Mangoes II
Improving quality through the supply chain
Sample points

Orchard

Packing shed

Transport

Wholesaler/ ripener

Retail

Pre-pack

Post-pack

Ex-shed

Market arrival

Market dispatch
Temperature monitoring positions
Temperature

Varies during:
* Pre-cooling
* Transport
* Market handling
Saleable life index (SLI)

60% yellow skin colour

? days

10% of fruit showing rots
How much saleable life is needed?
Retailers want 7+ days

- 60% yellow
- 7+ days
- 10% rots
71% of KP loads had less than 7 days SLI

But…

60% yellow

2 days

10% rots

71% of KP loads had less than 7 days SLI
And...

20% of loads had no saleable life
What affects saleable life index

- Orchard management
- Post-harvest fungicide treatment
- High ripening temperature
  - Mixed ripening
  - Delays in the supply chain
Orchard management

Grower A
Saleable life: 1 day
No fungicide

Grower B
Saleable life: 5 days
No fungicide
Post-harvest fungicide

No fungicide
Saleable life: 2 days

SpinFlo 51-52°C
Saleable life: 7 days
Exposed to 5 days over 24°C
Sampled at market dispatch
Saleable life: 0 days

High temperature
Sampled after packing
Held at 20°C
Saleable life: 4 days
Key findings

• Temperature is extremely variable

• Saleable life is affected by
  – High ripening temperatures
  – Mixed ripening
  – Handling delays
  – Orchard management
  – Post-harvest fungicide

• Two systems can work
  – Controlled ripening on-farm or at the market
  – Holding at optimum temperature

• R2E2 is similar to KP
Lychee Post
Harvest Review
Workshops
Goals For the Day

• Identify problems the issues with lychee post harvest.
• Discuss the current systems used, problems occurring and recent R&D.
• Discuss current best practise.
• Identify best R&D priorities.
What are the problems keeping you awake at night?

- Maturity
- Browning or Rots
- Destalking brushes, how to minimise damage?
- Is the packaging suitable for the chains?
- Hydrocooling is it right?
- Labour, Flying foxes, Low Prices
What are the issues at the markets

- Results of outturn monitoring 2001/2002
- 100 lines assessed in Brisbane, Sydney and Melbourne.
Fay Zee Siu

% Reject

% Reject

Stings  Wounds  Blemish  Browning  Rots

227
Tai So

%Reject

- Stings
- Wounds
- Blemish
- Browning
- Rots
Other Cultivars

![Graph showing % Reject for different conditions: Stings, Wounds, Blemish, Browning, and Rots. Browning has the highest % Reject.]

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What retailers said

• Browning in stores because of low humidity in cabinets
• Browning and immaturity from market.
• Customers including Asians want to try fruit.
• Everything works while fruit moves quickly.
What exporters said

• Low level of problems, browning is issue 90% of problems.

• Problems with destalking machines, condensation and packing wet fruit.

• Browning is issue in some markets eg China without coolchain - Thailand has containers.

• Need uniformity of packaging.

• Need new packaging for new markets.
What wholesalers said

• Not much problems (but 40% not suitable for chains)
• Issue is browning - blows up when it arrives hot (Condensation, Rots Browning)
• Need Uniformity in Packaging
• 90% Asian customers who handle quickly very price sensitive
Post Harvest R&D Experiences

• 1980 ACIAR project develops hot benlate and punnet packaging
Sulphur Treatments
Acid Treatment
Packaging Trials
Packaging Trials
Retail Display
Coatings
packline, coat, punnet, 6 days @ 5°C (40°F), 3 days A/C
Coatings

After 3 days on the lab bench

[Image showing the effect of coatings on water loss in lychee fruit]
What are current practices?
Agrilink Recommends

Figure 33. Postharvest flow chart
Important

Harvest Early with full turgor
Establish a Cool Chain Forced Air cooling or hydro cooling
Do not pack wet fruit
Chlorinate any water used
Handle quickly and be cool
Watch the bumps
Transport at 5 degrees
Rambutan
Disinfestation Trials
Rambutan Post Harvest Issues

• Picking
  – Fruit maturity
  – Time of day

• Packing Shed
  – Precooling, destalking, damage to spinterns from machinery, Packaging type (tray, punnet), cooling

• Farm gate
  – Suitable transport and maintenance of cool chain; 10 – 13°C (50 – 55°F)

• Retailer
  – Inappropriate display (low RH)
Mangosteen
Mangosteen Post Harvest Issues

• Picking
  – Fruit maturity, number of visits to the same tree
  – Dropped fruit

• Packing Shed
  – Cleaning under calyx, Identifying internal disorders

• Farm gate
  – Suitable transport and maintenance of cool chain (13 – 15°C (55 – 60°F))

• Retailer
  – Lack of awareness
Summary

• Tropical Fruit post harvest is still an relatively new research area
• For most tropical fruit attention to,
  – Pre-harvest
  – Picking
  – Packaging
  – Cool chain
• Best treatment is rapid purchasing and consumption at the retail end
GUIDE TO MINIMIZE MICROBIAL FOOD SAFETY HAZARDS

Fresh Fruits and Vegetables
(An Overview)

Food and Drug Administration
U.S. Department of Agriculture
October 26, 1998
THE U.S. FOOD SAFETY INITIATIVE

- Announced by President Clinton in January 1997
- Increased reports of foodborne microbiological illness
- Estimated costs of foodborne illness $5.6 billion or more
- Food product recalls from life threatening bacteria increased significantly
THE U.S. FOOD SAFETY INITIATIVE

Goal:
• To improve the safety of domestic and imported fresh produce through:
  – Guidance on good agricultural and good manufacturing practices (GAPs/GMPs)

Focus:
• A farm to table continuum through:
  – Education and outreach, technical assistance, and research
WHY PRODUCE? WHY NOW?

