PROCEEDINGS

Sixteenth Annual International Tropical Fruit Conference

September 29 to October 1, 2006

Outrigger Keauhou Beach Resort
78-6740 Alii Drive
Kailua-Kona, Hawaii

Sponsored by the

Hawaii Tropical Fruit Growers

and

County of Hawaii
Department of Research and Development
Sixteenth Annual International Tropical Fruit Conference Proceedings

“A Sweet Future for Tropical Fruit Growers”
October 21-23, 2006
Outrigger Keauhou Beach Resort
Kailua-Kona, Hawaii

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Proceedings Editor: Mike A. Nagao
University of Hawaii
College of Tropical Agriculture & Human Resources
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### 16th Annual International Tropical Fruit Conference

**Conference Agenda**

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<tr>
<td>5:00 p.m.</td>
<td>Registration Opens</td>
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<tr>
<td>5:30 p.m.</td>
<td>Reception &lt;br&gt;Heavy Pupus/No Host Bar</td>
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<tr>
<td>6:30 p.m.</td>
<td>Welcome &amp; HTFG Update &lt;br&gt;<em>Richard Johnson</em> &lt;br&gt;HTFG President</td>
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<td>7:00 p.m.</td>
<td>Tropical Fruit in Florida and Fruit Collecting Around the World &lt;br&gt;<em>Chris Rollins</em> &lt;br&gt;Keynote Speaker &lt;br&gt;Miami Fruit and Spice Park, Miami, FL</td>
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Saturday Conference Program
September 30, 2006

7:30 a.m.  REGISTRATION OPENS / Coffee

8:00 a.m.  Welcome
Richard Johnson, HTFG President
Diane Ley, Deputy Director, Hawaii County Department of
Research and Development
Membership Meeting - Richard Johnson

8:30 a.m.  From Germplasm Collection to Kaimana Lychee Production
Dr. Francis Zee, Dr. Lisa Keith, and Dr. Tracie Matsumoto,
US Department of Agriculture/Agricultural Research Service/
Pacific Basin Agricultural Research Center (USDA/ARS/
PBARC), Plant Genetic Resource Management Unit

9:30 a.m.  BREAK

10:00 a.m.  New and Rare Fruits and the Fruits of the Tropical Americas
Chris Rollins, Keynote Speaker

11:00 a.m.  REPORTS & UPDATES
Federal Crop Insurance
Dr. Kent Fleming, University of Hawaii, College of Tropical
Agriculture and Human Resources (UH CTAHR)
Quarantine Updates: fire ant and mixed fruit baskets for
export - Dr. Peter Follett (USDA/ARS/PBARC)
Cacao Chapter - Sara Moore
West Hawaii Chapter - Ken Love
East Hawaii Chapter - Lesley Hill
Fruit Cooperative - Bob Hamilton

12:05 p.m.  LUNCH

1:00 p.m.  PBARC Overview
Dr. Jack Armstrong (USDA/ARS/PBARC)

1:15 p.m.  Postharvest Treatment of Kaimana Lychee to Prevent Browning
Norbert Furumo (UH Hilo)

1:35 p.m.  Calculating Your Cost of Production
Dr. Kent Fleming (UH CTAHR)

2:00 p.m.  Lychee and Longan Research
Andrea Kawabata (UH CTAHR)

2:15 p.m.  BREAK

2:45 p.m.  Bringing Quality Fruit to Market
Maureen Datta (Adaptations)
Bill Gerlach (Melissa's)
Graham Quayle (Four Seasons Resort Hualalai)

3:30 p.m.  Fruit Tasting & Wrap Up

5:30 p.m.  No Host Bar

6:30 p.m.  Dinner & Live Auction

Dinner & Auction
Join Hawaii Tropical Fruit Growers for a fun and informational day on site at the **12 Trees Project** in Napo'o'o, where our workshops will present valuable information on practical farming concerns.

The 12 Trees Project is a demonstration orchard with twelve species of fruit, which were selected by 54 Hawaii Island chefs interested in using them in their culinary creations. There will be a tour of the site, which demonstrates sustainable and organic agricultural practices, and a tour of the historic Kona Pacific Farmers Cooperative.

Workshops will be presented RAIN or SHINE, so be prepared!

- **8:30 a.m.** Leave Hotel for 12 Trees Project and Kona Pacific Farmers Cooperative
- **9:00 a.m.** Introduction to 12 Trees Project - Ken Love
- **9:10 a.m.** Kiosks and Field Signs - Dick Kuehnert
- **9:30 a.m.** Grafting Workshop - Marla Hunter (Eke Nui Nursery)
- **10:15 a.m.** Ground Covers for Orchards Workshop - Jeff Knowles (USDA/Natural Resources Conservation Service)
- **11:00 a.m.** Composting Workshop - Piper Selden (Rainbow Worms) OR (select one) Fruit Fly Project Update Workshop - Mike Klungness (USDA/Agricultural Research Service)
- **11:45 a.m.** LUNCH & TOUR OF COOP
- **12:45 p.m.** Vegetative Propagation Techniques Workshop - Craig Elevitch (Permanent Agriculture Resources)
- **1:30 p.m.** Pruning Demonstration - Chris Rollins (Miami Fruit and Spice Park)
- **2:15 p.m.** END

**HTFG Board of Directors**

- Richard Johnson, President
- Bob Hamilton, Vice President
- Jenny Johnson, Secretary
- Virginia Choobua, Treasurer

**HTFG Board of Directors**

- Don Baker
- Lesley Hill
- Ken Love
- Doug Mccluer
- Lily Armstrong, Executive Director

**HTFG Board of Directors Advisory Group**

- From the Department of Tropical Plant and Soil Sciences, UH at Manoa
- **College of Tropical Agriculture and Human Resources (UHM-CTAHR)**
- **Mike Nagao** - Horticulturist, Researcher
- **Mel Nishina** - Agricultural Extension Agent
- **Virginia Easton Smith** - Agriculture Extension Agent

**Conference Committee Members**

- Virginia Easton Smith, Co-Chairperson
- Ken Love, Co-Chairperson
- Lily Armstrong
- Steve Marquis
# 16th Annual International Tropical Fruit Conference

**“A Sweet Future for Tropical Fruit Growers”**

## KEYNOTE SPEAKER

Christopher B. Rollins  
Keynote Speaker for 2006 Conference  
Preston B. Bird & Mary Heinlein Fruit & Spice Park  
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<thead>
<tr>
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<th>Affiliation</th>
</tr>
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</table>
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Craig Elevitch
*Traditional Trees of Pacific Islands: Their Culture, Environment, and Use* edited by Craig R. Elevitch. This book covers many important fruit trees including bananas and plantains, citrus, mango, coconut, breadfruit, etc., as well as many other multipurpose species of the Pacific.


**Enhancing the Competitiveness of Hawaiian Fruit Producers Through the Marketing and Branding of Locally Grown Avocado**

Catherine Chan-Hallbrendt
Avocado Project Team
UH CTAHR 
NIHMA
This project is about increasing the sales of Hawaii grown avocados through reducing waste and providing consistent quality supply to niche buyers such as hotels and restaurants.

**Rare Fruit Council International (RFCl)**
Maurice Kung will be distributing complimentary copies of "Tropical Fruit News" magazines and displaying the RFCl special Tropical Recipes cookbooks which will be available at a discounted price. In addition, he will be offering conference attendees a discounted price on garden tools from RFCl.

**Adaptations, Inc.**
Hawaii's Gourmet Growers
PO Box 1070
Captain Cook, HI 96704
Phone: 808-324-5606
Fax: 808-324-0199
Contact: Maureen Datta, Alice Sherer or Cindy Brady

**Plant It Hawaii, Inc.**
Susan Hamilton
P.O. Box 188, Kutztown, HI 96760
808 966-6633
hami@plantithawaii.com

Plant It Hawaii is Hawaii's largest and most complete selection of high quality fruit trees for your home, commercial orchard or retail garden store, since 1971, specializing in fruit tree cultivars that excel in Hawaii.
We are located in Kutztown and open by appointment Monday-Friday. While enjoying the conference, talk with Jamie Runnells, sales manager of Plant It Hawaii.

**Current Research on Lychee and Longan Flowering**
Tracie Matsumoto, Tsuyoshi Tsumura, Mark Keskea and Francis Lee
USDA ARS-PBARC-TPCGBU P.O. Box 4487
Hilo, HI 96720
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**USDA, Farm Service Agency**
Miki Miyasato, Farm Loan Officer
Hawaii County FSA Office
Federal Bldg., Room 219
154 Waianuenue Ave.
Hilo, HI 96720
Phone: 808-933-8181

The Farm Service Agency (FSA) helps small farmers and ranchers stabilize farm income, work with them to conserve land and water, and provide loans to new and disadvantaged family-size farmers and ranchers.

**Fresh From the Farm Managing Member/Creator/Market Coordinator**
Mrs. Juana Kavamoto-Brown
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Honolulu, HI 96817
Phone: 808-429-3813
Email: farmfreshhawaii@yahoo.com
Please visit our Web site for info on what our group is about at farmfreshhawaii.com.

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**MAHALO NUI LOA TO**
Jamie Runnells from Hula Brothers/Plant It Hawaii for being our auctioneer!

**SPECIAL THANKS TO**
the County of Hawaii, Department of Research and Development and the Hawaii Tourism Authority! The funds they contribute through their grant program allow Hawaii Tropical Fruit Growers to provide this conference. We greatly appreciate their continuing support for our organization!

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**The 16th Annual International Tropical Fruit Conference**
has been presented by the
**Hawaii Tropical Fruit Growers**
P.O. Box 1582 • Hilo, HI 96721-1582
Phone: (808) 966-6444 • Fax: (808) 966-4677
htfghawaii@hawaiiantel.net • www.hawaiitropicalfruitgrowers.org
President’s Address

Richard Johnson
HTFG President
16th Annual HTFG International Tropical Fruit Conference

I’m Richard Johnson, the President of Hawaii Tropical Fruit Growers. Welcome to Hawaii Tropical Fruit Growers’ 16th Annual International Tropical Fruit Conference. Thank you to the County of Hawaii for their continuing support of our organization and this conference through their generous grant. 2006 has been a turning point for our industry with some significant threats such as the proposal to allow irradiated fruit from Thailand to be imported into the United States as well as some amazing opportunities such as the $200,000 USDA grant for research supporting Hawaii’s tropical fruit industry. HTFG has been right in the thick of things to help us capitalize on the opportunities and mitigate the threats on behalf of our membership and our industry.

I will now call to order the annual Member’s Meeting of HTFG.
I’ll begin by providing an update of our achievements in each of HTFG’s Focus Areas:

Managing the Organization:
We were successful in obtaining and applying several grants in 2006 including:

- County of Hawaii: $10,850 to support this conference, our 2007 calendar publishing and attendance of representatives to the PMA (Produce Marketing Association) trade show in San Diego.
- Hawaii Department of Agriculture: $29,000 to do research on “Optimal Field Management Strategies for Rambutan, Lychee, Longan, Durian and Mangosteen”.
- County of Hawaii: $25,000 to the West Hawaii Chapter to build a kiosk and provide educational signage for the 12 Trees Project.

We purchased general liability insurance for the first time this year which will provide coverage for our activities in meetings, exhibits and fruit sampling. We updated and simplified our dues structure which should make them more “user friendly” for our members. We also authorized the formation of a Hearts of Palm chapter.

Research:
The Research Committee maintains a prioritized list of our strategic research needs which helps us focus our requests for grants. As I mentioned previously, we were successful in receiving a $29,000 grant from the Hawaii DOA for “Optimal Field Management Strategies” for various tropical fruits. The most exciting news for the year was that, thanks to Senator Inouye, the USDA had created a $200,000+ grant earmarked to Hawaii tropical fruit research and marketing. The grant is administered by UH-Manoa in partnership with HTFG. We were able to fund 8 major projects with this money including:

- Research: Improving flowering of longan and lychee; Improving fruit quality of rambutan and longan; Hot water immersion treatment for longan; and Field control of Little Fire Ant.
- Marketing: Market development for rambutan, longan and lychee; Marketing and branding Hawaii avocados.
• Product Development: Cacao processing methods; Commercial viability of Surinam cherry.

Although there are no guarantees, we believe that will be other significant USDA grants in the future earmarked for Hawaii tropical fruit and HTFG will be prepared to invest this money into our most strategic needs.

Information:
We have been actively engaged in dealing with the biggest threat our industry has had to face to date, a USDA “Proposed Rule” which, if approved, will allow the importation of irradiated tropical fruit from Thailand. HTFG, in partnership with Representative Abercrombie’s office, have been rallying HTFG members, legislators, University of Hawaii experts and Florida growers and legislators to provide input to the Proposed Rule. We were able to point out a number of significant errors and omissions in the Proposed Rule analysis and these will have to be reconsidered by USDA-APHIS before the Proposed Rule can be processed further. Thanks to our HTFG members who took the time to input their comments to USDA. Our input will definitely have an impact. I believe that the results of our input will be as follows:

• USDA will have to redo the Proposed Rule correcting the errors and omissions.
• Approval of the Proposed Rule will be delayed, however, due to free trade agreements and other factors, it will eventually be approved in a modified form, but the approval will be significantly delayed due to the modifications.
• Irradiated Thai fruit will not be allowed to be imported to Hawaii and, possibly, Florida.

I know that many of our members are concerned that allowing irradiated Thai fruit into the mainland will destroy our markets there. I believe that the Thai fruit will take over a significant share of the market segment that has been our “bread and butter” for the last 10+ years. However, the potential market for tropical fruit in the mainland has barely been tapped and there are many opportunities for Hawaii-grown fruit to be sold to other market segments such as gourmet grocery stores and resorts. HTFG has known that this threat has been coming and our Board and our advisors have been focusing our research and marketing strategies to help our growers overcome this threat with projects aimed at getting better yields thus lower unit costs, superior product quality and marketing opportunities that will allow our members to grow profitably as their production grows. HTFG will continue to take a leadership role to mitigate this threat to our industry.

Our local Chapters have continued hosting informational meetings for their membership throughout the year. West Hawaii Chapter has been particularly active. HTFG will be represented as part of the Hawaii booth at the Produce Marketing Association trade show in San Diego in October. Thanks to Ken Love and a grant from the County of Hawaii, we’ve published our 2007 HTFG tropical fruit calendar which has proven to raise awareness of Hawaii’s vast trove of exotic tropical fruits. Our new web site, www.hawaiitropicalfruitgrowers.com is up and running and we will continue to develop this site as a valuable information source for members and anyone else interested in Hawaii-grown tropical fruit.

Representation:
We continued our participation in the Hawaii Farm Bureau Federation Commodity Advisory Group. Doug MacCluer is our representative to the CAG and participates with the CAG to provide guidance to the Farm Bureau, Department of Agriculture, and State Legislature on our
behalf. Doug is also a member of the State Agriculture Committee. This year, our Research Committee actively “bugged” the USDA-APHIS to approve a number of tropical fruit treatment protocols that have been in the works for up to 8 years and we have finally gotten some high level attention in APHIS that has committed to complete the approval of these protocols very soon.

**Community Service:**

The West Hawaii Chapter has continued to support the 12 Trees Project throughout the year with sweat, creativity and money. You’ll see the results of their work at the workshops tomorrow which will be held at the 12 Trees Project. We have continued our scholarship awards to culinary and agricultural students.