- Foodborne illness linked to fresh produce is increasing
- Increased consumption of fresh produce in the U.S.
- Changes in distribution patterns, new products, and technologies
- New pathogens and increasing virulence of pathogens

- **March 8, 1999.** FDA announces nationwide voluntary recall of certain brands of frozen mamey
- **July 9, 1999.** Consumers advised of risks associated with raw sprouts (Salmonella outbreaks in California, Colorado, Oregon, Washington)
- **July 10, 1999.** FDA issues nationwide health warning about Sun Orchard unpasteurized orange juice brand products
FRESH PRODUCE GUIDE

• Broadscope - practices common to the growing and packing of most fresh produce
• Applicable to non-processed produce
• Guidance only - no new requirements
  – Meat and poultry industries already have mandatory food safety requirements
• Regulations already in place for processed produce (HACCP programs)
• Risk reduction, not elimination
FRESH PRODUCE

Scope:

• Fruits and vegetables sold in an unprocessed or minimally processed, ready-to-eat, form
• May be intact or cut during harvest
• Includes “fresh-cut” and other specialty products
PRINCIPLES
OF MICROBIAL FOOD SAFETY

1 Prevention is favored over corrective actions.
2 Growers, packers, and shippers should use good agricultural and management practices.
3 Fresh produce can become microbiologically contaminated at any point along the farm-to-table food chain. Major source of microbial contamination is associated with human or animal feces.
4 Minimize the potential of microbial contamination from water used with fresh fruits and vegetables.

5 Practices using animal manure or municipal biosolid wastes should be managed closely.

6 Worker hygiene and sanitation practices during production, harvesting, sorting, packing, and transport play a critical role.
7 Follow all applicable local, state, and Federal laws and regulations.

8 Accountability at all levels of the agricultural environment (farm, packing facility, distribution center, and transport operation) is important to a successful food safety program. There must be qualified personnel and effective monitoring to ensure that all elements of the program function correctly and to help track produce back through the distribution channels to the producer.
USE OF THE GUIDE

• Increase awareness of common microbial hazards for fresh produce

• Useful when practices recommended to minimize hazards are adapted to specific operations
  – Assess individual operations
  – Institute appropriate cost effective
KEY POINTS IN GUIDE

- Agriculture and Processing Water
- Manure and Municipal Biosolids
- Worker Health and Hygiene
- Sanitary Facilities
- Field Sanitation
- Packing Facility Sanitation
- Transportation
- Traceback Issues
Third-Party Food Safety Auditing Companies
(this is not an endorsement of any kind)

• American Institute of Baking (Manhattan, KS)
• Davis Fresh Technologies (Davis, CA)
• Safe, Quality Foods (Australia's answer to food quality certification)
• PrimusLabs (Santa Maria, CA)
• Scientific Certification Systems (Oakland, CA)
Safeway Saga

• About 3 years ago, Safeway took this issue of 3rd party auditors very seriously
• Several other regional chains followed.
• They voluntarily made it a requirement for farms to be certified in order to sell to them.
• Three categories:
  – Fruits and vegetables eaten with minimal processing (leafy vegetables, fruits eaten without peeling, etc.)
  – Fruits and vegetables that could be cooked or peeled prior to eating.
  – Fruits and vegetables that are usually cooked prior to eating.
Safeway Saga

• Publicly announced reason to insure a safer food product to the consumer.
• Most likely motive was to pinpoint the blame if someone got sick.
• Did not have a consistent policy.
• Did not affect the fruit industry much.
New Food Safety Concerns

• Bioterrorism
• Concern is with plant and animal diseases on the farms and ranches,
• As well as contamination of food supply with harmful agents.
• This is a totally different subject.
SUMMARY

• Illnesses from food borne microorganisms in fresh produce is a serious problem
• Responsibility to minimize hazards shared by everyone involved:
  – Growers, farm workers, packers, shippers, transporters, importers, wholesalers, retailers, government agencies, and consumers
• Farms should follow “Good Agricultural Practices”
• Food Safety Initiative for fruits and vegetables is Guidance only - no new requirements
• Regulations already in place for processed fruits and vegetables.
• Marketing opportunity
Guide Available On-Line

• http://vm.cfsan.fda.gov/~dms/prodglan.html
For More Information

General Food Safety
- http://www.hawaiianag.org/foodsafefoodsa.htm
- http://www.fda.gov
- http://vm.cfsan.fda.gov

Site for Good Manufacturing Practice document