**Summary:**

Our organization continues to grow and prosper. At this time in 2004 we had 112 members which grew to 150 members in 2005. Now we have 158 members, including 29 commercial growers. Our treasury remains healthy. We are always looking for persons who are willing to help out in the management of our organization by participating in Chapter or the State Boards and committees. We are opening the doors to the formation of new Chapters and there is the possibility of forming new chapters for Kauai, Heart of Palm, Mango and/or Avocado in the future.

In accordance with the HTFG by-laws, it is my responsibility to nominate a slate the 2007 HTFG Board of Directors. I hereby nominate the following individuals to the Board:

Don Baker – 2006 East Hawaii Chapter President
Gini Choobua – 2006 Treasurer and Cacao Chapter President
Bob Hamilton – 2006 Vice President
Leslie Hill – 2006 Board Member
Jenny Johnson – 2006 Secretary and Research Committee Chairperson
Richard Johnson – 2006 President
Pete Kincaid – New Board Member
Brian Lievens – New Board Member
Doug MacClure – 2006 CAG Representative
Ken Love – 2006 West Hawaii Chapter President
Eric Weinert – New Board Member

The Board, after being elected by the membership will select the HTFG officers for 2007. Are there any nominations from the floor? (There were none).

(A motion to approve the slate as presented was moved and seconded and the motion was approved by a voice vote.)

Thank the West Hawaii Chapter for all of their hard work in planning this conference and thank you all for attending. We hope that it is a productive conference for you.
Featured International Speaker

Chris Rollins

Chris Rollins, of the Fruit & Spice Park in Miami-Dade County, Florida, will be the featured speaker at the 16th Annual Tropical Fruit Conference. He is the founder of the South Florida Tropical Fruit Growers and a dynamic speaker with a wealth of information to impart to us here in Hawaii!

As the Park Director for more than 20 years, Chris, has played a key role in introducing growers and the public to tropical plants new to the United States. The Park's active exchange program has brought in plants from Central America, Africa, Southeast Asia and Australia, and provides germplasm for nurseries, farms, and backyard growers.

Chris is responsible for garden and botanical policy, design, and all aspects of maintaining this wonderful park which has over 500 varieties of fruits, vegetables, spices, herbs, nuts and other commercially important plant specimens from around the world. The park showcases 125 varieties of mango, 75 varieties of bananas, 70 bamboo varieties, and numerous other exotic edibles.

Special garden and ethno-botanical tours and fruit safaris for botanists, students, growers and restaurateurs from all over the country are organized and led by Mr. Rollins to collect fruit, plant specimens, and enjoy cultural exchange. Past tours, from 9 days to 32 days, have included England, Honduras, Costa Rica, Belize, Guatemala, Malaysia, Thailand, Vietnam, Cambodia, Philippines, Hong Kong, Bali, Java and Borneo.

Chris will be sharing his vast knowledge and expertise with us in two presentations and a workshop. His presentations will include “Tropical Fruit in Florida and Fruit Collecting Around the World” on Friday evening and “New and Rare fruits and the Fruits of the Tropical Americas” on Saturday. At Sunday’s workshops, he will discuss and demonstrate pruning. We hope you’ll join us in welcoming this fascinating speaker!
New Fruits

Photography by Chris Rollins

The photographs are for use in the conference proceedings. They are the property of Chris Rollins and cannot be used for any other purpose. Additional distribution is only possible with the permission of Chris Rollins.

As the world struggles toward globalization cultures and cuisines collide and merge. It has not always been so. In the USA few new fruits were accepted by American society that weren’t brought with Europeans. Americans were meat, potatoes, and apple pie kind of folks. The first tropical fruits to break through to American were the banana (Musa hybrids) and pineapple (Annanas comosus) during the days of the clipper ships. Huge profits and giant companies developed in Central America based upon these fruits. The power and influence of these fruit companies was far reaching and resentment in parts of tropical America still exists from the abuses of the banana republics. A century passed until the kiwi (Actinidia deliciosa) arrived in the nineteen sixties. The kiwi was delivered to the United States by careful marketing and deliberate planning. The kiwi originated in the Chinese mainland. It was embraced and developed as a crop in New Zealand. Its established English name was Chinese gooseberry. At the time of its New Zealand development the “Bamboo Curtin” and communism associated with China by the free world was considered a negative marketing factor. Thus the name Chinese gooseberry was discarded and the kiwi fruit was born. The long shelf life of refrigerated kiwi was a significant enhancement to produce marketing concerns willing to try a new product. Kiwi became a part of our produce.

Twenty more years passed until new fruits were absorbed into the American groceries. In the early 1980’s several factors coalesced to create a new mood of acceptance in the American public. The return of military veterans from tropical climes, immigration and expanding ethnic populations from the tropics around the world and the emergence of affluence or Yuppie’s combined to create acceptance of new foods.

In 1983 I was visiting a lime farmer in Homestead, Florida. Limes were at that time an established crop. About 8,000 acres of limes were grown in south Florida. My friend had five acres of limes. They had just been harvested and Mr. Gordon was awaiting a check from the large nationally known packing house in the Redland farming district. Instead of a check he received a bill for 25 cents per bushel as the entire picking was sold at a loss. The next day he started pulling the lime trees out of the grove and putting them into burn piles. Looking at 5 empty acres he had no idea what to plant. As a supporter of the Fruit & Spice Park and member of the Rare Fruit Council, International he took a gamble and planted lychee (Litchi chinensis), longan (Dimocarpus longan), and star fruit (Averrhoa carambola). These were at the time of this planting fruits not commercially grown in Florida with no existing market. Within a few
years Mr. Gordon generated high profits. A whole attitude toward new fruits had changed within
the country. Soon the Redland farming district was home to commercial groves of mamey
sapote (Pouteria sapota), lychee, longan, carambola, passionfruit (Passiflora edulis), guava
(Psidium guajava), sapodilla (Manilkara zapota), jackfruit (Artocarpus heterophyllus), and
monstera (Monstera deliciosa). Simultaneously, in California the Cherimoya (Annona
cherimola), Feijoa (Feijoa sellowiana), and others crops were also developing.

This turnabout is also illustrated by another incident. In 1979 I was at an agricultural
meeting in southern Florida. I asked the president of a large tropical fruit packing company if he
was interested in Carambola. At the time commercial tropical fruit in Florida meant mango,
avocado, lime and papaya. He looked exasperated and said that he was in business to make
money and wasn’t a part of it. Less than three years later that same executive had his entire staff
scouring the farms and gardens of south Florida for any trees that could provide any quantity of
fruit for packing. He hadn’t changed but the market had abruptly.

Before 1983 the local paper would write an article every year or so about the odd fruits
and the quaint garden called the Fruit & Spice Park. During the rest of the eighty’s and nineties
the stories with new view points appeared. Publications like Florida Trend Magazine, Wall
Street Journal, New York Times and Reader Digest ran articles on new crops and their
expanding market. The trend continues today.

One of the interesting aspects of marketing new tropical fruits is the use of ethnic
populations. Asian and Hispanic population centers yield an immediate developed market. The
Hispanic market has readily accepted such favorites and mamey sapote, sapodilla, sugar apple
(Annona squamosa), Spanish lime or mamoncillo (Melicoccus bijugatus), and star apple
(Chrysophyllum cainito). Using associations to with known crops to launch a new one can be
successful. The lychee was promoted in Hispanic markets as “mamoncillo chino” or Chinese
Spanish lime. Abiu (Pouteria caimito) is an example of a relatively unknown tropical fruit is the
U.S. market. It is actually a fruit from the Amazon. In spite of its origin the abiu produces well
in Florida, Australia and Hawaii. The abiu is related to mamey sapote, star apple, lucumo
(Pouteria lucuma), and sapodilla. It is a smooth, yellow fruit the size of a baseball. Inside it
taste like a homogenized gel made of melon and persimmon. It should appeal to the American
palette. In order to begin in the Hispanic market I would sell it as the “camito amarillo”.

New fruits for the development can even be found in the familiar Citrus family. The
oldest Citrus cultivar is the Buddha’s hand citron a mutation of citron (Citrus medica) Buddha’s
hand has been propagated by cuttings for centuries by cuttings as it has no seeds. It is esteemed
in to orient now as it has been for centuries not for it edibility but for the fragrance it exudes as it
ferments. It has great potential as an ornamental fruit. One Citrus that has finally achieved
national marketing is the Pummelo (Citrus grandis). It tastes like a sweet grapefruit without
bitterness. Pummelo is originally from southern Thailand where it is highly esteemed. It is the
fruit from which the grapefruit was derived after pummelo had been taken to the Caribbean. A
number of other interesting Citrus developed in the Caribbean. The ugli from Jamaica is one of
the most successful of these. Other still wait to be exploited. The Cuban white orange and the
chirjona (Puerto Rico), shaddette (Haiti), are pummelo by orange crosses that have potential.
The pummelo exhibits an interesting cultural preference. Pummelo in its homeland is often too
sweet and insipid to please Western palettes. Pummelo varieties selected and appreciated in Florida although sweet are considered too acid by those raised on Southeastern Asian pummelos. The perception of taste and flavor is sometimes highly variable with some fruit. Antidesma (Antidesma bunius) a small purple berry from Australia is actually perceived differently by a small percentage of our population. To most the antidesma taste somewhat like a blue berry but about 3% of tasters it tastes very bitter. The ability to taste bitterness in antidesma is a genetic trait passed through families and is not connected to any other traits. Antidesma is used for wine, jelly, and juice. White sapote is another tropical fruit that taste like rich vanilla custard. A small percentage of people taste white sapote as bitter.

Even such standards of the market place as banana and pineapple have much unexploited diversity. Anyone who has traveled to tropical areas can attest to sweeter and more flavorful bananas and pineapples.

As the cultural richness of America grows new products appear with expanded cultural representation. Mexican and Cuban food has been established in American groceries. Now new products are appearing on grocery shelves that represent other Central American populations. From Honduras, Guatemala and other nations come bottled fruits like: jocote (Spondias purpurea) pacaya (Chamaedorea tepejilote), pejibaye (Bactris gasipaes ) and nance (Byrsonima crassifolia).

One of the most interesting new fruits of this decade is also from tropical America, the dragon fruit (Hylocereus undatus and related species). The dragon fruit has been a favorite jungle fruit since ancient times and has generally been known as pitaya. The plant is a vining cactus that grows in the canopy of the forest. It has long been cherished by gardeners for it’s beautiful nocturnal flower and has been known as night blooming cereus. The flower is 9” wide and 14” deep and it survives a single night. It was carried by gardeners around the world for it’s flowers. Vietnam which had no cultural history with the plant or knowledge of it’s fruit spontaneously developed it into it’s leading export fruit before other nations grasped what was happening. Now dragon fruit is marketed globally. It is grown in the United States and many foreign producers are trying to gain the American market.

Two other jungle fruits with potential of fine quality are the willughbeia (Willughbeia spp.) and the keledang (Artocarpus lanceifolius). Although these have a flavor and texture immediately appreciated by the Western palette they a known only in a limited range by people close to the diminishing forest. Cultivation for fruit production has not been attempted. In fact with rapidly disappearing forest of Borneo genetic resources of these plants and others are being lost before they are fully known.

New techniques require the revaluation of even well known fruits. Processed fruit can be dried, candied, pickled, juiced, frozen, canned or shrink wrapped. The shrink wrap package is a new form that may utilize fruits not currently exploited in other processing. A shrink wrapped fruit is something between fresh, canned and dried. Jackfruit, mango, sapodilla, mamey sapote, lucmo, pineapple, would be among many good candidate for shrink-wrap.
Industrial fruits like the apple, peach, pear, citrus, date, grape and fig have been given scientific study and improvement for generations. Many tropical fruits have received only causal selection but not scientific breeding and commercial development. Many basic problems need to be solved to fully realize the potential of many tropical fruits. Some very desirable fruits have poor shelf life or cannot be harvested for shipment. White sapote is a delicious fruit. Good varieties taste like vanilla custard. The skin of the white sapote is thin and as the fruit approaches ripeness the can not be handled without being crushed or damaging the skin. If picked too green, the star fruit will not ripen. Star fruit is a crop that has been studied during the last few decades and has not yet overcome serious limitations. Star fruit is currently harvested unripe so that it has the durability and shelf life for shipping. Unfortunately, it does not ripen after harvest and will not develop the flavor of a tree ripened fruit. Even with green harvesting star fruit is shipped in packaging that does not protect the fruit from damage. Star still has great potential value. Technology and proper handling techniques need to be improved. The cherimoya is a sweet pudding fruit in the Annona family and is successfully marketed in many areas. Other members of the family that are wonderful fruits but don’t have shelf life and shipping qualities are the soursop (Annona muricata), widely available as frozen pulp, sugar apple, custard apple (A. reticulata) and Illama (A. diversifolia).

Fruits have much potential not just for food but also for their health qualities. The success of the noni (Morinda citrifolia) in the last ten years is legend. Mangosteen juice or acai palm juice as healthful antioxidants are following in the successful marketing trail of noni. Garcinia cambogiana of tropical Asia once only had the distinction of being eaten dried with fish. Suddenly the health food industry recognized it as having weight loss properties and it is now cultivated and marketing on a large scale. The saw palmetto palm (Serenoa repens) of the lower southeastern United States went from a traditional agricultural impediment to a valuable pharmaceutical overnight when its berries became accepted as a way to prevent prostate enlargement.

New fruit will continue to emerge for years to come. Selection and breeding will improve many tropical fruit. Well known ethnic and botanical species will emerge for new uses and processing. Ethnic forces will continue to expand our cuisine and health factors may promote many lesser fruits.

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Carambola

Dragon fruit in Saigon.
**Hylocerus guatemalensis.** Better color and flavor than white some white dragon fruits.

**Mamey sapote**

Mayan pitaya later to become the Vietnamese dragon fruit

**Monstera**

**Assorted pummelos**
Sapodilla fruit

Spanish lime
White sapote

Willughbeia
The Sapotaceae gives us several important Tropical fruits from tropical America. Sapodilla (Manikara zapota) has migrated from its home in the Yucatan to become pan tropical. The delicious fruit has a tan russeted skin and soft sweet pulp. The pulp could be likened to a gritty pear mixed with brown sugar. Maple sugar candy is another common comparison. Fruit size ranges from that of a chicken egg to softball. Fruit are harvested mature but before softening. Shipping qualities of sapodilla are acceptable if handled promptly. The white milky sap was used by the Mayans as chewing gum and it was the basis for modern chewing gum until it was replaced with a synthetic material in the early 1960’s. Canistel (Pouteria campechiana) from the lowland Central America and the Lucma (Pouteria lucmo) from the lower Andes are important in their homelands. Both fruits have a texture of the yolk of a hard boiled egg and the flavor of a pumpkin or sweet potato. They are appreciated fresh by many but clearly have potential as a basis for milkshakes and ice cream. Star apple (Chrysophyllum cainito) or camito is a well known Central American that long ago traveled the globe. Its astringent, dark purple rind and pure white sweet center make it delicious and beautiful. The leaves of the star apple are dark green and shiny on top and coppery and fuzzy on the bottom. The mamey sapote (Pouteria sapota) is a common an appreciated fruit in Central America and in many Hispanic communities in the United States. In Miami it is greatly valued in the Cuban population. As a boy in Miami in the 1960’s in saw mamey sapote sold for as much as, eight dollars per pound. Startling when you consider that some fruits may weight as much as five pounds. The mamey sapote tastes like a sweet potato pudding. It produces superlative ice cream and milkshakes. Ice cream and imported frozen pulp can be purchased in Hispanic centers across the United States.

This is a good time to define the word sapote. Common names are extensive for all tropical fruits and all the names used in this article have many popular alternatives. The name sapote is from an ancient dialect from Central America. It roughly translates to mean a sweet and soft fruit. Indeed all the fruits named sapote are from tropical America and are sweet and soft. The most common sapotes are: mamey sapote, Ross sapote (Pouteria sp.), black sapote (Diospyros ebenaster), white sapote (Casimiroa edulis and C. tetrameria), South American sapote (Quararibea cordata), sapote (sapodilla – Manilkara zapote), green sapote (Pouteria viridis), and yellow sapote (Pouteria lucmo).

Black sapote and white sapote are both Central American. In spite of their names they are not closely related. White sapote (Casimiroa edulis & C. tetrameria) is in the Rutaceae
family and black sapote (*Diospyros ebenaster*) is in the Ebenaceae. White sapote can range in size from a golf ball to a grapefruit. Good seedling or selected varieties taste like vanilla custard. Black sapote has sweet but bland dark brown pulp and appearance of chocolate pudding.

Another plant family of significance is the Annonaceae. The most famous of which is the cherimoya (*Annona cherimola*). Cherimoya is a plant of the cool lower elevations of the Andes. It thrives in a Mediterranean climate. In Florida the trees grow well but don’t fruit in a useful manner. Outside of its natural range cherimoya has done well commercially in southern California, Spain, Australia and South Africa. There are many other edible members of the Annonaceae in tropical America. Soursop (*A. muricata*) is widely used for commercial purposes. As a frozen pulp its unique flavor and aroma are used for ice cream, milkshakes and daiquiris. Several additional low elevation species have potential but would need to be improved to be a large scale commercial crop. The sugar apple is in this category. It thrives in the tropical lowland but does not have the better handling qualities, pulp quality or shelf life of the cherimoya. The Atemoya is a hybrid between the sugar apple and the cherimoya. It has higher pulp quality, almost equal to that of a cherimoya and does well in humid and low elevations. Improved varieties of custard apple (*A. reticulata*) have been located but it hasn’t been developed as a large scale crop. One of the most interesting and best of the Annona family is the Ilama (*A. diversifolia*). Its flavor is equal to the cherimoya but it splits as it ripens. This spitting problem has retained the ilama to the realm of the dooryard. All of the about mentioned Annonas have a short shelf life and ripen to a soft easily damaged product.

Guava (*Psidium guajava*) is native to tropical America. It is used extensively for jelly, paste, juice, ice cream, and shells. Cas is another *Psidium* that is closely identified with Costa Rica. It is the size of a ping pong ball and is quite sour. When sweetened it has a flavor like strawberry and pineapple. Cas is universally known in Costa Rica but little known elsewhere. Guava shares the Myrtaceae Family with many other American fruits. Jaboticaba is a fascinating specie with an interesting cauliferous flowering habit (flowers form on the trunk and large branches). It may flower as many as five times each year under good conditions. The dark purple jaboticaba fruits form on the trunk and main branches of the tree. The fruit is the diameter of a quarter and has a sweet white pulp tasting like a Concord grape and small single seed. Jaboticaba is from the moderate climate of southern Brazil and does not do well in hot tropical zones. Camu Camu from the Amazon is a small purple fruit produced on a shrub and has one of the highest vitamin C levels of any fruit. Else where in tropical America the Barbados cherry (*Malpighia glabra*) of the Malpigaceae family is runner up in Vitamin C and both are used in the health and natural food market. Brazil boasts numerous edible fruits in the Myrtaceae family from the Amazon region and the southern Atlantic coast. Gruminchama (*Eugenia brasilensis*), cherry of the Rio Grande (*Eugenia aggregata*), and pitomba (*Eugenia luschnathiana*) are a few suited to dooryard use. Many other Myrtaceae in tropical America produce edible fruits and are used to produce jelly and wine.

Mamee apple (*Mammea americana*) should not be confused with mamey sapote. Mamee apple is a grapefruit sized, brown skinned fruit with a dense flesh that taste like a dried apricot. Seedling trees are slow to come into bearing taking as long as fifteen years. Mamee apple trees have male and perfect flowers on separate trees. Mamee can be easily grafted and more
selection is needed to locate improved cultivars. Mamee apple is in the Clusiaceae family as are a number of other species in the genus Garcinia (previously Rheedia) that produce small yellow fruits of local interest. The mamee apple and the American Garcinias need more study and collection to obtain more useful materials.

The Sapindaceae family yields the well known Spanish lime (*Melicoccus bijugatus*) and a number of *Talisia spp.* Spanish lime enjoys wide approval in the American tropics. To those not used to the Spanish lime its popularity may be a bit of a mystery. These round green fruits have a diameter about like a quarter and a sweet to tart pulp that adheres tenaciously to the large round seed. Stories of free stone Spanish limes abound but if they exist they are not widely availability. Trees of Spanish lime form either male or female flowers, thus two of these large trees are needed to produce fruit. Grown from seed a tree may take many years to flower. Only then can its sex be determined. Spanish limes are grafted with difficulty and large “broom handle” size branches can be air layered if they are in thrifty condition. An interesting alternative to the Spanish lime are the species of the genus *Talisia*. *Talisia* fruits are very similar to Spanish lime but have a thicker more useful pulp. They are smaller than the Spanish lime trees and are perfect flowered and self pollinating.

Passion fruit (*Passiflora spp.*) are vines native to the America. The early Spanish chroniclers exploring the American tropics were inspired by the intricate blossoms of the passion flower. Most of these men were priests or church trained. Perhaps the Inquisition and general political climate inspired the vision of the passion of Christ suffering on the cross when gazing upon passion flowers. There are many species of Passion flower and several are considered edible. Passion edulis is a round purple fruit with a thin, firm shell about 2 to 3 inches in diameter. Within the hollow chamber of the fruit are many seeds, each of which is enveloped in a juice sac. The juice is extracted for use and the seeds and rind is discarded in all but one passion fruit. The Giant granadilla (*P. quadrangularis*) is a large, green fruit, 5 inches in diameter and 10 inches long. The shell wall of the giant granadilla is about an inch thick and fleshy. In addition to the juice the shredded pulp is eaten. Among others, *Passiflora alata* is another valued edible passionfruit. May pop (*P. incarnata*) is a species native to eastern North America and grows far into the temperate zone.

Papaya (*Carica papaya*) is now a pan tropical fruit. It did originate in tropical America. Because of the long viability of the seeds it was distributed around the globe during the early period of exploration. Papaya is well known as a fresh tropical fruit. It is cooked when green as a vegetable as often as it is eaten as a ripe fruit in many cultures. The flowering of papaya is unusual. Plants can produce male flowers, female flowers and bisexual flowers (perfect). Often when a plant is broken off or damaged the new sprout may emerge and produce flowers of a different sex than the plant previously produced. Fruit size can range from a 4 oz. golf ball to a 30 pound melon two feet long. The papaya is a fast growing herbaceous plant with large deeply lobed leaves. The sap of the papaya contains the enzyme papain which is much like pepsin in the human stomach in that it digests protein. Papaya sap is thus a great tenderizer for meat. Papaya tablets are manufactured as an aide to digestion for some with stomach issues.
The delicious monster of the jungle is the monstera (*Monstera deliciosa*). Monstera is a member of the Aroid family and unlike other members of that family its ripe fruits are edible. Aroids like dumb cane, taro, and elephant ear are notorious for their irritating qualities when eaten raw. The monstera leaf is large dark green, oval shaped leaf with “swiss cheese” holes. The fruits are cucumber sized fruit that is held erect by a stem on the bottom of the fruit. The skin of the monstera is covered with thick hexagonal plates that separate when the fruit is ripe and drop from the fruit to expose a soft white pulp within. The fruits are clipped from the vine when a fine yellow line appears between the scales or when scales begin to loosen and drop from the fruit. If the fruit is eaten before it is ripe strong irritation will result from the presence of calcium oxalate in the flesh. Some sensitive individuals taste within ripe pulp a peppery, scratchy sensation in the fruit and don’t enjoy it. For most people the ripe pulp taste like a sweet pudding made of pineapple and banana.

Cashew (*Anacardium occidentale*) is from the dry savannahs of northern South America. The useful part of the cashew is the cashew nut and the thicken stem or cashew that attaches it to the plant. Several weeks before the nut is mature the stem is pencil thick. The stem then swells to produce a large soft structure or “cashew apple” that is eaten and often mistaken for the fruit. The fruit is the structure that houses the seed or cashew nut that is attached to the end of the cashew apple. The cashew apple is often eaten be twisting of the cashew nut and sucking the watery spicy pulp from the hole where the nut was attached. Cashew nuts must be handled with care. The nut is encased within a husk that is impregnated with an irritating sap. This is understandable when you realize that cashew is related to such irritating plants as poison ivy, sumac, poison wood and mango of the Anacardiaceae family. Cashew nuts are usually processed by heating in a ventilated oven that cooks off the volatile oils and renders the nut safe for handling.

The strawberry fruit (*Muntingia calabura*) from Central America might best be thought of as backyard candy. Strawberry fruit get its name from the fact that the flower looks much like that of a conventional temperate strawberry. The pink fruit of this small but fast growing tree taste like cotton candy and is a little smaller than a marble. It is eaten by children in the tropics around the world but of no economic significance. Strawberry tree thrives when self sown in disturbed and untended sites.

The Cinderella story of tropical fruits for the new millennium is that of the dragon fruit (*Hylocereus undatus*). Dragon fruit ranges in size from a baseball to that of a softball. It has a red scaly rind and a soft moist pulp with small black seeds embedded throughout the pulp. The pulp can be white, red, or magenta and has a mild bland flavor. It might be excessive to say that it taste like dry water. Faint sweetness and flavors are often present. The dragon fruit has been known since antiquity as the pitaya in its native Central America. Although eaten commonly it never realized large commercial stature there. Dragon fruit is a vining cactus that grows in the canopy of tropical American forests. The dragon fruit has a beautiful large white nocturnal flower that has been popular with tropical gardeners. Known as night blooming cereus, dragon fruit was spread to green houses and tropical gardens around the globe as a flowering specimen. I suppose the French took dragon fruit to Vietnam. The Vietnamese developed the dragon fruit as a commercial crop of significant importance. It is now Vietnams leading export fruit.
Vietnam got the jump on the rest of the world in developing dragon fruit. In fact the Vietnamese gave the pitaya or night blooming cereus its new marketing name of dragon fruit. It is called dragon fruit because the stem of the plant has crenulated ridges like the spine of a dragon. Dragon fruit in now grown in Florida, California, and Hawaii. Many countries now produce dragon fruit. A yellow pitaya (Selenicereus megalanthus) has been grown in tropical America successfully as a commercial crop but has never achieved the wide spread popularity of dragon fruit. Yellow pitaya is slightly smaller than dragon fruit and has thorns the dragon fruit does not but is much sweeter and more flavorful. Peruvian hedge cactus produces a smooth, pink fruit twice the size of an egg. It does indeed taste like dry water. It is grown as an ornamental plant but is also grown in a small way for the market.

There are more than 2,000 bromeliads in the world and all but one comes from the Americas. The bromeliad esteemed for its fruit is of course the pineapple (Ananas comosus). Pineapple was taken from the new world by Columbus and found great favor in Europe. It became a symbol of opulence and hospitality and as such was often found on buildings, gates and furniture of the era. The production, economic value and use of pineapple make up a sophisticated and vast industry and won’t be discussed here. I would point out however, that many consumers have never tasted a pineapple in its fully ripe and most delicious stage due to shipping and handling constraints.

Three Amazonian fruits that have still untapped potential beyond their native region are the South American sapote (Quararibea cordata), Abiu (Pouteria caimito), and the Amazon tree grape (Pourouma cecropiifolia). Of the three fruits mention above only abiu is cultivated outside its natural range. Abiu trees are well established in Florida and California in rare fruit collections. It is a promising crop. Abiu is grown commercially in Australia. South American sapote is a jungle fruit that produces a gray to green pointed fruit with orange pulp. The pulp is fibrous and pleasantly sweet. The Amazon tree grape yields purple, grape sized fruits in large clusters. Their flavor is juicy and sweet. Although work has been done in their native countries, like so many tropical fruits these three could benefit with more selection and horticultural improvement. Brazil which has studied and selected some of these native fruits is generally unwilling to share germplasm.

The discussion above is incomplete but should provide a basis to begin the study the interesting fruits of tropical America. For the traveling botanist, gardener, cook or anthropologist I have two words: the market. The market is the best way for a traveler to quickly glimpse a capsule of local life. Many tropical countries have tradition of daily marketing. This is because processed foods are not available, affordable or desired. Refrigeration is limited or nonexistent. Along with fresh produce markets exhibit to the traveler street stalls for ready to eat food, clothing, medicinal herbs, and hardware and everyday household items. A market could be a few vendors under a tree by the forest edge or hundreds of stalls in an urban setting. There is also a social component to shopping in markets. At first it may seem that a typical large market may have many vendors selling the same thing. A closer look will often show markets divided by cultural background. Chow Kit market in Kuala Lumpur is a good example of this cultural separation. Chinese, Malay and Indian vendors are largely favored by customers in their respective cultural groups. You may tell a vendor by some
his merchandise. In Chow Kit an Indian vendor will present such things as snake gourd (	extit{Trichosanthes cucumerina}), drum stick (	extit{Moringa oleifera}) and a specific cultivar of bitter melon (\textit{Momordica charantia}) not found in Chinese or Malay stalls. The personal relationship of a vendor and his daily customer allows many small booths to each have a following.

In addition to fruits and vegetables markets contain other products. The seafood part of a market can be an extensive zoology lesson. The meat market may not be for the faint of heart. Each market has its own character. Some can be dangerous. Ask at your hotel, taxi driver or other tourist. It is wise to visit market with a fellow traveler and often more fun to share the experience. If you feel uncomfortable you should follow your instincts. Pick pockets and purse snatchers are found the world over. Some markets like those in Manila, Guatemala City or Jakarta could be very dangerous. Other markets are quite safe to shop alone such as: Chiang Mai, Bangkok, Kuala Lumpur, Hong Kong and Singapore. The tourist in the market should be polite, modest, and interested. This will offer a chance to interact with locals in a way not possible for a tourist in other circumstances. Take your time. Purchase fruits that you can peel and eat. Leafy and unwashed items should not be eaten raw. Share with other shoppers. Be generous. Let the vendor show you how to eat or peel your purchase. Ask questions and pay attention when he explains or demonstrates. Knowledge of the language isn’t essential. If you learn a few words it shows that you have invested some effort and this is often appreciated. When you want to make a purchase you should ask a price and then bargain. It is expected. Often it is customary to pay 20 to 30\% less than the asking price. Do not try to drive a cruel bargain. You will often be speaking of pennies. Never make and offer for an item and then refuse to buy it when your price is met. As you are uninformed don’t worry about small jokes and giggles at your expense. Always be good natured and willing to look a little foolish.

Photography should be done in a respectful manner. I don’t like to pay people for photographs unless they are clearly there and costumed for tourist photos. Do not use a telephoto lens and shoot subjects as if they were wild animals. That type of photography is intrusive and insulting. Your choice of subject matter should not be degrading or negative in content. This will justifiably generate resentment. I often ask vendors I have interacted with if I can photograph them or their families. Often this request is happily honored. If a photo request is denied be pleasant and thank them anyway and move on. Never take a photo if you are asked not to or if a subject is trying to avoid the picture. I find a good way to get photos is to shoot someone who is involved in an activity rather than a self conscience static portrait. Try to get smiles. Most parents the world over think their children are natural subjects and understand your interest in simple photos. The best photos are those in which the subject is interacting with the photographer. You can replace that telephoto with a wide angle lens. The display on the back of a digital camera will allow you to show your subjects what your pictures look like. This gets them involved. Often subjects become much more relaxed and willing to be photographed when they see what you are doing. You may sometimes have to take a few extra photos to include everyone in the process. Being able to instantly share your pictures can be great fun.
For more information and fun with tropical fruits visit the Fruit & Spice Park in Homestead, Florida.

Email: fsp@miamidade.gov
Website: www.fruitandspicepark.org
Telephone: 305-247-5727

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Active night market.  Amazon tree grape fruit cluster.
Fruit market in Saigon

Floating market on Mekong

Saigon street corner market

Chris Rollins and mangosteen

Cashew before rapid formation of the cashew apple

Cashew
Common guava    Jaboticaba

Dragon fruit     White fleshed dragon fruit

Yellow pitaya    Mayan pitaya later to become the Vietnamese dragon fruit
Mamey sapote

Canistel

Black sapote

Mamee apple

South American sapote

White sapote
Monstera

Papaya

Passiflora edulis

Sapodilla

Spanish lime and Talisa

Star apple
From Germplasm Collection to Kaimana Lychee Production Management

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¹USDA-ARS-PBARC-TPGRMU, Hilo, HI  96720  
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The Tropical Plant Genetic Resource Management Unit, USDA/ARS, Pacific Basin Agricultural Research Center (PBARC) is located at the Waiakea Agricultural Experiment Station, Stainback Hwy, Hilo, Hawaii. The unit has three scientists and 10 technicians, two research programs, a tissue culture laboratory, 33 acres of field plantings, greenhouses, manage and service the unit’s GRIN database for the National Plant Germplasm Program. The current collection is about 1000 accessions comprised of 14 designated tropical fruit and nut crops. The mission of the unit is to collect, maintain, evaluate and distribute available germplasm for research to scientists nationally and internationally. We have always work closely with the University of Hawaii CTAHR on research topics important to Hawaii; some examples are: 1) Longan and lychee flowering management, Drs. M. Nagao, T. Matsumoto, Mel Nishina and F. Zee; 2) Ginger wilt management, Drs. Anne Alvarez, Lisa Keith, Bernard Kratky and F. Zee; 3) New crops: tea / blueberry Dwight Sato, Milton Yamasaki, Randy Hamasaki and F. Zee.

The 1999 extension publication on lychee management by Zee, Nagao, Nishina and Kawabata is still a good guide on production management of Kaimana lychee. It is available through the UH CTAHR, Cooperative Extension Services.

Some of the important points in the bulletin and additional suggestions are:

1. “Kaimana” is a variety selected and released by Drs. Richard A. Hamilton and Philip J. Ito, University of Hawaii, for the CTAHR 50th anniversary. Kaimana is the most suitable lychee variety for Hawaii because of its superb qualities and relatively low chill requirement for flowering.

2. The order of effectiveness in lychee flower induction is:  
   Low temperature > Low Nitrogen in leaves > Water stress  
   Sufficient low temperature during December to February overrides all other floral induction signals.

3. The lack of seasonality is evident on perennial trees in Hawaii in having all stages of growth on the same tree. A Kaimana tree that is not managed may have actively growing shoots, maturing growth, fruiting branches and all stages of growth on the same plant. Since only fully mature shoots are responsive to low temperature flower induction, the lack of uniformity and synchronicity in vegetative growth, along with the lack of consistent and sufficient cold period (55-60 °F for 7 + days) are factors negatively impact the production potential of Kaimana lychee.

4. The tests in the use of pruning and foliar fertilizer to synchronize and condition Kaimana lychee trees for production were conducted at the USDA/ARS PBARC lychee orchard
for two consecutive seasons (2005, 2006). The productions of twenty four 8-9 year old “Kaimana” trees averaged about 100 lb per tree per year for the two seasons.

Table 1. Kaimana tree harvest information at the USDA/ARS, PBARC, Germplasm unit 2006.

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<th>Date</th>
<th>Number of trees</th>
<th>Fruit weight (lb)</th>
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<td>206</td>
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<tr>
<td>July 12, 2006</td>
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<td>326</td>
</tr>
<tr>
<td>July 28, 2006</td>
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<td>125</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>20</strong></td>
<td><strong>3,188</strong></td>
</tr>
</tbody>
</table>

   - Remove 8 to 12 inches of the branch along with the fruit cluster at harvest.
   - Cut back 8 to 12 inches on all non bearing branches from the tip or to where the branch diameter is about that of a pencil to that of a permanent marker.
   - It is okay to put the leaf litter under the canopy, as long as they are evenly spread, and not piled up against the trunk. Remove all branch litters that are over an inch in diameter as they may harbor wood boring insects and wood rot organism.

Composition of the foliar nutrient in 100 gallons of water:

1. 3 lb of 19-19-19 (9.5% Ammonical, 9.5% Nitrate) plus micro (B 0.02%, Cu 0.05%, Fe 0.1%, Mn 0.05%, Mo 0.001%, Zn 0.05%)
2. 1 quart of “Pack hard” (Ca 8%, B 0.5%) 
3. ½ quart of “Clean Crop 4.5% Iron HEDTA” liquid iron (chelated Fe 4.5%)
4. The nutrient is thoroughly applied on the canopy of each tree
5. 3 gallons per tree

6. Apply foliar fertilizer within one week after pruning to induce vegetative growth

7. New vegetative growth should be visible between 2 to 3 weeks after foliar application. New growth matures between 4 to 6 weeks depending on the weather. It is important to control erinose mite prior to vegetative flush.

8. No fertilizer should be given to the tree between first flush mature to flowering (from September to January, February or March). We are conducting studies to determine if a second application of foliar fertilizer after the first flush is beneficial.
9. There may be natural vegetative growth after the first induced flush matured. This is normal, do not panic, just observe. The important point is that all new leaves need to mature by the end of November and early December.

10. The reasoning behind the use of foliar fertilizer after pruning is to induce and synchronize vegetative growths at a time we designed and desired. Use of foliar fertilizer minimizes the chance of having residual granular fertilizer under the trees due to lack of rainfall or irrigation after application. Left over fertilizer released by late season rain may interfere with flower induction by inducing and promoting active vegetative growth.

11. If vegetative growths occur during the critical floral induction period, i.e. December to January, new shoots reaching the first open leaf stage should be pinched back and leave a stub of one inch at the base (Nagao, Ho, Nishina and Zee, 2001). This will delay or inhibit bud break of the axially buds immediately below for about four to six weeks, and may allow for successful flower induction of these buds.

12. Manage erinose mite before flowering. Make sure treatment application cover the tree trunk.

13. Use high potassium granular fertilizer such as Banana Super (10-5-40) when fruits reach pea size, about 5 lb per tree (this is my call with no supporting data).

14. Irrigate thoroughly after fertilized, and maintain even moisture during fruit growth. Having a good leave mulch under the canopy maintain even soil moisture, and reduce fruit cracking.

Drs. Matsumoto, Mike Nagao, Mr. Mel Nishina, Ms. Virginia Smith and Zee are expanding field trials to further evaluate this foliar synchronization of Kaimana lychee in Hilo, Kona and Hamakua.
Tropical Fruit Diseases

Dr. Lisa Keith
Research Plant Pathologist
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USDA-ARS, PBARC

Tropical Fruit Growers Conference
September 30, 2006
Tropical Fruit Diseases

- Rambutan disease surveys were conducted and a variety of fungal pathogens were isolated and identified as the causal agents of fruit and leaf lesions. Our overall goal is to gain a better understanding of what fungi affect rambutan fruit quality and determine if pathogen management practices can result in improved fruit quality. The fungi identified included *Lasmenia*, *Colletotrichum, Phomopsis, Lasiodiplodia* and *Pestalotiopsis*. Growth studies at a variety of temperatures were conducted to determine if certain temperatures could suppress disease. Disease incidence was compared for six rambutan varieties. Fungal isolates were also evaluated for sensitivity to fungicides registered for use in Hawaii.

Tropical Fruit Diseases

- Until recently, lychees in Hawaii were relatively free of pre-harvest diseases affecting fruit or foliage. This research aims to benefit the lychee industry in Hawaii by establishing the extent of disease problems, raising awareness of the incidence and damage, and eventually evaluate some potential control measures. Since growers may be unaware of the symptoms of lychee diseases and consider them as an unspecified “blemish”, it was felt that growers would immediately benefit from accurate identification and early intervention.
Rambutan - *Nephelium lappaceum*
Common Field Symptoms
Rambutan

Day 0  Day 7  Day 9

Disease progression of a natural field sample
Rambutan - Main Fungi
Artificial inoculations showing symptoms

Lasmenia, 7 days
Phomopsis, 5 days
Pestalotiopsis, 7 days
Colletotrichum, 5 days
Lychee - *Litchi chinensis*
Common Field Symptoms
Lychee - Koch's Postulates

Main fungi on lychee include *Colletotrichum*, *Phomopsis*, *Lasiodiplodia*, and *Pestalotiopsis*

Kuai Mi Pink

Lychee - Susceptibility Study

*Colletotrichum*  
*Phomopsis*

*Pestalotiopsis*  
*Lasiodiplodia*

Kaimana/Kuai Mi Pink, Non-wounded/Wounded, 7 days
Conclusions

* Similar symptoms for numerous fungi

* Pathogens can affect several hosts

* Multiple factors contribute to the onset of disease

* Fungi were identified morphologically and molecularly

Conclusions

* Differences in growth depending on temperature

* Trilogy does not appear effective for control of fungal pathogens on rambutan

* Differences in variety susceptibility

* Fungi can cause significant losses
Goals/Impact

• Characterize host-pathogen interactions

• Develop disease control methods

• Evaluate how pre-harvest practices affect post-harvest quality

• Additional fungicide trials; field trials

• Determine resistant varieties

The Team
Quarantine Updates: Little Fire Ant and Mixed Fruit Boxes

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New quarantine treatments

*Bananas:* Irradiation has been approved for all cultivars of bananas for the first time, and several shipments of apple bananas using irradiation treatment were made in Sep-Oct. The 400 Gy irradiation treatment for bananas is an alternative to the non-host status treatment that has been available for several years but not widely used.

*Generic irradiation treatments:* A generic treatment is the “holy grail” for a quarantine entomologist. A generic treatment is a single treatment that controls a broad group of pests without affecting the quality of a wide range of commodities (Follett and Griffin 2006). Traditionally, entomologists have developed treatments one pest and one commodity at a time, so generic treatments for broad groups of pests and commodities could save years of research time and resources. Generic treatments have been discussed for many years but never applied due to the lack of sufficient information on a broad and important group of insects or due to problems with fruit quality. Irradiation is the ideal technology for developing generic treatments because radiation—from an isotope source (cobalt-60) or x-rays—penetrates fruit easily and is effective against insects at doses that generally do not injure the fruit.

On January 27, 2006, USDA APHIS published a rule proposing a generic irradiation dose of 150 Gy for all tephritid fruit flies. We currently irradiate all our fruit at 250 Gy for fruit flies. Lowering the irradiation dose for fruit flies would reduce costs and increase capacity for treatment facilities by decreasing the required treatment time, and could accelerate the approval of irradiation quarantine treatments for specific crops, and thereby rapidly expand exports for Hawaii (Follett and Neven 2006). Also, if another fruit fly species should invade Hawaii, exports would not be interrupted. The same Proposed Rule includes a generic irradiation treatment of 400 Gy for all insects except Lepidoptera (moths and butterflies) pupae and adults. These generic treatments apply to all commodities. Therefore, fruits with no Lepidoptera quarantine pests associated with the fruit in the pupal or adult stage have a ready-made treatment.

*Future exports approvals:* Progress is being made on new export protocols for Hawaii’s tropical fruits. A rule is in preparation by USDA APHIS for cherimoya, soursop, breadfruit, jackfruit, dragonfruit, mangosteen, and Korean melon. The new fruits are bundled together and APHIS says they will be “ready for the September 2007 harvest season”. This suggests the proposed rule might be published by the end of 2006 or soon afterward.
Little fire ant

Background: The little fire ant (LFA), *Wasmannia auropunctata*, was first discovered in 1999 near Pahoa, Puna district, and has become a problem for several tropical fruit growers on the Big Island. LFA is native to Central and South America and now occurs in nearly all Neotropical countries and Caribbean islands (Krushelnynych et al. 2005). In September 1999, three populations of LFA were known in Hawaii totaling 12 ha in size, but this number escalated to 31 populations on 76 ha by January 2004. Eight populations in January 2004 involved nurseries that were still selling plants. LFA is now established at 37 sites in the Hamakua coast, Hilo, and Puna areas (Fig. 1, courtesy of Pat Conant, HDOA) and the list continues to grow.

LFA is a serious pest that can attain enormous densities. We estimated an LFA population density of 90 million per acre at Honoalani Orchards in Papakou in February 2006. LFA has a powerful sting that poses problems for domestic animals, wildlife, agricultural workers and others who come into contact with infested plants. In some cases, agricultural workers refuse to harvest from ant-infested trees, and exporters may refuse harvested fruit from infested orchards. LFA is listed as one of the 100 worst invasive species in the world (Global Invasive Species Database 2004). Like many sugar-loving ants, LFA will tend Homopterans such as scale insects and mealybugs for their honeydew, which causes plant stress and can lead to increased prevalence of these pests and sooty mold on harvested fruit. LFA is one of several species of ant causing rejection of fruit in California and return shipment.

LFA is a difficult pest to detect and control. LFA is very small (1.5 mm in length), light colored and slow moving, and this inconspicuous behavior makes the ant difficult to detect at low levels. Once LFA is well established on more than a few acres it is difficult to eradicate. Amdro (hydramethylnon) granular ant bait is the primary pesticide used for control (Wetter and Porter 2003). Amdro granules are carried by workers back to the colony as food and fed to the queen, killing her and thereby destroying the colony. Broadcast application of Amdro was used successfully to eradicate LFA populations on Santa Fe Island and Marchena Island in the Galapagos (Wetter and Porter 2003). In bearing tropical fruits orchards, the original labeled use for Amdro was in bait stations deployed at approximately 50 ft. intervals (every other tree). A supplemental label was published recently allowing for closer spacing of Amdro bait stations in orchards. Recent research identified the most cost effective bait station (Taniguchi et al. 2004).

LFA has a short foraging distance, and therefore the bait station approach may leave much of the ant population unaffected (e.g. in drive rows and along borders) and ready to re-invade trees when Amdro efficacy diminishes. Also, LFA often nests in trees under moss and in other protected sites, limiting the effectiveness of baits applied to the ground. No information is available on the effect of bait station spacing and density for LFA, or methods to control LFA in trees. Broadcast applications of Amdro are not permitted at this time, but heavy rainfall hampers the effectiveness of Amdro applied as a broadcast treatment. Esteem Ant Bait (pyriproxyfen) is an insect growth regulator registered for use in tropical fruits and broadcast application is permitted. Esteem interferes with ant growth and development, and typically takes 12 weeks or more before ant populations become noticeably reduced.

Although LFA is slow to disperse, many tropical fruit farms in Hawaii will be invaded in the coming years through the movement of nursery stock, landscape and ornamental plants, farm equipment, harvested fruit, etc. Information on the best control methods for LFA is critical for the industry as this ant continues its spread into new areas. Results of this study should also help
in the management of problematic non-stinging ants such as the big-headed ant, which tend mealybugs and scales and can cause fruit shipment interruptions during export.

Research: Field tests are in progress to compare the effectiveness several ant control chemicals: Amdro (in bait stations), Esteem (a growth regulator), and Conserve (a contact insecticide). At 12 weeks, densities of ants in the Amdro and Esteem plots were low compared with densities in the Conserve and untreated control plots (Fig.2). Sampling in weeks 13 and 14 showed that Esteem reduced ant numbers even further and may be superior to Amdro in bait stations. The advantage of Esteem is that it can be broadcast and so is easier to apply than Amdro. Esteem is an insect growth regulator that prevents development in immature ants, and therefore ant numbers do not start to drop for several months after treatment begins at which time adult ants begin to die off naturally without being replaced. None of the ant control treatments applied to the ground controlled ants nesting in the trees. Additional tests have been started to evaluate the potential for placement of Esteem and Amdro in trees to control ants there.

Mixed fruit boxes

Background: Current requirements for irradiation of tropical fruits for export are one fruit type per box using standardized box types and weights. Consequently, we treat and ship one fruit at a time. Wouldn’t it be great to be able to ship mixed-fruit gift boxes like Harry & David? From a regulatory viewpoint, there are two ways to do this: (1) fruit could be treated as usual then repacked into mixed boxes in an APHIS-certified pest-free packing house, or (2) several fruits could be packed in a box to begin with and irradiated to achieve the minimum/maximum dose requirements without having to repack. APHIS suggested that a certified repack facility would be the easiest route and most convenient for them. The design of the repack facility could follow the standards developed for quarantine treatment facilities.

Alternatively, mixed fruit boxes could be packed on the farm before irradiation treatment, which would be more efficient for growers as they would only have to pack fruit one time. The approved generic dose for all our fruits is 400 Gy which makes this approach a possibility. Irradiation of mixed fruit boxes, however, is more challenging as the density of each box and the density of carrier load during treatment are less uniform than single fruit boxes.

Research: Research is underway to better understand bulk density relationships between mixed-fruit boxes and single-fruit boxes. We would like to demonstrate that there is one belt speed for the irradiator at Hawaii Pride that provides the minimum dose requirement (400 Gy) for the range of bulk densities presented by our fruits (in different combinations) without exceeding the 1000 Gy maximum allowable dose. This research will require a year or more of testing and then the research would be reviewed by APHIS. A repack facility could be built and certified in a relatively short period of time, allowing export of mixed fruit gift boxes immediately thereafter. HTFG members interested in shipping mixed fruit boxes should meet and decide whether there is sufficient interest to warrant building a repack facility.


Little Fire Ant Distribution
March 1999 - June 2005
37 Infested Sites

Fig. 1
Fig. 2. Effect of various ant control treatments on ant density after 12 weeks. Insecticides were applied biweekly to the ground in a rambutan and mangosteen orchard in Papaikou, HI. For each treatment, densities are averages from four ¼-acre replicate orchard blocks, with seven samples taken across the row in each replicate.
Nutrient Requirements During ‘Kaimana’ Lychee Production

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Abstract
An initial consideration in development of a fertilizer program for bearing lychee trees is the amount of fertilizer nutrients contained in the harvested crop. Leaf analysis data from well-producing trees can also provide useful information on the leaf nutrient content of productive trees. Samples of mature ‘Kaimana’ fruits were collected from 5 different orchards in East Hawai‘i from 2004 and 2006. Trees were between 8 and 14 years old. Leaves were initially sampled from 5 year-old ‘Kaimana’ trees beginning in 2001 and re-sampled during the 2002, 2003, and 2006 flowering seasons from an orchard in Panaewa, Hawai‘i, which had consistent production. Leaf samples were dried and analyzed for mineral nutrient content by the UH Agricultural Diagnostic Service Center. Mature fruits were harvested, weighed, dried to constant weight, and analyzed for mineral nutrient concentrations. This report provides results from nutrient analyses of mature fruits and lychee leaves sampled at the onset of flowering.

Leaf nutrient concentrations ranged from 1.59-1.87% N, 0.21-0.28% P, 0.76-0.96% K, 0.57-0.60% Ca, and 0.31-0.33% Mg. Concentrations of N, P, K, Ca and Mg based on the dry weight of mature fruits were 0.79%, 0.14%, 1.01%, 0.15% and 0.17%, respectively. Nutrient concentrations in the fruits expressed on a fresh weight basis showed that the relative order of nutrient concentration in mature ‘Kaimana’ fruit was K > N > Mg > Ca ≥ P. Based on the fresh weight of whole fruits, about 0.22 lb K (0.27 lb K₂O), 0.17 lb N, 0.04 lb Mg, 0.03 lb Ca, and 0.03 lb P (0.05 lb P₂O₅) were contained in 100 pounds of harvested fruits.

Introduction
‘Kaimana’, a selection of the ‘Haak Ip’ cultivar, is a popular early-bearing lychee cultivar grown in Hawai‘i. This cultivar produces large, heart-shaped fruits with a reasonable percentage of “chicken-tongue” seeds and has a low-chill requirement for flower initiation (Zee et al., 1999). For this reason ‘Kaimana’ is considered a good-bearer compared to other cultivars grown in Hawai‘i.

Bearing characteristics are dependent on tree age and weather conditions; however mineral nutrition can also play a critical role in productivity as well as tree vigor and overall health (Menzel and Simpson, 1986; Menzel et al., 1994). Some initial steps to understanding nutrient requirements for ‘Kaimana’ trees are to determine a range of adequate mineral nutrient concentration in leaves and to determine the amount of mineral nutrients that are depleted from the soil due to the removal of mature fruits at harvest. In Australia, leaf nutrient analysis studies have been conducted on leaf samples taken during the period from vegetative flush maturation in autumn to early panicle development when leaf nutrient concentrations are most stable (Menzel and Simpson, 1987; Menzel et al., 1988a; Menzel et al., 1992a)
Generally, leaf samples are comprised of leaflets from 8 most recently matured leaves per tree from flowering branches 1 to 2 weeks after panicle emergence (Galán Saúco and Menini, 1989; Menzel et al., 1992a; Menzel et al., 1994). Using this method Menzel et al. (1992a) has developed sufficiency standards for leaf nutrients for lychee trees in Australia (1.50-1.80% N, 0.14-0.22% P, 0.70-1.10% K, 0.60-1.00% Ca, and 0.30-0.50% Mg). Additional suggested optimal leaf nutrient levels during periods of flowering and fruit set have been reviewed by Menzel (2005b).

By monitoring nutrient levels in the leaves at different times of the year, Menzel et al. (1992a) were able to show that leaf N, P, and K concentrations reached a maximum, Ca values reached a minimum, and Mg concentrations slowly declined during panicle emergence. However, these results varied slightly between the different cultivars and planting locations.

Few studies have focused on the nutrient content of mature lychee fruits. According to Zee et al. (1999), lychee fruits are harvested in Hawai’i by removing the entire fruit cluster including 2 leaves near the base of the panicle. Since lychee fruits are non-climacteric, further ripening does not occur following harvest, and fruits should be harvested at optimum ripeness. Similar to results from leaf analyses, fruit nutrient concentrations also varied among cultivars. Nutrient concentration ranges for ‘Tai So’ and ‘Bengal’ lychee fruits were as follows: 0.85-1.06% N, 0.19-0.23% P, 1.04-1.40% K, 0.10-0.22% Ca, and 0.16-0.18% Mg (Menzel et al. 1988b).

When determining fertilizer requirements it is important to remember that older, bearing lychee trees require greater amounts of nutrients than young, non-bearing trees (Menzel and Simpson, 1987). Removal of nutrients from pruned twigs and leaves should also be taken into account when replenishing soil nutrients, since leaves, twigs, and small branches contain the highest concentration of nutrients (Menzel et al., 1992b). Nutrients in aborted flowers and immature fruits may also be important if the soil surrounding the tree base is swept or raked of fallen debris. Rainfall patterns and soil type, which influence leaching and nutrient uptake, should also be considered for each production site. This study presents information on nutrient concentrations in mature ‘Kaimana’ fruits and also presents data on leaf mineral nutrient concentrations for healthy, well-managed ‘Kaimana’ lychee trees grown in a Papai extremely stony (A’a lava) muck soil in Panaewa, Hawai’i. The relationship between flowering intensity and leaf nutrient concentrations at the onset of panicle development are also discussed, along with fertilizer requirements as they relate to lychee fruit production.

Materials and Methods

Collection of leaf samples from ‘Kaimana’ lychee trees in an orchard located at 200 ft elevation in Panaewa (site A), Hawai’i was initiated in 2001 and was continued in 2002, 2003 and 2006. In 2001, the trees were 5 years old and grown in a Papai extremely stony muck soil. Leaf samples were collected from terminal branches at the onset of panicle development. Each sample was comprised of leaflets from the most recently matured leaf below the panicle on 12 randomly selected flowering terminals from each tree. Leaflets from 4 additional terminals were collected in addition to the 8 leaves suggested for sampling (Galán Saúco and Menini, 1989; Menzel et al., 1992a; Menzel et al., 1994) to obtain a sizeable sample for analysis.

Seven samples of mature ‘Kaimana’ fruit were collected from a total of 5 orchards located in Kea’au (250 ft elevation), Panaewa (site A and B; 200 ft elevation), Kurtistown (site A; 800 ft elevation), and Kurtistown (site B; 845 ft elevation) in East Hawai’i over 3 harvest
seasons (2004-2006). Soils in the orchards ranged from a Papai extremely stony muck to an Olaa silty clay loam. In 2004, the lychee trees were between 8 and 14 years-old. Fruits were harvested 13 to 17 weeks after full bloom when the pericarp (peel) was uniformly red. At least 1 to 2 pounds of fresh whole fruits were harvested at each sampling period.

All leaf and fruit samples were rinsed in distilled water and dried at 158°F in a Precision Scientific Inc. (Winchester, VA) Thelco Laboratory Oven until constant weight was obtained. The fresh and dry weight was recorded for each fruit sample and all samples were analyzed by the UH Agricultural Diagnostic Service Center for N, P, K, Ca, Mg and micronutrients.

In addition, the amount of flowering on 9 ‘Kaimana’ trees were recorded monthly as a percentage of terminals bearing flower panicles. The percent of terminals producing vegetative flushes (data not shown) was also recorded during that time. Data was taken from Jan. 2002 to Aug. 2006 at the Panaewa (site A) orchard.

Results and Discussion

Leaf nutrient analysis. All ‘Kaimana’ lychee leaf samples (Table 1) contained concentrations of K and Mg similar to that recommended by Menzel et al., 1992a. High K is thought to be beneficial to lychee flowering by suppressing vegetative growth during winter (Banta, 1952 cited in Menzel and Simpson, 1987). Menzel and Simpson (1986) investigated the effects of high K supplied in autumn and found that flowering was greatest with a leaf K concentration of 0.94% prior to panicle emergence. Figure 1 shows the intensity and duration of flowering at the Panaewa (site A) orchard and includes N and K levels found in the leaves of samples taken at the onset of panicle emergence for the corresponding year.

‘Kaimana’ leaf K levels in 2002 (0.96%) and 2006 (0.94%) were high, but the development of flower panicles is influenced by several factors working in unison. The principal factors are cool temperatures, water stress, low N, and high K leaf concentrations (Nakasone and Paull, 1998). Although K levels were high during panicle development of the 2003 season, leaf N concentrations were also high and could have had an influence on the level of flowering.

‘Kaimana’ leaf N concentration results for 2001, 2003, and 2006 fell within the ranges suggested by Menzel et al. (1992a). The highest N concentration (1.87%) occurred in 2002. When N levels are high increased flushing may occur in January and February and reduce panicle development. This relationship between N concentration, flushing, and flowering in ‘Tai So’ was demonstrated by Menzel et al. (1988a). They observed a strong inverse correlation between flowering percentage in spring and the percentage of terminals flushing in the month preceding panicle emergence. Very active flushing occurred from May to June when leaf concentrations exceeded 1.85% N in the previous month (April). Flowering was also reduced during the following season when the leaves contained 1.91% N or greater. In addition to high nitrogen studies, research from India showed that the greatest yields on ‘Bombai’ were achieved when leaves sampled 10 days prior to flowering contained low leaf N (1.38-1.50%) concentrations (Ghosh and Mitra, 1990).

In 2001, 2002, and 2006, P concentrations were slightly higher than concentrations reported by Menzel et al. (1992a) but fell within range in 2003. P deficiencies are not typically visible in orchards and excess (up to 0.44% P) levels do not appear to affect fruit production (Menzel et al., 1994).

Ca concentrations were slightly lower than recommended levels in 2001, 2002, and 2006 but were adequate in 2003. According to Menzel et al. (1987), severe Ca deficiency (leaf levels
not reported) can affect fruit set but does not appear to affect flowering. Ca is an integral component of cell walls. Low Ca levels during fruit development have been shown to lead to fruit cracking in susceptible cultivars (Menzel, 2005b; Pereira et al., 2005). If low, Ca concentrations in leaves and developing fruit can be increased with spray applications.

*Mature fruit nutrient analysis.* ‘Kaimana’ trees produce some of the largest fruits which are comparable to some Taiwanese and Chinese cultivars such as ‘Sanyuehong’, ‘Sah Keng’, and ‘Feizixiao’ (Menzel et al., 2005a). The weight of individual ‘Kaimana’ fruits ranged between 0.8 to 1.3 ounces, with 14 to 19 fruits contained in each pound. Moisture content of each fruit sample ranged from 77.2% to 79.7% with a mean of 78.3% based on fruit from all locations. Analyses of ‘Bengal’ fruits showed that fruits contained between 72.3% and 80.3% moisture (Menzel et al., 1992b).

Table 2 shows the nutrient concentration of ‘Kaimana’ fruits based on its dry weight. The relative order for macro-nutrient concentration in mature ‘Kaimana’ fruit was K > N > Mg ≥ P ≥ Ca, and concentrations of N, P, K, Ca and Mg based on the dry weight of mature fruits were 0.79%, 0.14%, 1.01%, 0.15% and 0.17%, respectively. The mineral nutrient concentration found in the fruit varied slightly when compared to the different growing locations and years. Compared to fruit nutrient studies conducted on ‘Tai So’ and ‘Bengal’ (Menzel et al., 1988b), ‘Kaimana’ fruit contained less N, P, and K and similar amounts of Mg. Ca levels were higher in ‘Kaimana’ than ‘Bengal’ but were lower than ‘Tai So’.

Results of the fruit analysis were converted from percent of the dry weight (Table 2) to pounds of each nutrient element contained in 100 pounds fresh lychee fruits by utilizing the fresh weights recorded for each sample (Table 3). The results showed that at harvest, 100 pound crop of ‘Kaimana’ lychee contained 0.17 lb N, 0.03 lb P, 0.22 lb K, 0.03 lb Ca, and 0.04 lb Mg. The concentration of other nutrients (Na, S, Fe, Mn, Zn, Cu, and B) was small (less than 0.02 lbs per 100 lb crop). Based on average yields per tree (Menzel et al., 1992b), ‘Bengal’ fruits contained greater amounts of N, P, K, and Mg but contained less Ca than ‘Kaimana’ fruits. Nutrient concentrations in mature lychee fruits appear to vary between the different cultivars.

Soil type influences the absorption, availability, and leaching of different elements. Studies by Tamimi (1980) demonstrated the high leaching characteristics of N and K. Increased watering due to irrigation and rainfall led to increased N losses. P losses due to leaching were found to be minimal and as a result over-fertilizing with phosphate fertilizers could lead to Fe immobilization and Fe deficiency in crops like macadamia. Soils containing high organic matter or the addition of organic matter to the base of trees can reduce excessive leaching of N and K.

The timing of fertilizer applications is also important. Studies (Lynch, 1954; Young, 1954; Nakata, 1956; cited in Menzel and Simpson, 1987) have found that late summer (August/September) applications reduced flowering and yield and suggest that the application of N fertilizers be withheld from late summer to the period of floral initiation. Although this report provides information to help establish a basis for nutrient replenishment based on the removal by harvested mature fruits, the soil type, rainfall, tree size, and fruit load will differ between growing locations. In addition nutrient losses due to leaching and pruning should also be considered. As a result, fertilizer applications should be modified to meet the needs of the individual orchards.
Literature Cited


Table 1. Concentration of nutrients based on dry weight of ‘Kaimana’ leaves sampled at the onset of flower panicle development. Samples were obtained from trees grown on a Papai extremely stony muck soil near Hilo in Panaewa, Hawaii.

<table>
<thead>
<tr>
<th>Sampling Date</th>
<th>% of Dry Weight</th>
<th>µg/g of Dry Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>P</td>
</tr>
<tr>
<td>12/13/2001</td>
<td>1.72</td>
<td>0.27</td>
</tr>
<tr>
<td>12/31/2002</td>
<td>1.87</td>
<td>0.24</td>
</tr>
<tr>
<td>12/18/2003</td>
<td>1.73</td>
<td>0.21</td>
</tr>
<tr>
<td>2/10/2006</td>
<td>1.59</td>
<td>0.28</td>
</tr>
<tr>
<td>Mean</td>
<td>1.73</td>
<td>0.25</td>
</tr>
<tr>
<td>SD</td>
<td>0.11</td>
<td>0.03</td>
</tr>
</tbody>
</table>

* Not an accurate analysis; not included in mean and standard deviation calculations

Table 2. Nutrient content of 7 mature ‘Kaimana’ fruit samples based on dry weight.

<table>
<thead>
<tr>
<th>Sampling Date and Location</th>
<th>% of Fruit Dry Weight</th>
<th>Mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004 Panaewa A</td>
<td>0.74 0.13 0.89 0.13 0.15</td>
<td></td>
</tr>
<tr>
<td>2004 Panaewa B</td>
<td>0.79 0.15 0.99 0.09 0.13</td>
<td></td>
</tr>
<tr>
<td>2004 Kurtistown A</td>
<td>0.75 0.13 1.03 0.12 0.21</td>
<td></td>
</tr>
<tr>
<td>2004 Kurtistown B</td>
<td>0.79 0.14 1.00 0.25 0.18</td>
<td></td>
</tr>
<tr>
<td>2005 Kurtistown A</td>
<td>0.81 0.15 1.03 0.20 0.16</td>
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<tr>
<td>2006 Panaewa A</td>
<td>0.87 0.14 1.08 0.15 0.18</td>
<td></td>
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<td>2006 Keaau</td>
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<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.79 0.14 1.01 0.15 0.17</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>0.04 0.01 0.06 0.05 0.03</td>
<td></td>
</tr>
</tbody>
</table>
Table 3. Pounds of N, P, K, Ca and Mg in 100 pounds of fresh, mature ‘Kaimana’ fruits.

<table>
<thead>
<tr>
<th>Sampling Date and Location</th>
<th>lbs per 100 lbs Mature Fresh Fruit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>2004 Panaewa A</td>
<td>0.18</td>
</tr>
<tr>
<td>2004 Panaewa B</td>
<td>0.18</td>
</tr>
<tr>
<td>2004 Kurtistown A</td>
<td>0.17</td>
</tr>
<tr>
<td>2004 Kurtistown B</td>
<td>0.19</td>
</tr>
<tr>
<td>2005 Kurtistown A</td>
<td>0.16</td>
</tr>
<tr>
<td>2006 Panaewa A</td>
<td>0.18</td>
</tr>
<tr>
<td>2006 Keaau</td>
<td>0.16</td>
</tr>
<tr>
<td>Mean</td>
<td>0.17</td>
</tr>
<tr>
<td>SD</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Figure 1. Monthly flowering means (9 trees) based on the percentage of ‘Kaimana’ lychee tree terminals bearing flower panicles at anthesis for 2002, 2003, 2004, and 2006. Insets indicate corresponding N and K concentrations (% dry weight) derived from leaf samples taken at the onset of flower panicle development.
Postharvest Treatment of Kaimana Lychee to Prevent Browning

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Introduction
Lychee is a stone fruit grown in many tropical and subtropical climates. At harvest, the pericarp, or peel, of this fruit has a pleasing red color that becomes brown within 48 hours. This biochemical change greatly reduces the marketability of lychee and therefore, the economic power of lychee growers. The goal of this research is to find a simple and economical method that growers can use to treat their lychee crop which will delay browning enabling them to ship the fruit to wider markets. According to the literature, methods involving sulfur dioxide and hydrochloric acid showed the most promise. Since SO2 treatment is not an option for fruit grown in the US (except for grapes), hydrochloric acid (HCl) treatment alone was investigated on thawed and fresh lychee.

It has been known that oxygen is required for browning so some proposed treatments involved coating the fruit with substances that prevent O2 absorption by the fruit. However, complete removal of oxygen results in the fermentation of the fruit so some oxygen must be present. These treatments include chitosan, fruit waxes, vinyl resin plastic coatings, and lecithin. Also, antioxidants have been used to prevent browning by neutralizing reactive oxygen species. Antioxidants used include vitamin C, glutathione, citric acid, and cysteine. Physical methods such hot water treatment or hot water brushing has also been used to delay browning. None of these chemical or physical methods have had significant success delaying lychee browning. Finally, storage of fruit under controlled atmospheres of reduced O2 and elevated CO2 and reduced temperature, has been shown to have the greatest success in extending the shelf-life of lychee. Currently, fresh fruit are packaged in 4 x 5 lb bags containing holes and put into boxes. The shelf-life of fruit packaged in this manner is two weeks.

Experiments

HCl Treatment

Overall, three experiments were performed to determine the effect of HCl treatment on delaying the browning of lychee. The first experiment was performed on fruit that were harvested in July of 2005 and stored at -18°C. Samples were thawed and incubated in 5% HCl at 4°C for twenty minutes. In a second experiment, a one pound batch of fresh lychee was incubated in 3% HCl for 15 min and stored at 4°C. Finally, two pound batches of fresh lychee were chilled to 4°C and incubated in either 2, 4, or 6% HCl for 15 minutes and stored at 4°C for 6, 10, 15, and 20 days. At the end of each time period, sample fruit were removed from the refrigerator, photographed, and tested for soluble solids (Brix).
Activities of Browning Enzymes

Peels from treated and untreated lychee were extracted (after 0, 7, 14, and 21 days of storage at 4°C) in a pH 4.0 citric acid buffer by first cutting the frozen peels into small pieces using a food processor. This was followed by homogenization on ice (using a rotor/stator type tissue homogenizer) in 5 mL of citrate buffer per gram of peel. Homogenization was performed until all of the pieces of peels were of uniform size. The extraction solution also contained 1% by weight of peel of polyvinylpyrrolidone (PVP), which was added to remove phenolic compounds that may interfere with the enzyme assays. After homogenization, the extraction solution was centrifuged for 30 min at 4°C. Samples of extracts were assayed for polyphenol oxidase (PPO), peroxidase (POD), and anthocyanase activity.

Results

HCl Treatment

Treatment of thawed lychee with 5% HCl for 20 min at 4°C had a dramatic impact on browning (see Figures 1 and 2 below). Fruit treated in this manner retained their red color for more than four weeks without evidence of mold while the control fruit turned brown within several hours after thawing. It was noticed that thawed fruit will brown much more quickly than fresh fruit which is reasonable since freezing and thawing leads to the breakdown of cell walls allowing for enzymes to access compounds upon which they convert to brown products.

![Figure 1](image_url)

**Figure 1**: Day 0 of thawed lychee treated with HCl, citric acid, vitamin C, or both citric acid and vitamin C.
Figure 2: Day 5 post-treatment of thawed lychee treated with HCl, citric acid, vitamin C, or both citric acid and vitamin C.

Bulk (1 lb) fresh lychee treated with 3% HCl for 15 min showed good color retention 14 days post-treatment (see Figure 3)

Figure 3: One pound of untreated (left) and treated (right) lychee with 3% HCl for 15 min and stored at 4°C.

In a related experiment, fresh lychee was incubated in two pound batches in 0, 2, 4, or 6% HCl for 15 min at 4°C. Brix and color were measured at 0, 6, 10, 15, and 20 days. Fruit treated with 6% HCl had the best appearance 20 days post-treatment while the 2% treated fruit had the worst appearance (see Figure 4).
The 6% treated fruit also showed the smallest change in Brix values (compared to a control group) as indicated in Figure 5 while the 2 and 4% treated fruit Brix values declined significantly.

Figure 5: Percent change in Brix measurements compared to a control of fresh lychee treated with 0, 2, 4, or 6% HCl.
Activities of Browning Enzymes

While PPO and POD activities of peel extracts were measured at 0, 7, 14, and 21 days post-treatment, no anthocyanase activity was detected. Initially (at Day 0), the activities of PPO and POD from treated fruit were lower than untreated fruit indicating that HCl treatment inhibits PPO and POD. However, the activity of these enzymes did increase with days post-treatment but remained lower than untreated fruit (except for PPO activity of 2%-treated fruit) as shown in Figures 6 and 7.

Figure 6: Polyphenol oxidase (PPO) activity of HCl treated fruit (0, 2, 4, or 6%) measured at 0, 7, 14, and 21 days post-treatment.
Figure 7: Peroxidase (POD) activity of HCl treated fruit (0, 2, 4, or 6%) measured at 0, 7, 14, and 21 days post-treatment.

Conclusions

Treatment of fresh lychee with HCl at concentrations between 3 and 6% show great promise in retarding pericarp browning. Fruit treated with HCl retained good color and taste. This treatment is effective because the low pH imparted by HCl stabilizes the red form of anthocyanins, the class of compounds responsible for fruit color. Figure 8 shows the dramatic effect of pH on anthocyanin color.

Figure 8: The effect of pH on color retention in peel extracts from a control fruit ("Con.") and from fruit treated 20 min with 5% HCl ("HCl").

Improved color retention may also be increased due to HCl treatment by the inhibition of browning enzymes polyphenol oxidase and peroxidase. Data presented in Figures 6 and 7 show that the activities of these enzymes are inhibited after HCl treatment. POD in inhibited the most by HCl, especially after the 6% treatment, while PPO is inhibited to lesser extent. An interesting observation is that the activities of both of these enzymes increase as the fruit age, however, the activities of the acid treated fruit never catch up to the untreated fruit with the exception of PPO activity of the 2% treated fruit (Figure 6). So it appears that HCl provides a one-two punch in retarding lychee browning by (1) stabilizing the red form of anthocyanins, and (2) by inhibiting enzymes responsible for pericarp browning, PPO and POD.
HAWAII: BRINGING QUALITY FOOD TO MARKET
Sept 30, 2006

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Hawaii offers food marketers unique fresh opportunities as a tropical oasis in the mid Pacific. For instance, in a world where plant species number anywhere from 235,000 to 400,000, Hawaii with its geographic isolation abounds in exotic tropical species like dragonfruit, mangos, pineapples, carambola, jackfruit, caimito, sapodilla, papaya, rambutan, longan, lychee, and mangosteen.

The United States is now a country of 300 million consumers with population being fed by immigration and rising birth rates among ethnic groups, particularly Latin origin. Demographic changes and issues of health and medical security are causing consumers to look at produce as the first medicine cabinet in the line of defense against disease, obesity, and pre-mature aging.

Health micro segments include Aging Baby Boomers, Diabetics, Clinical Overweight/Obesity, Allergies, and Celiacs and frequently the categories overlap. For instance Celiac Disease, an auto-immune intestinal disorder, now affects 1 in 133. For people with this disease, gluten must be avoided, and for many sufferers fruits and vegetables fill the carbohydrate void.

At the same time, increased cross cultural exposure due to immigration and travel has fostered an interest in novelty fruits and vegetables.

Mirroring these population and health demographics, are the following trends we have observed in our wholesale sales patterns:

- Hispanic vegetables, chiles, and herbs
- Asian vegetables
- Colored vegetables
- Baby vegetables
- Exotic melons
- Tropical fruits
- Organics
- Greenhouse off-season
- For Health Items including Allergen-free; gluten free

Foodwatch Magazine, Minneapolis, which tracks food trends, has noted the following, and I have included in parentheses the corresponding category. :

Emerging (Stage 1): Persimmons (Asian, Tropical Fruits), Kumquats (Asian), Acai berry juice (Tropical Fruits, For Health).
Gaining Popularity (Stage 2): Cinnamon (For Health), Quinoa (For Health), White Tea (For Health, Asian, Tropical)

Mainstream (Stage 3): Pomegranate Juice (For Health), Dark Chocolate (For Health, Tropical), Green Tea (For Health), Heirloom Potatoes, Tomatoes (Colored Vegetables, For Health).

An aging population is one of the biggest factors in the US as far as food marketing. By 2030, over 70 million Americans or nearly 20% of the population will be 65 or older. This is double the current level of about 35 million Americans aged 65 or older. Marketing to this group presents some unique challenges in healthy items, convenience, packaging visuals, nutrition, and logistics. Healthy items like cruciferous vegetables, dark leafy greens, whole grains, and items perceived as SuperFoods (e.g., tomatoes, blueberries, walnuts, beans, oats, blackberries, cranberries, acai, pomegranates, soybeans, and dark orange vegetables) are expected to soar. This is especially true because many in this population are either uninsured or under-insured. Staring at mortality, this demographic in particular seeks out, and pays attention to, health information about fruits and vegetables. “More Matters” is not lost on them.

Consumer surveys have shown that within this demographic, over 9 out of 10 shop specifically looking to reduce their fat intake, and 86% shop following the medical advice of their doctor. Most importantly, 72% of seniors are shopping to reduce the risk of a specific disease (e.g., CVD, cancer, osteoporosis, diabetes, etc). Over 7 out of 10 specifically shop for products helpful in reducing cholesterol levels. Many of these consumers have been conditioned to know that the color of fruits and vegetables is important, as color relates to specific phyto-nutrient properties (e.g., anthocyanins, lycopene, flavonoids, terpenes, iso-flavones, carotenoids, etc.) useful in regulating disease risk or onset.

Obesity is another huge market demographic. Too often, we are like the elephant in the mirror that finally recognizes its self image and does not like what it sees. We in produce have a special obligation: If we are to walk the walk, then our size, silhouette, and profile ought to match what we are pontificating. Our growing red states in the US have nothing to do with politics: the CDC has documented obesity as the second biggest preventable killer in the US after heart disease. Some 44 million Americans or 15% are considered clinically obese with Body Mass Index ratios exceeding healthy guidelines. Unfortunately, this is just not a “Fast Food Nation” in the US, but a worldwide phenomenon: as income, leisure, and food availability increase, researchers have documented similar problems in Europe, Japan, and China. In China some 66 million are considered at risk for obesity related diseases, e.g., diabetes, hard disease, elevated blood pressure, even cancer.

Like Aging Baby Boomers, this demographic is looking at produce for making healthy substitutions in the diet. Items like bittermelon and sunflower chokes with their low glycemic index and inulin properties can help.

The ubiquity of cheap fast foods, high in fats, sodium, and caloric content, doesn’t help. In fact, in a lot of ways, obesity is regressive as fatty foods are relatively cheaper, and often subsidized.
(e.g., sugar, corn (HFCS) relative to healthy ones. Policy makers are beginning to address such issues in school vending machines, advertising, stoplight rankings, and even taxation arenas.

As obesity is growing, so is diabetes, often hand-in-hand. From 1980 through 2002, the number of Americans with diabetes more than doubled--from 5.8 million to 13.3 million. Now in 2006, 16.7 million have been diagnosed and nearly half have Adult Onset Diabetes Type II. Accordingly, many in this demographic are looking for dietary interventions to regulate, manage, or minimize conditions.

The growth of the Latin demographic has been the biggest surprise of all. In 1990, there were a little over 20 million Hispanics living in the US. Now there are 37 million, making Hispanics the largest ethnic group. By 2020, the number will exceed 50 million. Salsa is now the number one condiment in the US, surpassing ketchup. And tortillas are rapidly overtaking bread in sales. This population, very diverse in itself representing a panoply of cultures and traditions, has introduced a number of new flavors and heat intensities to the American cuisine. Melissa’s largest category is Latin and this comprises not only chiles, tomatillos, jicama, and cactus leaves but canella, jamaica, epazote, chayote, malanga, yuca, coconuts, papayas, mangos, sapotes, cherimoyas, plantains, pineapples, and key limes, as well.

Asian Americans, however, comprise the fastest growing ethnic group with a population growth rate of 46% between 1990 and 2000. Currently at 4% of the population, Asian Americans are projected to number 18.5 million by 2020. This demographic is associated with fusion cuisine and increased interest in tropical fruits like carambola, dragonfruit, loquats, kumquats, rambutan, longan, lychee, langsat, durian, jackfruit, passion fruit, and mangosteen.

Finally, all these ethnic and health demographics converge to create tremendous interest in organics. As in many companies, organics is Melissa’s fastest growing category, increasing nearly 350% since 2000 at an annualized growth rate or more than 30%!

These consumer demand variables and market segmentation have also had an impact on the derived retail demand, as well. For one thing, in response to these consumer market trends, retailers have become more concentrated. For one thing, the retail landscape is dominated by Wal-Mart. Basically, there is Wal-Mart and everybody else. Wal-Mart accounts for $317B in annual sales and the next 9 grocers combined still fall slightly short of $300B. For many retailers, this has meant survival does not depend on price competition as it does on points of differentiation in products, service, formats, neighborhood marketing, shopping experiences, décor, etc.

One sees a proliferation of format stores taking on the big cookie-cutter model. Witness Safeway’s “Lifestyle”, SuperValu’s “Sunflower”, Publix’s “Sabor”, Food Lion’s “Nature’s Place” and Ralph’s “Fresh Fare”. All of these stores are looking for points of difference to help them stand out against the competition.

This is where high quality US-produced Hawaiian exotic tropical fruit comes in. Few other items can lend such an instant uniqueness and freshness appeal to a store.
The key to successful marketing to supermarkets is to give the buyer what she or he wants. That is not only high quality reliable produce, but produce that consistently exceeds minimum USDA grades, is certified food safe, and delivered in the right type of packaging meeting consumer expectations, as well as the customer’s need for a unique look.

Buyers expect all parties in the food delivery chain to be real comfortable with technology. This means use of a refractometer to measure sweetness, digital photography to provide development of the crop in progress, packaging that is colorful and invites impulse buys and sustained consumer use, and on-going communication via e-mail. The expectation is that both the wholesaler and the grower have done due diligence by planning ahead and diversifying sources and locales of production to minimize supply risks and fluctuations. This also goes for modern treatment and disinfection methods, e.g., irradiation, cold treatment, etc. The cardinal sin is to short the buyer. In Wal-Mart parlance, this means failure to provide Customer Fulfillment, a scorecardable offense. Retail buyers are planning advertising ahead and typically working on 6-9 month planning horizons, and growers and wholesalers need to be thinking in the same time frame, and communicating accordingly, as well. This involves a reasoned and educated ability, and not aversion, to forecast. As far as the modern businessman is concerned, this is just a part of due diligence.

More and more the norm is an expectation that the grower has foolproof firewalls in place to prevent any kind of food safety incident. The retailer will never assume liability in the event of a food safety incident with private labels supplied to him. That responsibility will be pushed all the way to the private label supplier or co-manufacturer. It is a presumption that food safety and bio-security are paramount and that the grower exercises due diligence in this arena above all else. This means more and more that the grower should take pains to become independently certified for Good Agricultural Practices and Good Manufacturing Practices. If it is a processing facility, the grower-packer-shipper should really go all the way and become HACCP-certified. Hazard Analysis Critical Control Point is a comprehensive, integrated program that identifies critical control points, and seeks to mitigate, document, and minimize risks. It is a formal rigorous program requiring periodic third party inspections and product sampling for both microbiological and chemical residues.

Quality Assurance is much more than just packing to minimum USDA grades. QA encompasses elements of specific customer parameters, food safety, risk reduction, and anticipating and overcoming problems in transit, storage, and food display presentation.

To that end, the Retail Customer expects the wholesaler and grower to devise innovative and distinctive packaging that is functional, addresses real customer needs, and that lends to product interest and excitement. For the Aging Baby Boomer, this may involve a more ergonomic package--easy to handle, open, use and close--with lettering and fonts correspondingly enlarged. For younger consumers, this may mean packaging more dynamic, bolder, and hip that speaks of energy, vitality, and creativity.
The bottom line is that Hawaiian tropical fruits—papayas, rambutan, longan, lychees, apple bananas, etc.—benefit from modern treatment methods in Hawaii to minimize pest and other risks. Hawaiian tropical fruits also fit a great niche in retailers’ designs to differentiate them from the competition. If suppliers can deliver these items in the form needed to enhance that differentiation, Hawaiian growers will find themselves in a very privileged and favorable position.

Appendix:

Developing a Farm Marketing Plan and Selling to a Specialty Buyer

- Identify and promote product, niche
- Seek out Price, Consumption trends
- Understand market dynamics
- Be able to meet minimum USDA grades
- Start with soil fertility & water quality
- Be able to forecast supply
- Get and supervise skilled picking/packing crews
- Use GAP, pre-cool product
- shelf life extension

- Packaging attractive/useful
- Seek reputable freight forwarder
- Seek reliable refrigerated trucking
- Know your costs and breakeven
- Know your buyer’s initiatives
- Seek LT relationship with buyer
- Minimize risks
- Work together with buyer on Federal-State inspections
- Develop markets for off-grade products
Grafting Mangos

Pete Hunter and Marla Hunter
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P.O. Box 978
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October 1, 2006

Aloha

Introduction of Eke Nui Nursery

• Pete and Marla Hunter started Eke Nui Nursery in 1998.
• There were several cultivars already in full production at time of purchase in 1997 on their property.
• We currently have 25 varieties of mango cultivars after changing some cultivars and adding others.
• Mangos love hot and dry conditions with wind protection.
• They have latex that can cause allergic reactions, since they are related to poison oak and poison ivy. Christmas berry is also a relative.

Reasons to graft mangos

• Fruit is generally the same quality and size as that which comes from the tree where scion was obtained.
• Trees bear fruit from two to three years earlier generally when grafted.
• Farmers need something to do with all that extra time.

Styles of grafting techniques used at Eke Nui Nursery (see handout)

• Splice graft
• Whip or side graft

Materials needed…these can change depending on personal choice and ease of acquiring

• Grafting knife
  - We use Tina out of AM Leonard’s mail order magazine. 800-543-8955
  - Item #605 T or for Leftys..605LH
  - They also have a new Heavy Duty Tina 600AT

• Grafting tape
  - We use 1” clear tape currently…Marla is meditating on whether or not to try rubber bands.
• The advantage of rubber bands is that they do not need to be removed in a couple months after the graft has taken.
• The advantage of using the clear tape is that it stays strong until the graft has taken completely and is manually removed (the winds we get can be forceful and may damage the grafts).

• Parafilm
  ▪ This is used to seal the graft area and up over the scion. It keeps the wood’s moisture intact until the graft starts to take and the rootstock can supply enough moisture.
  ▪ Hawaii Chemical & Scientific
    www.hawaiiscientific.com
    808-841-4265  Tell them Eke Nui Nursery sent you.

• Demo
  ▪ Marla will attempt to demonstrate splice grafts and whip or side grafts. No talking while this is going on due to the extreme danger.

If there is time, we hope to have a few from the audience try to graft their own tree.

By Marla Hunter
Eke Nui Nursery
P.O. Box 978
Naalehu, Hawaii  96772
(808) 929-8127
Marla’s Favorite Ways to Graft Mangoes
Vegetative propagation is frequently used to multiply selected cultivars that have superior qualities (e.g., fruit, nut, or medicinal). Commonly used techniques include propagation by cuttings, grafting, and air layering. Each of these methods has advantages and disadvantages. This presentation focuses on vegetative propagation by cuttings as a means to rapidly, cheaply, and easily multiply woody plants such as fruit, nut, medicinal, and native Hawaiian trees and shrubs.

Research into rooting ability of cuttings has shown that nearly all woody plants can be propagated by cutting if certain factors are recognized. These factors include

- the environment from where the cutting is collected
- selection of cutting material
- post-severance treatment of cuttings
- the propagation environment.

These factors will be discussed in depth with hands-on demonstrations.

A design for a non-mist propagation box will also be presented as a low-cost, easily constructed alternative to mist propagators. The non-mist environment has several advantages over mist environments and has shown to frequently yield superior results.
HANDOUT
Vegetative Propagation by Cuttings Using a Non-mist Propagator
Hawai‘i Tropical Fruit Growers Conference
12 Trees Project, Nāpo‘opo‘o, October 1, 2006

Craig Elevitch
Permanent Agriculture Resources
Holualoa, Hawai‘i

Based on a presentation by:
Roger R.B. Leakey
Agroforestry and Novel Crops Unit
School of Tropical Biology
James Cook University
Cairns, Australia

Recommended reading


http://www.agroforestry.net/events/pres/Leakey_Introduction%20to%20Vegetative%20Propagation.pdf
Abstract

With the Area Wide Integrated Fruit Fly Pest Management Program in Hawaii (HAW-FLYPM), a number of issues have emerged regarding lure-trapping methods and their effectiveness alone or in combination with bait sprays and sanitation. The traditional lure toxicant system (95 or 99% liquid lure with 1 or 5% dibrom or malathion respectively, in use for many years in detection and eradication programs throughout the United States and elsewhere) is being evaluated against new trap designs and new products. The restriction of lures to monitoring and detection uses in the U.S.A. is also being reevaluated. While use of these lures for population suppression is currently restricted to government eradication efforts, registration is progressing for products that growers can use for mass annihilation of male fruit flies. At the same time, there are increasing restrictions on the use of organophosphate pesticides, which necessitates advancing alternative trapping methods. USDA-ARS experiments have determined that the traditional water+lure trap approved for monitoring fruit fly populations in Hawaii, continues to be one of the most efficient traps for catching flies compared to lure-toxicant traps and one-way entrance traps. Nevertheless, these latter two trapping methods mentioned have their appropriate uses.

For back yards and residential areas, it is possible that the USEPA will not approve traps containing organophosphate-based toxicants. In these situations, the one-way trap plus lure are the easiest for the grower to use. Although the water+lure trap will catch more flies, it is more labor intensive. For commercial growers, new products are going through the EPA registration process nationally, and there will most likely be specific registrations for the State of Hawaii. Individually packaged toxicant strips have been tested by the USDA, and individually packaged lures are currently available in Hawaii. However, over-reliance on lures alone may not achieve the levels of control required. The combination of lures, GF120 Naturalyte bait spray, and sanitation has proven to be the most effective integrated pest management approach.

Introduction

In recent years the United States Department of Agriculture (USDA), Agricultural Research Service (ARS) has made a large commitment to the suppression of the tephritid fruit flies in the Hawaiian Islands (Kaplan, 2004; Woods, 2001; Vargas et. al., 2003a). At the time this program was initiated, under the name of the Hawaii Area Wide Integrated Fruit Fly Pest Management Program (HAW-FLYPM), the only products available in Hawaii for fruit fly control were protein food baits that could be added to tank mixtures of organophosphate pesticides permitted for each crop. Organophosphate cover sprays that targeted fruit flies as well as other pests were common. Detection-trapping was restricted to the use of protein baits or...
lures attractive to the males. In the case of the lures, the trapping was limited only to monitoring purposes and used only water as a killing agent.

The HAW-FLYPM program first obtained a 24C registration to apply liquid lure mixtures with Dibrom® concentrate (EPA regulation no. 5481-480), based on a similar 24C registration by California. Unfortunately most Hawaii growers did not adopt the use of this liquid mixture for the following reasons. Dibrom® Concentrate was only available in 55 gal. drums from a supplier in the continental USA (AMVAC Chem. Corp., Los Angeles, CA). The HAW-FLYPM program purchased that quantity and paid a handling fee to have the supplier decant the Dibrom® Concentrate into approved 5 gal. carboys, and shipped to Hawaii. Nevertheless, many of the growers were not able to use it. Only the larger growers in Hawaii maintain pesticide applicator licenses, and of those who do, few were prepared to follow the stringent safety procedures for this technical grade toxicant. Consequently, the project managers realized the need for an alternative form of toxicant. Vaportape II™ (Hercon®, Emigsville, PA) is widely used for insect trapping programs throughout the continental USA (Durkin and Follansbee, 2004) because of its less stringent handling regulations (being individually packaged, the applicator is not exposed to the product until it opened to be deployed). Hercon had obtained registration for use of vaportape in Hawaii for fruit fly control. However, there was no specification regarding its use in combination with lures.

A permanent solution to the problem of trapping fruit flies has not been provided, particularly when population suppression though male annihilation is the objective. Various alternatives to Dibrom Concentrate® have been tested, including spinosad (Vargas et. al., 2003b), fipronil (Vargas et al., 2005), and various solvent combinations (Pandey et. al., unpublished data). Registration of various toxicants and lures is in progress at the time of writing, but it is uncertain if the Environmental Protection Agency will authorize the use of such toxicants in residential neighborhoods. In addition, the use of these products may continue to be restricted to licensed pesticide applicators. Many farmers in Hawaii are small growers living in what might be considered residential or high occupancy neighborhoods. Others are certified organic growers who are reluctant to employ organophosphate pesticides even when enclosed in traps.

Therefore, the HAW-FLYPM program pursued a policy of trying to find alternative trapping methods for those who could not or would not use pesticide traps (Jang, unpublished data, Pandey et al., unpublished data). This study specifically compares the use of various configurations of 1-way entrance traps (Tan 1985, Hiramoto et al. in press and Jang, unpublished data) to similar configurations of Vaportape traps.

In addition, this study considers the impact of a border array of these various traps in a small orchard situation typical of what might be found in Hawaii’s diversified agricultural landscape. The HAW-FLYPM program recommended proteinaceous bait spray as part of its “1-2-3” approach to fruit fly control (Jang, 2003; Prokopy et. al. 2003; Prokopy et al., 2004). The product used in these trials, GF120 Naturalyte®, is fully registered for use under most conditions (including organically registered farms) and on most fruit and fruiting vegetable crops grown in the State of Hawaii. Sanitation (proper disposal of infested fruit) (Liquido, 1993) and male annihilation (mass trapping) (Cunningham and Suda, 1986; Vargas et al., 2000) are also highly recommended for population suppression. This study considers the application of methyl eugenol for male annihilation, as previously proposed by Stiener et al. (1965), without additional suppression components.
The null hypotheses (i.e. the treatments will have no effect) are that the trap catch will not differ among the trap configurations, and the deployment of these traps around an orchard will not impact the fruit fly population within the orchard.

**Materials and Methods**

*Comparison of trap designs:*

Thirty methyl eugenol traps were placed in random order around the border of a small orchard (Fig. 1) on June 20, 2006. The trap area bordered an area of ca. 1.3 ac. (0.526 ha.), which was equivalent to a trap density of 24.6 traps/ac (60.79 traps/ha. These traps were divided into 6 treatments, 5 replications of each treatment, and each treatment had a different trap configuration (Table 1). In addition, six multilure traps containing Solulys protein bait were distributed throughout the orchard to monitor male and female oriental fruit flies (*Bactrocera dorsalis*) within the orchard. A similar orchard was used as a control. It contained blocks of guava (*Psidium guajava*) varieties that match in number the varieties in the treatment block. Only protein bait traps were deployed in the control field in a similar distribution to the treatment field. One difference between the orchards is that a particularly attractive (to fruit flies) variety of guava is found on the south side of the control orchard, whereas that attractive variety is planted on the north side of the treatment orchard. Although both orchards are surrounded by other fruit tree species, the distribution of these is not identical in both orchards.

The thirty traps were randomly distributed around the border of the treatment orchard. These traps were all 20.96 cm dia. by 20.32 cm high opaque plastic buckets (volume = 132 oz., or 3.90 Kg.) with lids, entrance holes on the side of the bucket and drain holes on the bottom. The **toxicant traps** (VT) contained Hercon® Vaportape™ II strips. This product contains 2, 2-Dichlorovinyl dimethyl phosphate or DDVP). The **one-way entrance traps** (HIR) relied on micro-centrifuge tubes (capacity 1.5 ml, 11mm o.d., 41.6 mm length) to help deter the flies’ escape from the trap. The specific differences between the traps are described in Table 1, and consist of differences in the number and size of entrance holes and drain holes.

These traps were monitored on a ca. weekly basis from Jun. 27, 2006 until Sep. 26, 2006, and biweekly thereafter. The flies in each trap were collected in separate paper (or plastic) bags, and returned to the laboratory for evaluation. Where large numbers of flies were caught, the volume was measured in a conical graduated cylinder. This volume was multiplied by a standard factor of 12, which had been determined in previous comparisons of volume to fly counts (Jang, unpublished data). If the sample was small, the flies were manually counted. The means and standard error of the mean (SEM) were plotted and a general linear models analysis (SAS® Institute, Cary, NC) was applied to the data.

*Impact of traps on fly population:*

The second objective was to determine if the trap array significantly impacted the density of male or female oriental flies within the orchard surrounded by traps. Trap catches were plotted
on a map, and the male fly density was interpolated over the area using “Geostatistical Analysis radial basis function with a completely regularize spline” (ARCInfo®). Sampling of the protein bait traps in both the treated and control orchard began on Jun. 13, 2006, and continued on a weekly basis to Oct. 13, 2006. Mean ±SEM of the five traps in each orchard was calculated each week and plotted. Regression models were applied to the data to compare orchards.

Results

Comparison of trap designs: reject null hypothesis.

Initially there was no significant difference between 1-way traps and vaportape traps (Fig. 2). Toxicant traps had the higher catch overall, while the difference between 1-way trap catch was not correlated to the number of entrance tubes per trap. By the 5th week of deployment, it was clear that the toxicant traps began to catch more flies than the 1-way traps (Fig. 2). Trendline models illustrate the population fluctuation over the sampling period (Fig. 3). These models were associated with 80.6% of the variation in all toxicant trap catches, 82.9% of the variation in all 1-way trap catches, and the two groupings differed significantly (F_{1,375} = 24.92, P>F = 0.001). Over the sampling period, a significant difference between trap types developed (Table 2). By the 10th week, only the toxicant traps with ¾ inch (1.9 cm) holes had a higher mean catch than all of the 1-way traps. Toxicant traps with 5/16th inch (0.71 cm) holes did not catch significantly more flies than a 1-way trap with 8 entrance tubes, until Aug 22, 2006. Nevertheless, the 5/16th inch entrance trap with Vaportape began to catch more efficiently as the DDVP vapor dissipated. By week 13 (Sept. 26th), the 5/16th inch entrance trap had the highest mean catch. The three trap-types with toxicant did not consistently and significantly differ from each other in mean catch until Sept. 15th (F_{5,24}= 2.56, P>F = 0.0478). The difference in the area of the drainage holes had marginal effect on the trapping rate.

The peak catch occurred in the 13th week (3.25 months, right at the limit of the vaportape’s ability to release toxicant). By the 15th week there was a clear decline in toxicant trap catch, compared to only a very slight decline in 1-way trap catch (Fig. 3). Nevertheless, the high capture rate indicated that there were both adequate lure and residual toxicant present in the trap at that point in time.

Impact of traps on fly population: Null hypothesis can not be rejected.

The mapping of the methyl eugenol traps and computing the density around and within the treated orchard (model -.059x +56.942, mean 1.962, root mean^2= 40.88) was helpful to illustrate the influence of the traps on male oriental fly. Comparing the actual ratio of the trap with maximum catch to the trap with the minimum catch (max/min) on each sampling data, it became clear that the differential was greatest when the population was lowest (Fig. 4). The lowest differential occurred on Aug. 29th when the population reached 43.4 flies/trap/day (Fig. 5).

Protein bait traps within the treatment and control orchards indicated that male oriental fly populations had declined and remained under 0.2 FTD within the treatment orchard until Oct 13th (Fig. 6). This occurred in spite of a large increase in lure trap catch over the period of lure
deployment (Fig. 7). Male catch by the protein bait increased in the post fruit drop period when infested fruit were on the ground. While the control orchard had little population at the outset, by the 9th week, both male and female numbers within that orchard began to increase. After fruit-drop the population peaked, and male population remained low in the control orchard. There is no evidence of a carry over effect from the treatment orchard, which was at a distance of 1826 feet (556 m), but methyl eugenol has been reported to attract flies at a distance of >1 Km. However, male population in the treatment orchard increased, in spite of the surrounding trap array. The fact that the male population in the control orchard was also increasing by the 19th week probably reflects the increase in overall fly population. Female population increased in both treatment and control after the fruit drop, but 6 weeks later it began to decline in both orchards, even though the methyl eugenol trap catch was rising rapidly.

Discussion

Comparison of trap designs:

The implications of these results for trap design are as follows. The toxicant trap, where appropriate and with the proper entrance size, is more efficient at catching flies than 1-way traps within the period that the toxicant is effective. Nevertheless, there is an initial period of nearly 3 months when the fly capture in the toxicant trap catches at approximately the same rate as the 1-way trap. We suspect this is due to the dichlorvos vapor in the trap being too concentrated and preventing some flies from entering the trap. Previous tests (Hiramoto et al., in press and Jang, unpublished data) indicated that recharging the Vaportape negatively impacted the catch rate of the trap for a period 80 to 100 days. In those experiments the traps had either smaller volume, or had smaller entrance holes (equivalent to the diameter of the tubes in the 1-way traps). This would suggest that there was a vapor exchange rate difference. Jang, unpublished data, offered evidence that flies were dying outside the traps, most likely due to the DDVP (dichlorvos) surrounding the trap. It is also possible that the concentration of the vapor in the trap was sufficient to deter some flies from entering the trap, in spite of the very attractive lure odor (methyl eugenol). Further tests are needed to determine if this is the case. The information from this experiment regarding traps of different hole size suggests that the rate of dissipation of the DDVP into a larger volume and out through larger entrance holes, leads to a more rapid decrease in the concentration of vapor within the trap. This in turn leads to a more rapid increase in the trapping efficiency of a large toxicant trap.

Currently, Vaportape can only be used by licensed pesticide applicators, and has only a 2 to 3 month range of toxicity, after which the trap must be serviced and the toxicant replaced (Hiramoto et al., in press). There are also issues of contamination of the tissues of leaves and fruit that are proximate to the trap (Cam. et al. 1990), and there may possibly be future restrictions on the use of organophosphate pesticides. New products are under development (spinosad and fipronil) which may provide toxicant and lure in the same matrix. These should be designed such that the lure and the toxicant deplete at a similar rate and duration. It would also be preferable that the toxicant be more environmentally acceptable (Vargas et. al., 2003b).

One-way traps, on the other hand, can be deployed as long as the lure is attractive, which can be up to 6 months in the case of methyl eugenol presented in Scentry Biologicals’ plastic matrix. These are also safe to deploy in back yards and residential areas where there may be
children and pets. While the 1-way traps are not as efficient as water traps (Jang, unpublished data) they can catch substantial numbers of fruit fly with minimum labor requirements.

Impact of traps on fly population:

The implications of this test for lure trapping are as follows. It is apparent that lure trapping alone, at the annihilation density that will probably be allowed by the Environmental Protection Agency (ca 10 to 20 traps per ac. or 25 to 50 per ha.), is not adequate for suppression in situations where the population of flies is large. Cunningham (1986) subjected a 155.5 ac. (63 ha) papaya field to 3.6 trap/ac. (9 traps/ha.) and achieved > 99% suppression of males oriental fruit fly, but only a 48% reduction in fruit infestation. Vargas et al. 1990 had shown the impact of area-wide regeneration of flies in host material outside the crop being protected. This study indicates that male lure traps have the most impact when the fruit fly population is low. Thus an integrated approach has been recommended by the HAW-FLYPM program to be the most effective approach to crop protection. While male annihilation (mass trapping) does impact the male population within the protected area, the addition of bait spray and sanitation is advisable to reduce female flies. This is particularly true when there is a large population of flies.

Development of suitable female lures for these species would be a significant improvement in the application of mass-trapping for fruit fly control and is being developed (Siderhurst and Jang, in press). In the absence of an efficient female lure, protein bait spray is the only attractant available for trapping female flies. Further tests are planned to compare the addition of GF120 bait spray and field sanitation to the trapping regime in this orchard experiment.

Acknowledgements

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References


Cunningham, R. T. and D. Y. Suda. (1986). Male annihilation through mass-trapping of male flies with methylleugoenl to reduce infestation of oriental fruit fly (Diptera:Tephritidae) larvae in papaya. J. Econ. Entomol. 79: 1580-1582.


Figures

Table 1. Trap specifications for the various trap treatments.
Table 2. Mean± SEM of oriental fruit fly catch over 15 weeks by trap type.
Fig. 1. Maps of the two orchards. The upper map is the treatment orchard and the lower map is the control orchard.
Fig. 2. Performance of 1 gal. bucket traps over 15 weeks with and without toxicant.
Fig. 3. Trendline models for the combined toxicant traps and 1-way entrance traps.
Fig. 4. Population in the treated field 23 days after traps were deployed.
Fig. 5. Population in the treated field 45 days after traps were deployed.
Fig. 6. Mean± SEM of the population of oriental male and female fruit flies within the control and treated fields as measured by protein bait trap captures.
Fig. 7. Mean± SEM of the population of oriental male surrounding the control orchard as measured by methyl eugenol traps.
Table 1: Comparison of the trap designs

<table>
<thead>
<tr>
<th>Entrance dimensions</th>
<th>Killing method</th>
<th>Drainage holes</th>
<th>Traps and Treatment codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/16(^{th}) inch. 0.79 cm dia. 4 holes</td>
<td>Four 1-way tubes</td>
<td>none</td>
<td>Hir 4</td>
</tr>
<tr>
<td>5/16(^{th}) inch. 0.79 cm dia. 4 holes</td>
<td>Six 1-way tubes</td>
<td>none</td>
<td>Hir 6</td>
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<tr>
<td>5/16(^{th}) inch. 0.79 cm dia. 4 holes</td>
<td>Eight 1-way tubes</td>
<td>0.16 cm dia., 6 holes</td>
<td>Hir 8</td>
</tr>
<tr>
<td>5/16(^{th}) inch. 0.79 cm dia. 4 holes</td>
<td>Vaportape™ II</td>
<td>0.16 cm dia., 6 holes</td>
<td>VTSM</td>
</tr>
<tr>
<td>3/4 inch. 1.9 cm dia., 4 holes</td>
<td>Vaportape™ II</td>
<td>0.16 cm dia., 6 holes</td>
<td>VT</td>
</tr>
<tr>
<td>3/4 inch. 1.9 cm dia., 4 holes</td>
<td>Vaportape™ II</td>
<td>0.3 cm dia., 4 holes</td>
<td>SVT</td>
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</table>
Table 2: Oriental fruit fly catch over 15 weeks by trap type

<table>
<thead>
<tr>
<th>Trap design</th>
<th>Total flies caught</th>
<th>N</th>
<th>Mean FTD</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vaportape 5/16th inch. entrance</td>
<td>34,040</td>
<td>50</td>
<td>46.32a*</td>
<td>7.78</td>
</tr>
<tr>
<td>Vaportape 3/4 inch. entrance (6 drain holes = 0.483 cm²)</td>
<td>34,253</td>
<td>50</td>
<td>45.74a</td>
<td>8.27</td>
</tr>
<tr>
<td>Vaportape 3/4 inch. entrance (4 drain holes = 0.322 cm²)</td>
<td>31,089</td>
<td>50</td>
<td>42.46ab</td>
<td>6.68</td>
</tr>
<tr>
<td>1-way 8 entrance tubes</td>
<td>19,028</td>
<td>50</td>
<td>25.45abc</td>
<td>3.82</td>
</tr>
<tr>
<td>1-way 4 entrance tubes</td>
<td>13,810</td>
<td>50</td>
<td>20.70bc</td>
<td>3.30</td>
</tr>
<tr>
<td>1-way 6 entrance tubes</td>
<td>12,536</td>
<td>50</td>
<td>17.44c</td>
<td>2.42</td>
</tr>
</tbody>
</table>

*Tukey pairwise comparison tests. ANOVA: F₅,₃₇₅= 5.23, P>F = 0.0001
Zee Areawide Guava Project

Fig. 1.
Performance of large bucket traps with and without vaportape

Fig. 2.
Fig 3.
Fig. 4.

7-13-06 Collection

Range = 0.62 to 22.5 FTD
Max/Min = 36.0
Mean of all traps = 9.3± 1.5 FTD
Fig. 5.

8-29-06 Collection

8-29-06 Prediction Map

8-29-06 collection
FTD
- 0.00
- 0.01 - 17.14
- 17.15 - 34.29
- 34.30 - 68.57
- 69.58 - 137.14

Range = 9.71 to 137.1 FDT
Max/Min = 14.1
Mean of all trap = 43.4 ± 5.9 FTD
Fig. 6.
Fig. 7.

Increase in male oriental fly population at treatment site

- Mean of 30 traps
- Poly. (mean of 30 traps)

$R^2 = 0.9679$
i Better World Manufacturing, Fresno, CA
ii Roquette America, San Francisco, CA
iii Hercon Environmental, Emigsville, PA
iv Fisher Scientific, Pittsburgh, PA
v Environmental Systems Research Institute, Redlands, CA